THE DEVELOPMENT OF AN OFFSITE CONSTRUCTION ADOPTION STRATEGIC GUIDELINE FOR THE IRAQI CONSTRUCTION INDUSTRY

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Ph.D. Thesis **2020**

THE DEVELOPMENT OF AN OFFSITE CONSTRUCTION ADOPTION STRATEGIC GUIDELINE FOR THE IRAQI CONSTRUCTION INDUSTRY

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Salford, UK

Submitted in Partial Fulfilment of the Requirements of

the Degree of Doctor of Philosophy

2020

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Declaration

This research is submitted under the University of Salford rules and regulations for the award of a PhD degree by the research. While the research was in progress, some research findings were published in refereed conferences papers prior to this submission.

The researcher declares that no portion of the work referred to in this research has been submitted in support of an application for another degree of qualification of this, or any other university or learning institution, either in the UK or another country.

Nehal Saffar

Acknowledgments

I would like to thank my supervisor, Dr Kaushal Keraminiyage, who has consistently been a source of great inspiration in his dealing, guidance, encouragement, and assistance throughout the period of the undertaking of this research.

Further, thanks and sincere appreciation go to my previous supervisor Prof. Mohammed Arif who first believes on my research and assist me during the first year, the second thanks go to my second supervisor, Prof. Carl Abbott, who also helped me in the second year. Many thanks go to my father, Dr. Adel Al-Saffar, who paved the way for this journey of self-development and achievement of knowledge in the United Kingdom (UK). Many thanks go to my father in law, Dr. Hadi Zibon, for his support and advice. Many thanks go to my brothers, Nawar Al-Saffar Mustafa Al-Saffar , and my husband Ahmed Hadi, who supported me during the journey of my study. I would like to thank, Dr. Thair Shahar, for his assistance in understanding the statistical tests. Many thanks go to Mr. Husam Kashmoola (Director of the Construction Projects for the Ministry of Oil) and Dr. Basim Al-Shakirche (Designer Manager of Rhodes Precast Concrete Ltd) for their valuable discussion and advice.

I would like to extend my thanks to all the interviewees who have agreed to be part of this study and participated through sharing their experience, knowledge and time, not forgetting also the academic and supporting staff at the University of Salford for their unlimited support.

I also would like to extend the acknowledge and my warmest gratitude towards all my colleagues. I wish to express my appreciation to Dr. Wael Al-Naseri for his invaluable support throughout my whole PhD journey and for a wonderful friendship. My gratitude is also forwarded to Dr. Adnan Al-Shahrani, Dr Hajer Al-Dahash, Dr Balqais Allali and Dr. Taha AL-Obaidi for their support and for being companions during my PhD study.

My special thanks and gratitude go to my dearest parents, who have been the main reason and inspiration for this stage of my life. My father's never-ending love has been supporting me in each and every step I take, and I am sure he would be proud of my work. To my mother never-ending love for the continuous support and the strength she has given me throughout my entire life. My deepest thanks and appreciation for my husband and lovely son and daughter, who have shown me enormous patience and tolerance in this endeavour, always offering support, help and encouragement to make this long journey easier. My gratitude goes to my brothers for their continuous prayers and support.

Dedication

I would like to dedicate this research endeavour to my dearest father Adel, mother Alaa, my beloved husband Ahmed, my lovely son Yousef and my gorgeous daughter Nadeen, who are true gems, and my brothers Nawar & Mustafa, who are always close to my heart.

List of publications

Seffar, N., & Abbott, C. (2017). *The use of OSC method to reconstruct Iraq.* Paper presented at the 13 th international postgraduate research conference 2017.

Saffar, N. & Keraminiyage, K (2019). Drivers for using OSC in Iraq. The 14th International Postgraduate Research Conference 2019, The Salford University, The UK.

List of abbreviations

OSC	Offsite Construction
CC	Construction companies
USECB	University scientific engineering consulting bureaus
UNDP	United Nations Development Programme
IMMPERST	Interactive Method for Measuring Preassembly and Standardisation
MMC	Modern Methods of Construction
IBS	Industrialised Building System
IGCC	Iraqi government construction companies
OSF	Off-Site fabrication
OSM	Off-Site Manufacturing
OSCT	Off-Site Construction Techniques
OSP	Off-Site Production
ICT	Information communication technology
PPP	Private public partnership
PPE	Personal protective partnership
CITB	Construction Industry Training Board
ECITB	Engineering Construction Industry Training Board
DSM	Decision Support Model
SWOT	Strengths, Weaknesses, Opportunities, and Threats

Abstract

Offsite construction (OSC) has been recognised as one of the alternative technological solutions to address the housing shortage and historical problems associated with the construction industry's performance, such as labour shortages, time and cost overruns. Most developed countries have already adopted offsite construction and are benefitting from its advantages; however, the slow adoption of such technologies is evident in some developing countries. Iraq is one such developing country, despite the vital and urgent need to rehabilitate the country after the disasters of the last decade.

This research aims to develop a strategic guideline to help increase the knowledge and use of OSC in the Iraqi construction industry by investigating the drivers and barriers affecting the adoption of OSC in Iraq. Therefore, in order to develop an appropriate and effective strategic guideline to support the adoption of OSC in Iraq, the researcher adopted a mixed-method approach, combining both quantitative and qualitative data. Questionnaires were developed and distributed to two different groups - construction companies (CC) and Universities' Scientific Engineering Consulting Bureaux (USECB). The CC group reflects the practical facet of projects, while the USECB group reflects the theoretical side related to design with the use of modern technologies. Data from the questionnaire were further analysed using the Chi-Square for Independence test to determine whether there is a relationship between factors affecting the use of OSC in Iraq. Furthermore, a correlation test was conducted to identify the strength of these relationships, whilst the Kruskal-Wallis test was applied to identify differences between construction companies and USECB regarding the factors affecting the use of OSC in Iraq. To collect qualitative data, semi-structured interviews were conducted amongst 14 expert participants in the construction industry in Iraq. The collected qualitative data were analysed using a thematic analysis technique to identify themes and patterns.

The results showed no significant gap in perception between both the CC and USECB groups on the adoption of OSC in Iraq. Both groups support the use of OSC in Iraq and strongly believe that its use will increase in the coming years; however, they are concerned about its adoption due to the existence of many barriers, such as client resistance, lack of guidance and information, the unstable security situation and financial issues.

Nevertheless, the findings indicate that the presence of drivers is fundamental to the adoption of OSC in Iraq. Indeed, the effective availability of such drivers could ultimately enhance the successful adoption of such technology in Iraq, which in turn could increase housing delivery, improve construction performance, reduce CO_2 emissions, and improve energy efficiency. The findings revealed eight main drivers enhancing the use of OSC in Iraq, and nine main barriers can hinder its use in the country. The results also highlighted significant relationships between time, quality and cost related drivers for both CC and USECB. In comparison, highly significant relationships are found between the related barriers of industry & market culture with skills & knowledge as well as supply chain & procurement with project complexity for both groups. These findings will not only benefit the construction industry in Iraq but also contribute to an increased understanding of these influences and their relationships in other construction industries in different countries. The valuable contributions of this research are the schematic diagrams of the relationships between the influential factors, which could be integrated into higher education programmes within construction-management-related disciplines.

The strategic guidelines produced at the end of the thesis are designed to enable solutions and offer guidance on how to combat the negative factors that can inhibit the optimal outcomes following the application of OSC in Iraq. It also offers effective tools to facilitate the shift in focus of these construction companies towards the best management of OSC projects. The proposed strategic guideline is expected to benefit governments, policymakers, industry and academics by enabling them to identify areas of concern and determine best practice in order to take full advantage of the benefits offered by OSC for all types of buildings.

Chapter 1 **Introduction**

1.1 Background of the research

The construction industry is one of the most important employment sectors in any country, playing a vital role in the provision of buildings, public institutions, infrastructure, job creation, environmental improvements, and economic development. Ultimately, the success of a construction project can be assessed according to the degree to which it meets the key project management indicators of time, cost and quality, and the overall level of satisfaction for the client, end user and general public. As the construction industry has historically suffered from poor performance worldwide, many initiatives have been established to improve its performance and image. Offsite construction (OSC) was introduced under the comprehensive umbrella as one of the 'modern methods of construction' and as a means for both improving and changing the construction industry's way of thinking and its practices (Akintoye, Goulding, & Zawdie, 2012).

Many research findings demonstrate that OSC techniques offer numerous advantages, including the minimisation of construction time, a reduction in the number of skilled labourers onsite, an increase in project quality, the improvement of onsite safety performance, increased labour productivity, and the consideration of environmental issues (Wu et al., 2019; Al-Mutairi, 2015). Further benefits include eradicating commercial risk, overcoming skills shortages, and meeting the needs of the local market (Goulding & Arif, 2013). Therefore, the use of OSC to combat and resolve housing crises in different countries has been widely explored in the literature (Ojoko, Osman, Rahman, & Bakhary, 2018; Bendi, 2017). Moreover, Krishnanunny and Anoop (2018) conclude that OSC is an ideal replacement for traditional construction due to the social, economic and sustainability advantages that it offers.

Although most developed nations have already accepted OSC techniques due to their many advantages, OSC has had a relatively low uptake in the construction industries of developing nations. One example of this is Iraq where there has been a slow adoption of such construction techniques despite their benefits (Abbood, Al-Obaidi, Awang, & Rahman, 2015). Indeed, during the mid-seventies to mid-eighties, Iraq's government purposely embraced and adopted new structural techniques and different methods of construction that sped up the construction process whilst minimizing the housing shortage problems.

However, during this time in Iraq, there was also a fluctuation in production and a gap between what was required and what was produced (Abod, Hussain, & khafaji, 2011).

Indeed, Iraq faced a series of disasters between 1980 and 2014, as each disaster severely impacted the country and subsequently lead to further catastrophes (Jaffar, 2015). In fact, during the Iran-Iraq War of 1980 to 1988, investment in the construction industry came to a halt due to decreased revenue and the diversion of the country's wealth to fund the war effort (Al-Obaidi, 2018). Moreover, in 1991 the First Gulf War occurred, and its subsequent draconian sanctions lasted for the next 13 years, as the international response to the Iraqi invasion of Kuwait wreaked havoc on an already distressed economy and caused a collapse in the Iraqi infrastructure (Sanford, 2003). Thus, international economic sanctions prohibited Iraq from working out any trade or financial actions with other countries.

Moreover, in 2003, the Iraqi regime was felled as the result of invasion and war, which lead to the destruction of most of the country's infrastructure. Indeed, security, political and economic issues have arisen and proved unstable since that time. Furthermore, from 2014 to 2016, Iraq faced the entry of a terrorist organization (**Islamic State of Iraq and Syria)** that resulted further financial, economic and political problems and halted most construction projects in the country (AL-Azawi, 2015; Al-Kafaji & Salman, 2015).

Even though the Iraqi government attempted to establish various strategic plans to overcome the financial and housing crises, such as the public housing scheme (1980-2000) and the National Development Plan (2010-2014) these proposals did not achieve their objectives due to either circumstances related to war or economic, administrative and security-related hinderances (Jaffar, 2015). Consequently, this succession of crises, challenges, and weak or unsuccessful policies have all exacerbated problems deepening their impact and affecting all aspects of Iraqi society (Iraqi Ministry of Planning, 2018). This has meant that the aforementioned policies adopted by the government have not achieved their objectives.

1.2 The rationale for this research

Iraq has been subjected to dramatic change, especially in its political and economic systems. Politically, the country has altered radically from dictatorial and centralised systems to a more modern democratic system that believes in pluralism and the sharing of governance. On an economic level, for the first time since 1990, Iraq has been able to freely use and invest in oil revenues in the reconstruction of its economy and infrastructure that was completely destroyed by the wars and international sanctions during the 1980s and 1990s (Al-Obaidi, 2018). However, reconstruction projects in Iraq have experienced a high failure rate due to immature and unprofessional development plans, problematic routine procedures, and a lack of properly qualified people and ongoing training (Al-Turfi, 2017). Additionally, according to Khaleefah and Alzobaee (2016), the proportion of failed projects in Iraq is relatively large due to poor management performance and insufficient knowledge of the ethical application of construction project management.

Moreover, Bekr (2017) states that construction projects in Iraq suffer from many problems in performance, such as time, cost, quality and safety, mainly due to its political and security situation. In fact, Iraq's economy, including the construction sector, has clearly been adversely affected by a series of wars; additionally, after 2003, it became a base for a terror organization, thus becoming a region of "explosion and instability". Indeed, research by Al-karawi (2018) points out that the construction sector in Iraq has failed to achieve the same level of development and competition as similar sectors globally. Moreover, political, financial and administrative problems alongside tenders and security issues could threaten construction projects and negatively impact their performance (Al-karawi, 2018; Mohammed, 2018; Bekr, 2017).

Furthermore, there are other problems associated with construction in Iraq that mainly depend on classic construction. Khammas, Mohamed, and Rzayej (2014) indicated that Iraq's field of construction suffers from a problem with waste of materials as a result of traditional construction activities. In addition, this construction system is no longer sustainable due to the increasing effect of technological advancement and global warming (Abbood et al., 2015; Kadury & Ali, 2010). The continuing energy crises in Iraq since the Gulf war highlighted the difficulties in achieving energy efficiency, whilst the situation worsened due to the invasion in 2003. In addition, the crises are likely to increase by 2028 due to the increasing population and inability to meet the demands for energy (Abbood et al., 2015; Istepanian & Al-Khatteeb, 2014;

Kazem & Chaichan, 2012). However, Abbood et al. (2015) showed that OSC is able to decrease the demand for heating and cooling in Iraq compared with conventional systems. Another problem is the low productivity of workers, which causes problems for local contractors and sub-contractors. Indeed, Toama and Adavi (2015) ascertained that, in most countries, but especially in Iraq, low labour productivity is a big problem for the building and construction industry. In addition, the shortage of skilled workers is one of the greatest challenges facing the Iraqi construction industry (Alkinani, 2013). This labour shortage has forced the construction industry around the world to find creative solutions to meet the demand for such services. OSC methods provide a possible solution to the labour shortage (Killingsworth, Mehany, & Ladhari, 2020). Moreover, Mahmoud (2009) and Mohammad and Rasheed (2014) indicated that a poor safety record in the Iraqi construction industry compared with other countries could lead to increased costs from the treatment of injuries. Indeed, a long period of traditional construction can cause many problems, such as difficulties in securing payments from contractors and owners, increasing materials prices or stolen materials, and changing client requirements. However, the advantages of using OSC are substantial as it can reduce the familiar problems of the Iraqi construction industry through shorter project durations, enhanced health & safety, fewer workers required onsite, better labour productivity, and improved environmental aspects (Wuni & Shen, 2019; Al-Mutairi, 2015). Furthermore, the simplification of OSC design helps the contractor to organise work activities in an appropriate sequence and this includes the ability to freeze design early to reduce late changes by clients (Yunus, 2012a). Furthermore, the risk of onsite OSC equipment theft significantly decreases, as costly components/elements of construction are finished in the factory and assembled on site (Paliwal, 2019).

Notably, one of the biggest problems in Iraq is the shortage of housing. As previously mentioned, the housing crisis has increased due to the destruction and catastrophes that have occurred as a result of wars and terrorist acts (Teen & Gramescu, 2018; Abramov, Stepanov, & Ibrahim, 2017; Al-Hafith, Satish, Bradbury, & de Wilde, 2017). Moreover, Al-Hafith et al. (2017) argued that the country's housing production is weak, its financial system is inefficient, and there are problems with the infrastructure services and availability of construction materials. Furthermore, the production deficit is evident from the growing gap between the annual housing production and household formation since the 1990s (Al-Hafith, Satish, & de

Wilde, 2019). Furthermore, the population of Iraq is estimated to increase by 51,211,700 in 2030 according to the Iraqi Central Statistical Organization (Iraqi Ministry of Planning, 2013).

An estimation of housing needs in Iraq for the end of 2016 was placed at 2.5 million housing units, furthermore the number of informal settlements totalled 521,947 houses, while the population of the slums reached 3,292,606 people in 2017 (Iraqi Ministry of Planning, 2018). According to Al-Hason (2016), Iraq needs more than 5 million housing units to fill the existing deficit whilst an estimation of the increasing number of units needed amount to millions each year (Al-Hason, 2016). In comparison, Teen and Gramescu (2018) estimate that Iraq currently requires 4 million housing units. In addition, there is a need to repair and rebuild infrastructure after the destruction it suffered as a result of the wars (Iraqi Ministry of Planning, 2018; Teen & Gramescu, 2018).

Consequently, although the Iraqi government has attempted to outline and deliver certain policies to rebuild and develop the country, particularly the housing sector, not all objectives have been achieved due to the crises that have occurred. Therefore, in order to improve and develop the country, the government has prepared a National Development Plan (2018-2022), with support from the UNDP and other UN Agencies, to develop a reconstruction framework for the country (United Nations Development Programme, 2018).

Two of the key objectives detailed in the National Development Plan and adopted by the Iraqi Ministry of Planning are:

- To encourage large private companies in Iraq to contribute to the financing and implementation of residential complexes through the establishment of low-cost housing instead of slums.
- To secure the implementation of housing units according to modern methods and techniques, in order to contribute to the fulfilment of the housing deficit for all regions, including those that have been destroyed by terrorist and military operations (Iraqi Ministry of Planning, 2018).

Moreover, there have already been some academic attempts to highlight the OSC concept when addressing the issue of housing shortages in Iraq. Abod et al. (2011) ascertained a need to rehabilitate the OSC industry and keep up with technological developments in the construction field. This would enable the implementation of residential buildings and limit the issues and challenges encountered as traditional construction is unable to implement construction in such a short time. Moreover, Mohee (2011) affirmed the presence of a knowledge gap related to OSC in Iraq, whilst Afif (2013) believed that pre-fabrication companies were rare in Iraq despite the declaration in 2013 by the Ministry of Housing and Construction that a pre-fabricated system would be the main construction system used. Furthermore, a recent study by Abbood et al. (2015) confirmed that OSC in Iraq is rare and that there is insufficient and limited knowledge of prefabrication construction and its application. In addition, Abod et al. (2011) stated that the poor quality of prefabricated building products constructed between 1970 and 1980, was the main reason for their rejection, thus increasing the cost of production and reducing the production performance economically.

Furthermore, recent studies also offer several recommendations regarding the use of OSC. For instance, Al-Taai (2015) stated that the housing shortage in Iraq was estimated at 6.5 million housing units; therefore, the researcher recommended the involvement of both the private sector and government when addressing this issue and the development and introduction of prefabricated manufacturing factories. Moreover, in order to improve the construction performance in Iraq, emphasis has been placed on the importance of introducing modern technology including OSC, the use of modern materials, and the development of project management systems (Khaleefah & Alzobaee, 2016). In addition, Abramov et al. (2017) recommended the use of prefabricated reinforced concrete for reconstruction housing in Iraq, while Teen and Gramescu (2018) recommended the use of modern technology and construction materials to resolve the housing and infrastructure deficiencies in Iraq. Another possible solution was suggested by Al-Hafith, Satish, Bradbury, and de Wilde (2018) who believe that the mass construction of multi-family courtyard residential buildings could offer a solution for the housing shortages in Iraq. Meanwhile, Al-Hafith et al. (2019) recommended the support of formal, private, sector-led housing production as a promising primary approach as it has enabled countries to benefit from the development of sustainable housing.

In brief, there are calls to use OSC by both the government and academic researchers in Iraq, but so far there has been slow progress in such production within the Iraqi construction industry. Moreover, there is no comprehensive study on the status of OSC in Iraq, especially with regard to the factors affecting its adoption to date. Likewise, there is no evidence of the successful implementation of OSC within an Iraqi context in the literature. The best construction organisations will constantly search for proven technologies to gain a competitive advantage in the industry; however, insufficient information regarding the benefits of new technologies and a lack of awareness will discourage industry stakeholders from embracing new practices (Yang et al., 2007). Therefore, the driving factors of this research aim to leverage knowledge and awareness of this type of sustainable construction, which can present benefits to Iraq in terms of: -

- Cities rehabilitation in the face of excessive destruction due to disaster (in comparison, the application of classic construction would take longer);
- Meeting housing needs around the country by providing mass production in a short time.
- Meeting the need to rehabilitate the infrastructure of the country as a whole.
- Improving the performance of construction projects with regard to time, cost, quality and productivity.
- Improving safety records in construction projects.
- Reducing the problems associated with waste materials and improving environmental aspects.
- Improving labour productivity.
- Solving the problem associated with the skilled labour shortage.
- Reducing energy demand.
- Contributing to the transference and exchange of global knowledge in the Iraqi construction industry in order to progress and improve the prevailing situation.
- The current research intends to fill gaps in the available literature thus raising awareness and highlighting the benefits and constraints of OSC.

Therefore, addressing the high demand for housing and infrastructure facilities, along with a sustainable built environment, and the transference and exchange of global knowledge in the Iraqi construction industry is vital in order to progress and improve the prevailing situation. As a result of this research, the researcher aims to develop an OSC strategic guideline for the extensive implementation of off-site practices for the Iraqi construction industry.

1.3 Research questions

- What factors drive and hinder the stakeholders in pursuing OSC practices in Iraq?
- What types of good practises does the construction industry require to support and maximise the uptake of OSC?
- How can stakeholders be persuaded and guided to move from conventional method to best use of OSC?

1.4 Aim of the research

The aim of this research is to develop a strategic guideline that will assist in increasing the knowledge and use of OSC in the Iraqi construction industry.

1.5 Objectives of the Research

1. To review and explore the current knowledge about OSC concepts, and the barriers and drivers for using OSC in both developed and developing countries.
2. To investigate (professional and practitioner) perceptions towards the barriers, drivers, and good practices of utilizing OSC in Iraq.
3. To establish the relationships and interdependencies between factors that impact on the implementation of OSC in Iraq.
4. To formulate the strategic guideline that support the use of OSC in Iraq.
5. To refine and finalise the strategic guideline through validation from industry experts.

1.6 Scope of the Research

This research study is broadly focused on the development of an OSC strategic guideline for Iraqi construction organisations. During the process, it investigated the current state of OSC in Iraq along with the drivers and barriers to the adoption of its practices. The research scope and population for the data collection was limited to large Iraqi construction companies owned by Ministry of Construction and Housing, and one significant private company in Iraq; therefore, medium and small sized companies were not considered. All required data were collected through a questionnaire and interviews methods, whilst the developed strategic guideline validated through semi-structured interviews. However, the researcher does not address how to implement this guideline or the factors that can affect the implementation process.

1.7 Structure of the Thesis

The thesis consists of seven chapters, which were composed as follows:

1) **Introduction to the Research**: This chapter provides an introduction, outlines the need for this research, states the research problem, research aim and objectives, and delineates the scope of the study.
2) **Literature Review**: The first section of this chapter discusses OSC and the various related terms. The advantages, disadvantages, drivers and barriers related to OSC are identified in this chapter. The next section highlights the current challenges and problems in the construction industry in Iraq along with the current application of OSC.
3) **Methodology**: This chapter discusses all key steps involved in the research, including the research philosophy, research approach, research strategy, choice of data gathering tools, procedure and data analysis methods.
4) **Quantitative Data Analysis:** This chapter includes an analysis (considering the research objectives) of the data collected from the administration of the questionnaire survey.
5) **Qualitative Data Analysis**: This chapter includes an analysis of the data collected from the interviews.
6) **Discussion:** This chapter discusses the main findings generated from the questionnaires, interviews and literature review. Emphasis is placed on both drivers and barriers related to the use of OSC in Iraq.
7) **Strategic guideline**. In this chapter guidance is provided on how to deal with both the drivers and barriers of using OSC in Iraq.
8) **Validation:** In this chapter, the strategic guideline will be validated by a number of expert participants working in OSC field in Iraq.
9) **Conclusion:** In this chapter, conclusions are drawn from the study based on the main findings from the quantitative and the qualitative methods. Future work will be provided in the context of OSC in Iraq.

1.8 Summary

Iraq has faced many disasters, which have led to countless challenges and issues, including the destruction of infrastructure, a severe housing shortage and the halt of several construction projects. Therefore, this thesis has introduced OSC as a solution to help reconstruct the country and support government initiatives to develop the field of construction in Iraq. However, there is a knowledge gap and a slow adoption of OSC within Iraq. Moreover, there is a gap in academic research related to the Iraqi context in terms of OSC, specifically regarding the drivers and barriers. In addition, there is no clear management system to enhance its use. Therefore, the research aims to develop a strategic guideline to enhance the use of OSC in Iraq. Moreover, five objectives are considered in order to gather sufficient information and understanding of the research topic and to offer validated guidelines which can then be used to support and enhance the implementation of OSC in Iraq. Subsequently, there is a need to understand the drivers and barriers when using this type of construction, in order to avoid any potential pitfalls and encourage good practice when employing this strategic guideline in the future.

Chapter 2 **Literature review**

This chapter presents an understanding of OSC and the different terms from the existing literature. The first part documents the relevant literature on OSC, the terminology, the various practices, and worldwide trends.

The chapter reveals the larger picture of the application of OSC techniques across the worldwide, and attempts to identify the similarities that can be drawn with respect to the current research area, Iraq. In detail, it introduces the term of OSC, and the various terms related to it. It also gives a discussion of the main types of OSC techniques, the drivers and barriers towards OSC adoption.

Nevertheless, the second section examines the current construction industry in Iraq. It highlights the problems associated in this industry. It also discusses the available literature in OSC related to Iraq. It also identified the recent application in OSC in Iraqi construction industry.

SECTION A

2.1 Background

Industry stakeholders in many countries have started consider innovative ways of constructing by incorporating off-site and on-site activities (Ansari, Thaheem, & Khalfan, 2016). A significant amount of published literature exists on offsite technologies and their use in the worldwide construction industry. In the UK, OSC has been promoted as an innovation to improve the efficiency of construction (Pan & Sidwell, 2011). Rogers (2003, p. 12) defined innovation as "an idea, practice, or object that is perceived as new by an individual or other unit of adoption". **Diffusion of Innovation** (DOI) theory is one the oldest social science theories developed by Rogers, Morgenthaler, and Morgenthaler (1962). It generates communication to explain how, over time, an idea or product gains momentum and becomes diffused through a specific population or social system. Moreover, it explains the rate at which users will adopt a new product or service. Therefore, the theory helps marketers understand how trends happen, and supports companies to assess the likelihood of success or failure of new initiatives. Moreover, Rogers (2003) model of innovation adoption advocates a set of stages before an initiative is implemented. Individuals develop the ability to express attitudes, make decisions, apply, and confirm whether innovations should be practiced. The concept of innovation in construction indicates the creation of new ideas in design, production, and implementation processes, where attention focuses on planning, technical solutions and implementation (Larsson, Eriksson, Olofsson, & Simonsson, 2014). Taylor (2010) indicated that OSC is an important contributor to the continuous development of construction processes and site procedures. Moreover, Akintoye et al. (2012) clarified that OSC has been adopted as one means of enabling the construction industry to overcome skill shortages and meet market demands. Despite an organizational decision to adopt technological innovation, its actual use depends on how workers execute an innovation. Therefore, it is important to assess the adoption of innovations by workers within organizations because, if there is no acceptance among workers, the desired benefits cannot be achieved and the organization may ultimately abandon the innovation (Talukder, 2012). Accordingly, Roger's theory of innovation will be adapted for this research in order to understand and assess the adoption of OSC technology in the Iraqi construction industry. Further sections discuss the concept of OSC in more detail; furthermore, researchers have examined the diversification of the concept, its terminology and the definition of OSC in several contexts and backgrounds. Researchers stated that OSC was extensively used after World War II due to the need for housing. Indeed, OSC can now be used for a variety of applications including residential, educational, health care, civil engineering, infrastructure, and so forth.

2.2 Off-site construction (OSC) and related terms

OSC is a method that was introduced under the comprehensive umbrella of the 'modern method of construction' as a means for both improving and changing the construction industry's thinking and practices (Akintoye et al., 2012). OSC is the manufacture and pre-assembly of building components, elements or modules before installation into their final locations Goodier and Gibb (2007). Moreover, Fraser, Race, Kelly, and Winstanley (2015) refer to OSC as the part of the construction process that is carried out away from the building site; for instance, in factories or in especially created production facilities close to the construction site. In other words, it means moving some activities that used to be implemented and completed onsite to a manufacturing environment where products are manufactured prior to their final installation on site (Gibb and Pendlebury (2006). For Elnaas (2014), the preferred definition is that OSC is understood to be a construction strategy aimed at producing more in less time, with better quality and less environmental impact, by using an off-site manufacturing processes that takes place under a factory-controlled environment. It transforms the traditional construction site into an assembly workshop of prefabricated elements and/or components. The adoption of OSC involves the use of standardisation, technology, and labour more efficiently and provides a well-organized, integrated product management process, both offsite and onsite.

Hence, this research concludes that the definition adopted by Elnaas is a closer description and is thus adopted in this study. The reasons for this are detailed as follows:

- It is quite a comprehensive definition as it summarises several definitions identified by other researchers and gives a broader picture of the concept of OSC.
- Moreover, section (1.2) highlighted several issues regarding the Iraqi construction industry as a consequence of the wars that left large destruction to the infrastructure. Also, many of its factories are either destroyed or stolen while others need rehabilitation. Therefore, Iraq needs to rehabilitate its manufacturing factories and support its local production. Although developed countries have achieved good progress in the supply of different types of OSC product, in Iraq few factories produce such materials. Elnass states that OSC is produced via a manufacturing process that transforms the traditional construction site into an assembly workshop of prefabricated elements and/or components and modules. These components or elements include panels, pods, doors, doors handle, trusses framework, and so forth. Accordingly, Iraq in a post war era, needs to produce different levels of OSC or import these internationally. The levels of OSC will be explained in the next section
- The first chapter identifies the poor performance of the construction industry in Iraq, which mainly depends on facets of classic construction, including time, cost and quality. Therefore, Elnaas' definition clarifies the benefits associated with OSC, which helps to enhance the construction project performances in Iraq.
- Poor labour productivity is another issue highlighted in section 1.2. Elnass' definition demonstrated that OSC improves labour efficiency as the products are prefabricated under a factory environment that provides a good work environment that mainly depends on machines and reduces the need for workers onsite, which contrasts with classic construction.
- The large-scale destruction of Iraq and its subsequent housing shortage (clarified in section 1.2) necessitate the need for technology and standardisation in design in order

to produce simple units and rapid assembly. Indeed, Elnaas' definition pinpointed the use of technology and standardisation when applying OSC.

There are different terms for OSC in the literature, which are considered worth highlighting. Off-site construction, off-site manufacturing, manufactured construction and modern methods of construction are some common terms that have been used interchangeably in the literature to describe pre-fabricated construction; the commitment is to move some of the construction effort into the controlled environment of a manufacturing facility (Goulding, Rahimian, Arif, & Sharp, 2012). It is important to know the differences between modern methods of construction and OSC. The OSC is a sub-set of modern methods of construction (MMC). Therefore, most OSC can fall under MMC but not all MMC can be considered off-site. Despite the terminology differs in many countries, attention towards OSC is significant worldwide. It is widely known as Modern Methods of Construction (MMC) in the UK, Off-Site Construction Techniques (OSCT) in the US, ,Offsite Manufacturing (OSM) in Australia and Industrialised Building Systems (IBS) in Malaysia (Bendi, 2017).

2.3 Types of OSC

The classification of the construction industry for OSC technologies is based on the degree of innovation in the process, products, construction materials and system (Elnaas, 2014). Two production sites are involved when using OSC technologies. These are off-site factory and on-site (Mostafa, Chileshe, & Zuo, 2014). Factory assembly offers advantages for manufacturing of complex components or highly repetitive building elements, which means that off-site is not restricted to the prefabrication of volumetric or big building elements (Hall, 2010).Various authors classified OSC into a number of types, namely volumetric, non-volumetric, modular, component manufacture and sub-assembly, and hybrid (Jonsson & Rudberg, 2014; Mostafa et al., 2014; Gibb & Pendlebury, 2006). These are detailed in the following sub-sections.

2.3.1 Volumetric system

A type of OSC that includes units providing usable space produce volumetric buildings (Gibb, 1999). These units' form parts of a building but do not form a whole building. Very little work is needed to complete these units on-site because they are almost completed in the factory and ready for transportation and installation on site. Volumetric buildings involve 3D modules and commonly refer to pods that are pre-assembled (Ross, Cartwright, & Novakovic, 2006).

Volumetric buildings design to be easily dis-assembled, moved and repositioned (Hall, 2010). Some examples of volumetric building are toilets, rooms, bathrooms, and plant rooms (Gibb & Isack, 2003).

2.3.2 Non-volumetric system

Non-usable spaces are typically enclosed by pre-assembly units (Gibb, 1999); some examples for this type of OSC are pre-cast concrete bridge sections, structural steel work, timber trusses, pipework, and so forth (Gibb & Isack, 2003).

2.3.3 Modular system

This type of construction produces pre-assembled volumetric units, which form a whole or part of a building, including the envelope and structure (Gibb, 1999; Mostafa et al., 2014). Most work on the units is done off-site. However, some work may be completed on site, such as finishing the operation and assembly of the modules. There is also a possibility of 10 assembling fully fitted out modules before transportation to the site (Elnaas, 2014). Examples include prison cell units, hotel/motel rooms and restaurant facilities.

2.3.4 Component manufacture and sub-assembly

This falls short of being categorised as systemic OSC but utilises factory manufactured innovative sub-assemblies or components. This category refers to relatively small items such as light fittings, windows, door furniture and trusses (Gibb & Pendlebury, 2006). The sub-assemblies and components are always produced off-site (Mostafa et al., 2014). However, there is other system indicated in the literature which is the following:

2.3.5 Hybrid system

Arif and Egbu (2010) have mentioned a new category of OSC as a combination of any two or more volumetric or non-volumetric systems, named as Hybrid systems. Such as: factory finished bathrooms with interior finishing, plumbing and electrical service, factory completed office room (Lu, 2007).

2.4 Influential factors to OSC adoption

Following significant progression in the concept of OSC, researchers started to focus on clarifying the factors that predominate as the real drivers of, and barriers to, OSC. This helps the stakeholders to gain an understanding of how the benefits of OSC can be used to increase its uptake and how obstacles can inhibit this uptake if not properly overcome. In this regard, a number of studies have attempted to analyse these factors (for example, (Al-Mutairi, 2015; Arif, Bendi, Sawhney, & Iyer, 2012; Pan, Gibb, & Dainty, 2008; Blismas & Wakefield, 2007). Moreover, since the current research aimed to develop a strategic guideline to enhance the adoption of OSC in Iraq, the identification of such factors is essential. Therefore, this part will highlight a brief listing of drivers that affect the use of OSC as identified by different authors. It will also discuss each driver. While the second part in (2.5) will highlight the brief list of barriers identified by different researchers in different countries, it will also provide a discussion for each barrier later.

Researchers worldwide have identified the advantages of using OSC, which are somewhat similar to the drivers. In this regard, Goulding and Arif (2013) indicated that the drivers behind global interest in the use of OSC methods are generally similar in terms of the benefits that they can deliver including faster, safer, better-quality and cheaper construction capable of being delivered at scale and meeting the needs of the local market . This is supported by Bendi (2017) who stated that the term ‘driver’ is known as the factor that affects the positive adoption of offsite techniques in construction activities. In similar vein, Mohamad Kamar (2011) indicated that OSC methods have apparent advantages that drive industry stakeholders to adopt it in their projects; these benefits lead to cost advantages.

In this regard, Gibb and Isack (2003) identified the expectations and drivers for using OSC in a project from construction clients' perspectives in terms of time, cost, quality and productivity benefits through the minimisation of on-site processes and duration, less congestion on site, improved health and safety, and greater and more predictable quality**.** However**,** Pasquire, Gibb, and Blismas (2004) confirmed Gibb and Isack findings, but decide to restate the original project driver sets of cost, time and quality and create sub-sets to accommodate the major variables under those headings also adding two softer drivers, which are sustainability and health & safety**.** Later, Blismas, Pendlebury, Gibb, and Pasquire (2005) noted that the verified list of benefits in the original client guide and toolkit provided both positive and negative aspects for OSP; it was these attributes that would determine the use of OSP on a project. The positive influences evolved into the driver subsets and the negative influences were labelled constraints to the process. It is worth to mention that one of the objectives of this toolkit was to help the stakeholders in identifying the key project drivers and barriers and support the project team in enhancing the benefits of standardisation and preassembly.

However, Pan (2006) declared that this developed method for assessing standardisation and preassembly has contributed to understanding the drivers for using offsite in a project context. However, the organisational context seems to be less reassessed in the drivers identified in the toolkit. This may include organisations’ considerations for the organisational strategy, and commercial drivers, the government's environment and revisions to building regulations. Hence, Pan added new drivers to be considered when using OSC.

Further, Pan et al. (2008) examined a list of drivers and highlighted the most important from housebuilders’ perspectives when using OSC, which are quality, time, cost, productivity and health and safety. However, Goodier and Pan (2010) believed that one of the important factors to drive the move towards OSC is the need to achieve higher environmental standards. Pan and Goodier (2011) indicated that the UK Government’s sustainability and 'zero carbon' homes agenda undoubtedly provide incentives for the UK housebuilding business to consider adopting innovative technologies, which offer an important driver for OSC. Also, government-funded social housing has traditionally been the main driver for offsite technologies. Blismas and Wakefield (2009) identified drivers for using OSC in the Australian construction industry under the features of process and programme, cost/productivity, people and OHS, quality and environmental/sustainability.

Sustainability aspects seem to be largely consider by the decision makers for their consideration of using OSC. Lawson, Ogden, Goodier, and Goodier (2014) agreed with other researchers in consideration of the drivers by emphasising on the importance of understanding of decision-making parameters of cost, time, and quality, which in turn can be quantified in financial terms. The researcher further added that in modern building projects, the range of decision-making parameters are further extended to include sustainability in terms of its economic, environmental, and social impacts (Lawson et al., 2014).

Consequently, it seems that researchers acknowledge the drivers for using OSC. There is also development in assessing the drivers for using OSC, which also includes assessing drivers at the project and organisation levels. Indeed, it seems that most researchers considered the benefits of OSC as drivers. This may be because researchers consider every positive factor towards the adoption of such construction as a driver. This research will also consider every positive factor as a driver, which also aligns with the findings of Bendi (2017) and Mohamad Kamar (2011). This introduction gave a brief summary of the drivers; however, the next section will provide more detail as well as the related drivers which will cluster similar factors in one cluster.

2.4.1 Time related drivers

The traditional construction is unable to meet the demand in the short run. In addition, time overruns and project delay remain as a critical issue in the sector of construction industry. As such, the construction industry recognised the need for a construction technique in order to speed up the construction process represented by OSC. Legmpelos (2013) stated that time is a significant factor for all projects; a typical saying "time is money" is particularly true for the construction industry, and enormous benefits can be achieved from early completion. Gibb and Pendlebury (2006) indicated the significant value of time when using OSC; this is due to the associated benefits, including less time required for onsite activities, a predictable completion date (because it is not weather dependent). This is also supported by (Fraser, Race, Kelly, Winstanley, & Hancock, 2015).

Therefore, numbers of researchers supported the related time drivers such as reduction of construction time or speed of construction as indicated by (Gibb and Isack (2003). This is also supported by Mohamad Kamar (2011) & Goodier and Gibb (2007); GOODIER and GIBB (2005).

The saving on time when using OSC is result from a large number of onsite activities being moved offsite into a factory. This is supported by (Alazzaz & Whyte, 2014) who founded reduction onsite time as most significant benefit for using OSC. This is also agreed by Lawson et al. (2014) who indicated that slow unproductive site activities are replaced by more efficient and faster factory processes when using OSC. The writers also mentioned that further savings in time on site can be achieved in projects_with high levels of OSC and this in turn can be beneficial if the project need to be built in poor weather or in difficult site working conditions (Lawson et al., 2014).

Similarly, a number of authors (Fraser, Race, Kelly, Winstanley, et al., 2015) argued that there are some factors that cause reduction on time duration of the project including:-

- Less equipment and fewer facilities need to be removed at the end of the project, thus decreasing disruption, noise, dust, etc for local residents and minimising time.
- The concurrency of activities allows the overall project schedule to be shortened; for example, the groundworks on site can occur whilst major elements of the facility commence offsite. Furthermore, offsite work can be conducted in several different locations at the same time. This approach also helps co-ordination between different jobs.
- Higher productivity rates in factories result in shortened times. In fact, as productivity tends to reduce the delivery time, it is expected that individual benefits are greater under such circumstances (Yokota & Aye, 2016).
- The use of OSC contributes to the progressive commissioning of the overall facility. This is because the onsite M&E phase can be shortened (due to factory testing) and may be started earlier and completed easier on a zone-by-zone basis.
- Both time and cost are reduced, mainly due to the fact that building offsite removes the unknown elements and variables associated with assembly on site. Indeed, it is less costly to use OSC to build large and repetitive designs within a short time (Mydin, Sani, & Phius, 2014).

On the other hand, time reduction driver has positive affect on other factors. The reduction of time on site can have marked and beneficial effects on contractor cash flow and the cost of finance (Krug & Miles, 2013). This is because a shorter build time leads to reduced site management costs and an earlier return on investment. In addition, the speed of construction confers a major financial advantage to the building developer in the form of reduced financing costs. Fraser, Race, Kelly, Winstanley, et al. (2015) agreed with Krug & miles and further added that reducing time on site means that commissioning (electrical & mechanical services) can start sooner. Thus, both reduced the commissioning programme and improved the commissioning process leading to cost benefits. Indeed, clients considers time is an issue, as many would incur significant costs if they failed to meet agreed completion dates for their projects and some would benefit from the early income stream from shorter projects (Gibb & Isack, 2003).

Furthermore, the early completion is fundamental and highly benefits to some projects. This is supported by Krug and Miles (2013); Gibb and Isack (2003) and Fraser, Race, Kelly, and Winstanley (2015) as they found that time is crucial for some types of projects, such as:

- Airports: when a long time is required due to operational disruption, this can have substantial negative effects on the primary revenue-generating operations of the client.
- Prisons: time is important for security considerations.
- Hospitals: private hospitals have a very strong financial drive to open sooner, and National Health hospitals have a combination of financial and public policy drives.

Moreover, supporters of OSC argue for the faster delivery of projects than with on-site construction. Bendi (2017) confirmed that the speed of delivery is an important driver to the use of OSC in India, and the other two significant drivers include ensuring time certainty and minimising the onsite duration. Vernikos (2016) also agreed with Bendi (2017) in terms of faster onsite delivery and assembly when using OSC. Krug and Miles (2013) further added that OSC methods are up to 60% faster than conventional construction methods. Indeed, Fraser, Race, Kelly, Winstanley, et al. (2015) determined that, if OSC is adopted early in the design process, it can cut build times in half depending on the project.

The researchers further indicated benefits obtained from faster delivery of the project. In this regard, Legmpelos (2013) illustrated the benefits from accelerating the project that can impact positively on people, which are: -

- Most projects need to borrow money (raise debt) to be constructed. Each month interest has to be paid for borrowed money. It will be a major advantage to pay back faster than scheduled.
- The net present value of the project is also significantly increased by saving money from interest and receiving a positive cash flow faster. For example, if a hotel is delivered three months earlier than schedule, the benefits from renting rooms three months earlier are tremendous. Consequently, the overall investment might become much more favourable.
- It can help the contractors to move faster to the next project as well as save money on insurance and interest if they have outstanding loans.

The shorter project duration when using OSC has a positive impact on other factors. Gibb and Isack (2003) mentioned that shorter project durations mean less risk in terms of market changes. Pan (2006) further mentioned that, for a private housing development, it was significant to match the build speed with the rate of sales in order to reduce market risks. The researcher's case study company was motivated to maintain control over the speed of construction, by ensuring time certainty through using offsite technologies. The company had a negative experience of market change, and so desired to benefit from the time predictability in using OSC within their projects.

In the similar vein, Jiang, Mao, Hou, Wu, and Tan (2018) stated that the benefits of time saving could bring significant financial savings and social benefits and help reduce the risks associated with stakeholders. For example, for the contractor this meant less site work (concreting, plastering, etc.) and risks (falls from heights, etc); for the client this meant less loan interest and a faster return on investment, whilst for the government this meant more available dwelling units and related infrastructure. OSC can also reduce the need for onsite workers and difficult activities because part of the onsite work is taken off site into factories.

Accordingly, time-related drivers have been explored widely in the literature such as the speed of construction, reduction of overall project duration and ensuring time certainty and it can, therefore, being investigated for their impact on the driving of the use of OSC in Iraq. The time-related drivers also seem to have a positive impact on other factors, such as cost and quality management, the reduction of health & safety risks, enhancing environmental aspects, and so forth.

2.4.2 Quality related drivers

The biggest advantages of OSC over traditional construction were the decreased construction time on site, increased quality, more consistent products, reduced snagging and defects, and the reduced whole life cost (GOODIER & GIBB, 2005). Pan, Gibb, and Dainty (2007) also indicated that high quality is one of the most important drivers to use OSC in UK.

Moreover, according to the results of an interview survey conducted with major UK construction clients, Gibb and Isack (2003) demonstrated that quality is the second most cited reason for using OSC. The researchers explained that: -

- The quality obtained from factory-made components is better than on site.
- The ability to ensure consistent quality
- Parts were more liable to be engineered to fit together correctly. This means preventing the need for (snagging) remedial works to achieve the required standard; this is one of the goals in re-engineering construction in order to get rid of waste from the process.

- Another factor that appeared to be important is the ability to visit the factory and see the final product before installation on-site.

There are many factors contributed to achieve high quality indicated by researchers. As OSC methods are factory based, this offers better potential to ensure high functional and design quality standards (Burwood & Poul, 2005). Alistair (1999) also indicated that producing high-quality products is more conductive in a factory environment. Manufacturing facilities usually have a stable workforce who can be trained properly and are likely to produce higher quality work (Alistair, 1999). Also, quality control and assurance procedures are easier to apply in the factory environment. Fraser, Race, Kelly, and Winstanley (2015) further agreed with Alistair (1999) that the components and assemblies are made under better factory quality control and are tested prior to delivery on site. Hence, better quality and more reliable assemblies reduce the need for re-work and result in fewer total resources.

Another driver related to the quality factor is OSC products are less defects than traditional construction products. Taylor (2009) further mentioned that factory-controlled conditions mean a better quality of build, a better finish, and fewer defects. Also, all snagging is complete, and all services are tested. These benefits are matched by those for the skilled labour who implement the work – a warm, controlled and enclosed workplace using production line techniques that pointedly reduce the risk of accidents and ill health.

Similarly, Blismas and Wakefield (2008, 2007) identified that one of the important drivers for the use OSC in the Australian industry is to provide higher quality, better control, and greater levels of consistency. Furthermore, product testing allows for the better control of safety factors/margins, improved component life, and reduced whole life cost and defects through a quality-controlled factory environment. Design can be refined in manufacture to improve quality and enable the use of new/different materials and processes.

Within the Malaysian market, Mohamad Kamar (2011) mentioned that the first most important driver for contractors using OSC is high quality. This is because OSC offers improvements to quality, productivity and efficiency from the use of factory-made products, thus reducing the possibilities of poor workmanship and a lack of quality control. Complex shapes and finishes can be inspected, and any sub-standard components can be rejected before becoming incorporated into the structure (Mohamad Kamar, 2011).

Furthermore, OSC offers good quality products with better surface finishes, which are more refined than those made possible by traditional construction. This is because the former are typically made of superior quality materials which use advanced technologies and are produced under the supervision of prominent experts in the field (Mydin et al., 2014).

Nevertheless, the survey results gathered by Zhai, Reed, and Mills (2013) explored the driving forces for using OSC in the urban residential construction industry in China shows that the most frequently mentioned key benefit of off-site production, namely improved quality, was not as highly rated as in previous studies (e.g. Jaillon and Poon (2008)) in which improved quality control and waste reduction were the most significant benefits. This means that the industry was suspicious about the potential to 'achieve a high building quality' with OSC, which might describe the reason why off-site applications are hardly ever used in structural construction process for high-rise apartment buildings. However, this opinion may no longer supported by researchers in china offsite market. A SWOT analysis by Jiang et al. (2018) on promoting the use OSC in China shows ensuring building quality as a strength for the use of OSC. This is because prefabricated products tend to be developed in manufacturing factories in which each component is millimetre-perfect, which significantly reduces the need for site-measuring and problem-solving. Consequently, OSC is increasingly seen as a worthwhile approach for the delivery of high-quality products; this is due to the higher quality control in a factory environment.

However, to obtain optimal quality of the final products and finishing, it requires to consider some factors such as design and implementation process. Gibb and Pendlebury (2006) argued that the correct design and execution of OSC products will: consistently achieve a predefined quality in a factory-controlled environment; decrease damage from handling and storage onsite, and limit the risk of damage from follow-on trades by using modular units and sealed volumetric.

In the same vien, Callistus, Felix, Ernest, Stephen, and Andrew (2014) found that there are some factors related to consultants that can affect the quality performance in the project including fraudulent practices and kickbacks, lack of coordination between designers and contractors and; poor monitoring and feedback. In addition, other factors related to contractor can affect the quality which are: lack of training on quality by teamwork, lack of management leadership and lack of contractor experience. In the same vein, Gan et al. (2017) highlighted that there are factors can affect the quality in OSC divided into categorises which are:

❖ Factors related to production such as:

- Poor quality raw materials

- A lack of production quality management system in the factory production process.
- A lack of quality assurance measures for the storage and transportation of OSC components
- A lack of production codes and standards for OSC components.

❖ Factors related to construction such as:

- Inadequate construction of the connecting points between the core components
- Poor-quality components due to the lack of on-site checking measures and poor equipment testing.
- Limited construction time imposed by project clients.
- A lack of technical guidelines for the construction of OSC projects
- Low cost adopted in the contract for the construction.

❖ Factors related to design

- Low cost allocated in the contract for the product design.
- Failure in funding the whole project.
- Lack of design codes and standards for OSC components
- No building information modelling (BIM) application
- Change design
- Unsuitable design

Therefore, Callistus et al. (2014) and Oke, Aigbavboa, and Dlamini (2017) demonstrated some recommendation which are:-

- Developing skills.
- Completing a suitable design available at the right time.
- Decreasing the numbers of design change. Clients need to be aware of the consequences of changes as OSC needs an early design freeze to produce components
- Evaluating design before construction

- Implementing a monitoring system has during the project process in order to ensure quality performance.
- Ensuring proper material procurement
- Implementing a quality assurance programme
- Improving monitoring systems
- Ensuring proper structured site management and supervision
- Ensuring clear communication and cooperation

Accordingly, the researchers emphasised on the quality related drivers such as; achieving high quality, quality control review during manufacturing process and site assembly and OSC products are less defects than traditional construction products. The researcher also explored the reasons that can contribute to achieve high quality of the products with less defects than traditional construction such as manufacturing environment which involves quality test and assurance before it being shipped to the site and skilled staff. Meanwhile, there are some factors can affect the quality of the final products including teamwork, design change and so forth. Therefore, the quality factor needs to be investigated within Iraqi construction industry to understand its related drivers to the adoption of OSC in Iraq.

2.4.3 Cost related drivers

There is an opportunity for OSC to present itself in a positive light regarding the growing emphasis on sustainability (Goulding & Arif, 2013). This is because OSC can deliver a tighter building envelope, by using materials such as structurally insulated panels, together with smart components and materials. It can also offer savings in transportation, waste and the use of embodied energy in the construction process. Therefore, a viable cost-effective solution is presented and strongly defended using OSC. These can also embrace other benefits, including improved in-use and lifecycle costs and safer working environments. These benefits, in turn, need to be more obvious and more readily available (Goulding & Arif, 2013).

Therefore, it is recommended to evaluate the immediate and life cycle cost when using OSC. This is emphasised by Fraser, Race, Kelly, Winstanley, et al. (2015) in which costs need to be evaluated in the total context of the project, including the beneficial impacts on project durations and risks, in order to understand its value to projects. In the same vein, Hashemi (2009) clarified that cost can be divided into two main groups of immediate cost and life costs; the immediate costs are involved in the building process, while life-costs mean building running costs in the long term, such as energy requirements and maintenance. When applying a modern method of construction both cost types should be considered; however, in practice, many people are usually more concerned with the immediate cost than life costs (Hashemi, 2009).

In the same vein, Blismas et al. (2006) found that the evaluation system currently used to select the optimal construction approach solely relied on a direct cost-based, rather than value-based, system. However, Blismas and Wakefield (2007); GOODIER and GIBB (2005) emphasised the importance of measuring the cost savings over the whole life cost of OSC products. This can be achieved by understanding the value rather than only emphasising the direct cost of materials/labour.

On the other hand, there are some factors can affect the cost of OSC projects. In this regard, Vernikos, Goodier, Gibb, Robery, and Broyd (2012) stated that the country and location of the project considerably affects the variances in cost; for example, some countries in the Middle East have very cheap workers, and where local natural rock armour is not obtainable in the scale needed, concrete is employed. Other factors affect material costs; for example, "in Australia the cost of concrete is higher therefore it is sometimes cheaper to ship huge precast units from Asia (4000 miles) to Australia because it may cost less" (Vernikos et al., 2012). In the UK, rocks of the required size and quality may be available from quarries nearby, or precast units may be sourced.

In the same vein, the following key factors involved in the finished modern method of construction prices have been illustrated by Hashemi (2009), which are: transportation, fixed factory running costs (labour, storage, energy, etc), design, material, labour, maintenance, machinery economy stability, price fluctuation and inflation, quality, waste, speed & time, building type, area and number of storeys, volume (mass production), and characteristics of the construction industry. All factors mentioned under practicality, have direct or indirect effects on the finished MMC price.

Additionally, some of the cost related factors mentioned above were identified as a cost benefit. The use of prefabrication techniques within a project allows for cost savings at every stage of the production chain due to mass production (Lu, 2009); for example, material savings at the procurement stage and labour savings at the construction stage. Moreover, design for offsite methods allow for greater standardisation, the use of off-the-shelf products, and in turns the contribution to reduced material cost and lower material waste (Fraser, Race, Kelly, Winstanley, et al., 2015). Other cost savings may include savings from fewer material deliveries and reduced crane usage; the cost of transporting a large assembled unit may offer savings over several deliveries of individual pieces, as well as lower tracking and storage costs (Haas & Fagerlund, 2002).

Haas and Fagerlund (2002) and Mohamad Kamar (2011) confirmed that reductions in cost were attributed to the lower cost of offsite labour as a result of less labour required onsite. Fraser, Race, Kelly, Winstanley, et al. (2015) further added that the cost of factory-based labour is characteristically less than the cost of site labour. This is because factory facilities can be located where skilled labour is more readily available and the costs of labour, power, materials, space and overheads are lower. Also, the increased labour productivity in a factory environment has a direct effect on the financial outcome of a project.

Other associated benefits that lead to cost saving include Elnaas (2014) a faster construction programme that leads to reduced overall project costs. Cost benefits will result both from a reduced commissioning programme and improved commissioning process (Fraser, Race, Kelly, Winstanley, et al., 2015). The use of OSC can lead to reductions in the time required to complete a project, lessen the need for skilled craft labour on-site, reduce the number of incidents causing on-site disruption by other adjacent operations and, finally reduce costs (Al-Mutairi, 2015).

The risk of accidents and injury are reduced and this, in turn, contributes to reduced project cost. Fraser, Race, Kelly, and Winstanley (2015) confirmed that reduced on site labour means fewer health and safety risks from site activities. The equivalent activities in a factory environment can be better organised and managed and have been shown to have better safety records. The cost of stoppages, injuries and investigations are all to be avoided. In fact, the total reduction in site hours worked on OSC; projects can easily lie in the range of 60-80% and the reduction of workers required onsite can be expected to reduce the occurrence of major injury and death, which in turn leads to financial benefits based on the cost of treating injuries (Krug & Miles, 2013).

Another cost benefit results from the quality control environment; Alistair (1999) highlighted that cost savings occur as a result of the reduction to unplanned onsite remedial works. This is due to higher quality finished products that are made in factory environment. However, advantages such as increased quality and reduced snagging are rarely included in costings and many projects are still judged purely on first or initial costs (Goodier & Gibb, 2007).

This quantifiable cost saving is also demonstrated by Fraser, Race, Kelly, Winstanley, et al. (2015); Gibb and Isack (2003); Gibb (1999).The site initial cost for fully modular buildings most likely forms 7 to 8% of the total build cost leading to savings of 5 to 8% compared with site-intensive building projects (Alistair, 1999). The advantages include:

- A reduced number of site personal and hence costs and facilities needed.
- Minimised waste
- A decreased need for shuttering and scaffolding, or formwork, as offsite products are often self-supporting
- Reduced labour
- Reduced plant, tools and craneage
- Less site storage and related security and management
- Reduced water and energy utilisation because of onsite activities
- Decreased installation time, with associated quality control by the installer, contractor and for customer benefits.
- The minimised effect of a terrible climate at the building site.
- Reduced overall energy costs.
- Less site congestion

In the same vein, Gibb and Pendlebury (2006) identified some cost savings that should be considered when using offsite manufacturing. These include: -

- Cost certainty and decreased risk.
- Less unsuccessful work and fewer defects.
- Improved quality so reduced maintenance, etc.
- Minimised construction time, which can result in cost advantages from earlier occupation
- Reduced overall lifecycle costs

Cost related drivers of using OSC indicated in different developed and developing countries. A survey by Pan et al. (2007) involving 100 UK housebuilders demonstrated that ensuring cost certainty is a key important driver for the use of OSC in UK housebuilding. Elnaas, Gidado, and Philip (2014) also agreed with Pan in which a reduction in overall project cost is a key driver of the use of OSC in house building in the UK. Moreover, the findings of Bendi (2017) regarding cost drivers were similar to those from the UK market, confirming that ensuring cost are major driver for the extensive adoption of OSC in India. Reduced demand for labour, lower costs and ensuring project cost certainty are also seen as key drivers for the use of OSC in China's housing construction industry (Zhai et al., 2013).

In fact, considerations of the economic benefits of off-site production should be an all-inclusive and the whole-life cost concept rather than a direct and immediate cost saving. This is also linked to enhanced cost certainty, reduced maintenance costs, lower overall lifecycle costs, minimised site access and additional economic benefits from early occupations (Zhai et al., 2013; Blismas, Pasquire, & Gibb, 2006).

Therefore, it appears that many drivers related to cost when using OSC are acknowledged by researchers worldwide such as reduce construction cost, reduce maintenance cost and reduce life-cycle cost. However, sometimes stakeholders neglect some indirect costs, such as reduced cost as a result of other benefits, like minimising the time required onsite which leads to cost savings and only concerns direct cost. It is important to focus on the direct and indirect costs to fully understanding the cost related drivers when using OSC.

2.4.4 Productivity & market related drivers

Productivity "is the ratio of output to all or some of the resources used to produce that output" (Construction McGraw Hill, 2011). Thus, the resources can include capital, labour, energy, raw materials, etc. Stakeholders are closely aligned in the belief that the primary drivers to the future usage of OSC will be the improvements it can offer to elements of productivity including time, cost, safety and quality (Alazzaz & Whyte, 2014; Construction McGraw Hill, 2011). Eventually, this means that the process is more productive over traditional construction per unit of input.

Accordingly, the improved productivity of OSC is one of the benefits perceived by clients as a result of fewer difficult activities onsite and a reduction in the need for wet trades (Gibb & Isack, 2003). Moreover, Durdyev and Ismail (2019); Gibb and Isack (2003) emphasised improvements to productivity due to lower site disruption from less equipment, materials and less congestion on site.

Furthermore, a potential solution to the need for a successful increase in housing supply is offsite manufacturing (Blismas & Wakefield, 2008). The UK government sought to promote house building rates using OSM (Krug & Miles, 2013). This was due to the inability of the current UK housing supply to cope with the demand in addition to inability of those on low incomes to afford the increasing houses prices in UK (Ross et al., 2006). Chairman (2012) pinpointed that factory productivity can reach 80% in comparison to only 40% for typical site production. Thus, the use of OSM systems can contribute to improved housing supply rate in the UK. Moreover, the shortage in housing supply is one of the drivers to use OSC in the UK (Elnaas et al., 2014).

Researchers also found a large housing shortage in Nigeria, Rahimian, Goulding, Akintoye, and Kolo (2017) believed that OSC has been proffered as a potential solution to address this challenge, particularly due to its ability to deliver high volumes of units at reduced costs and improved quality. However, barriers need to be assessed before this can be considered a viable solution. Nevertheless, Ojoko, Osman, abd rahman, and Bakhary (2018) found that embracing OSC to overcome the huge housing shortage in Nigeria would represent a move in the right direction.

Similarly, in China at least 6 million housing units need to be provided in the next 36 years thus demonstrating an urgent need for the construction industry to significantly increase its productivity and expand its dwelling inventory to meet this growing demand for living (Jiang et al., 2018). OSC improves the build rate of housing schemes by dramatically increasing the number of houses completed over a period of time (Mohamad Kamar, 2011). This could help stakeholders to meet demands for housing and support government objectives to provide a sufficient supply of affordable housing. Moreover, Bendi, Arif, Sawhney, and Iyer (2012) demonstrated that the demand for affordable housing is also reflected in the Indian government agenda through its strategies and policies, which could also act as a driver for the adoption of OSC. The aim of mass housing is to provide proper housing units at affordable costs for people who cannot deal with the huge investments associated with land acquisition and the direct construction of buildings. Therefore, the governments and private sectors need to develop strategies to meet this need through public private partnership (Ezema, Opoko, & Oluwatayo, 2017).

Furthermore, Javed, Pan, Chen, and Zhan (2018) indicated the important drivers and constraints concerning construction productivity in Hong Kong, and explored the interdependence of these factors in driving or hindering productivity enhancements. They found that this is underpinned by five strategic aspects - policy formation, regulatory requirements, planning and design, site construction and project management, and administration – which operate at three focus levels, namely industry, project and activity. The researchers further identified enhancement to the productivity at the site level such as:

- The adoption of OSC and automated production.
- Enhancing the standardisation of productivity measurement tools.
- Effective site management and efficient supervision system.
- Effective planning and scheduling (Javed et al., 2018).

2.4.5 Labour related drivers

One of the advantages of using OSC is the reduction the numbers of workers required onsite; this is a consequence of moving much of the work offsite into factories (Jiang et al., 2018). Alazzaz and Whyte (2014) also agreed on this and stated that one of the major factors behind stakeholders' favourable impressions of OSC was the fact that it alleviates skills shortages in the construction industry Jaillon and Poon (2008) indicated that, as OSC components are produced in a factory, fewer carpenters, plasterers, and steel reinforcement workers are required on-site. Furthermore, Fenner, Razkenari, Shojaei, Hakim, and Kibert (2018) refer to improvements in workforce productivity and wellbeing as a result of the automated and/or repeated functions that lead to reduced unnecessary moves in the factory and in the number of exhaustive activities performed by workers.

Nevertheless, Fraser, Race, Kelly, and Winstanley (2015) believed that the use of OSC requires less labour onsite, although also recognised that higher levels of skill are required for implementation than for traditional construction. These skills include the assembly of ready-made components, the use of new materials and systems, the handling of large building modules and the need to ensure that sophisticated systems work as they should. Also, at the manufacturing stage, appropriate skills are needed to match production requirements. These findings were also emphasised by (Alawag, Yunus, handan, Kasim, & Hussain, 2019).

The findings of a study by Fernando, Fernando, and Gunarathna (2016) found that less motivation amongst labourers, poor examination of their skills and limited guidance are the major hindrances for the development of skills in the construction industry of Sri Lanka. However, training, motivation and a safe workplace are required to improve the productivity of workers and the quality of the final product (Fraser, Race, Kelly, & Winstanley, 2015).

2.4.6 Social related drivers

Traditional construction is a relatively dangerous activity which has a poor reputation worldwide due to the lower status working environment (Krug & Miles, 2013; Zhai et al., 2013). Indeed, the traditional construction involves many activities with risks, such as working from height and working with heavy machinery; thus, many researchers believe that reducing health and safety risks is a driver for using OSC (Wuni & Shen, 2019); Bendi (2017); Blismas et al. (2005). Indeed, the use of OSC can improve the safety and stability of workforce working conditions which can significantly reduce the number of accidents and occupational illness, as most work would be implemented in the factory that provides a more controlled environment and reduces the number of risks (Krug & Miles, 2013; Zhai et al., 2013).

Fraser, Race, Kelly, and Winstanley (2015); Elnaas (2014) agreed with Krug and Zhai by illustrating that reductions to time, onsite labour and activities onsite alongside the increased control of site activity can potentially reduce the overall number of serious and fatal accidents on site, which in turn results in cost reductions. This is because to most of the activities are moved offsite which result in increased health and safety and reduced risks, including:

- Better welfare facilities in the factory environment,
- Cleaner work conditions with less risk of fall and slip
- Automation use reduces manual handling
- Safe from all-weather working
- Reduced need to work from height.

However, others argue that the use of OSC may not completely eradicate the risk of accidents in the processes involved, although the risks are more predictable and can be more effectively managed during the design and construction processes than with classic construction (Chairman, 2012). Therefore, onsite work still has to be made as safe as possible by ensuring the timing of delivery, the assemblage of components, and the requirement for mechanical handling and strategies are considered in minimising potential risks (Fraser, Race, Kelly, & Winstanley, 2015; McKay, 2010).

Consequently, the use of OSC is generally considered safer than traditional construction. Thus, the control of work situations by providing safe conditions, and the application of safe working methods and procedures alongside effective safety training is the aim of accident prevention (McKay, 2010). One example of such safety measures was stated by Lawson, Ogden, and

Bergin (2011) “The modules can be installed with pre-attached protective barriers or, in some cases, a protective “cage” is provided as part of the lifting system.”

Another OSC driver associated with social drivers is the ability to offer employment opportunities for local communities with long term secure job (Elnaas, 2014; Zhai et al., 2013; Yunus, 2012a; Blismas & Wakefield, 2007). Using OSC can offer potential improvements to working conditions, as factory-based jobs offer greater long-term security for individual workers with better training (Ross, 2002). Factories usually try to recruit employees from a local community with offers of permanent jobs in order to save time and transportation for employees; moreover, they are likely to offer good training to ensure they sustain appropriate standards in work. A greater OSC uptake means more labour involved in training process which in turn produces semi or skilled labour who can achieve better salaries than traditional labour (Zhai et al., 2013).

Thus, researchers believe that OSC has a better potential to improve working conditions for workers by reducing health and safety risks and offering secure jobs, particularly for local communities. Therefore, these related themes will be considered as social drivers for testing in this research.

2.4.7 Environmental related drivers

The use of OSC methods can contribute to the conservations of materials and reduction to waste, since the waste generated from OSC is easier to re-use and recycle (Jaillon & Poon, 2008). Moreover, Mtech Consult and Yorkon (2008) stated that improved designs often associated with OSC can decrease material wastage by nearly 50% and reduce on-site waste by up to 90%, particularly with using volumetric construction. Meanwhile, Fraser, Race, Kelly, and Winstanley (2015) indicated that a 90% reduction in material waste occurs when using OSC compare with traditional construction. This is because the design for manufacturing usually ensures that the process of ordering and cutting materials to size is far more controlled to ensure fewer faults and waste, whilst recycling is also easier to control. Moreover, Jaillon and Poon (2008) indicated that many environmental benefits occur when using OSC, including material conservation, reductions to waste, and lower air pollution and water consumption. The reductions to waste are explained by the move of most trades into factory environments, for example tiling, which results in higher quality, greater durability and less maintenance due to the quality control processes in a factory. This permits the easy identification of defects and the rejection of unsuitable precast elements before they are transported to the site resulting in less wastage on site arising from defects and rebuilt works. Moreover, OSC reduces the time spent working on-site; this means that the impact of construction sites on the local environment is reduced and fewer hours are spent working in extreme weather (Wasket, 2001).

A recent study by Gunawardena, Ngo, Mendis, Aye, and Crawford (2014) found that OSC construction has proven to be more environmentally friendly than traditional construction because it requires minimum access to roads. Prefabricated units can be shipped or transported on trucks and placed on-site using mobile cranes, whilst less work is required for installation on-site. Therefore, less pollution is generated by OSC. Fraser, Race, Kelly, and Winstanley (2015) agreed with this finding and stated that benefits were generated from OSC by using less vehicle delivery compare to traditional construction, which in turns leads to less pollution, noise and congestion around the site.

Another driver related to the environment is energy efficiency during construction and building in use. When they conducted a comparison between the two types of construction for a residential building in Iraq, Abbood et al. (2015) found that 61% greater energy efficiency was achieved for cooling and heating when using OSC than for traditional construction. Fraser, Race, Kelly, and Winstanley (2015) also found that energy use in onsite reduced by 70-80% as a result of less time spent on construction and fewer resources required onsite. Moreover, the researchers added that the use of OSC can deliver better building performances for the finished product with reduced energy-in-use. This is because there are reduced opportunities for human error and the build quality tends to be better; for example, improved fabric and structural quality can reduce heat loss, improve energy efficiency, and improve sound performances. Likewise, building operational efficiency can be enhanced – for instance, preassembled and commissioned mechanical and electrical elements can deliver test and operational performances that are much closer to the target than those assembled and commissioned onsite.

Zhai et al. (2013) found that among the top ten factors that drive the use of OSC in China those related to the environment represented the largest proportion, which included: reduced construction waste, reduced on-site dust, less noisy pollution and fewer local community disruptions, reduced material waste, and reduced energy consumption in construction. Hence, it appears that environmental related drivers for the use of OSC have been widely studied. Most of the highly related drivers recognised were reduced waste resources (materials and water), improved energy performances and reduced environmental impacts, such as less noise, pollution and congestion onsite.

2.4.8 Policy related drivers

One of the most important milestones for OSC policy is the regulation of OSC in the construction industry (Mohamad Kamar, 2011). Moreover, Jiang et al. (2018) found that the absence of government regulations and incentives were perceived as the most critical barrier to the adoption of OSC in China. They identified that a number of transferable driving factors, including strategic roadmaps, appropriate policies and sufficient workable guidelines, are needed to enhance such construction. In fact**,** the positive intervention of government has always been the driving force for the advancement of OSC; therefore, the existence of strong OSC policies and legal frameworks represent policy drivers for OSC (Wuni & Shen, 2019). OSC policies highlight the commitment of decision-makers to support the approach. Indeed, the government is the greatest stakeholder and actor in the OSC revolution in the UK, Hong Kong, Malaysia, India, Iraq and many other countries. As such, there is government support, regulations, policies promotion schemes and incentives to encourage its implementation.

A significant policy driver is the revision of building codes and regulations, and permits to encourage the adoption of OSC (Elnaas, 2014; Azhar, Lukkad, & Ahmad, 2013; Pan et al., 2007). The UK Government and industry are working on revisions to regulations and standards in order to address some aspects of new offsite manufacturing products, for example the Buildoffsite Registration Scheme (Elnaas, 2014). There are several policy initiatives that recognise and promote the adoption of OSC in many countries. In the report "Advancing the Competitiveness and Efficiency of the US Construction Industry", the National Research Council of the United States officially stipulated that the wider use of prefabrication, preassembly, modularization, and offsite fabrication represent one significant breakthrough that is needed in the construction sector within the next two decades (Council, 2009). Moreover, the Cooperative Research Centre for Construction in Australia introduced the initiative "Construction 2020" to encourage the use of OSC in the country (Hampson & Brandon, 2004), whilst the New Zealand government is currently promoting the use of OSC to deliver prefabricated housing. Furthermore, the government of Iraq presented a 2018-2022 plan to rehabilitate the country and promote the use of OSC by providing 100,000 housing units in an attempt to address the housing shortage (Iraqi Ministry of Planning, 2018). These suggest that there are diversified policies and practice priorities worldwide to enhance the use of OSC; hence, this study argues that policy is a critical driver for OSC.

2.4.9 Systematic references of the literature review for drivers of the using of OSC

The table below shows the systematic references of the literature review for the drivers of using OSC that used later in the questionnaire stage. From literature, developed a 25 items-questionnaire, under 8 factors.

Table 2-1: Systematic references of the literature review for drivers of OSC

Factors	Drivers	References
Time	Reduce the overall project time	Wuni and Shen (2019); Fraser, Race, Kelly, and Winstanley (2015); Blismas et al. (2005); Gibb and Isack (2003)
	High speed of construction	Lawson et al. (2014); Krug and Miles (2013); (Pan et al., 2007); Gibb and Isack (2003)
	Ensuring time certainty	Pan et al. (2007) (Bendi, 2017); Fraser, Race, Kelly, and Winstanley (2015); (Pan et al., 2007)
Quality	Achieving high quality	Mohamad Kamar (2011); Pan et al. (2007); Blismas et al. (2005); Gibb and Isack (2003)
	Quality control review during manufacturing process and site assembly	Fraser, Race, Kelly, and Winstanley (2015); Taylor (2009); Blismas and Wakefield (2007); Alistair (1999)
	OSC products are less defects than traditional construction products	Mydin et al. (2014); Taylor (2009); GOODIER and GIBB (2005); Gibb and Isack (2003)

Cost	Minimizing maintenance and replacement cost	Fraser, Race, Kelly, and Winstanley (2015); Elnaas (2014); Hashemi (2009); Pasquire et al. (2004)
	Reducing construction cost	Elnaas (2014); Hashemi (2009); Blismas and Wakefield (2007); Blismas et al. (2005)
	Minimizing overall life-cycle cost	Elnaas (2014); Goulding and Arif (2013); Goodier and Gibb (2007); Blismas et al. (2005)
Social	Reducing accidents onsite	Elnaas (2014); Krug and Miles (2013); Zhai et al. (2013); Taylor (2009)
	Offers employment opportunities for local communities with greater long-term security for the individual worker	Fraser, Race, Kelly, and Winstanley (2015); Elnaas (2014); Yunus (2012a); Blismas and Wakefield (2007)
	Improves working conditions for workforce and industry	Fraser, Race, Kelly, and Winstanley (2015); Elnaas (2014); Krug and Miles (2013) Blismas and Wakefield (2007)
Policy	Revision to building regulation to support OSC	Elnaas (2014); Azhar et al. (2013); Mohamad Kamar (2011); Pan et al. (2007)
	Government promotion and support	Wuni and Shen (2019); Rahimian et al. (2017); Elnaas (2014); Hashemi (2009); Pan et al. (2007)
	Availability of legal, standards and codes framework to cover all stages of the project	Wuni and Shen (2019); Rahimian et al. (2017); Azhar et al. (2013); Goulding and Arif (2013)
Productivity & Market	Improve overall project productivity	Durdyev and Ismail (2019); Alazzaz and Whyte (2014); Gibb and Isack (2003)
	Addressing the problem of housing shortage in Iraq	Iraqi Ministry of Planning (2018); Teen and Gramescu (2018); Rahimian et al. (2017); Abbood et al. (2015); Elnaas (2014); Abdulrazak and Mori (2012); Blismas and Wakefield (2008)

	High volume production of mass units in short time	Ezema et al. (2017); Rahimian et al. (2017); Elnaas (2014)
	Providing affordable housing	Arif et al. (2012); Mohamad Kamar (2011); Ross et al. (2006)
Environmental	Decrease the energy use during construction and building usage	Abbood et al. (2015); Elnaas (2014); Zhai et al. (2013); Blismas and Wakefield (2007)
	Reduce materials waste	Fraser, Race, Kelly, and Winstanley (2015); Zhai et al. (2013); Jaillon and Poon (2008); Blismas and Wakefield (2007)
	Reducing environmental impact during construction	Fraser, Race, Kelly, and Winstanley (2015); Zhai et al. (2013); Jaillon and Poon (2008); Blismas and Wakefield (2007); Pan et al. (2007)
Labour	Reduces labour required for onsite construction	Jiang et al. (2018); Fraser, Race, Kelly, and Winstanley (2015); Jaillon and Poon (2008)
	Improve labour productivity performance	Fenner et al. (2018); Al-Mutairi (2015); Elnaas (2014)
	Improves management and coordination among workers at the site	Fenner et al. (2018); Elnaas (2014); Blismas and Wakefield (2007)

2.5 Barriers to the use of OSC

Many researchers explored barriers towards OSC worldwide. Some of these barriers are similar between countries such as cultural resistance and skills shortage. However, the priorities of barriers may differ from country to country or even from project to project. It is worth to emphasise that there is mature market in adopting OSC, while there is immature market represented in most of developing countries.

In regard to UK construction industry, Gibb and Isack (2003) found that a negative image from past experiences of poor quality, disjointed offsite products and limitations in the supply chain can hinder the use of OSC in the UK. There is also a belief that OSC is more expensive than traditional construction, which is the main barrier to its use (Goodier & Gibb, 2007; GOODIER & GIBB, 2005). Also, the researchers found longer lead in times, client resistance, a lack of guidance, few codes and standards, and negative images represent various kinds of barriers to its adoption. These barriers were also mentioned by Pan et al. (2008) in their survey results from UK house builders; they found that higher capital costs, longer lead-in times, and current manufacturing capacities pose significant deterrents. Also, they added that interfacing problems and delayed planning processes can hinder the use of OSC. Furthermore, at different importance ratings, Elnaas et al. (2014) also illustrated that system, process, regulatory, logistics, resources, and costs were barriers to the use of OSC in UK housing building. Thus, barriers such as negative image, high capital cost, long lead time seem like significant barriers for the adoption of OSC that agreed amongst researchers for the construction industry in UK.

There are some barriers similarities to UK identified within Australian construction industry for the use of OSC. Blismas et al. (2005) indicated four important project level barriers to the uptake of OSC in Australia, which are process, value, supply chain and knowledge, as a result of a survey involving the majority of construction industry stakeholders. Further, Blismas and Wakefield (2009) highlighted a number of features with related barriers for the use of OSC , such as process/programme, cost, skills knowledge, logistics and site operation, environmental concerns, regulations, industry and market culture, and supply chain and procurement. The same barriers have been examined by Shahzad (2011) in the New Zealand construction industry.

In the same vein, recent research by Rahimian et al. (2017) identified three related barriers to the uptake of OSC in Nigeria, which are human, technical and industrial barriers. Consequently, it seems that researchers have acknowledged the barriers to the adoption of OSC. This introduction gave a brief summary of the barriers; however, in the next section, more detail will be provided, and the barriers related to similar factors will be clustered as appropriate.

2.5.1 Cost related barriers

The increased capital costs and higher initial costs have long been criticised as the most significant factors that hinder the wider adoption of off-site production (Zhang, Lee, Jaillon, & Poon, 2018; Rahimian et al., 2017; Pan et al., 2007; GOODIER & GIBB, 2005).

The OSC method of building construction is more expensive than the traditional method. Faghirinejadfard et al. (2015) explained that the main reason for the cost differences directly relates to the industrialized process for OSC components. High expenses must be paid to purchase the transport and mechanization tools, and to assemble the prefabricated components at the construction site. In the same vein, Fraser, Race, Kelly, and Winstanley (2015) suggested that the main barrier to the adoption of OSC in the UK is the perception that it is more expensive than traditional construction. This can be attribute that there is not enough knowledge about the cost of the overall project including life cycle cost caused by lack of effective cost benefit analysis tools. Furthermore, one of the root causes for the low uptake of OSC in western Australia was found to be the reluctance amongst stockholders to adopt a relatively ‘unfamiliar’ building method. They were particularly worried about unfamiliar costs and cash-flow streams for delivering OSC projects. This is exacerbated by the limited availability of cost information regarding OSC projects, which were mainly residential projects (Sutrisna, Cooper-Cooke, Goulding, & Ezcan, 2019). Therefore, it seems that there is a need for having a clear cost benefit analysis tool for the whole of the project of OSC including life-cycle cost. Moreover, Alomairi, Aboud, and Mahmood (2019) recommended to reduce the length of the implementation chain when using OSC in Iraq as this increases the cost of the housing unit; as the tender refers to several parties and each party wants to achieve a profit, which leads to an increase in the final cost of the product. In the same vein, Yunus (2012a) recommended early occupation of the constructed building for cost effectiveness, and emphasised on the importance of offering work to local workers in order to reduce cost and sustain work.

In regard to China market, Jiang et al. (2018) believed that higher initial costings were the most noticeable barrier to the use of OSC in China, as the country is at the stage of tentatively adopting OSC techniques, which requires an extensive upfront investment. However, this could be addressed with the increasing application of OSC that could lead to reduced component fabrication costs.

Transportation cost believes to be higher than traditional construction, particularly when there is long distance involved. Jaillon and Poon (2008) found that the transportation costs for prefabricated elements were higher compared with conventional construction due to the factories locations which requires long distance to construction sites in China. Therefore, Xue, Zhang, Su, and Wu (2018) believed that the location of OSC factories were important and thus should be determined with consideration of both economic outcomes and reasonability. Indeed, there may be limited supply source options or limited capacity as they may have long order books leading to increased transportation requirements (Fraser, Race, Kelly, & Winstanley, 2015). This is because, in this situation, the need to purchase from an alternative supplier who may be far from site can increase the cost of transportation.

However, researchers recommended evaluating direct and indirect cost and life cycle cost. in order to compare cost barriers related and cost benefits related enabling understanding the real cost of the project. In this regard, Blismas et al. (2006) found that the evaluation system used to select the optimal construction approach solely relied on a direct cost-based, rather than a value-based, system. Hence, it is imperative to address stakeholders' barriers in terms of cost, and to understand the cost related benefits of using OSC in order to help achieve a step-change towards its faster adoption. In addition, components can be standardised to reduce the initial cost of the project. Goodier and Gibb (2007) indicated the importance of using a life cycle cost approach to compare between OSC and traditional methods of construction.

Accordingly, the primary barrier frequently cited in the literatures is the expensive cost of off-site production that results from high initial costs, including the transportation and installation of components onsite. However, this barrier can be offset by other factors such as reduced project time, less labour required onsite, and minimised waste and resources. Therefore, this research will study the cost related barriers regarding the Iraqi construction industry to evaluate the effect of this factor in inhabiting the use of OSC in this country.

2.5.2 Industry & market culture related barriers

Market resistance is regarded another important obstacle to the application of off-site production, particularly in the residential sector. In European countries, Japan and Australia, the sharp growth of off-site production for prefabricated housing was initiated following the Second World War when it was perceived as the most effective solution to severe housing shortages (Elnaas, 2014; Zhai et al., 2013; Blismas & Wakefield, 2007). However, Blismas and Wakefield (2007) indicated that "the whole industry is conservative", with resistance to change noted amongst stakeholders. Indeed, the historically negative attitude towards OSC is common to both Australia and the UK; this is due to the poor application of housing built during the post-war and in the 1960-70's when social housing projects gave OSC dwellings a poor reputation. Although the client profile has since changed, some of this sentiment remains, and is often reflected in a client's desire for particular structures or traditional finishes (Blismas & Wakefield, 2007). Client resistance and scepticism and negative images are also barriers within the Indian construction industry (Bendi, 2017). Peoples' attitude towards housing and building materials is a major barrier to the uptake of OSC in India; the house is treated as an important investment for any individual, hence there is strong resistance towards the adoption of new building materials and technologies (Bendi, Arif, Sawhney, & Iyer). In the same vein, Alomairi et al. (2019) found that the length of the implementation chain in Iraq when using OSC increases the cost of the housing unit; this is because the tender refers to several parties and each party wants to achieve a profit, which leads to an increase in the final cost of the product and this consequently leads to reluctance of people to buy a house.

Another issue related to the industry and market culture is the difficulty in obtaining finance from institutions that are more familiar with traditional approaches (Shahzad, 2011; Blismas & Wakefield, 2007). This is may be justified by the lack of understanding for the OSC method by local regulators and authorities (Elnaas, 2014). Consequently, many worldwide markets may still suffer from negative attitudes towards the application of OSC. Therefore, strategies need to leverage knowledge about this type of construction and its benefits.

2.5.3 Skills & knowledge related barriers

Offsite technology needs highly skilled labour during the manufacturing and onsite phases. In fact, OSC adoption is described by a high degree of mechanization; it necessitates the presence of sufficiently highly qualified construction workers as a lack of qualified labour leads to poor erection practices which affects the final structural integrity (Polat, 2010). As a result, incorrect skills or the inadequate training of labour impacts on a project's operation, its productivity and its performance. Moreover, unclear targets, poorly communicated interfaces, poor monitoring and control, and a lack of clear responsibility can all lead to poor quality, delays and errors (Fraser, Race, Kelly, & Winstanley, 2015).

Although the skills shortage in construction is most likely to be a worldwide phenomenon, some industries in developing countries consider this to be one of the main barriers to the uptake of OSC. India shows a significant skills shortage in its construction industry, both within the design and implementation of OSC, whilst there is also a lack of guidance and information and no experience of its use (Bendi, 2017; Bendi et al., 2012).

Likewise, a lack of requisite knowledge and skills was the second highest factor influencing OSC performance in Nigeria (Ojoko, Osman, abd rahman, et al., 2018). This problem is widespread in countries like Nigeria where the level of OSC is small and dependent on expatriate skills.

China also shows a shortage of skills and expertise within its OSC industry, as Jiang et al. (2018) indicated that a lack of extensive upskilling has become the bottleneck to the spread of OSC in China. The lack of skills is also agreed by Jiang, Huang, Peng, Fang, and Cao (2020) who argued that China has barriers in adoption OSC such as lack of skilled workers and lack of technical experienced suppliers, designers and contractors which in turns can cause problems such as inferior site management and poor structural performance. The researchers further added that the lack of integration of between different stakeholders in the project can lead to problems such as mismatch in design, lack of skills labour and quality problems. the process In the same vein, the lack of knowledge and expertise is also indicated by the study of Gan, Chang, and Wen (2018) and Gan, Chang, Zuo, Wen, and Zillante (2018) who further found that a lack of knowledge and expertise directly affected some factors, causing ineffective logistics, complicated management, poor manufacturing capacities, high initial costs, limited market demand and poor quality performance. However, addressing this factor by leverage awareness and knowledge amongst the public through workshops, training and academic courses could offer positive influences and improve the uptake of OSC.

Similarly, Bendi et al. (2012) also emphasised the importance of systems integration and assembly skills in developing the use of OSC in India. In addition, team building, motivation and creating a shared identity with a common goal for the project are key to effective workforce management. In comparison, within the Iraqi industry, researchers illustrated the lack of knowledge regarding OSC (Abbood et al., 2015; Mohee, 2011). Moreover, Teen and Gramescu (2018) illustrated the benefits and importance of OSC in meeting housing shortages in Iraq as traditional construction cannot meet this requirement due to the length of time it takes.

In addition, a lack of research and development seems to represent another barrier under the skills and knowledge factor, particularly amongst developing countries. Indeed, Bendi et al. (2012) stated that very little research is being undertaken on OSC in India. However, in order to develop the use of OSC within the country, there is a significant need for research through academic- industrial collaboration. Similarly, the Chinese construction sector has long been impacted by both a lack of research and development practice and motivation as well as a reluctance to innovate due to the lack of R&D investment (Mao, Shen, Pan, & Ye, 2013). Although China is promoting OSC, it still lacks a national standard that justifies the techniques and process. Furthermore, there is also an absence of qualified and tested organisations to assess the quality of manufactured components, which results in greater uncertainty toward products entering the market. To bridge the gap, university-industry collaboration is needed (Jiang et al., 2018).

Indeed, the recent OSC advancements in the Australian construction industry demonstrated that the collaboration of industry, academia and government authorities can heavily impact on its growth for the fundamental benefit of society (Navaratnam, Ngo, Gunawardena, & Henderson, 2019). However, the market in Australia still shows limited awareness of the performance, benefits, skills and knowledge required for prefabrication design and construction practice. These still need to be expanded and strengthened to increase the uptake of OSC. Accordingly, skills and knowledge include these related barriers; a lack of knowledge and awareness; a lack of previous experience and skilled workforce, and a lack of research and development. This will be tested in this research within an Iraqi construction industry context.

2.5.4 Project complexity related barriers

Technological innovations in any area face a series of knowledge-based hardships and the construction industry is no exception. OSC works are more complex compared with traditional construction methods, since the use of OSC needs integral knowledge alongside specific machinery processes and operations that require effective coordination between developers, designers, contractors and off-site manufacturers and suppliers.

However, from the perspective of the designer and developer, an inflexible design and resistance to change significantly influences the inclination to use off-site production (Venables, Barlow, & Gann, 2004). Indeed, the inability to make changes onsite during construction and limited design options were noted as challenges in the US and barriers to the uptake of OSC (Lu, 2007). Moreover, Fenner et al. (2018) also illustrated some barriers regarding design limitations; the nature of OSC production processes represent limitations on designers and builders that could threaten the spread of this method. Also, the design should be locked as early as possible so that the module fabrication can start. This requires earlier design decisions and a resistance to change orders. A lack of proper design, and minimal regulatory and contractual frameworks to support modular construction also weakens the adoption of modular construction.

Jaillon and Poon (2008) also pinpointed the same issues regarding the limitations on design, which could inhibit the use of OSC in China. This is because the elements are prefabricated offsite before construction starts, which results in a lack of flexibility for late design changes to meet market needs; therefore, early cooperation between the designer and contractor is required. In this regard, Yunus (2012a) recommended:

- improving the aesthetic value and providing variation to the external outlook.
- Providing creativity for interior design.
- Providing a building design or components that are sufficiently flexible to adapt to future requirements.

Moreover, Zhai et al. (2013) found the biggest obstacle to the use of off-site production in China is the lack of available codes and standards. The scarcity of relevant legislation for the variety of OSC in China is a broader societal problem, which increases difficulties in applying this method. Although numerous OSC-related policies and regulations have been introduced in China, most are seen as general implementation frameworks and incentive mechanisms rather than specific decision-making guidance, detailed goals, steps and measures, effective working procedures and sufficient standards (Jiang et al., 2018). Moreover, Bendi et al. (2012) found that the scarcity of standards and data, such as codes of practice and guidance, functions as a major barrier to the implementation of OSC in India, in addition to the lack of guidance and information, and restricted regulations.

Although the Nigerian government have embraced OSC since 2011, there is still no defined policy statement, standards and codes that enable the efficient uptake of OSC (Ojoko, Osman, abd rahman, et al., 2018; Rahimian et al., 2017). Thus, to ensure the success of this construction, the vision of all stakeholders has to be anchored in clear and precise goals with OSC policies incorporated into construction development plans and reinforced with regulatory institutions. Indeed, countries have adopted this approach with a good measure of success in OSC implementation (for example, Sweden and the UK).

A longer lead time is needed for design and pre-planning (Blismas & Wakefield, 2007), as this can become a problem if it is not understood sufficiently early. Indeed, Fraser, Race, Kelly, and Winstanley (2015) indicated that lead in times can become a barrier as a result of late decisions to adopt this method, Therefore, they recommended an early decision to adopt OSC. This is fundamental to ensure the development of appropriate project strategies sufficiently early in the project and tends to be driven by clients and their consultant advisers. Some authors found this factor was a barrier, such as Bendi (2017), while others did not find it a significant barrier, such as (Zhai et al., 2013) and (Fenner et al., 2018).

Accordingly, this research will study these related barriers under the project complexity factor: Complex and limited design options, the inability to make changes in the field when using OSC, and the need for building regulations/a legal framework.

2.5.5 Supply chain & procurement related barriers

A lack of manufacturing capacity is seen as a barrier in different countries. Blismas and Wakefield (2007) indicated that the Australian market appears to have emphasised limitations in the OSM supply-chain due to the relatively small size of the market coupled with the massive physical discrepancy of production centres. Manufacturing capacity was another barrier to the uptake of OSM as there are only few factories involved in the manufacturing of OSM components (Rahimian et al., 2017). However, these issues are eliminated in countries where OSM has already been established, (e.g. UK, US, Japan and Nordic countries) as these tend to have a robust supply chain, including manufacturing factories, to support the OSM market (Rahimian et al., 2017; Blismas & Wakefield, 2007).

However, a recent study by Fenner et al. (2018) in the US still shows a low market share and limited diversity of product types, which has hindered the spread of OSC. The researcher explained that, due to the high level of investment needed to establish factories that explain the slow spread of such construction, especially amongst companies that are classed as small to medium size. Therefore, strong marketing strategies and the introduction of new products to the market can improve this weakness (Fenner et al., 2018). Similarly, the findings of a case study project in the UK (Arif, Killian, Goulding, Wood, and Kaushik (2017) emphasised the importance of assessing the supply chain capacity and its experience in OSC. At the same time, researchers found that the project would have benefited from the application of a more integrated approach in both the design management and supply chain as the team suffered from the lack of integrated communication. OSC requires a procurement strategy that can clearly recognize the supplier, manufacturer and sub-contractor with not only minimal costs but with the right capability, competence and capacity (Mohamad Kamar, 2011).

The poor integration of the supply chain was noted as a barrier for the use of OSC in China (Zhai et al. (2013). Indeed, the lack of manufacturers and suppliers of prefabricated components along with experienced collaboration groups, prefabrication contractors, and design consultants in China clearly reflects the fragmented nature of the industry (Mao et al., 2013). Moreover, Jiang et al. (2018) indicated that the immature development conditions of the OSC market in China mainly revealed from two aspects; firstly, a less developed supply chain, and secondly, dependence on the government. In recent years, OSC has been more widely adopted in public projects, such as public rental housing, affordable housing, and schools, which are driven primarily by the government, rather than the market itself.

A firm control of the supply chain was mentioned as a barrier by Shahzad (2011) in New Zealand. Therefore, other previously mentioned researchers ascertained the importance of effective integrated communication throughout the supply chain in order to ensure the optimal results. This is due to the fact that the OSC supply chain involves complex information and material flow between project participants; therefore, managing the entire supply chain requires a good level of coordination between these participants (Polat, 2010). Hence, participants can benefit from using OSC if, for example: the timely delivery of prefabricated components is achieved; manufacturers have a daily production capacity; there is storage patio availability, and rigorous planning and the efficient management of the project overcome any restraints on transportation.

Another barrier under this cluster was found by Blismas and Wakefield (2007), which was the potential loss of project control, especially onsite, and different payment terms and cash-flow arrangements for OSM. Shahzad (2011) agreed with the findings of Blismas and Wakefield, although believed that these issues could occur where mixed offsite and onsite components are required. Hence, Shahzad stated that a requirement for multiple account system would be required, which could be quite cumbersome to follow. Indeed, Fraser, Race, Kelly, and Winstanley (2015) believed that, when there is a site, there will never a project that is 100% offsite. Therefore, the optimum mix of offsite and onsite content can be achieved by an early consideration of the options by designers to eliminate risks and arrange a procurement strategy and supply chain partners.

Furthermore, if products or materials need to be imported from overseas, such products are critical or require a lengthy design or fabrication period; hence, payments need to be made in advance of any delivery (Construction Excellence South West, 2018). The key elements of practical risk are arrangements for the transportation of products, complications due to longer delivery periods, such as payment arrangements, finance and security arrangements, cash flow concerns and additional insurance requirements, and currency fluctuations.

Although Fraser, Race, Kelly, and Winstanley (2015) agreed with other researchers that there could be limited supply sourcing options for OSC, which may limit choice, or lead to extra time and cost needs due to transportation from remote locations where the number, location and capacity of suitable providers of offsite work components is limited. However, they indicated that there are numerous capable offsite M&E manufacturers that are well established in the UK. Also, the researcher emphasised on the importance of setting up effective supply chain management and integration in order to achieve the time, quality and cost benefits of OSC.

Hence, it was found that the limited capacity in supplying different types of OSC products may hinder the use of OSC, particularly in developing countries. Therefore, strong strategies are required to manage this gap. Also, integration is required between project participants from the early stages in order to maintain a firm control over the supply chain. Moreover, different terms of payment are required when using OSC, especially when there is a need to import materials internationally or to mix onsite and OSC.

2.5.6 Logistic and site operation related barriers

The barriers related to this factor have been widely addressed in the literature, including: Restricted site layouts, space sizes, access, storage and site locations along with difficulties in the transportation of materials and components from the factory to site (Elnaas, 2014; Shahzad, 2011; Blismas & Wakefield, 2007). The study by Jaillon and Poon (2008) shows that narrow sites, site access and transportation, and the lack of on-site storage areas are critical when using OSC in dense urban environments. The researcher found that site access for large precast components appeared to be an issue due to narrow access roads and traffic congestion. Shahzad (2011) agreed with the findings of Jallion and Poon, who indicated that the solution for transportation issues is the transportation of large-sized items during off-peak hours or midnight, even dispersed from manufacturing factories to minimise travelling distances. Indeed, transportation issues and erection logistics need early attention during the design of offsite components (Elnaas, 2014). The researcher added that unit storage on building sites before erection is another issue that is not recommended when using OSC. This is perhaps due to limited storage space on site, to avoid theft or to reduce the possibility of handling of material costs when building site storage decreases. Therefore, Fraser, Race, Kelly, and Winstanley (2015) on the importance of improving site tidiness and provision of suitable equipment, cranes and special transport vehicles for lifting and transporting products. The researchers added that early consideration for site related issues need to be considered such as transporting moving, accessing and lifting components especially large components. Moreover, to face disturbance in supply chain, the company can have redundant suppliers since its since it is unlikely that all suppliers would be disrupted at the same time (Chopra & Sodhi, 2004).

Another barrier related to the logistic and site operation cluster could be the restriction to sites by external parties; this was illustrated by Blismas et al. (2005) as a possible barrier related to site constraints. Moreover, Pasquire, Gibb, and Blismas (2005) indicated the factors to measure site benefits, such as restrictions on site or factory works by other parties, such as neighbouring residents, local authorities, etc; however, for countries with safety and political concerns, such as Iraq, external parties could be militias. Haitham and Shibani (2016) found that war, military operations and terrorist attacks were the most significant risk factors to threaten construction projects in Iraq. (Mohammed, 2018) reported that the instability of a project region and disputes over land ownership are also risk factors that confront construction projects in Iraq; these can arise due to the existing weak security situation following the extinction of the regime in 2003 when Iraq became a base for many terror organisations. Hence, logistics and site operations will be investigated in this study, as this could be an important factor inhibiting the use of OSC in Iraq.

2.5.7 Management related barriers

The adoption of OSC requires the relocation from a conventional building process to a manufacturing process. The huge change in approach from traditional to OSC, requires enormous support, a clear vision from management (particularly from the leadership), and commitment, and motivation, which are critical for convincing decision makers, customers, clients and one's own organisation structure to utilise OSC (Kamar, Alshawi, & Hamid, 2009). Indeed, there are numerous benefits of OSC, although these can only be achieved if it is implemented with a capable team along with OSC knowledge, a fully industrialised and integrated process from the beginning along with client leadership in the adoption of OSC (Arif et al., 2017). Moreover, Ozorhon, Abbott, and Aouad (2013) agreed with Arif and added that, in order to obtain better results from innovation processes, like modern methods of construction, a stronger relationship is needed between the project parties. Another important factor is the effective leadership of the managing director, which indicates that innovation champions play a key role in seeing through the challenging innovation process. On the other hand, a lack of effective management and leadership can cause project failure in construction. The study by Damoah, Akwei, and Mouzughi (2015) found that poor leadership is the biggest cause of the Ghana government's project failure; this was followed by management and administration practices. Similarly, Al-Turfi (2017) found that reconstruction projects in Iraq show a high failure rate due to immature and unprofessional development plans, a lack of properly qualified leadership, slow decision making and a lack of ongoing training, deficiencies and corruption in managing projects, and the absence of efficient communication and information systems. Furthermore, Khaleefah and Alzobaee (2016) emphasised that financial and administrative corruption are key failure factors for construction projects in Iraq. Therefore, they recommended developing the abilities and characteristics of project managers and engineers with a focus on leadership through proper and continuous training programs.

Meanwhile, OSC methods need new delivery and integrated practices; hence, improper management and a lack of construction industry knowledge and understanding about this method damage the extent to which OSC is considered an option in early project design and planning (Fenner et al., 2018). These issues, along with poor management and coordination in construction companies, need cultural reform.

Furthermore, poor project planning can cause problems with co-ordination, the correct sequencing of trades and incur project delays. In fact, OSC should be considered during the earliest stages of a project, before the option has inadvertently been excluded; this allows any benefits to be maximised and risks minimised (Fraser, Race, Kelly, & Winstanley, 2015). It can help inform the procurement strategy for the project, supply chain partners and key aspects of the contracts used, along with the selection of a design team who are able to appreciate the design requirements to enable efficient OSC.

Accordingly, throughout the literature review, it was found that a proper management system has a significant role in affecting the adoption of OSC worldwide. At this point, it is important to investigate the management factor within Iraqi construction for its importance in the adoption of OSC, as it seems that there are many deficiencies in the management system as a whole, which will be clarified in greater detail later in this study. Hence, the following barriers (amongst others) will be included under the management cluster for analysis in this study: delayed decision making from leadership, deficiencies and corruption in dealing with projects, and a lack of coordination between teamwork.

2.5.8 Political & economic related barriers

One of the major barriers to OSC is the lack of demand, as with consumers are unaware of modern methods of construction or their potential benefits to deliver better, safer, cleaner, faster buildings (Saint-Gobain & Construction Leadership Council, 2016). Therefore, if OSC tends to make a positive contribution to both industry and society, research is needed to identify the pivotal issues associated with the socio-political and cultural drivers, along with societal, economic and business needs (Goulding & Arif, 2013).

Accordingly, it may be necessary to investigate the political and economic aspects in Iraq to examine the possibility of leveraging the adoption of such construction in Iraq. In fact, the Iraqi economy has suffered political, economic and social problems, like war, inflation, high unemployment rates, corruption of all types, displacement, and other factors, that contributed to the increasing size of an informal economy (Al-Mehannah, Jasim, & Al-Mousawi, 2019). The informal economy is part of the economy that is neither taxed nor monitored by any form of government. This phenomenon is significant in developing countries, which has many negative effects, such as tax evasion, a lack of social protection for workers, and the deformation of data and statistics. Bekr (2017) found that Iraq's political and security conditions negatively affect its construction projects causing delay and cost overruns. Moreover, Khaleefah and Alzobaee (2016) found that most success factors for Iraqi construction projects are: contractor financial efficiency; security, political, economic stability; the project manager's competence and integration, and clarity of contract documents. While the most critical failure factors were the financial difficulties of the owner, and corruption and external circumstances.

Indeed, Khaleefah and Alzobaee (2016) recommended the use of OSC and a proper management system in order to meet the market demand and enhance cost, quality and time performances. However, financial constraints and government policy are issues that need to be addressed to enhance the uptake of any innovation in Iraq, such as OSC (Salahaddin, 2016). Moreover. As long as terrorism is a threat in Iraq, it is vital to provide practical alternatives for any destroyed project, instead of building new one (Hatem & Al-Tmeemy, 2015). The researcher added that designers and contractors have to improve safety in design and structure that can endure or resist terrorist attacks.

Hence, the issues related to the Iraqi construction industry show an unstable security situation, fluctuations in financial status, and unstable current market conditions. These need to be investigated further to examine the possibility and suitability of adopting and encouraging the method of OSC in this industry.

2.5.9 Systematic reference of the literature review for barriers of the using of OSC

The table below demonstrates the systematic reference of the literature review for barriers of using OSC that used later in the questionnaire stage. From literature, developed a 24 items-questionnaire, under 8 factors.

Table 2-2: Systematic reference of the literature review for barriers of using OSC

Barriers	**Sub-themes barriers**	**References**
Logistic & site operation	Unsafe sites restricted by external parties	Mohammed (2018); Haitham and Shibani (2016); Hatem and Al-Tmeemy (2015); Blismas et al. (2005)
	Restricted site layout, space size, access, storage and site location	Elnaas (2014); Shahzad (2011); Jaillon and Poon (2008); Blismas and Wakefield (2007)
	Transport of materials and components from factory to site	Elnaas (2014); Shahzad (2011); Jaillon and Poon (2008); (Blismas & Wakefield, 2007)
Project complexity	Complex and limited design options	Fenner et al. (2018); Elnaas (2014); Shahzad (2011); Jaillon and Poon (2008); Lu (2007)
	Inability to make changes in the field by using OSC**.**	Shahzad (2011); Jaillon and Poon (2008); Blismas and Wakefield (2007); Lu (2007)
	Building regulation/legal framework requirement	Fenner et al. (2018); Jiang et al. (2018); Zhai et al. (2013); Arif et al. (2012)
Cost	Higher transportation cost where long distance is required	Fraser, Race, Kelly, and Winstanley (2015); Shahzad (2011); Jaillon and Poon (2008); Blismas and Wakefield (2007)
	OSC is often considered more expensive compared to traditional methods	Faghirinejadfard et al. (2015); Fraser, Race, Kelly, and Winstanley (2015); Pan and Sidwell (2011); Shahzad (2011); Goodier and Gibb (2007)

	Higher initial cost	Jiang et al. (2018); Bendi (2017); Shahzad (2011); Blismas and Wakefield (2007); Pan et al. (2007)
Political & economic	Unstable security situation	Bekr (2017); Khaleefah and Alzobaee (2016); Hatem and Al-Tmeemy (2015)
	Financial status fluctuation	Khaleefah and Alzobaee (2016); Salahaddin (2016); Jaber (2015)
	Unstable Current market condition	Al-Mehannah et al. (2019); Saint-Gobain and Construction Leadership Council (2016); Abod et al. (2011)
Industry and market culture	Clients desire traditional construction and custom made	Fenner et al. (2018); Arif et al. (2012); Blismas and Wakefield (2007); Pan et al. (2007)
	Negative image from past attempts of the application of OSC may limit acceptance	Fenner et al. (2018); Arif et al. (2012); Blismas and Wakefield (2007); Goodier and Gibb (2007); Pan et al. (2007)
	Difficult to obtain formal approval (financial- insurance for this type of construction.	Elnaas (2014); Shahzad (2011); Blismas and Wakefield (2007)
Skills & Knowledge	Lack of knowledge and awareness	Gan, Chang, Zuo, et al. (2018); Abbood et al. (2015); Mohee (2011); Blismas and Wakefield (2007)
	Lack of R&D in OSC	Mao et al. (2013); Arif et al. (2012); Shahzad (2011)
	Lack of previous experience and skilled workforce	Navaratnam et al. (2019); Jiang et al. (2018); Bendi (2017); Shahzad (2011); Polat (2010)
	Industry capacity to supply diverse varieties of OSC is limited due to lack of infrastructure support and resources	Bendi (2017); Rahimian et al. (2017); Mao et al. (2013); Blismas and Wakefield (2007)
	The use of OSC requires firm control of supply chain which can involves high risks.	Shahzad (2011); Polat (2010); Blismas and Wakefield (2007)

Supply chain & procurement	More complex payment terms & cash flows process and financial administrations where mixed offsite and onsite components are required	Fraser, Race, Kelly, and Winstanley (2015); Shahzad (2011); Blismas and Wakefield (2007)
Management	Delay of decision making from the leadership.	Al-Turfi (2017); Dakhil, Naji, and Faleh (2017); Damoah et al. (2015)
	Absence of effective communication between project team members	Jiang et al. (2020); Al-Obaidi (2018); Fenner et al. (2018); Dakhil et al. (2017); Alkinani (2013)
	Deficiencies and corruption in dealing with managing project	Al-Turfi (2017); Khaleefah and Alzobaee (2016); Mohammed and Abdulrazzq (2014)

2.6 Summary of section (A)

Firstly, the paper clarified a definition of OSM and its types in relation to its use in construction. These are some terms that are used in the literature review and globally such as OSM, OSC, MMC and prefabricated construction.

Several researchers have indicated many drivers and barriers regarding OSC. There are numerous drivers of OSC such as time, quality, productivity and environmental issue. With the application of OSC reducing the overall project time and offering better control and consistency (high quality). It also improves overall project productivity and provides high-volume production. Moreover, the use of OSC can contribute to an improvement in the environment through increased recycling and the re-use of units and modules as well as a reduction in waste materials.

Regarding the barriers of OSC, the literature review indicates numerous barriers such as logistics and site operation, project complexity, cost, political and economic, skills and knowledge, industry and market culture. However, some barriers and drivers differ from country to country and project to project.

Next, section B will examine the current construction industry situation in Iraq and highlight the problems that are faced.

SECTION B

2.7 The construction field in Iraq

Iraq has suffered from sequential wars, international sanctions and an oppressive, state-dominated economic system that harmed the economic growth and development of this country (Alkinani, 2013). Abdulrazak and Mori (2012) cited that Iraq is in a post war situation and endures two contradicting faces at the present time. On the one hand, there is a continuous conflict in the post-war era, along with an unclear agenda for what should be the base for rebuilding society. On the other hand, there are opportunities to achieve a promising environment if the potential of Iraq, such as its abundant wealth and human resources, in addition to its geographical location, is accompanied by a well-managed reconstruction. The authors also affirmed the importance of this background to show the current situation in Iraq, as it is clear that there is a need to reconstruct the country, especially in the housing sector. In this regard, the ministry of planning established an Iraqi development plan 2018-2022 for reconstruction and development for long term implementation focused on four main pillars: -

- Governance, and the associated pillars and constituents.
- The private sector is a fundamental pillar for advancement and development, and a transformer for economic diversification policies.
- A road map for post-crisis reconstruction and development of governorates.
- Reducing multidimensional poverty in all governorates.
  (Iraqi Ministry of Planning, 2018)

The National Development Plan 2018-2022 supposed to pave the way for building the nation of the future that Iraqis' people look forward to. It represents a government commitment to fulfilling the aspirations of its citizens. The role of the executive authorities is essential in involving in the various stages of the government program in crisis management such as Response Emergency, Reconstruction, and Development. These authorities are :-

- General Secretariat for the Council of Ministers
- Ministry of Planning, Ministry of construction and housing, Ministry of finance,
- Sectoral bodies (e.g. private sector),
- Local councils
- Security authorities

The Supreme Committee for Reconstruction and Investment chaired by the Prime Minister ensure the momentum and preservation of the sustainability of efforts for reconstruction and investment and development working on the level of Iraq as a whole. At the same time, the implementation bodies of reconstruction and development plans are the Ministry of Planning and Finance, Ministry of Housing and Construction and private sectors. Banks' committees and international grants could participate in the strategic plan to offer finance support for investors.

This section will be divided in two parts. The first part identifies some problems in construction industry of Iraq. The second part will demonstrate the current research literature found about the OSC in Iraq and some examples of application of using the OSC in Iraq.

2.8 Classifications of construction problems in Iraq

It is helpful to highlight and classify some problems of the construction field in Iraq in order to understand the challenges in this field.

2.8.1 Housing and infrastructure problems

Iraq's housing policy has been insufficient for meeting the needs of the country's 26 million people for the last two decades and up to the day before the recent war. The housing shortfall for the centre and south alone is estimated at 1.4 million. While in the Kurdistan region in the north of Iraq, an estimated 1 in every 3 people lives in grossly substandard housing or neighbourhoods. In addition, the urban infrastructure in Iraq is inadequate and needs renewal, re-investment and new operation and maintenance (UN-HABITAT, 2003)**.**

In the period between 1989 and 1996, on the supply side, construction dropped from 16.09 million square metres to only 347.9 thousand square metres in the centre and south of Iraq. Moreover, lack of maintenance and overcrowding has taken a part in the decline of the current housing stock and infrastructure. However, a noticeable change happened in the year 2000 because of the insertion of the housing sector into the Oil-for Food Programme by the UN Secretary-General. Subsequently, investment in shelter and services started to improve as Iraq was permitted to import the necessary building materials, equipment and spare parts for the construction industries.

In 2002, Iraq's annual production capacity reached 70,000 housing units, which was appropriate to keep pace with the increasing population. In addition, in mid-2002, the government started to provide subsidised loans for the construction of new houses, causing an obvious increase in building permits. The figure below shows the residential built area and population growth 1989-2002.

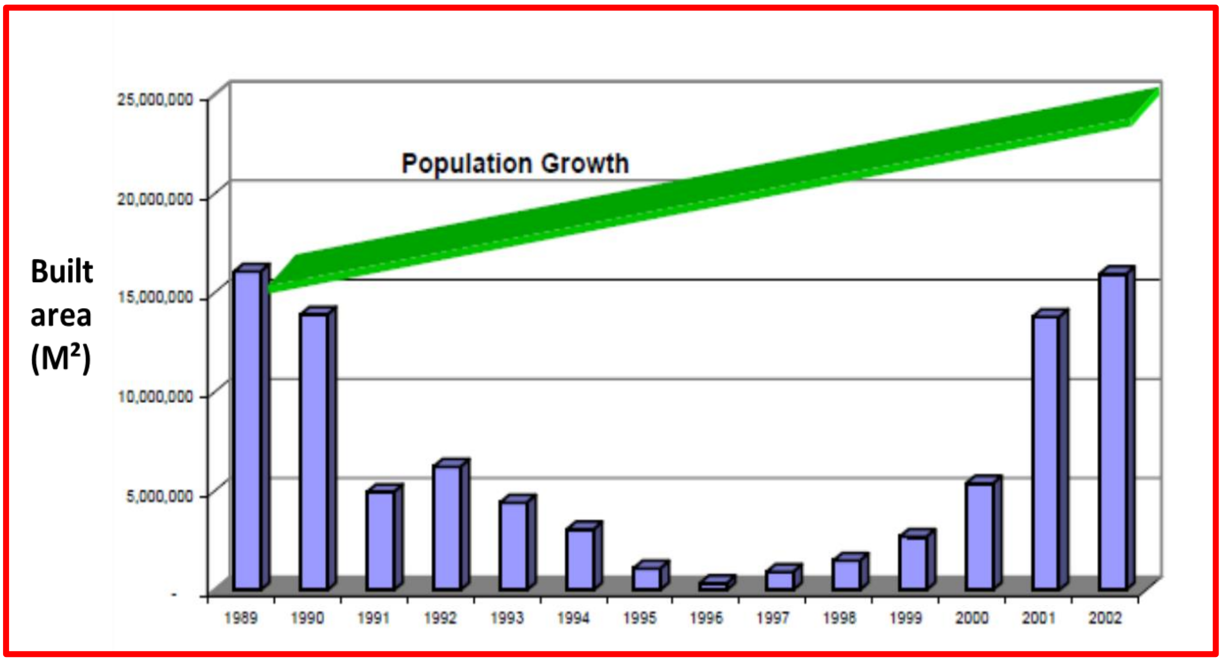


Figure 2-1: Residential built area and population growth 1989-2002 (adapted from (UN-HABITAT, 2003)

After the war in 2003, the UN-HABITAT presented a reconstruction plan for shelter and urban development in Iraq for the period between 2004-2008 and beyond for Baghdad and some cities. The problem of housing shortage is a result of a dysfunctional, centralized system of housing and land. The insufficient infrastructure and services is a key concern among the household (PADCO, Community Development Group, & Iraqi Central Office of Statistics and Information Technology, 2006).

Recent research by Abdulrazak and Mori (2012) highlighted problems such as the destruction of many areas in the cities and the devastation of the basic infrastructure such as roads, bridges, water supply, sewers, and electrical grids. In addition, the increasing number of homeless and displaced people and the population explosion in the cities due to immigrants and refugees are considered difficulties of great magnitude that are facing Iraq.

Table 2-3 shows that the housing shortage in Iraq will reach 3,528,585 housing units by 2015, which should have been covered within 10 years by producing 352,859 housing units per year starting from 2006. However, the government tried to solve the housing shortage problems through some ambitious plans, but these well-motivated plans are always exposed to the problems of housing production and to contradictions in housing regulations. The researcher added that in order to achieve the goal of the reconstruction process, the government needs to adopt a more innovative approach to effectively and rapidly address the trade-off between the short term and the long term objectives of the reconstruction process (Abdulrazak & Mori, 2012).

Table 2-3: Estimation of the population, number of families and the Iraqi housing need from 2006-2015 (adapted from (Abdulrazak & Mori, 2012)

Year	Population (people)	Number of families	Housing need(units)
2006	28,782,429	3,737,978	277,423
2007	29,645,901	3,850,117	295,866
2008	30,353,278	3,965,621	315,370
2009	31,451,336	4,074,589	335,989
2010	32,394,876	4,207,127	357,786
2011	33,366,722	4,333,341	380,821
2012	34,367,723	4,463,341	385,163
2013	35,398,754	4,597,241	398,381
2014	36,460,716	4,735,158	402,924
2015	37,554,537	4,877,213	428,862
Total			3,528,585

Another article indicated Republic of Iraq Ministry of Construction and Housing, UN-HABITAT, and AECOM International Development (2010) the importance of innovation in the housing sector. It stated that in order to improve conditions in the housing sector, innovation would offer the key solution. The innovation can be through design or building materials, as this will lead to improved quality of housing units. Thus, the demand for housing will be meet through an innovative housing production method. It also highlighted the infrastructure situation as he mentioned that the current infrastructure is on-going and an urgent need to restore sufficient levels of service (Republic of Iraq Ministry of Construction and Housing et al., 2010).

A study by Othman (2014) illustrated the housing shortage problem in the Kurdistan region of Iraq. In addition, the quantity and quality of housing have seriously deteriorated throughout the country. The researcher also affirmed the importance of developing a strategy, not only for the short time, but also for the long term. In comparison, in another article, Gunter (2013) described the challenges facing the Iraqi reconstruction infrastructure and emphasised the need to spend huge sums on infrastructure investment in order to repair the damage caused by three decades of conflict and to enable the country to profit from increased oil exports.

Iraq suffers from a nationwide shortage of nearly 4 million housing units, requiring the construction of 650,000 units per year in order to provide housing for an expected population of 38 million by 2018. This is according to the Construction and Housing Ministry and Ministry of Planning's data (Project Iraq Baghdad, 2014).

An estimation of housing needs in Iraq for the end of 2016 was placed at 2.5 million housing units, furthermore the number of informal settlements totalled 521,947 houses, while the population of the slums reached 3,292,606 people in 2017 (Iraqi Ministry of Planning, 2018). According to Al-Hason (2016), Iraq needs more than 5 million housing units to fill the existing deficit whilst an estimation of the increasing number of units needed amount to millions each year (Al-Hason, 2016). In comparison, Teen and Gramescu (2018) estimate that Iraq currently requires 4 million housing units. In addition, there is a need to repair and rebuild infrastructure after the destruction it suffered as a result of the wars (Iraqi Ministry of Planning, 2018; Teen & Gramescu, 2018).

Accordingly, there is a big problem of the housing shortage in Iraq as well as insufficient infrastructure as a result of series wars and embargo and population increase. Countries worldwide used OSC as an alternative solution to meet housing demand for the ability of this construction in producing mass structural units in less time. Consequently, Iraq can benefit from this type of construction to solve the housing shortage and rehabilitate infrastructure.

2.8.2 Project time & cost overruns problems

Although there is a trend in Iraq for building and reconstruction projects, several them are suffering from delay. Delay in materials laboratory tests, awarding contracts to the lowest bidder, difficulties in financing the project by the contractor, sudden rise in the prices of materials, and incorrect contractor estimation for contract duration have been highlighted by Ewadh and Al-handawi (2007) as the most important causes of delay in construction projects.

However, another study showed that mistakes and discrepancies in design documents, followed by the contractor’s ineffective planning and scheduling of the project was considered the most significant causes of delay in construction projects in Iraq (Jahanger, 2013).

Furthermore, some similar factors that agreed with the previous studies were illustrated in a recent study by Bekr (2015), who determined the most significant causes of delay affecting time overrun in public projects in Iraq. These are: security measures, changing of regulations and bureaucracy by government, official and non-official holidays, insufficient performance of the lowest bidder contractors in the government tendering system, owner’s change of opinion, design change by owner and consultants, owner’s payment delay, problems with the local community, lack of experience of the owner in construction as well as local and global economic conditions. Moreover, Bekr (2017) found that the time & cost overruns occurred in construction project in Iraq due to political and security conditions.

However, an effective cost and time management and control technique for construction projects is important in managing risk of cost and time overrun in completion of projects (Tahir et al., 2018). The researcher further added that the use of the Building Information Model would be able to increase efficiency and quality of output in the construction industry by reducing the issues causes of delay and cost overrun.

On the other hand, Tahir et al. (2018); Muianga, Granja, and Ruiz (2014) presented a group of factors that can cause cost & time overruns in the following :-

- **Governmental relations: -** Factors related to laws, governmental bureaucratic procedures.
- **Contractual issues: -** Factors related to commitments of contracts, contractual limitations and inadequate contracts.
- **Organization** Factors related to relation between different parties in project supervision and leadership
- **Management** such as lack of cost planning & monitoring and delay of decision making **and** Factors relating to the site management, communication and coordination of work.

- **Financing** Factors related to owner like difficulties and delay of payment, funding shortage.
- **Design and documentation** Factors related to quality of project; problems related to project design and documentation work like errors in design and change in design.
- **Schedule and control** Factors related to scheduling, planning, and commitment.
- **Materials** Factors related to shortages of materials, fluctuations in the price of materials, lack of assessment in relation to location and local suppliers.
- **Labour and equipment** Factors related to skills of the workforce, job instructions, constructions, methods, tools and equipment.
- **External factors** like weather conditions, law change, etc

  However, Memon, Rahman, and Azis (2012) demonstrated some mitigation measures such as:

- ❖ Effective site management & supervision
- ❖ Improve contract procedure
- ❖ Allocate sufficient contractors and sub-contractor
- ❖ Affective planning of work
- ❖ Improving contract award procedure by focusing on the contractor capabilities and experience rather than focusing on price
- ❖ Provide training for unskilled labour.
- ❖ Enhance communication between project team

Moreover, Al-karawi (2018) indicated that the owner of the project should pay fines in case of the delay paying any of the contractor's owed payments.

Accordingly, it seems that the Iraqi construction industry who mainly depend on traditional construction suffers from a problem of cost and time overruns. Therefore, the factors that can cause time and cost overruns in any type of construction has to be considered and evaluated when making a decision of using any type of construction to prevent its negative effects. However, the using of OSC can contribute to improving time and cost performance as it is more organised and requires fewer activities onsite compare to classic construction. Time and cost related benefits when using OSC could be enhancing its use in Iraq.

2.8.3 Lack of understanding of the Sustainability concept

An article by Al-Saffar and Salman (2014) indicated a lack of awareness and understanding of the benefits of a sustainable approach in Iraq's construction sector. This has resulted in the absence of sustainable construction practices in this country. The authors added that there is an enormous deficiency in realizing the techniques of sustainable construction. Therefore, the researchers proposed a management system for construction practices and suggested using this system in future sustainable building projects in Iraq. They also recommended improving the sustainability of present construction techniques and practices in Iraq. Indeed, Mohsin and Ellk (2018) found that there are some barriers to the adoption of environmentally friendly construction materials in Iraq, due to: a lack of awareness gained from dealing with such materials; a lack of adequate data on the potential environmental impacts of the building materials used through their life cycle, and the difficulty to secure the acceptance from society for the use of new instead of traditional materials. Moreover, the absence of regulations and codes that encourage the use of green building. On the other hand, applying sustainable construction project financing and policies helps encourage the distribution of green construction technologies in the construction industry (Shan, Hwang, & Zhu, 2017).

Thus, another problem found in the Iraqi construction industry is lack of knowledge and awareness about sustainable construction. This may lead to slow adoption of new methods of construction including OSC. Thus, leverage awareness and efficient management system to explore environmental benefits in the construction industry when using a modern method of construction is essential in order to drive the direction of change from traditional construction to OSC as this construction contributes to achieving environmental benefits.

2.8.4 Workers productivity problem

After 2003, the Iraqi government invested huge sums of money in the building and construction sector in all Iraqi cities. An important issue that caused a nuisance to local contractors and sub-contractors was the productivity of workers. Labour productivity is a big problem in the building and construction industry in most countries, especially in Iraq (Toama & Adavi, 2015). The main objectives of Toama and Adavi (2015) study were to determine the impact of external factors and human productivity of workers on a construction project in Iraq based on the views of consultants, contractors, project managers and engineers by collecting data on the basis of a survey, which was conducted in the province of Maysan, Iraq. The results indicated that lack of experience was the strongest factor under the human factors group, while the delay of payment and the absence of training and weather conditions were the most influential factors under the external factors group (Toama & Adavi, 2015). Therefore, to enhance labor productivity in any construction project, it is required to manage the impact of various factors and to reduce their negative impact on the construction projects.

In the same vein, Dakhil et al. (2017) found corruption, fraud dishonesty and wasting time and payment delay are the most significant factors that affect construction labour productivity in Basra city in Iraq. However, working under hard weather conditions was not found as strong factor.

It seems that there is a problem of poor productivity of workers in the construction industry in Iraq which mainly used classic construction. There are factors can affect labour productivity in the construction industry which is recommended to overcome to reduce its negative impact on labour productivity. Meanwhile, the use of OSC can enhance the labour productivity for the advantages that this construction contains, involves fewer activities required onsite, repetitive process, working in manufacturing environment which can ensure decrease the risks of accidents and working under severe weather. Consequently, the use of OSC can enhance labour productivity in Iraq which in turns be a driver for its use.

2.8.5 Weak understanding and implementation of Health and Safety system.

Mahmoud (2009) and Mohammad and Rasheed (2014) indicated a poor safety record in the Construction industry in Iraq in comparison with other countries. They also ascertained a lack of awareness in the top management of construction companies in Iraq about the importance of safety issues in their business; both researchers concluded that safety issues are not a priority for construction companies in the same way as cost, time and quality are priorities. Managing risk in most construction companies in Iraq depends on judgement, intuition and experience. Mahmoud (2009) also concluded after evaluation of H&S in a large construction company in Iraq that the safety programme was inadequate, with a lack of documentation on accidents and their cause. The researcher confirmed the effectiveness of correctly implemented H&S in eliminating injures and accidents. The researcher also indicated that the increasing percentage of non-fatal accidents in (2007-2008) was a result of the increasing volume of construction projects.

Similarly, Mahjoob (2014) stated that there is a severe shortage and lack of interest in H&S and in the requirements for personal protection in construction companies in Iraq. The author concluded that the number of injures is higher among young workers because they have less experience in their jobs and work directly without training, as usually there is absence of education and training among workers about H&S procedures and the risks from neglected them. The author also determined that construction workers are more susceptible to injury in on-site construction than workers in other specialities. Another study by Aljuboori and Abdulmahdi (2014) supported the findings of Mahjoob (2014) about the rate of accidents of workers during their jobs in which a high percentage of injuries affect young workers more than others. In addition, accidents occur mainly during daytime and those affected tend to be primary school graduated workers. Figure 2-2 below shows a high level of injuries in the manufacturing sector (48.4% of injures) with a significant percentage in the construction sector (16.9%). The highest fatality/permanent disability rate was among the work-related road accidents.

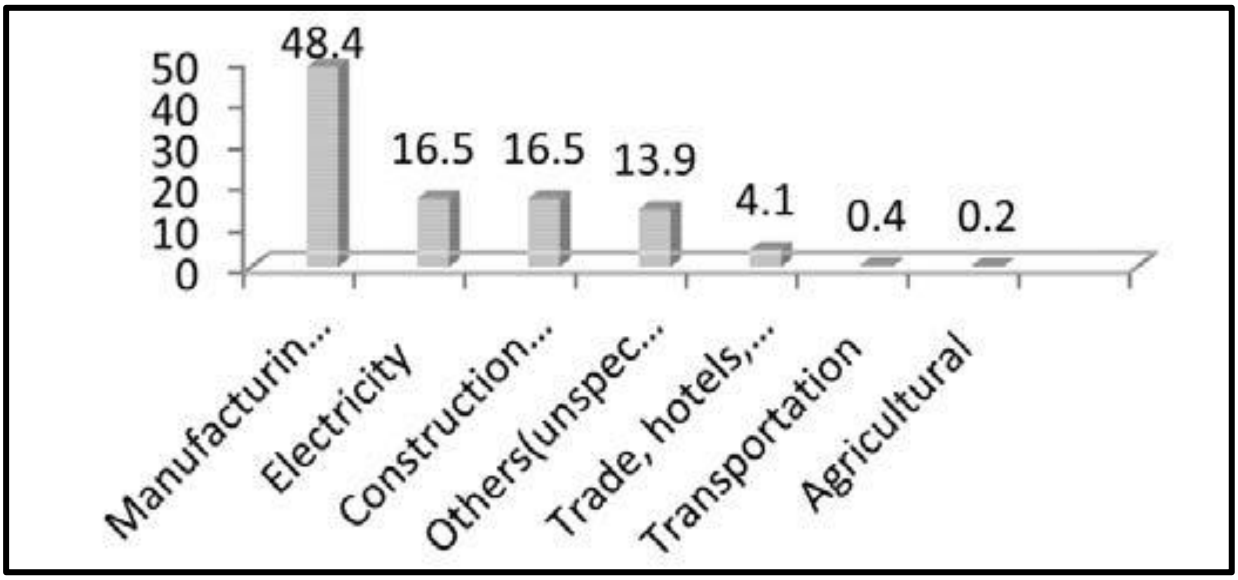


Figure 2-2 Distribution of workplace injuries according to Industrial sector (source: (Aljuboori & Abdulmahdi, 2014)

A recent study by Rasheed (2016) concluded that health and safety systems are absent from construction companies and their sites. The author also determined that even if there are H&S principles’, there is insufficient commitment to their application. In addition, there is no interest in H&S systems from top management. The author also found that there is no special department with enough workers to deal with H&S systems; even if there is such a department, no appropriate or adequate power is given to it. This clarifies that the problem of absence or improper systems of H&S in Iraq still exists in construction companies, although a number of initiatives have been made to improve the system.

- All the research studies mentioned above have recommended the implementation of an adequate H&S system in construction companies in Iraq, as it can minimise injures among workers. In a ‘high hazard’ organisation, such as a manufacturing factory or construction project, different specialists (engineers, medical doctors, trainers, work planners, supervisors, etc.) may be appointed the responsibility of helping the manager or director responsible for H&S in the organization in making certain that the H&S regulations in the firm are up to the point (Cooney, 2016a). In this regard, Supreme Judicial Council (2020) issued decision for occupational H&S instruction; Based on articles 152 and 108 / second from work Law No. 71 of 1987.

Article 1 involved the instructions apply to private, cooperative and mixed sector projects. Article 2, the inspection section in the Department of work and Vocational Training is responsible for:

- Supervising the implementation of occupational safety and health in accordance with the provisions of the work Law No. 71 of 1987 and the instructions issued pursuant thereto.
- Coordinating with the National Centre for Occupational Health and Safety on the implementation of work and safety precautions, and health and safety
- Following-up and completing transactions related to occupational health and safety.

Article 3, First: The competent work inspection committee shall confirm its observations on the level of work precautions and the extent of the employer's and worker’s obligations with these instructions in its report on the inspection visit to the project.

Second: The work Inspection Committee shall be responsible for disciplinary action, if it intentionally neglected or neglected the description of work precautions and the extent of commitment to implement occupational safety and health in the project.

Article 4, for projects with more than 100 and up to 500 workers, responsibility is assigned to a committee within the project called the Occupational Safety and Health Committee, which is formed according to the following membership:

- The business owner or his representative - Chairman
- The Technical Director and Heads of Technical Departments - members
- Project doctor or nurse - member
- A representative of the trade union committee - member
- One of the workers, responsible for occupational safety and health - full-time member
- A rapporteur of the committee, who should have passed a basic course at the National Centre for Occupational Health and Safety.

In this article also pinpointed the roles of this committee, as well as illustrated considerations to be followed by the employers when deciding to allocate a person who responsible to follow the application of H&S in the workplace. Also, illustrated the duties of this person who responsible for H&S application.

Moreover, McKay (2010) emphasised on the importance of optimal use of personal protective equipment in order to reduce injuries in a factory or onsite.

In the same vein, Yiu, Chan, Sze, Shan, and Chan (2019) identified motivations factors for better management system and were grouped into five categories including:

- Safety commitment by senior management such as “noticeable senior management commitment for instance allocate adequate teamwork that able to implement tasks safely” and “cost spent on safety issues”
- Competency profile like, appointed qualified and competent safety manager and sub-contractor who are competent in health & safety.
- Safety climate, referred to factor attributes including safety awareness of employees and key personnel

- Safety requirements and incentives referred to financial incentives, legal requirements, and certification requirements & contractual requirements of construction projects
- Project management, such as effective communication system starting from design stage to completion stage.

Accordingly, there is a problem of poor safety record in the construction industry in Iraq. There are numbers of factors causing this problem, such as lack of commitment from construction companies, lack of knowledge and awareness about health & safety risks, lack of interest in dealing with H& safety risks and lack of training. These factors need to be addressed when using any type of construction to remove or reduce the consequences of such issues on the safety of the workers. On the other hand, the use of OSC can contribute to enhancing health & safety for workers, as literature reviews shows the ability of such construction in reducing accidents on-site and because the nature of this construction that involves factory environment which usually ensure the safety of workers. Therefore, the using of OSC can enhance safety record in Iraq as a result of its health & safety-related benefits.

2.8.6 Problems regarding materials

Materials are considered vital resources to the construction industry. Materials are essential components of the productivity process. Therefore, it is necessary to pay attention to this important resource and to try to find ways of controlling and following it (Naji, 2010). For this reason, Naji (2010) evaluated the process of handing and transport of materials on construction sites related to Diyala University (Diyala is a city located in Iraq). The researcher found a lack of policy on the following aspects of materials handling:

- Control and handing material handling within the site.
- Reducing the cost of handling of construction materials and increasing efficiency.
- Reducing the proportion of construction waste materials.
- Control of excess material.
- Finding an optimum distribution of stores as well as an optimal distribution of materials inside stores and on-site.

- Finding an optimum number of machines for handling materials and an optimum number of workers for loading and unloading. Programs for control and follow-up of construction materials, which if applied can reduce the cost of transfer and handling of materials.

Moreover, Al-karawi (2018) found that construction materials changing prices due to inflation and declining in the country economic situation are important challenges that facing the Iraqi construction contractors. The researcher recommended to establish department of prices monitoring and documenting that responsible for dealing with changing prices throughout following up suppliers and materials manufacturers; in order to get changes of the construction materials, publish special circulars for the prices correcting and issuing these circulars and main materials prices updates to contractors.

Another study by Khammas et al. (2014) indicated that Iraq's construction field suffers from many problems and difficulties that cause great financial loss and one of these problems is waste, which includes waste of materials or waste of time. Therefore, the researcher focused on the importance of conservation of materials, by identifying the causes of waste, and limiting it. After a survey established by a researcher in Sulaymaniya (a city located in the north of Iraq), which included several construction companies, he concluded:

> "That there is a great deficiency in project management and the main causes of waste materials is managerial and organizational misconceptions, like that of contract-based errors and unsuitability of the construction site". Then, they made their recommendations in order to minimize these causes.

In the same way Khaled, Alshathr, and Hadi (2014) investigated the construction materials' waste percentage in the construction industry of Karbala(Iraq). Their results and recommendations are as follows:

- The percentage level of waste materials is high, and this percentage differs from project to project.
- All participants are uninterested in waste minimisation.
- Most contracting companies are lacking in knowledge about the management of construction waste materials and may not even know the amount of waste they produce.

- The researcher recommended the establishment of a waste management plan that is appropriate for the performance environment in Iraqi construction sites.
- By implementing some preventive measures during construction, it is possible to minimise the level of waste. With a sufficient design plan, it is also possible to implement sustainability concepts at the pre-construction stage.

Based on previous research, the same authors developed a system of managing waste of construction materials. This involves serving the construction projects in the local construction industry in Iraq by reducing waste at the execution stage and raising interest in waste reduction by all contributors.

This system was developed to address the increasing levels of waste of construction materials in Iraq and the researchers highlighted the effectiveness of this system when they tested and employed it in some construction projects in Karblaa city. The researchers recommended future research to develop integrated packages that link waste management with material management, project scheduling, inventory management, source optimization, and the fundamentals of sustainability (Khaled, Alshathr, & Hadi, 2015).

Accordingly, the classic construction in Iraq seems has issues in regard to materials and waste of materials. According to the literature review, there is a problem with handling, loading & uploading, storing and managing the waste of materials which can lead to the increased cost of the project in case not addressed carefully. Meanwhile, it seems that the management system in dealing with these issues is weak as well as the nature of classic construction that involves a large number of activities, materials and a large proportion of waste materials. Therefore, the applying of OSC within the construction industry in Iraq can contribute to eliminating or reduce the problem of waste materials. Reducing waste is one of the significant advantages of using this type of construction as most activities that can cause waste, be moved offsite as well as the prefabricated products have mainly required only the installation onsite which means protect the environment from the waste of materials and most likely not need to store materials on site.

2.8.7 Energy problems

Iraq belongs to one of three areas in the world with the highest temperature in summer. The building industry in Iraq has the largest demand for energy, mostly in residential buildings and these buildings mainly depend on traditional construction systems in which their normal wall and roof are often built without any thermal insulation. In the past, the traditional system used to deliver comfortable conditions during winter and summer but this construction system is no longer sustainable because of the increasing effect of technological advancement and global warming (Abbood et al., 2015; Kadury & Ali, 2010).

One of suggestions made by Hassan (2008) to minimise the use of energy in Iraq is to changing the type of materials used for constructing the roof and walls of buildings. Both Ibraheem, Shaweas, and Mahmood (2013) and Hassan (2008) supported the use of light weight concrete (Thermstone) which involves thermal insulation for saving energy. Hassan further found that using thermstone, the energy saving was about 16.69% and with the use of thermal insulation material, the energy saving was 34.3%.

Similarly, Alsaffar and Alwan (2014) studied the impact of insulation on energy consumption in Iraq's buildings and identified the quantity of energy savings from the use of the insulation in buildings. They concluded that an effective reduction in energy required for air conditioning will occur when using thermal insulation in the roof, floors, and walls as well as double glazing for windows in the building.

The continuing energy crises in Iraq since the Gulf war showed the difficulties in achieving energy efficiency and this is clear in figure 2-3, which shows the lack of electricity provision; Iraq's electricity infrastructure was severely damaged, and suffered from lack of investment and accessible equipment while under sanctions. The situation was worsened by the invasion in 2003 (Abbood et al., 2015; Kazem & Chaichan, 2012).

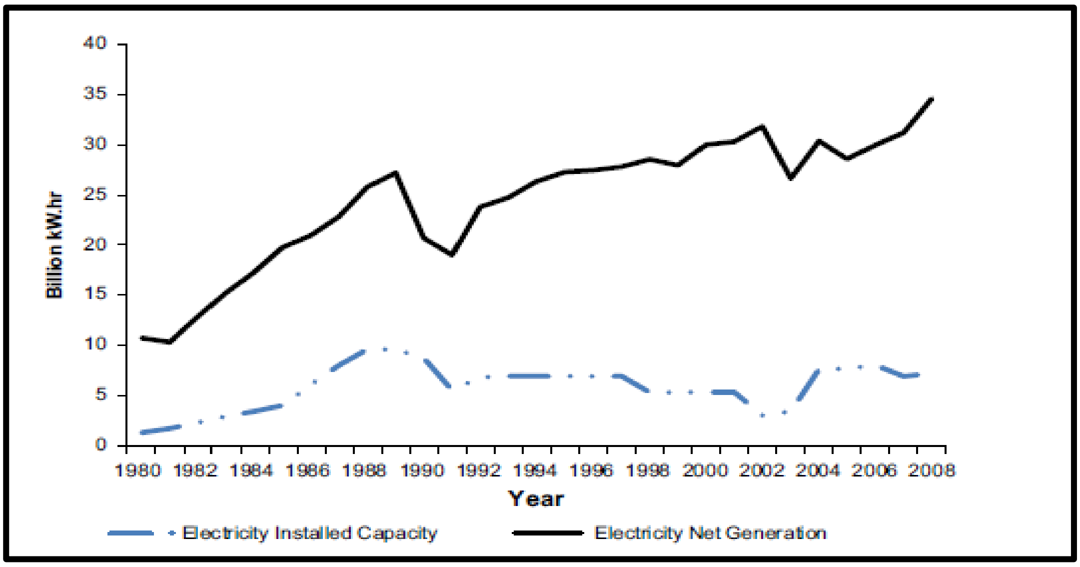


Figure 2-3: Electricity demand (adapted from: (Kazem & Chaichan, 2012))

Kazem and Chaichan (2012) stated that, as a result of increasing demand and population growth, Iraq requires more power day by day. They added that according to the Ministry of Electricity, the peak demand of power was 12000 MW in 2008, while only 6000MW was supplied. This shortfall is likely to increase to 25000 MW by 2020. The researchers recommended the use of renewable energy, such as solar and wind energy, to meet future increase in electrical demand.

Another study indicated that the demand will increase substantially over the next two decades and will reach 52.2 GW in 2028 as depicted in figure 2-4**.** This is different from the demand expected by the ministry of planning data, which is 32 GW IN 2028 (Istepanian & Al-Khatteeb, 2014).

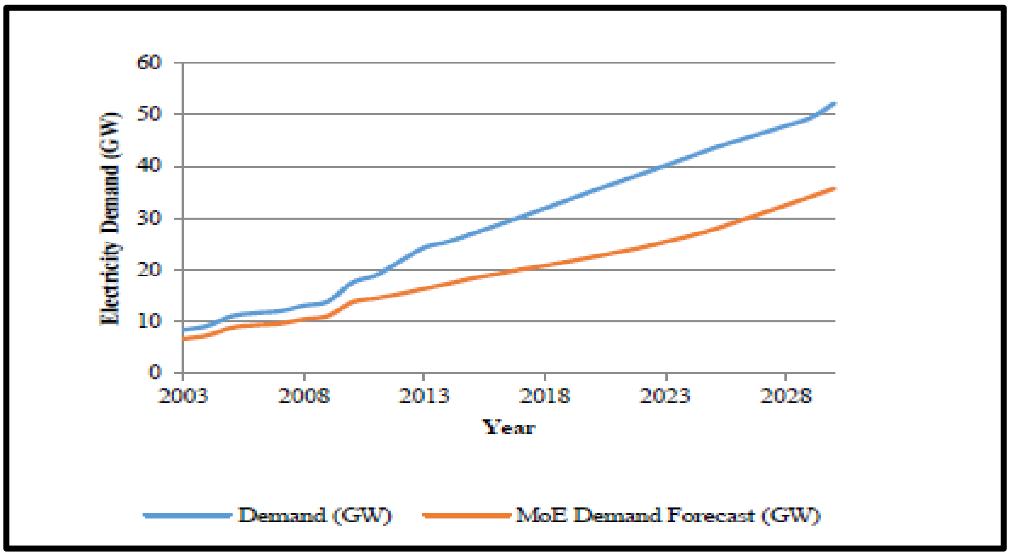


Figure 2-4: Electricity demand in Iraq (adapted from: (Istepanian & Al-Khatteeb, 2014)

Nevertheless, a study by Abbood et al. (2015) might be the only study which presented the energy evaluation efficiency for a typical house located in Basra city(south of Iraq) by comparison of two types of construction, which are conventional and industrial building system(IBS). Their findings showed that the OSC is able to decrease energy demand for heating and cooling in comparison to the conventional system. The yearly energy required for heating and cooling for the conventional system was around 19,311.99 kWh whereas for the IBS system, it was 7374.57 kWh. This means that the IBS system decreases the energy needed for heating by about 37.32% and for cooling by 65.36% in the yearly energy requirement. Moreover, the saving in energy cost is noticeable because the industrial building system housing consumed $81.61 per annum while the conventional house required $431.54 per annum. Thus, the difference in yearly saving was $349.93, which was achieved with the IBS system.

Accordingly, there is energy deficiency in Iraq, the use of classic construction is no longer able to save energy for the country that suffering hot weather during summer and electricity shortage. Researchers recommended using materials that can save energy such as lightweight concrete and insulation as well as renewable energy. Hence, the use of OSC in Iraq can contribute to overcoming this problem as one of the advantages of using OSC is saving energy during the use of the building, as a result of the high quality of materials are used to construct the building in addition to use insulations.

2.8.8 Project management system related problems

Researches by (Al-Ajeeli & Mehdi, 2015; Mohammed & Abdulrazzq, 2014; Saco & Al-taai, 2009; Al-Tamemi & Al-Saffar, 2006) highlighted some problems regarding management of construction projects.

The problems are as follows:

- There is a clear deficiency in the management and planning of construction projects and there is a lack in control, which leads to cost overruns, delay of projects and poor quality. Some factors contributing to this problem are as follows: -
- Lack of clarity of vision when planning.
- Do not give planning the required consideration.
- Lack of sufficient data and information for the projects.
- Weakness in the performance efficiency of private planning.
- Regarding the management of cost, there are some problems as follows:
    - There is a weakness in the efficiency of managing and planning the cost of construction projects. This is due to lack of awareness in using scientific methods in management and planning of cost through all stages of the project.
    - Reluctance in applying the principles of responsible planning and managing of project costs and investment. This is because financial allocations are

issued for every year individually and this is not suitable for construction projects that will last for more than one year.

- ❖ Lack of financial allocation that similar to original planning work. Khaleefah and Alzobaee (2016) attributed it to the absence of proper planning for the implementation and funding of projects, as well as the lack of planning for cost operation and future maintenance and requirements. Therefore, Fraser, Race, Kelly, Winstanley, et al. (2015) emphasised that costs need to be evaluated in the total context of the project including maintenance and operation particularly for OSC, including the beneficial impacts on project durations and risks, in order to understand its value to projects.
- ❖ The increasing cost of projects after 2003 because of increasing materials prices and increasing transport wages along with a lack of management of the project's resources. In general, the Ministry of Transport and Communications, with its organizational structure and current powers, is the closest to adopting a strategic direction in its planning for the national transport sector and the active participation of all other parties involved in the sector's operations (Flayeh, 2018). This entails:
  - Rehabilitating damaged roads and bridges, and establishing various new types of road including rapid, arterial, secondary, and rural.
  - Developing rail to reduce the road transportation of materials.
  - Legislating a new law or amending current legislation to impose fees at specific rates for the use of main and arterial roads.

- ➢ The management and monitoring and control of quality in the Iraqi construction project is insufficient, due to the following:
- ➢ Low interest in the process of organising the management team, which can lead to problems and defects in the products of projects after implementation.
- ➢ Lack of qualifications and training of workers to ensure compliance with the required scientific principles in performing the different stages of construction projects.
- ➢ Lack of an integrated system to enter and save information, which leads to the absence of informational cooperation between the departments of the projects.

- There is no real role for the manager in most of the construction projects. This leads to a lack of project services for following up the stages of implementing projects and for coordinating the roles of different participants of the projects.
- There is a great deficiency in the optimal use of computer applications that deal with managing and planning the cost of construction projects. This is due to a lack of responsible planning.
- Accumulation of experience only happens for workers who continuing working. Therefore, if these people are absent from work, it will lead to a loss of effort and experience from the people who are responsible of the work. Furthermore, there is a shortage of documentation of data, analysis and results of the work, especially the recording of daily costs and time, along with other circumstances.

Thus, the literature review shows deficiencies in managing projects in construction field in Iraq. the inefficient management system caused by many factors such as the insufficient role of the manager in dealing with projects, improper planning, lack of communication and coordination, lack of quality control and monitoring. Thus, these problems can lead to cost and time overruns and quality deficiencies. Therefore, the management system in the construction industry needs attention from the decision makers in order to improve the performance of the project. However, the use of OSC is usually more organised than classic construction and involves more clear steps and activities and the cost of materials are more specific and known. Meanwhile, the use of OSC also requires a firm system of management as it involves a series of steps that any defects in any step can cause cost and time overruns.

2.8.9 Contract, contractor, and contractor companies' problems.

The construction industry in general, and construction contracting are considered the most important areas for spending money and contracts at the present time in Iraq; this is because the civil and economic infrastructure in Iraq has suffered from widespread destruction, and there is a great need of reconstruction. This can be visualized as the amount of investment needed to improve the infrastructure and the amount of money that can be invested in construction projects and construction (Al-Najar & Hilal, 2012). However, nowadays, the Iraqi Construction field faces enormous challenges, which cause many problems in the cost, quality and duration of the projects (Razoki, 2008).

Some challenges and problems have been highlighted by (Mohamed & Ahmed, 2014; Al-Najar & Hilal, 2012; Razoki, 2008; Sarhan & Majol, 2007)

- There is a lack of knowledge on managing tenders. The first criterion in most cases for choosing the tender is selecting the lower-priced tender, although this offer is not the best one. There is also the problem of referral to certain companies bidding without competition, which leads to the emergence of serious problems, including humanitarian and economic.
- The second criterion is the selection of the contractor, which may sometimes be influenced by the acceptance of a bribe.
- There is a lack of clarity in the awarding of tenders. Each side applies the principles that suit them. For some, this may be price without regard to other considerations. Others look for quality regardless of price. This has led to the emergence of the phenomenon of burning prices and the concomitant disadvantages in the construction sector.
- The large number of companies licensed to operate in the market compared to the number of projects raised in the market, making many companies compete on price. In some cases, their price is less than the specified budget of the project and there is no action from the people responsible for the projects.
- There are some companies that do not care if they win or lose, but they are interested in obtaining projects to ensure continuation.
- Entry of some foreign giant companies, which are outside the scope of the competition due to their size and enormous potential to win the lion's share of large projects in the local market.
- The most competitive method is generally preferred in awarding the tender.

  However, in some cases, assigning the business to some foreign companies takes place without a competitive process.
- The people who are responsible of contracting often violate procedures established by the US government for protection from corruption, waste, and abuse. In addition, use of Iraqi money does not always follow the correct procedures, although observers have expressed that they are easy to follow. Recent reviews

highlight the granting of lucrative contracts to companies that have a well-established relationship, such as Halliburton. This phenomenon is not limited to US funds. The bulk of Contracts that were financed by Iraqi oil money went to Halliburton without any competition.

- The presence of large numbers of construction companies and contractors, but without a real actual rating.
- There is a lack of desire from referral and negotiation committees to take responsibility for choosing the most appropriate contractor instead of the least expensive.
- The conditions of contract for civil engineering works that were developed more than thirty years ago, have not been adjusted or revised to suit the present development in the construction sector. Councils are usually responsible for renewing contract and establishing codes and standards in cooperation with Ministry of Housing. For example, the council of Baghdad undertakes the provision of municipal services within the boundaries of the city of Baghdad to ensure its development in a planned manner commensurate with its being the capital of Iraq.

Therefore, Al-karawi (2018) and Khaleefah and Alzobaee (2016) recommended the following:-

- A comprehensive review should be conducted into current laws in the General Conditions of Contract for Works of Civil Engineering.
- Develop abilities and characteristics of project managers through proper and continuous training programs with focus on the leadership area.
- The adoption of a scientific basis is advisable for the correct, accurate and fair classification of contractors and their potential financial knowledge, experience and reputation
- The appointment of oversight committees and inspectors in order to monitor the flow of the work
- The project owners have to pay fines when they delay paying for the contractor's owed payments.

- Owner must ensure accurate and complete study for tender prices before awarding the tender to the nearest price.

Hence, the literature review shows issues related to construction contracting. These issues can negatively affect the construction industry in Iraq. Therefore, the stakeholders have to be aware of these issues when deciding to use any type of construction, particularly OSC to prevent any negative effect on the project. Nevertheless, the decision-makers have a role in revising the contract to be aligned with present development in the construction sector. Firm regulations have to be issued to protect the contractors especially the reliable contractors that have a long successful experience in the construction field at the same time protecting the rights of the clients. The decision-makers have to pay more attention to value bid rather than price bid. Meanwhile, establishing regulations that can support the use of OSC is required to leverage its use.

2.8.10 Lack of knowledge about risk management in the construction industry of Iraq

The construction sector in Iraq consists of a group of activities related to building and engineering construction plus maintenance work. This sector has a close relationship with all the other economic sectors, making it an important indicator for the movement of the national economy and trends. However, there are many risks facing the construction industry. The nature of this sector has risks that are difficult to avoid or and it is difficult to make predictions on their impact. Those risks can affect the implementation of projects and can cause delay, increased cost and reduced quality of work (Rasheed, 2015b). Effective risk management faces the following challenges:

- There is a lack of interest and experience among the owners and contractors of the projects about evaluating risks and their effects.
- The most significant risks in construction projects are the lack of plans for the network services passing through the site, such as electricity, water and telephone. In addition, there are differences between the implementation and specifications as a result of poor understanding of drawings and specifications.
- The most frequent risks in the construction sector are technical, placing, regulating, political and financial (Rasheed, 2015a, 2015b).

Moreover, Haitham and Shibani (2016) agreed with Rasheed and further emphasised on the importance of applying risk management in construction project in Iraq effectively in order to improve the project performance in Iraq.

Hence, risk assessment and management are required when applying any type of construction. However, the use of OSC is usually more organised than classic construction and involves more clear steps and activities and the cost of materials are more specific and known. Meanwhile, the applying of risk assessment and management is important for any project to be overcome any risks can affect badly on the project processes. Therefore, it is recommended to apply risk management in construction companies in Iraq, in addition, to work forward to improve the awareness about the importance of involving such management in Iraq.

2.9 OSC in Iraq (prefabrication construction)

The adoption of prefabrication construction in Iraq was introduced as a solution to minimise the housing shortage problem in this country. However, the trend of this type of construction is fluctuating because of the poor quality of the products since its introduction between the period of (1970-1980) (Abod et al., 2011).

There are few studies dealing with prefabrication construction in Iraq and the interesting thing that most studies found are called the OSC as precast concrete. It is useful to mention the academic research and articles highlighting this type of construction in Iraq to identify the need for future work. These studies are summarised below: -

Mohee (2009) presented a typology of prefabrication systems and described their role in reducing the growing housing shortage due to the current and accumulative housing needs and the deteriorated situation of the current buildings. The researcher proposed a standardised plan through gathering the advantages of the two types of systems. These systems can be applied easily by using prefabrication construction in order to minimise the time needed for implementation.

Abod et al. (2011) agreed with Mohee (2009) by stating that the method of prefabrication can be a solution to the increasing problem of housing. The researchers indicated that there is a lack of clear vision of the concept of performance and its effect on the prefabricated residential buildings as well as a lack of a mechanism to assess it. Therefore, the research aim was to provide a visualization of the performance concept and its influence on prefabricated residential buildings, as well as to re-assess them according to this concept.

Furthermore, there is a similarity between the Abod et al. (2011) study and the Mohee (2011) study, since both examined the performance behaviour of buildings. However, Abod et al. (2011) studied performance of residential buildings in Baghdad by distributing the questionnaire to the users of buildings, whereas Mohee (2011) studied the performance of a civil engineering building in Tikrit (north of Iraq) and the researcher distributed his questionnaire to the users and the workers who implementing the building.

Another study by Mohee (2011) studied the efficiency performance of the civil engineering building in the college of engineering in Tikrit University in Iraq. The evaluation of the building was according to structural properties, dimensions and characteristics of spaces. The researcher demonstrated that there is a gap in knowledge on prefabrication construction. Hence, the objective of his research was to show the Iraqi experiment in prefabrication which included carrying out a number of precast buildings. The researcher recommended the study of the prefabrication construction method in civil engineering and architecture universities. He also emphasised the importance of encouraging government officials to adopt this type of construction in future projects.

Moreover, Al-Saadi (2012) stated that there is a need for new methods of construction, which are more economical and realistic for solving the problem of housing and slums. The study focused on three types of building methods. These are structural houses, bamboo board houses and caravan houses (corrugated steel sheets and sandwich panel sheets). He also compared these types of method in terms of constructional, social, economic and environmental factors. It was found that all these methods have time and cost savings. In addition, he found that for caravans the sandwich panel houses are better than the corrugated houses, while the structural method is appropriate for luxury houses. Rural houses are suited to the bamboo board method, which is also considered a good option to solve the problem of poor families' houses.

The reliance on traditional methods of construction cannot solve the problem of housing shortage quickly. In this vein, Teen and Gramescu (2018) emphasised on the importance of using of modern method of construction for its advantages in reducing time and cost required for the project, reduction of labour, quality enhancement and environment development achievement such as reduce energy required and reduce pollution.

There was an attempt to measure the energy requirement when use of OSC by Abbood et al. (2015) who investigated and compared the level of energy efficiency in conventional construction and IBS construction (prefabricated construction). The findings showed that the annual energy demand for cooling and heating for IBS performed efficiently with 7374.57 kWh, while the conventional system was 19,311.99 kWh. As a result, IBS reduced the annual energy consumption by 65.36% for cooling and 37.32% for heating. However, his studies were based on simulations, as it was difficult to obtain data due to instability and insufficient provision of energy generation. The study targeted an existing house of two stories in Basra, one of the biggest cities in Iraq with a built-up area of 135 m2. This research supports the thinking of Mohee (2011) by refer to knowledge deficiencies about prefabrication construction in Iraq.

There are also two studies on the behaviour performance of some types of prefabrication materials; one of them by Fadhil and Yaseen (2015) examined the effect of adding waste plastic fibre (PET) to the precast concrete panels(which is used in Iraqi markets now). The results showed that this addition reduces the workability of all concrete mixes. In addition, this reduction increases as the fibre volume fraction increases. Al-Rifaie and Joma'ah (2010) stated that the advantages of the prefabricated ferrocement panels system in reducing the cost of construction, decreases the number of workers needed to implement the work make it a good solution to meet the need for inexpensive houses. The researchers investigated the structural behaviour of ferrocement members that would be used in the roof, wall and floor of housing buildings by laboratory testing at the University of Technology (Iraq) in the building of the construction and engineering department. His results showed that for low cost housing to be achieved, the proposed ferrocement flooring and roofing system could be satisfactorily used as housing components.

In the same way, Al-Rifaie, Ahmed, Ibraheem, and Al-Samarraie (2014) examined the energy required by the ferrocement construction system and the traditional method of construction. He concluded that the ferrocement eco housing system is able to produce a sufficient energy saving in dwellings. He also stated that a high level of thermal performance can be achieved by using thermal insulation as a part of the construction panels.

Accordingly, it seems that few researchers have explored the adoption of OSC in Iraq. Researchers believe that this kind of construction can help to overcome or minimise the problem of housing shortages in Iraq. Moreover, they also believe that there is a need to move towards this type of construction due to the advantages associated with its use. As such, researchers indicate some benefits, such as time and cost reduction, labour reduction, and quality and environmental enhancement. Such benefits are required to enhance the Iraqi construction industry, which suffers from time and cost overruns, quality problems and environmental issues due to the use of traditional construction. However, these researchers lack a roadmap or a strategy to enhance the use of modern construction methods by investigating in depth the factors that affect its adoption. Therefore, this research can address the gap by adopting a strategic guideline for the improved use of OSC in Iraq.

2.9.1 Recent applications about prefabrication sectors in Iraq

1) Rhodes Precast Concrete Ltd (Rhodes Precast Concrete Ltd (RPC)) was established in the year 2012, and is considered to be the first and the largest precast company in the world, in which established to produce the precast concrete components for Iraqi projects (Rhodes Precast Concrete Ltd (RPC)), 2015). This factory has now stopped production due to safety and mismanagement issues.

2) In 2012, the Iraqi government signed a contract with the director Hanwha Engineering & Construction Company for building the new residential city called Bismayah, which is located south east of Baghdad (Iraq), to be completed in seven years (Bismayah, 2016).

Some problems associated with this project were as follows:

- The investment of this project was transferred from Hanwah Construction Company to the national investment commission (NIC) of Iraq because of the reluctance of people to buy, although the NIC reduced the first payment when it registered to buy the housing unit.

- The city of Basmayah residential project was allocated a large sum of money but did not take the necessary time to study and research the challenges or discuss their plans with experts in architecture, planning and housing. This is a problem,

- The establishment of huge modern residential units, with facilities and services related to them confined in one area of a residential city was not a good choice. This project was designed and implemented by a specific company, namely Korean

> Hanwha Engineering and Construction, which does not have experience and knowledge of the customs and traditions of Iraqi society and the built environment of this country. In March 2016, the people who registered to buy houses demonstrated to demand their houses, as it was decided to receive them before the end of year 2015 (Al-Ansari, 2014).

Accordingly, it seems that a few applications, particularly after the fall of regime in 2003, lack an appropriate strategy to effectively manage the adoption of such construction. It seems that there are some challenges, such as cultural resistance, safety and mismanagement issues, a lack of risk assessment, misconception in the design, funding delays, delays to project completion, and a lack of knowledge. Therefore, these issues need to be studied carefully in order to enhance the use of OSC in Iraq.

2.10 Research gap

The literature review evidenced that the adoption of OSC has developed globally. However, there are still some barriers to its wider spread particularly amongst developing countries. Iraq is one of these countries that shows the slow adoption of OSC despite its vital need for this method. Although there are many Iraqi studies on traditional construction regarding its structure, behavior and performance, there are very few regarding OSC. Evidence from the few studies available on OSC reveal that there is a lack of knowledge and awareness and the slow of adoption of this type of construction in Iraq.

Traditional construction, as explained earlier, has been unable to cope with challenges facing Iraq nowadays. This is because Iraq is in urgent need for reconstruction after the disasters impacting the country caused infrastructure destruction and a rise in housing need. The literature review shows some deficiencies in the Iraqi construction industry, particularly amongst traditional construction. These include cost & time overruns, quality defects, management project system deficiencies, energy issues, waste construction problems, worker productivity, and so forth.

Accordingly, in order to meet the needs of the market to rehabilitate infrastructure and housing supply, and to leverage sustainability, the construction industry in Iraq needs to move from traditional to modern methods of construction, as represented by OSC. This can be seen as the most appropriate way to improve the construction industry’s performance, meet its needs and act as a competitive advantage. Yet the lack of a guideline or systematic way to fully manage and continuously improve the OSC adoption process at the core of the companies, means such change is hard to achieve in practice. Bendi (2017) found that the lack of guidance and information about OSC is a barrier to the adoption of such construction in India whereas the existence of such guidance can enhance its use. In this regard, Pan et al. (2007) recommended the provision of guidance, information, training and education to enhance the use of OSC in UK. Moreover, the lack of common language between the construction industry and training/education providers encouraged Nadim (2009) to propose a model of adequate training and education for the uptake of OSC in UK.

Nevertheless, Gibb (1999) argued that OSC required a project strategy to change the orientation of the project process from 'construction' to 'manufacturing and installation'. Moreover, in order to maximise the benefits of OSC, a 'project-wide' strategy should be developed at an early stage in the project to help measure the effects of the use of OSC (Nadim, 2009). In this regard, Al-Mutairi (2015) developed a strategy to implement OSC in Saudi Arabia by exploring the factors affecting its implementation as well as challenges. Moreover, Yunus (2012a) developed guidelines to provide a systematic decision support tool for stakeholders capturing sustainability. It demonstrates to the stakeholders how to manage sustainability and the approaches can be used to analyse sustainability and maximise the advantages of OSC application in Malaysia. Hence, some attempts have been made to develop the use of OSC worldwide, either through developing strategies, guidelines and training or education models. In the same vein, Mohamad Kamar (2011) developing a framework to support the shift of contractors to adopt OSC by identifying the critical success factors for its uptake in Malaysia.

Several factors may explain the slow adoption of such construction in Iraq, such as unstable political and economic issues, cultural resistance and a lack of knowledge and awareness about its concepts, the benefits of such construction and the lack of research and development or lack of strategy for effective use. These issues need to be comprehensively addressed, in order to provide a durable solution to the stated problem. Accordingly, it seems there is an urgent necessity to solve the existing research gap in OSC in Iraq by exploring the factors affecting its use from professionals and practitioners' perspectives. This will act as a platform to develop a strategic guideline to address and overcome the barriers for the adoption of OSC in Iraq and leverage knowledge of its benefits. Moreover, the strategic guideline would provide the construction industry with guidelines to offer effective tools to facilitate the shift in focus of these construction companies towards the best management of OSC projects. The proposed strategic guideline is expected to benefit governments, policymakers, construction industry and academics by enabling them to identify areas of concern and determine best practice in order to take full advantage of the benefits offered by OSC.

2.11 Review of selected models, framework, strategy, guidelines in OSC

To develop an offsite strategic guideline, the researcher extensively reviewed relevant literature on maturity models, frameworks, strategies, and guidelines. Some of the key initiatives, such as assessment models and frameworks, which have been extensively documented within existing literature, are listed in terms of the aim, developer, industry, survey method, and limitation (these are detailed in **Table 2-4)**. The researcher offers brief information on some developed countries and illustrates the level of OSC with some example of key initiatives. The discussion can be found in the next sections.

2.11.1 The UK's application of OSC

OSC is not a new concept to the UK construction industry as there is historical evidence of its use. The first known implementation of OSC was in the construction of the Crystal Palace around 1851 (Goulding & Arif, 2013). Although this market has, to some extent recurred, particularly after the First and Second World Wars, there was a second industrialisation movement in the 1950s and 1960s, and further growth in the uptake of modular construction around the 1970's (Taylor, 2009). Moreover, the Egan (1998) report titled ' *Rethinking Construction*' was instrumental in fostering the need for OSC as a way to improve productivity. The government, many researchers and some professional and academic institutions have subsequently conducted a large amount of research to examine the current use of OSC and identify the associated advantages and challenges.

Many researchers have considered OSC a potential solution for problems in the UK construction industry (Vernikos et al., 2012; Arif & Egbu, 2010; Goodier & Gibb, 2007). Loughborough University developed an Interactive Method for Measuring Preassembly and Standardisation benefits in construction (IMMPREST) through a software tool. This was an interactive tool to measure and evaluate the benefits from the adoption of standardization techniques (Blismas et al., 2005). Nadim (2009) adopted a system approach to OSC training and education using the Quality Function Deployment (QFD) method in order to develop an

OSC-QFD model. Its purpose was to identify and prioritise OSP training and education needs. Meanwhile, Elnaas (2014) developed decision making tools to provide a reliable system for use in practise at the early project stage. This helped to structure the decision-making process when choosing between traditional construction and OSC and improved the quality of the information on which a decision is based.

This market is now very mature, with a number of influential contractors, designers, manufactures and clients actively promoting OSC (Goulding & Arif, 2013). Buildoffsite is the major industry body championing the greater uptake of offsite in the UK and overseas. In this regard, Fraser, Race, Kelly, and Winstanley (2015) developed a guideline to provide a practical overview of OSC. This focused on the information needs of building engineering services contractors working on projects involving OSC. In creating this guideline, the authors directly and indirectly referred to many sources of information and organisations, in particular:

- Buildoffsite
- Heathrow Airport Ltd (the former BAA)
- Crown House Technologies and the wider Laing O'Rourke Group
- NG Bailey (who has contributed significantly to these case studies).

The guide is expected to be interactive, and thus accessible through a broad range of media as individual sections or as a whole integrated philosophy.

2.11.2 Sweden's application of OSC

In the last century, the social crises associated with housing problems in Sweden necessitated the introduction of the 'Small House Movement' programme. In this programme, the government financed 90% of the construction of small houses which were supplied with potable water and central heating (Nadim, 2009). The Swedish construction industry, which is regarded as the most industrialised and developed in the world, used OSC to construct 90% of its single-family houses (Thanoon, Peng, Kadir, Jaafar, & Salit, 2003). In the mid-1960s, the Swedish government projected a national mission to produce one million new houses within 10 years. However, the 'Million Program' houses was criticised as 'uniform' and of producing poor architecture (Hall & Vidén, 2005). Nevertheless, this misconception changed 25 years later due to cooperation between the research and construction industry, which investigated OSC habitation. Subsequently, in 1995 about 95% of the houses were prefabricated in a factory according to high-level energy-consumption and quality norms. The methods used were perceived to be 25-40% more economical than traditional techniques.

There are about 55 manufacturers offering OSC in Sweden and, apart from the local market, Swedish manufacturers export houses to many European countries. Their superb achievement in OSC is a result of direct and proactive government policies which include significant grants for research and development (Thanoon et al., 2003).

Moreover, the use of manufacturing processes in Sweden has developed substantially through several companies in the field of housing interiors and furniture. For example, IKEA has become the world's largest furniture provider. IKEA is a multinational group of companies; their design, production and sales strategy is based on the concept of 'ready-to-assemble furniture' (Elnaas, 2014). Thus, in an ideal world, prefabrication occurs in a factory and while the furniture assembly occurs onsite, in home or other facilities.

Nevertheless, there was a need for efficient experienced feedback from the construction industry, comprising companies that use a wide range of on- and off-site production methods to produce different types of project. Therefore, Meiling and Sandberg (2009) investigated a Swedish off-site house manufacturing company to close the feedback loops in off-site housing sales, design and production. An experience feedback model was proposed based on the literature review and case studies. The analysis shows how error detection can enhance the possibility of highlighting improvement actions as well as feedback targets.

2.11.3 United States' application of OSC

The use of OSC techniques in the United States (U.S.) construction industry originated approximately 100 years ago with the growth of the wood frame house (Lu, 2007). During the 1920's and 1930's, many leading architects and engineers started to construct mass-produced housing; moreover, by 1940 there were about 30 companies regularly manufacturing and selling prefabricated houses. In 1942, the Prefabricated Home Manufacturers Association was established in the US due to the demand for housing products. This association was created to distribute information, develop industry standards, improve manufacturing methods, perform cost and accounting studies, and serve as a forum for the interchange of ideas (Lu, 2007). Following World War II, companies began to produce homes in factories to meet the steady demand. The production of OSC has been on-going in the United States, but it became increasingly popular in the 1990s (Henderson, 2006).

The factory-built home industry is becoming an important alternative to the housing industry in the US. These homes can be customized for individual needs at a better quality than traditionally-built homes (Lu, 2007). The prevalence of modular manufacturers has evolved to create a very mature market. This is supported by openly demonstrating a range of efficiency measures, including improved productivity, lower costs, the ability to create sustainable and flexible solutions, and faster completion times (Modular Building Institute, 2015). The barriers to adoption in the US were transportation restraints, limited design options and an inability to make revisions during onsite execution. Moreover, misconceptions can arise around the quality of modular buildings and there can be a general lack of awareness of the benefits that offsite can bring (Goulding & Arif, 2013). Several practical recommendations were proposed by (Lu & Liska, 2008); Lu (2007) to overcome barriers to the use of OSC including eliminating transportation restraints, preventing onsite changes and increasing the design options. For example, this entailed developing and providing awareness training to manufacturers, designers and general contractors in the use of OSC in order to overcome the lack of knowledge about OSC techniques and its benefits.

Meanwhile, there is strong industry support across North America and Canada for modular building. It is expected that, by the end of 2013, 98% of the sector will be using OSC in some form (Goulding & Arif, 2013). This includes housing, healthcare projects, higher education, low-rise office developments, public buildings, and so forth. According to the Modular Building Institute, OSC business in the US has doubled in size to $8 billion over the last five years (Obando, 2019)

2.11.4 New Zealand's application of OSC

OSC has long been the innovative cornerstone of the New Zealand (NZ) construction industry since before colonisation in the early 1800s (PrefabNZ, 2013). The First World War caused housing shortages, which saw the establishment of a large factory in Hamilton/NZ to supply mass-produced homes. During the Second World War, factories in NZ were subjected to military construction activities producing over 30,000 transportable military buildings prefabricated and huts (Isaacs, 2008). After the Second World War, returning soldiers cooperated for a national state housing scheme by building and assembling prefabricated wall panels complete along with wall claddings (Bell & Southcombe, 2012). However, macroeconomic factors, such as the 1978 recession, design to manufacture shortcomings, and social cultural issues, led to the downfall of prefabrication (Mirus, Patel, & McPherson, 2018a). New Zealand has acknowledged the importance of offsite for delivering genuine benefits through innovation, improved efficiency measures, and streamlined building processes (Scofield, Wilkinson, Potangaroa, & Rotimi, 2009). With recent government schemes that aim to provide 100,000 homes within ten years and an announcement that this will be built by using OSC, OSC seems to be New Zealand's 'golden ticket' out of their current 'housing crisis'. However, for the successful implementation of this construction, New Zealand must first consider support in these areas including, the education of the workforce, the management of the current supply chain, and consistent government schemes, legislation and financial assistance (Mirus et al., 2018a). In this regard, academic research has explored challenges to the use of OSC in NZ and developed measures to improve its uptake. These measures address the following barriers: cost, logistic & site operation, industry & market culture, regulatory issues, skills and supply chain. Moreover, a prefabrication roadmap has been developed for 2013-2018 by PrefabNZ (2013) in order to meet the industry vision to produce high quality, well designed, affordable, inspiring residential and commercial buildings for satisfied consumers. This roadmap consists of success measures (clients, specifiers, producers, regulators, government) and challenges (start-up costs, misconceptions, market size, technical education). Moreover, actions that can address these challenges are also identified in this roadmap, for example, access funding for innovation, a portal website, online tools and information, international site visits and events, and online technical info with BIM product specifications.

2.11.5 Australia's application of OSC

The uptake of OSM in Australia has been steady and sustained (Goulding & Arif, 2013). The Australian construction industry has recognised that offsite should be part of the overall vision to improve the industry for the future (Blismas & Wakefield, 2008)

Hampson and Brandon (2004) expected more off-site production and more pre-finished elements and prefabrication in Australia by the year 2020. At the end of 2013, the Australian industry developed a network, PrefabAUS, as they were inspired by the advantages of OSC. Furthermore, they launched Buildoffsite in Australia in May 2014 (Khalfan & Maqsood, 2014). Hence, limited knowledge of the applicability, design and performance of prefabricated building systems in the construction industry is now minimised due to recent work by the industry, academia, and institutions, such as PrefabAUS, who have raised awareness of the benefits of OSC. Thus, the OSC industry is increasing in number in Australia (Navaratnam et al., 2019). Some recommendations by Navaratnam et al. (2019) to improve OSC in Australia and increase the market demand include the following:-

- As there are no specific testing standards for most prefabricated non-structural and structural elements, Australian design standards need to be developed to include recommendations for prefabricated structures and design specifications.
- The skills and knowledge required for OSC design and construction practices in Australia need to be developed and strengthened through relevant educational courses, conferences, workshops, and professional training.
- The limitations associated with transportation, regulations, and traffic control in the construction area are the most important factors for consideration in transportation planning. Therefore, more case studies need to evaluate the project planning, programming, and cost of small- and large-scale projects.

Navaratnam et al. (2019) ascertained that academic research will increase the market demand for OSC in Australia as well as in other countries.

Table 2-4 Worldwide Key initiatives for OSC application

	Initiatives	Aim	Data method	Country	Limitation
1.	DSM (Elnaas, 2014)	To develop a Decision Support Model (DSM) that can be used in practice to guide the choice between Off-Site Manufacturing (OSM) or Traditional On-Site (TOS) as a construction strategy for housing projects in the UK.	Semi-structured interviews, questionnaires and case-based precedence review of numerous housing projects	UK	• It is mainly applicable to the housing sector and may or may not necessarily be appropriate to other sectors within the construction industry. This is because the context of the study was scoped only to house building and the model was established using data and information collected from the house builders • The DSM has been based on UK house building within the construction industry; this means that the framework may be relevant elsewhere but the weighting of the key factors in the DSM may not necessarily be applicable in other countries

2.	IMMPREST TOOLKIT (Pasquire et al., 2005)	Developed to use in the OSC which provides a structured, value-based assessment of pre-assembly and standardisation. This toolkit consists of -Introduction and information tool (Tool A) -Interactive benefit indicator tool (Tool B) -Benefit measurement tool (Tool C)	Questionnaire and Interview	UK	• Provides a list of project drivers and barriers as part of a project-wide strategy to assess the use of OSC. However, the organisational context seems to be less reflected in the drivers and barriers identified in the toolkit.
3.	OSC guide for the building and engineering services sector in association with buildoffsite	This guide is intended to provide practical support for the effective use of OSC methods that focus on Building Engineering Services within the built environment. It acknowledges the wider interface	Case studies, and publication provided by buildoffsite and BESA and workmanship	UK	This publication relates to construction practice and projects in the UK and the Republic of Ireland. It is not designed for overseas work; however, some of its provisions will be appropriate or may form a basis for overseas work.

	(Fraser, Race, Kelly, & Winstanley, 2015)	with other construction specialists and focuses on how to deliver optimum solutions for clients.			
4.	• Measures to improve the uptake of OSC • Decision Support Model (Shahzad, 2011)	• To explore effective strategies to enhance the industry-wide uptake of OSC in New Zealand (NZ). • To develop a decision support model that offers a methodical evaluation of the marginal value offered by the use of OSC relative to that of classic and with regard to meeting the needs and preferences of clients in the procurement process.	Survey questionnaire and interview	New Zealand	• Measures conducted only for barriers to the of use OSC in NZ, whilst no measures have been developed for factors that can inhabit the drivers • The scope of this study was limited to the NZ construction industry. The study was based on the feedback collected from the stakeholders in the construction industry in NZ. • Time constraints did not permit the collection of sufficient data for the model's application in relation to the whole building, hybrid and component/element levels of OSC technology versus the classic systems. Therefore, only the modular level of OSC technology was compared against classic construction.

5.	Prefabrication roadmap (PrefabNZ, 2013)	Developed for prefabrication in New Zealand and draws from a rich and lengthy historical context to create a contemporary vision that aims to enhance the quality of prefabricated output and increase customer value. This vision is based on identifying key challenges, the resulting actions needed to address these challenges, and the applicable outcomes and outputs needed to achieve the actions.	Literature review	New Zealand	• Although the roadmap contains success factors and challenges, the actions were only developed for challenges within the context of New Zealand. • No actions for any factor can inhabit the effectiveness of the drivers. • Actions developed from a literature review; no practical data have been collected.
6.	• SWOT framework (Razkenari, Fenner, Shojaei, Hakim, & Kibert, 2020; Fenner, Zoloedova, & Kibert, 2017)	• A SWOT framework was used to assess the strengths and weaknesses of the industry's adoption of offsite strategies as well as the external opportunities and threats • Pre-construction strategies and project execution	Data was collected by means of unstructured interviews and a questionnaire	USA	• The report was designed to provide a snapshot of modular building design, component manufacture, and construction techniques within the USA • Strategies were mainly conducted to overcome barriers to OSC in the USA. No actions were suggested to eliminate factors that reduce the effectiveness of the drivers. For example, actions to overcome any factor can cause time overruns

	• Strategic implementation for best practice	strategies to overcome barriers and challenges for OSC			which can reduce the benefits associated with the schedule time reductions of OSC projects.
7.	A production strategy framework (Jonsson, 2014)	This framework can help construction firms to design the production system and find the right balance between productivity and flexibility	Literature review and case studies	Sweden	• This production strategy is developed for prefabricated multi-family housing, Smaller construction, such as single-family houses, civil engineering projects (e.g. roads, railway, bridges), and larger constructions (e.g. big arenas) are not taken into consideration in this research.
8.	A circular-economy framework (Minunno, O'Grady, Morrison, Gruner, & Colling, 2018)	A circular economy framework is applied to the prefabricated building sector to investigate the environmental benefits of prefabrication in terms of reduction, reusability, adaptability, and the recyclability of its components.	Literature review	Australia	• Focuses on aspect of one prefabrication advantage, namely environmental aspects • Although the final proposed guidelines of the framework can be used for a top-down or bottom up approach, it seems that these guidelines were only collected from a literature review. Therefore, researchers suggested further empirical study to test and validate the findings.

9.	Guidelines (Yunus, 2012a)	• To provide a systematic decision support tool that helps stakeholders to manage sustainability and the approaches that can be used to analyse sustainability, and to maximise the advantages of OSC application in Malaysia	Survey questionnaire, interviews, and case studies	Malysia	• Sampling process that focuses on government buildings in the public sector. As the private sector has not been include, the researcher recommended further investigative actions to consider this sector • The delivered decision support guides are intended for designers. These tools will be used in the design and early construction stages. Therefore, the researcher recommended extending the findings to include suitable decision mechanism and preferences for other stakeholders.
10.	Framework (Mohamad Kamar, 2011)	Developing a framework to support the shift of contractors to adopt OSC by identifying the critical success factors for its uptake in Malaysia.	Case studies and focus groups	Malysia	• The critical success factors identified in the framework are on the strategic and organisational level, so the unit analysis will be the organisation itself. Though it is perhaps associated to critical success factors, whether that means industry wide or on a particular project.

11.	Roadmap (Rahimian et al., 2017)	Developing a roadmap for the effective adoption of OSC in Nigeria.	Literature review and expert stakeholders	Nigeria	• Whilst the outline roadmap highlighted barriers, actions, stakeholders involved and goals required, this is the first step in capturing these variables in Nigeria. It will need to be refined and populated in more detail with specific, measurable, realistic, achievable, and time-framed (SMART) objectives so that clear priorities and directions can be established. Given this, from a generalisability perspective, interpretation is limited, to the data set and the context highlighted in this study.
12.	An offsite readiness framework (Bendi, 2017)	Developing the OSC readiness framework to assess the preparedness of Indian construction organisations to apply OSC methods.	Questionnaire survey, interviews and case studies	India	• The research scope and population for data collection is limited to construction organisations in India • A framework developed based on the cumulative results of the data analysis. However, it does not cover the importance of the driving factors of people, process and technology.

2.11.6 Summary of the worldwide key initiatives and the strategic guideline for this research

In the reviewed OSC models, road maps and frameworks, the majority of researchers have investigated OSC issues related to people, technology and processes. For instance, Goulding and Arif (2013); Goulding et al. (2012) explored nine core areas, representing the three majors dimensions of OSC – process, technology and people – and their impact on design, manufacturing and construction. Some of these models/frameworks also address the organisational environment in order to support the development process. For example, Bendi (2017) developed a framework to assess the OSC readiness of construction organisations in India; this was designed to enable the organisation to evaluate and scale its process in strategic and operational phases. It also helped to pinpoint areas of concern and the scope for further development to ensure optimal advantage from its OSC methods.

Moreover, other available OSC guidelines, models, frameworks and roadmaps have been studied in the course of developing the guideline for this study. Although it is possible to consult these references for this guideline, they would still be difficult to adopt and directly apply for many reasons.

- It is difficult to apply current examples from other countries, such as Sweden and UK, to the Iraqi construction industry as nearly a century of experience informs their supply chain and skilled labour sector. As Iraq requires a ten-year window to achieve high OSC production rates, there are numerous barriers that must first be addressed before the wider adoption of OSC by the industry.
- The guideline has been developed based on the Iraqi construction industry; this means that the weighting of the key factors is applicable to this country and not necessarily to other countries. It is suggested that every country has its own construction industry culture and such characteristics include different building regulations and standards from those used in the Iraq, and different requirements and targets from the Iraqi government, alongside different industry and specific needs by the population.
- Iraq is different from other countries, especially developed ones. It has, as previously mentioned, witnessed various conflicts, including post-war crises, and financial,

political and management issues, which mean the implementation of construction projects in this country face many obstacles. These issues clearly differ from other, more-developed countries with greater security and financial stability. The application of a new type of construction has several obstacles and drivers; while some may resonate with other countries others remain unique to this Iraq. Thus, some actions and the methods to eliminate obstacles may be specific to Iraq and dealt with differently in other countries.

- The nature of the frameworks, models, etc in Table (2.4) was explored in terms of the aim, developer, industry, data collection and limitation. It can be concluded that strategies are adopted by researchers in countries, with specific aims and data collection that differ from this study. Thus, this research has its own aim, data collection, and limitations concerning its context (Iraq), which means its strategic guideline differs from others. Nevertheless, this research used some of the available guidelines and frameworks as a reference with a careful understanding of their limitations. For example, the roadmaps mentioned in Table (2-4) for Nigeria and New Zealand suggested particular actions to address the barriers of OSC implementation. While the strategic guideline of this research contains actions to overcome obstacles that can inhabit the drivers as well as the actions to eliminate barriers to the use of OSC in Iraq. Moreover, Yunus (2012a) developed a guideline to provide a systematic decision support tool for stakeholders capturing sustainability. It demonstrates to stakeholders how to manage sustainability; moreover, the approach can be used to analyse sustainability and maximise the advantages of OSC application in Malaysia. The decision-making tools adopted in the guideline will be used in the design and early construction stage and are therefore intended for use by designers. However, the strategic guideline for this research is designed to include a suitable decision mechanism and preferences for other stakeholders as well as designers.

2.12 Summary of section B

Iraq is in a post war situation. The current situation shows a halt of most construction projects. This section has provided an overview of OSC in Iraq. Whilst some problems that the Iraqi's construction industry faces have been identified. These problems are:

- Housing shortage.
- Inadequate infrastructure services.
- Delay of projects.
- Lack of understanding of the sustainability concept.
- Worker productivity problems.
- Weak understanding and implementation of a health and safety system.
- Project management problems.
- Material problems, especially dealing with waste materials.
- Energy problems.
- Contract, contractor and contractor company problems.
- Dealing with the management of risks in projects.

This section has also highlighted a literature review of published reports about OSC in Iraq. It has found that only a few studies have been dealing with OSC in Iraq and most of the studies adopted the term of prefabricated construction to describe the OSC. The researchers declared that the OSC method can be a satisfactory solution to solve the problem of a housing shortage, however, there is a knowledge gap and slow adoption of this type of construction. This section has also introduced some problems associated with the application of OSC in Iraq. This section also reviewed research gap and key initiatives worldwide towards the adoption of OSC. It also identified the differences between the adopted guideline of this research and other worldwide key initiatives.

The next chapter will discuss the research methodology and methods adopted in order to meet the research aim and objectives.

Chapter 3 Research Methodology

This chapter discusses the research methodology adopted in this study. Specifically, it illustrates the choice of research methodology used to address the research problem and achieve the objectives. The chapter starts with the methodological framework on which all the sections are structured. The discussion clarifies the rationale and justification for the selected the research approach, strategy, data collection, and technique used in gathering and analysing the field data. Finally, the chapter discusses the main actions undertaken to ensure the validity and reliability of the research outcomes.

3.1 Research Methodology Framework

Research methodology is defined as the science of studying that aims to identify appropriate systematic ways to solve problems and gain knowledge. Its aim is to allocate the work plan of the research by studying the procedures, approaches and methods that can be used to explore, describe and explain different phenomena (Rajasekar, Philominathan, & Chinnathambi, 2013). Moreover, Silverman (2017) states that researchers select a research methodology as a specific approach in order to assist in the execution of research; this includes planning, data gathering and data analysis. As can be seen in Figure 3-1, the Nested Model represents a research framework in which the outer layer represents the research philosophy the underlying assumptions of the researcher (Kagioglou, Cooper, Aouad, and Sexton (2000). Furthermore, the inner layer represents the research approaches, which consist of dominant theory generation and testing methods, whilst in the center lies the research techniques comprising of the data collection tools.

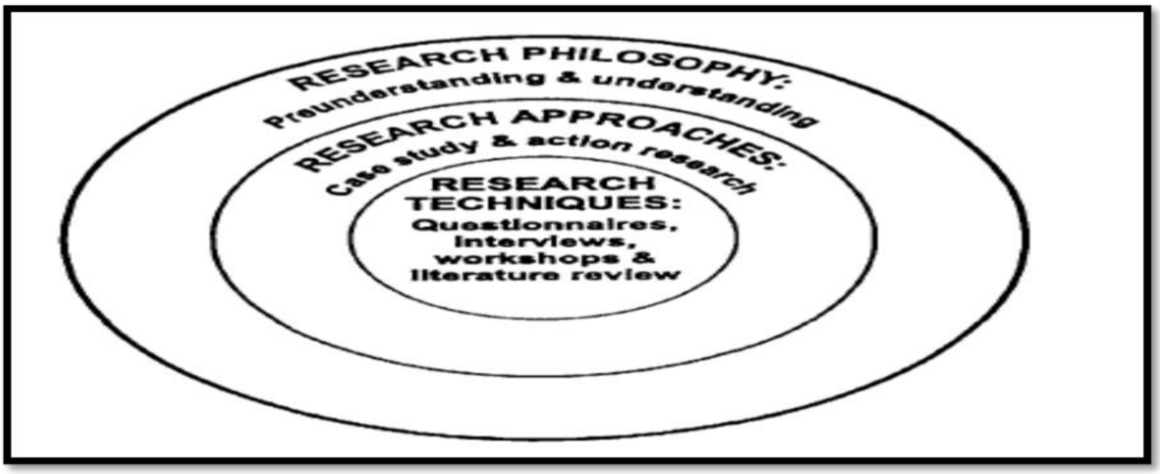


Figure 3-1 : The Nested Model (Source: (Kagioglou et al., 2000, p. 143)

However, Saunders, Lewis, and Thornhill (2016) model, called the "Research Onion", offers an enlargement of the nested model Kagioglou et al. (2000) by adding three more layers. The extra layers are methodological choice that involves selecting among quantitative and qualitative methods; research strategies that comprise the formal and clear procedures of action to achieve the aim and objectives, and the time horizon. The concept underpinning the Research Onion is that the researcher has to unfold each layer of the model to understand the next procedure. It further explains how each element and assumption is interrelated. Therefore, the Research Onion offers a more detailed illustration of the research framework than the Nested Model and was therefore selected for this study.

The Research Onion is depicted in Figure 3-2.

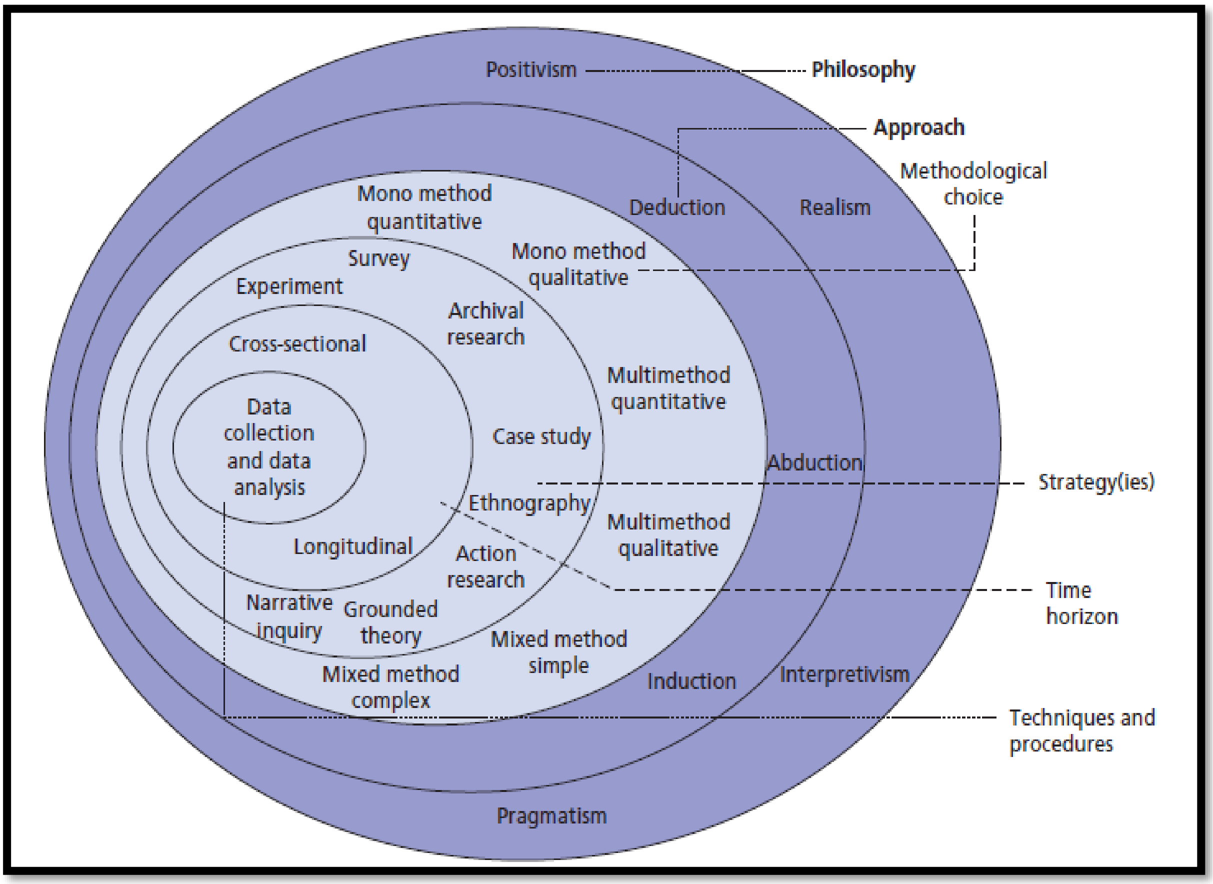


Figure 3-2 : Research Onion (Source: (Saunders et al., 2016, p. 164))

3.2 Research Philosophy

The term research philosophy, "*refers to the development and nature of knowledge*" (Collins, 2010, p. 36). Indeed, the choice of philosophical approach is influenced by the researcher's view of the relationship between knowledge and the process by which it is developed (Saunders, Lewis, & Thornhill, 2012). According to Easterby-Smith, Thorpe, Jackson, and Lowe (2008), research philosophies are important for three reasons:

1. To help researchers clarify the research design.
2. To identify which research design will work and which will not.
3. To identify and create designs that may be outside a researcher's experience.

Furthermore, Bryman (2012) indicates that three main philosophical perspectives should be taken into consideration before making any decisions, namely ontology, epistemology and axiology.

3.2.1 Ontological considerations

The term ontology comes from the Greek word 'ontologia' and is translated as "talking" (logia) about "being" (on/onto); meanwhile, ontological philosophy can be described as the science of existence or the study of being (Cimiano, 2006). Bryman and Bell (2015) indicate that, in the domain of social research, ontology is concerned with the nature of social entities, or *"whether social entities can and should be considered objective entities that have a reality external to social actors or whether they can and should be considered social constructions built up from the perceptions and actions of social actors"* (Bryman & Bell, 2015, p. 32).

Meanwhile, (Saunders et al., 2012) describe ontology as related to the nature of reality. It relates to the assumptions that researchers make about the way the world operates. Moreover, Bryman (2016) identified two ontological positions in social research, which are objectivism and subjectivism. Bryman (2016, p. 29) defines objectivism as an, "*ontological position that asserts that social phenomena and their meanings have an existence that is independent of social actors. It implies that social phenomena and the categories that we use in everyday discourse have an independent existence that is separate from social actors*". In comparison, subjectivism states that (multiple) realities are generated from the perceptions and consequent actions of those social actors, and is therefore subject to their experiences (Saunders et al., 2012).

3.2.2 Epistemological Consideration

Knight and Ruddock (2009) demonstrated that, in research, epistemology is fundamentally concerned with theories of knowledge. These theories try to answer questions surrounding the nature of knowledge. Additionally, Saunders, Lewis, and Thornhill (2009) define epistemology as a philosophy of knowledge concerning "*how we come to know*" or "*how we find out about the topic being investigated*". It is about what constitutes acceptable knowledge in a field of study. Moreover, within social science research, there are two main views on epistemology, namely positivism and interpretivism.

Positivism is explained as the view that the social world exists externally whose features should be measured objectively, rather than subjectively. In contrast, the interpretive paradigm assumes that knowledge and reality are constructed and developed in a social context as a result of the interface between individuals and the world they inhabit (Saunders et al., 2009; Crotty, 1998).

3.2.3 Axiology

Killam and Carter (2013) indicate that axiology in philosophy is a term that is concerned with ethics, religion and aesthetics. Additionally, axiology in research is regarded as what the researcher believes to be valuable and ethical. Generally, axiological assumptions concern values and how they influence the research in question. It involves judgments that consider the researcher's values, which determines whether they play a part in the research process (Saunders et al., 2012). In other words, it considers research assumptions as either value-laden or value-free (Collis & Hussey, 2009).

According to Saunders et al. (2009), a value free assumption focuses on the fact that the researcher collected the data in a value free method, which means that they are independent from the data. In contrast, a value laden assumption proposes that the data are biased by the world's viewpoints because they are influenced by cultural experiences and backgrounds (Saunders et al., 2016). In this sense, value plays a vital role in understanding and interpreting the results when either objective or subjective positions are adopted.

3.2.4 The Research Philosophical Position for This Study

From the aim and objectives of this study, it is clear that the objectivism/positivism paradigm is inappropriate, because the phenomenon for study concerns how to improve the use of OSC in Iraq. Therefore, the researcher needs to understand current construction problems and level of use of OSC in this country. Also, the researcher needs to clarify the drivers and barriers to its use in order to build a strategic guideline that helps decision-makers and construction companies to make the best use of OSC in Iraq.

Such understanding cannot be achieved by separating the research phenomenon (OSC development) externally, but instead should be built and improved through the perceptions and actions of social actors, tools, rules, and so forth. Therefore, the researcher needs to understand, explore, develop ideas, and elicit opinions, views and perceptions from the people involved in this research area including construction companies and USECB. Consequently, this research is more subjectivist (Constructivist) in terms of its ontological position, and more interpretivist in terms of its epistemological position and value-laden in terms of axiological position.

3.3 Research Approach

The research approach indicates the form of reasoning, and is typically defined by three approaches, namely deductive, Indicative, and abductive (Saunders et al., 2016; Lipscomb, 2012). The deductive approach develops a theory and hypothesis (or hypotheses) and tests them through empirical observation, in which particular examples are deducted from general inferences (Collis & Hussey, 2013; Saunders et al., 2009). Furthermore, its epistemological philosophy is more likely to be positivism. In contrast, the Indicative approach is considered to be more subjective because it is more flexible compared with the deductive approach. Therefore, data are collected, and a theory is developed as an outcome of the data analysis. Researchers using this approach tend to be more interpretive, beginning with the evidence and then building up a theory. Creswell and Clark (2011) confirm that an Indicative bottom-up approach means the researcher starts with the participants' views which are used then to build up outlines, theories and generalisations. Meanwhile, the deductive approach refers to a top-down method when the researcher tests a prior theory before a hypothesis (Creswell & Clark, 2011). To counter the stark differences between deduction and induction and merge their respective processes, Saunders *et al*. (2016) promote their combination as mixed methods through the use of an abductive approach.

Table 3-1: A comparison between deductive and Indicative methods

Deductive method	**Indicative method**
• Scientific principles • Moving from theory to data • The need to explain casual relationships between variables • The collection of quantitative data, and application of controls to ensure data validity • The operationalization of concepts to ensure a clear definition. • A highly structured approach • Researcher independence from the research subject • The need to select samples to offer generalised conclusions	• Gaining an understanding of the meaning humans attach to events • A close understanding of the research context • The collection of qualitative data • A more flexible structure to permit changes of research emphasis as the research progresses • A realisation that the researcher is part of the research process • Less concern with the need to generalise.

Due to the availability of rich literature in the major areas of this research, it was possible to employ deductive logic at the beginning with the aim of identifying the second objective of this research. This was achieved by reviewing and exploring the concept of OSC and its drivers and barriers worldwide, and by identifying the main problems in the construction industry in Iraq and the current use of OSC.

Moreover, the other two research objectives focused on investigating (professional and practitioner) perceptions towards the barriers, drivers and good practice when utilising OSC in Iraq and to establish the relationships and interdependencies between factors (drivers and barriers) that impact on the implementation of OSC in Iraq. Such an understanding cannot be achieved without involving both deductive and Indicative methods to fulfil these objectives. Therefore, a deductive method was applied to identify the drivers and barriers to using OSC in Iraq and to explain the causal relationships between them. However, an Indicative approach was applied in order to develop an in-depth understanding of these factors (drivers and barriers) and their relationships through consulting experts who were able to identify the best practice when using OSC in Iraq. According to Yin (2014) this allows for the collection of richer information and thus enhances the understanding of the researcher through an engagement with interviewees who are free to express their ideas and feelings towards the subject matter. Consequently, an abductive method was used for this study.

3.4 Research Choices

Methodological choice involves the selection of among qualitative and/or quantitative methods, whilst each method contains a research strategy and data collection methods. Qualitative methods usually concentrate on non-numeric (words) data (Creswell, 2014), while quantitative methods essentially examine a context numerically and rely on a range of statistical analysis techniques (Saunders *et al.*, 2016). However, Saunders *et al.* (2016) also indicate the presence of a mixed approach which represents a third type of research methodology. This results from the integration of quantitative and qualitative techniques under a single study.

However, it is also worth mentioning that each research approach comprises a number of data collection techniques and analysis methods. Therefore, in order to achieve the research objectives, a researcher would either employ the mono method which indicates the use of a single data collection technique and its corresponding data analysis procedures, or a multiple method which confirms the use of more than one data collection and analysis procedure. Moreover, multiple method is divided into multi method and mixed method study. (Saunders et al., 2012) define multi-method as the use of more than one method, either quantitatively or qualitatively, in a single study which then requires an analysis approach that complies with their related procedures. In comparison, the mixed method involves the use of both quantitative and qualitative data collection techniques in one research design. Moreover, mixed method research uses qualitative and quantitative data collection and analysis procedures in parallel or sequential time. Notably, the use of mixed methods enhances the validity and reliability of a study (Saunders et al., 2012).

Parallel mixed methods have been chosen for this research due to the advantages this offers in fulfilling the need to collect both types of data simultaneously. This need stems from the researcher's limitations in terms of the timeframe, the unsafe security context in Iraq, and in placing equal value on both types of data when understanding the research problem. Moreover, in order to achieve the aim of this research, which is to develop strategic guideline to improve the use of OSC in Iraq and its objectives, the researcher adopted the mixed method approach. For example, objectives 2 and 3, which focused on identifying the drivers and barriers and their relationships in the use of OSC in Iraq, requires the adoption of qualitative and quantitative methods. Thus, people from different backgrounds will share their knowledge by evaluating the drivers and barriers to using OSC in Iraq. The researcher will collect statistical data in order to analyse the results and identify the relationships between these factors. However, the qualitative method was also used in order to develop an in-depth understanding of these factors (drivers and barriers) and their relationships, and to explore best practice when utilising OSC in Iraq. Hence, a mixed method approach is vital to build the strategic guideline that enables the best use of OSC in Iraq by the decision-makers and construction companies.

There is evidence to suggest that a mixed method approach has previously been used for the collection of data when conducting research concerning OSC technologies in the construction industry. For instance, Gibb (2001) used a literature review, expert workshops and case study methods to provide guidance to project teams and to present the benefits and implications of pre-assembly and standardisation for construction projects. Furthermore, a mixed approach, which contained interviews and questionnaires, was applied by Danby and Painting (2007) to examine the interface problems with volumetric prefabrication systems when integrated with traditional methods of construction. Another study by Pan et al. (2007) adopted mixed methods to study the perspectives of UK house-builders on the use of modern methods of construction. The same approach was used by Pan et al. (2008) in a research project that aimed to explore the extent to which such OSC technologies were being utilised and the factors that affected their popularity.

Moreover, Elnaas (2014) uses a mixed method approach to collect data, including a literature review, questionnaires, interviews and a case study, in order to develop a decision support model for use in practice to guide the selection between offsite and traditional onsite construction. After considering the benefits and reasons for using mixed approaches and the experiences of previous researchers, this study also adopted the same approach.

Further examples of relevant studies regarding construction and the use of a mixed method approaches include Almutairi (2015), who used a mixed method approach to identify the factors related to OSC in Saudi Arabia. Moreover, Yunus (2012b) used a quantitative and qualitative mixed method approach that included questionnaires, which aimed to discover the sustainability attributes in OSC. The study examined the critical factors for improving sustainability efforts in OSC implementation. Yunus (2012b) also adopted interviews to explore detailed information on each critical factor identified in the questionnaire. In comparison, Hashemi (2009) used questionnaires and interviews in their mixed method approach. In this study, the questionnaires evaluated the current situation, such as the attitudes, risks and knowledge of the Iranian architect's profession with regard to OSC, whilst the interviews were used to elicit the opinions of key experts, such as architects, engineers and government bodies, regarding the application of OSC in Iran.

3.5 Research Strategy

The choice of research strategy depends on three conditions: the type of research question, the extent of the investigator's control over actual behavioural events, and the degree of focus on historical events or on contemporary situations (Yin, 2009). The most significant principles in choosing a research strategy are whether it will enable the researcher to answer the research questions and meet the objectives of the study (Saunders *et al.*, 2009). Table 3-2 shows the three conditions including how each relates to the five major research strategy.

Table 3-2: Research strategy methods (Source: (Yin, 2014, p. 9).

Research strategy	**Forms of research question**	**Requires control over behavioral events?**	**Focuses on contemporary events**
Experiment	How, Why	Yes	Yes
Survey	Who, What, Where, How many, How much	No	Yes
Archival Analysis	Who, What, Where, How many, How much?	No	Yes/No
History	How, Why	No	No
Case Study	How, Why	No	Yes

However, a further classification of research strategies has been highlighted by Saunders *et al.* (2009) to include grounded theory, action research and ethnography. Each strategy can be used for all three research purposes, namely exploratory, descriptive and explanatory.

Due to the focus of this research, the main data will be obtained from the social interactions of the construction practitioners in the Iraqi construction industry and academic field. Therefore, there is no control over the behavioural events required, as this research values the richness of the information provided from these social interactions. Considering that there is no requirement for controls over behavioural events, ***experiment*** and ***action research*** are removed from the selection process. Moreover, the following types of question are adopted including 'What' and 'How', in order to achieve the objectives of this research, which are exploring drivers, barriers and relationships on the use of OSC in Iraq and identifying good practise when utilising this construction method and formulate a guidelines that support the use of OSC in Iraq. Therefore, the research strategies of ***grounded theory***, ***ethnography***, and ***history*** are also discounted, as they are not designed to consider 'What' questions. Consequently, the strategies left for consideration are ***case study*** and ***survey and archival analysis. Archival analysis method*** involves the study of historical documents, although, it can be used for non-historical investigations of documents produced by and about contemporary organizations, often as tools to supplement other research strategies (field methods, survey methods, etc.) (Mohr & Ventresca, 2002).Thus, archival methods can also be applied to the analysis of digital texts including emails, and web pages electronic databases. However, this type of research focuses on a contemporary phenomenon in the construction industry as a whole which requires to collect rich data to achieve the research objectives instead of depending on the data have already been collected, Consequently, such method is not appropriate to fulfil the research objectives.

3.5.1 Case Study

Yin (2014, p. 16) defines a case study as, "*an empirical inquiry that investigates a contemporary phenomenon in depth and within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident*". In addition, this strategy has a key strength in supporting researchers to examine elaborate phenomena in natural settings. The case study strategy helps a researcher to investigate a studied phenomenon or real-life situation, whilst also allowing for the development of an in-depth understanding of the relationships and processes within the phenomenon (Denscombe, 2014). Due to these characteristics, a case study approach is more common in qualitative studies than in quantitative studies.

Moreover, Yin (2009) mentions that a case study strategy should be used when questions such as "how" and "why" are important and that it is preferable to use this approach to answer questions about contemporary sets of events over which researchers have no control. At the same time, Saunders *et al.* (2009) indicate that data collection techniques may be varied and are more likely to be used in combination with interviews, questionnaires, documentary analyses and observations. Meanwhile, Naoum (2012) recognise three different design types of case study, namely analytical, descriptive and explanatory. According to (Naoum, 2012); Naoum (2007) an explanatory case study is a theoretical approach to the problem, whereas a descriptive case study is applied to a detailed case and aims to count the number of respondents with certain opinions/attitudes towards a specific objective. In comparison, an analytical case study aims to establish relationships and associations between the attributes/objectives of a study. However, whilst the nature of a case study focuses on one aspect of a problem, the conclusions drawn cannot be generalised, but rather related to one particular event (Naoum, 2007).

The application of a case study strategy was considered for this research due to its many advantages; however, the nature of this research stipulates "What" questions, and these are best resolved by the survey research strategy, as specified by (Yin, 2009). Moreover, this study requires data from a large population, which will be more appropriate through a survey strategy. Hence, a case study has been eliminated as an option for this study.

3.5.2 Surveys

A survey is a research strategy that involves the structured collection of data from a large population in an economical way (Saunders et al., 2016, p. 728). The word survey is often used to describe any research that collects data (quantitative or qualitative) from a sample of people (Punch, 2013). Surveys operate on the basis of statistical sampling, which is commonly surveyed through questionnaires and interviews, and varies from highly structured questionnaires to unstructured interviews (Fellows & Liu, 2009). In surveys, the data can be gathered in the form of face-to-face interaction, telephone interviews, postal questionnaires and (increasingly) online surveys (Gilbert, 2008). Also, Fowler (2009) states that it is not uncommon to use a combination of data collection in surveys, such as mail, telephone, the internet, personal interviews or group administration, although most surveys typically use one data collection method.

Furthermore, Forza (2002) remarks that the main methods to collect data in survey research are through questionnaires and interviews. Forza similarly confirmed that interviews can be structured or unstructured, and they can be conducted either face to face or over the telephone. Moreover, the questionnaires can be administrated personally, by email, or by telephone to the respondents.

According to Gilbert and Stoneman (2015); Fowler (2009); Forza (2002), each data collection method has both benefits and weaknesses. For example:

- Overall, a self-completion questionnaire is quick and cheap and can be either paper based or completed online. Bias is reduced through this type of method and more reliable and valid responses can be obtained. However, with mailed questionnaires, sometimes a longer period is needed and there can be a low response.
- The overall advantage of survey interviews is that they are likely to conducted be face-to-face or over the telephone, so the respondents are more likely to provide more thoughtful and honest responses. Hence, the production of better-quality data can be achieved.
- The benefits of face-to-face interview surveys can include higher response rates, flexibility in sequencing question details and explanations, and the ability to contact a hard to reach population. However, this data collecting method can involve higher stress on both the respondents and interviewer, which can lead to interviewer bias.
- Data through survey strategy can be collected from a large population in an economical way.
- Telephone surveys can be affordable, enable rapid data collection and large-scale accessibility. On the other hand, there is less credibility, less control over the interview situation and a lack of visual material.
- It is easy to administrate the survey questions
- A broad range of data can be collected through survey method, including attitudes, opinions, beliefs and values.
- Data through survey method can be gathered in diverse ways, which offer an opportunity to conduct a remote data collection.

A survey strategy is commonly used in business and management research and is most frequently adopted to answer the questions "what", "who", "where", "how much" and "how many" (Saunders *et al.*, 2016). In addition, a survey strategy is considered invaluable when sorting data concerning the attitudes, trends, values, personal experiences, behaviour and opinions of a population, and this can be achieved by studying a sample of that population (Creswell, 2014; Gilbert, 2008). Nonetheless, the development of the survey research questions, the ways in which they are phrased, and the order in which they are placed can all affect the success of a survey.

3.5.3 The Adopted Strategy of this Research

After considering the aim and objectives of this study, and the benefits and limitations of the various research choices, a survey strategy was considered the most appropriate method for this research. The survey consisted of a list of questionnaires and in-depth interviews. The main purpose of the questionnaire was to identify the drivers and barriers of using OSC, which are the primary concern amongst stakeholders when deciding to adopt OSC. The survey was used because there is a lack of knowledge regarding the concept of OSC methods in Iraq. Therefore, a questionnaire survey offered a suitable means to identify a consensus from a large amount of data and diverse respondents. According to Naoum (2012) , a questionnaire survey is suitable when a large amount of data needs to be collected to investigate a respondents' views and experiences on a phenomenon within a limited time frame. In addition, Saunders *et al.* (2016) mention that the collection of a significant quantity of data and the application of descriptive and inferential statistical analysis can be achieved through a survey strategy. Moreover, data collected using a survey strategy can be used to suggest probable reasons for relationships between variables and to produce models of these relationships. Consequently, a survey method was used to enable the researcher to explore the drivers and barriers of using OSC in Iraq and to investigate the statistical relationships between them. This enabled the development of a strategic guideline to enhance the use of OSC in Iraq.

Many researchers have adopted a survey strategy when investigating the use and/or perception of OSC. For example, Almutairi (2015) used a survey strategy to collect data, which included questionnaire and interview methods. Thus, Almutairi applied a questionnaire survey to identify the drivers and barriers related to OSC in Saudi Arabia, in order to test certain behaviours and seek a numeric understanding of the phenomenon in order to confirm or refuse the study's hypotheses. Almutairi further used in-depth interviews to gain a greater insight into information about OSC.

Similarly, Yunus (2012b) used a survey strategy that included questionnaires to discover sustainability attributes in OSC, including the critical factors that are significant to improving sustainability efforts in OSC implementation. An interview method was also subsequently adopted to explore detailed information for each critical factor identified in the questionnaire survey. In addition, Elnaas (2014) used a survey strategy to collect data through questionnaires and interviews. Elnaas started with a semi-structured interview to build up information gathered from a literature review on OSC in house building; this helped to obtain a full and current range of house builder opinions and views on the use of OSC. After having established a robust set of factors and information on the greatest influences on OSC decision-making in-house building, the Elnaas used a questionnaire survey to build upon and further explore these findings. Similarly, Shahzad (2011) used a survey strategy that included a questionnaire designed to explore the constraints on the uptake of OSC. The researcher then used an interview method to validate the feedback received from the survey and to ensure that a significant number of additional barriers had not been disregarded. Recently, Bendi (2017) applied a survey strategy that used questionnaire and semi-structured interviews to determine the drivers and barriers to the concept of OSC in the Indian construction industry. This enabled the researcher to then build a readiness framework, which was validated through case studies. Thus, the research strategy approach for this study will be compatible with those of other researchers who have adopted a survey strategy for the data collection.

3.6 Time Horizon

To gain a better understanding of the time horizon, it is useful to look at time horizon subdivisions. (Saunders et al., 2009) divided the time horizon into cross-sectional and longitudinal. The longitudinal horizon focuses on a particular phenomenon and observes their changes over time (longer period); however, this study is considered to be cross-sectional because the cross-sectional focuses on a particular phenomenon at a particular time (in a shorter period).

3.7 Research Techniques

The analysis and interpretation of the data constitutes the main part of this research. Yin (2014, p. 126) states that analysis involves "*examining, categorizing, tabulating, testing data otherwise recombining the evidence to draw empirically based conclusion*". In this study, the researcher's target is to incorporate both qualitative and quantitative methods to extend knowledge about OSC. Through the application of questionnaire surveys, the quantitative method was incorporated to enhance the overall understanding of OSC in Iraq and to develop a general picture about the real situation of this method of construction in terms of level of use, drivers and barriers. The researcher also incorporated a qualitative method through semi-structured interviews, which were held in parallel to the questionnaire method. These aimed to achieve an in-depth understanding of the concepts of drivers and barriers by exploring the expert stakeholders' perspectives for this type of construction, to develop a fuller and clearer picture about this type of construction in Iraq, and to identify the best practise in terms of its utilisation.

Software such as SPSS and NVivo were used in this research to analyse the data and present it in an appropriate way. Subsequently, a strategic guideline was developed to enhance the use of OSC in Iraq, which was validated by experts' people.

3.8 Summary of Research Objectives and Techniques for data collection

This provides a summary for the research objectives and explains the step-by-step analysis procedures for the data collected. In order to add breadth and depth to this research, multiple sources of evidence were consulted, whilst primary and secondary data were considered to develop the findings of this research. Mixed-method research was employed within a survey strategy; this aimed to ensure rigour and that the findings could be generalised. See table below

Table 3-3 Research objectives and techniques for data collection

No	Research objectives	Literature review	Questionnaire	Semi-structured interviews
1	To review and explore the current knowledge about OSC concepts, and the barriers and drivers for using OSC in both developed and developing countries.	*		
2	To investigate (professional and practitioner) perceptions towards the barriers, drivers and good practices of utilizing OSC in Iraq.		*	*

3	To establish the relationships and interdependencies between factors that impact on the implementation of OSC in Iraq.		*	*
4	To formulate strategic guideline that support the use of OSC in Iraq.	*	*	*
5	To refine and finalise the strategic guideline through validation from industry experts.			*

3.9 Data Collection Methods

This research involved two types of data: primary and secondary. These data types helped the researcher to obtain the information required during the data gathering stage. Secondary data refers to those already gathered by others, which can be used in the research undertaken in several ways. It can be obtained from different sources, such as books, journals and company websites. Naoum (2012) mentions that the approach adopted for collecting data, depends on the nature of the investigation, and type of data and information required for the research. According to Schmidt and Hollensen (2006), the advantages associated with secondary data are that it is inexpensive, easily accessible, and a quick way to gather data. In addition, it can help researchers to expand their knowledge and develop their assumptions. This data can usually be accessed easily by searching online databases, government statistics and books. The literature review helped the researcher to identify the barriers and drivers to the adoption of OSC. Furthermore, examining related frameworks/studies helped to identify the practices of using OSC.

In comparison, the researcher collects primary data in accordance with the specific aim and objectives of their study. Examples of primary data collection methods include experiments, interviews, questionnaires, and focus groups. In terms of primary data, this study adopted quantitative and qualitative data collection to achieve the research aim and objectives, as the nature of this inquiry demanded both types of method. Quantitative data helped to determine the factors affecting the uptake of OSC through the application of questionnaires, whilst qualitative data helped to achieve more in-depth knowledge regarding the concept of OSC in Iraq.

3.9.1 The Questionnaire as a Data Collection Method

3.9.1.1 The Design of the Questionnaire

After the literature review had been completed and the required ethical application was submitted and approved, the design of the first draft questionnaire was started at the end of February 2017. It was based on the information and issues gathered from the in-depth literature review about the barriers, drivers and systems of OSC. The questionnaire was reviewed again in the beginning of March and several questions were added, while some themes were adjusted and grouped under factors.

When the design was complete, the researcher started translating the questionnaire into Arabic after receiving the ethical approval. The translation was carefully undertaken in order to ensure accuracy and thus minimal risk of misunderstanding. This stage was completed by the middle of March after which the pilot study was carried out.

3.9.1.2 The Questionnaire Layout and Wording

The questions needed to be simple and easy to understand, and their sequence was arranged from general to specific. The researcher divided the questionnaire into three parts. The first part of the questionnaire included broad questions about the respondent's background, such as their field of study, experience and educational level; this helped the researcher to understand the sample and link it with the research findings. The second part presented a list of drivers for using OSC, such as quality and time, while the third part presented a list of barriers to the use of OSC.

3.9.1.3 Pilot Study

Van Teijlingen and Hundley (2002, p. 1) refer to pilot studies as *"mini versions of a full-scale study (also called 'feasibility' studies), as well as the specific pre-testing of a particular research instrument such as a questionnaire or interview schedule"*. Similarly, Saunders *et al.* (2009) define a pilot test as a small-scale study to test a questionnaire or an interview in order to reduce the likelihood of respondents having problems in answering the questions and thus create data recording problems. In addition, a pilot allows for an assessment of the validity and reliability of the data collected. Thus, Maldaon and Hazzi (2015) highlight that a pilot study is a vital step in performing a successful research study, whatever the type of research. They state that the role of a pilot study is important, as it contributes to improvements in the quality and effectiveness of the main study.

As the researcher adopted self-completion questionnaires, a pilot study is particularly important to clear up any confusion or justify any unclear questions. Therefore, one of the advantages of conducting a pilot study is its ability to offer warnings about where the main research project could fail, where research protocols may not be followed, or whether proposed methods or instruments are inappropriate or too complicated.

Therefore (Bryman & Bell, 2007; Van Teijlingen & Hundley, 2002) suggest that there are some valid reasons to adopt a pilot study:

- Tests the adequacy of research instruments for interviewers or respondents of self-completion questionnaires.
- Assesses the feasibility of a survey.
- Assesses whether the research protocol is realistic and practical.
- Checks whether the sampling frame and technique are effective.
- Evaluates the likely success of proposed recruitment approaches.
- Identifies logistical problems, which might happen arise when using proposed methods.
- Assesses variability in outcomes to support determining sample size.
- Determines what resources (finance, staff) are needed for a planned study.
- Evaluates the proposed data analysis techniques to uncover potential problems, such as how well the questions flow and whether to move some.
- Convinces funding bodies that the research team is competent and knowledgeable, and the main study is feasible and worth funding.
- Persuades other stakeholders that the core study is worth supporting.
- Offers the ability to identify questions (within interview surveys) that make respondents feel uncomfortable and detect any tendency for loss of interest amongst respondents at certain junctures.
- Improves the research questions and research plan.
- Gathers preliminary data.

It is vital to test the questionnaire and interview questions on a group of experts or colleagues, with previous experience in questionnaire design, interview skills, data collection and analysis. Additionally, it is necessary to select participants who are familiar with the research topic. Therefore, the researcher tested the questionnaire on a small size sample targeting several current PhD students at University of Salford and experts in Iraqi construction industry. The researcher approached Iraqi PhD students who were available at the time of organising the questionnaire. Interestingly, these students were either Iraqi academic lecturers or engineers from Iraqi construction companies who advised the researcher to either remove or add some descriptions into the questionnaire.

3.9.1.4 The Questionnaire Pilot Study

At the beginning of 2017, the questionnaire was distributed to two PhD students with previous experience in questionnaire design. Also, four experts in the topic of OSC took part in the pilot study. To obtain proper feedback, the researcher explained both the purpose of the questionnaire and the research topic.

The participants were asked several questions about the questionnaire in terms of layout, clarity of the content, the number of questions and the questionnaire duration. From the feedback, the researcher found that some parts of the survey questionnaire needed to be rephrased. The researcher added broad questions about participants, such as educational level. Their feedback gave the researcher better ideas about writing a cover letter for the questionnaire to make it easier for the participants to understand the research problem and the purpose behind the questionnaire. In addition, they suggested that the questions needed to be in a better order.

The following offers some examples of rephrased questions, after receiving feedback from participants of the questionnaire pilot study:

- In part one, some questions have been added and adapted, such as the question of ticking the OSC applications used. In this question, one of these choices was ‘government’ and the other ‘private company’. Pilot study participants, especially experts in OSC, advised changing the choice of private company to ‘schools’, and changing ‘government’ to ‘government institutions’.
- Based on the experts’ advice, the researcher rearranged some factors, such as ‘market factor and its themes’; this was united with the productivity factor.
- Some factors were rephrased, such as ‘occupational safety factor’, which was changed to ‘social factor’ to make it clearer for respondents.

- ❖ In part three, participants advised adding a definition of the term 'supply chain' to clarify the meaning of the term.

After receiving ethical approval and finishing the questionnaire sample and pilot study, the researcher started to distribute the questionnaire to some companies in Iraq, who are familiar with OSC as well as Universities' scientific and engineering consultant bureaus.

3.9.2 Semi-Structured Interviews as a Data Collection Technique

An interview is a data collection method commonly used in qualitative research. According to Saunders et al. (2009, p. 318) the research interview is, "*a purposeful conversation between two or more people, requiring the interviewer to establish rapport and ask concise and unambiguous questions, to which the interviewee is willing to respond, and to listen attentively*". Also, qualitative interviews refer to either face-to face between the researcher and participants, or engaging participants over the telephone, through the internet or via focus groups (Creswell, 2014).

Moreover, (Yin, 2014) states that the interview is generally conversational in nature, directed by the researcher's mental agenda, and that interviews are commonly found in case study research. Furthermore, Saunders *et al.* (2016) indicate that there are three ways to conduct interviews - structured, semi-structured or unstructured - and each has its own advantages and disadvantages. In unstructured interviews, interviewers express freely without restriction, and the data analysis process may become more difficult due to an absence of consistency (Myers, 2013).

Meanwhile, a structured interview refers to the use of pre-formulated questions, typically asked in a specific order and within a specific time limit (Myers, 2013). Instead, a semi -structured interview means that the researcher prepares some themes that can be varied, in terms of the order in which questions will be asked. This also allows the researcher to ask new questions in the context of the research situation (Saunders *et al.*, 2016). It is most commonly used in management and business. This approach is more flexible, particularly compared with structured interviews, as it allows the detection or elaboration of information that is significant to participants but that may not have previously been considered relevant by the research team (Gill, Stewart, Treasure, & Chadwick, 2008).

Like the pilot study held for the questionnaire survey the semi-structured interview questions were also piloted with four voluntary experts. The aim of this pilot study was to increase the reliability and validity of the research tools in terms of the interview questions and the time allowed for the interviews.

In order to fulfil the research objective, a semi-structured interview was adopted. Interviews were held to gain an in-depth understanding, as well as insights and suggestions prior to proceeding with the next stage. A further purpose of an interview is to gather more detail and validate each identified potential factor (drivers and barriers) that affect the use of OSC in Iraq. The interviews were carried out with experts from construction companies and USECB. By focusing on the main factors that affect its use, the findings were used to outline suggested actions to develop the implementation of OSC in Iraq. Based on participants' feedback, a general awareness of OSC and the potential for OSC to provide better construction is determined. Moreover, the interviews helped to gather recommendations for improvements to the use of OSC in Iraq. This enabled the researcher to develop a strategic guideline that supported stakeholders as to the best use of OSC.

3.10 The Sample

A sample is a sub-group of a population, which forms the focus of a researcher's enquiry and is selected in such a way that represents the study population. A sample is consulted to save time, money and other resources (Kumar, 2014). According to (Saunders et al., 2016), sampling is essential for research. The sample selection is mainly guided by the research objectives. When deciding sampling techniques, the researcher should not ignore key factors, such as time limitations, finance, and accessibility to the resources. Two strategies can be used in sampling - random sampling/probability sampling and non-random sampling/non-probability sampling. In random sampling, the chance of each element being selected from the population is usually equal; in contrast, non-random sampling does not offer an equal chance of each element being selected.

Saunders *et al.* (2016) indicates that probability sampling is commonly related to survey research strategies, when the researcher needs to make inferences from the sample about a population to answer the research questions and achieve research objectives. Moreover, Saunders added that with all probability samples, it is important that the sample size is large enough to provide the researcher with the necessary confidence in his/her data. However, Kumar (2014) highlights that the use of sampling within quantitative and qualitative research differs. Kumar states that a sample size in quantitative research is important as it used to represent the study population, whilst sampling size in qualitative research does not play any significant role , the sample size in qualitative method is one that can provide the researcher with detailed, accurate and complete information which means the sample size is determined through data saturation stage during data collection. Additionally, Nadim and Goulding (2009) argue that there is a lack of shared understanding between industry and academia in the UK with respect to skill requirements and the preferred means for collaboration. They add that further research is needed to bridge the gap between these apparent differentiated views. Mohamad Kamar (2011) emphasises the importance of the government in enhancing cooperation between construction industry participants and academia in exchanging information and experiences and the development of new techniques and advice on promoting and implementing OSC.

This research centres on developing a strategic guideline to utilise OSC in construction organisations in Iraq. Therefore, organisations applying OSC are more familiar with both the philosophy and the principals involved. Hence, the best samples for this inquiry are construction organisations, which have adopted OSC techniques in their projects, although the total number of Iraqi construction organisations implementing OSC is unknown.

Currently, there are no organisations, like Build-offsite in the UK, which are dedicated to promoting OSC in Iraq. Therefore, the researcher approached the Ministry of Housing, Construction, Municipalities and Public Work in Iraq to identify large government companies under the umbrella of this ministry. The main selection criteria for this research was that the Ministry of Construction and Housing is considered a leader in reconstruction efforts across Iraq. The Ministry is responsible for the planning and implementation of most of the infrastructure projects in the country. Consequently, it controls the largest number of Quasi-Governmental Construction Companies (QGCC) (Al-Obaidi, 2018). Therefore, from a total number of six large government construction companies, two were selected which were actively involved in the industry and had been established for more than 10 years. It is important that the firms have been active with more than a decade of experience as they would have experienced how policies set by the government or trends in the current construction industry affect their business and change how they manage their projects. Moreover, these companies were chosen for the survey due to their reputation and experience in OSC in different types of the projects, such as buildings, bridges and housing complexes. Both government companies have several locations around Iraq, but their headquarters are in Baghdad city. Furthermore, both companies belong to same owner, are subject to the same government regulations and it is expected that they are managed in a similar way. However, other remaining construction companies have been eliminated from the selection because they are either experts in particular types of project (like bridges) or there is no recent experience of OSC projects. Also, to enlarge the selection of the survey another large private company that uses OSC in their projects was selected. The third company specialises in precast concrete and is located in Basra, in the south of Iraq and was established more than 10 years ago. They implement different projects involving classic and prefabrication construction. Since 2007, this company has been awarded International ISO Certifications in quality, safety and the environment.

Due to the un-settled security and political situation in Iraq, it was not easy for the researcher to conduct enquiries about construction companies outside the middle and southern regions of Iraq. The western and northern parts of Iraq were thought to be unsafe locations for the researcher; therefore, the companies that the researcher dealt with were based in other regions of Iraq. This may be considered a strata sampling selection criterion, as the two selected regions of Iraq represented a geo-political homogenous region. Moreover, these regions in the centre and south of Iraq produce most of the country's oil. Therefore, the researcher chose Baghdad as the capital city and Basra, which are the first and the second largest cities in Iraq and their region represents an economic base, offering substantial possibilities for Iraq's construction industry. The other strata selection criterion is size. The researcher selected two of the biggest government companies due to the previously explained selection criteria.

The third selection involved the distribution of the questionnaire, which was sent to the top and middle management professionals of these companies/departments by using random sampling. Therefore, the selection of companies, location and types of participants based on stratified sampling which means (the total population is divided into smaller groups or strata to complete the sampling process), while distribution of data amongst participants was randomly. A target sample of 196 participants was selected randomly from the total population of around 400 amongst the selected companies (see Table 3-4 for the sample size selection adopted from (Saunders et al., 2012)). The researcher received 112 copies, which indicated 57.14% of the actual sample size. The researcher excluded seven incomplete copies and five copies where the participants did not have OSC experience. The total valid return rate was 100, which indicated 51% response rate.

Table 3-4: Sample sizes for different population sizes at a 95-confidence level*

* assuming data are collected from all cases in the sample

Population	Margin of error 5%	3%	2%	1%
50	44	48	49	50
100	79	91	96	99
150	108	132	141	148
200	132	168	185	196
250	151	203	226	244
300	168	234	267	291
400	196	291	343	384
500	217	340	414	475
750	254	440	571	696
1 000	278	516	706	906
2 000	322	696	1091	1655
5 000	357	879	1622	3288
10 000	370	964	1936	4899
100 000	383	1056	2345	8762
1 000 000	384	1066	2395	9513
10 000 000	384	1067	2400	9595

One of the researcher objectives is to build the final strategic guideline that involves different stakeholders' opinions to adopt best practice in using OSC in Iraq and to develop its use. Hence, the researcher involved academic participants as well as those from construction companies; this aimed to ensure the researcher could generalise the results obtained. It also intended to ensure an understanding of consultants' views regarding the drivers and barriers for using OSC in Iraq as these participants have a significant role and substantial experience in consulting with different construction projects in Iraq including those adopting OSC. Moreover, academics have a significant role in spreading knowledge among students through courses and lectures in universities with a particular emphasis on design, technology and basic management skills. Hence, the objectives of the research will be achieved and the importance of cooperation between academic and construction industry will be highlighted. Therefore, the researcher approached three scientific and engineering consultant bureaus, which were located in three well-known, top-ranking universities in Iraq, and a random and snowballing approach was adopted to consult professionals within this field. These bureaus have these objectives:

- Providing engineering, scientific and technical expertise in the service of development plans.
- Providing a level of consultancy and specialised expertise for different sectors of projects in the country.

- Increasing the experience of faculty members in the professional and applied fields and reflecting these experiences on total engineering and scientific specialisations to raise the level of education
- Providing economic feasibility studies for projects.
- Preparing engineering designs for infrastructure projects and buildings in all departments and ministries
- Evaluating studies on the effects of construction projects on the environment
- Supervising the implementation of various projects and providing technical and engineering advice.
- Checking the plans and all specialties are included in the different bodies.
- Organising development engineering courses.
- Providing technical assistance and advisory services in the field of qualifying companies to obtain a certificate of quality.

According to the appropriate sample size for survey strategy (see Table 3.3), the expected USECB sample size for this study regarding was 132 from a total population of 200. The researcher received 104 copies, amongst which three were incomplete and one noted no experience in OSC. The total valid copies were 100, which indicated a 78.78% response rate. Figures 3-3 and 3-4 explain the participants of the two samples.

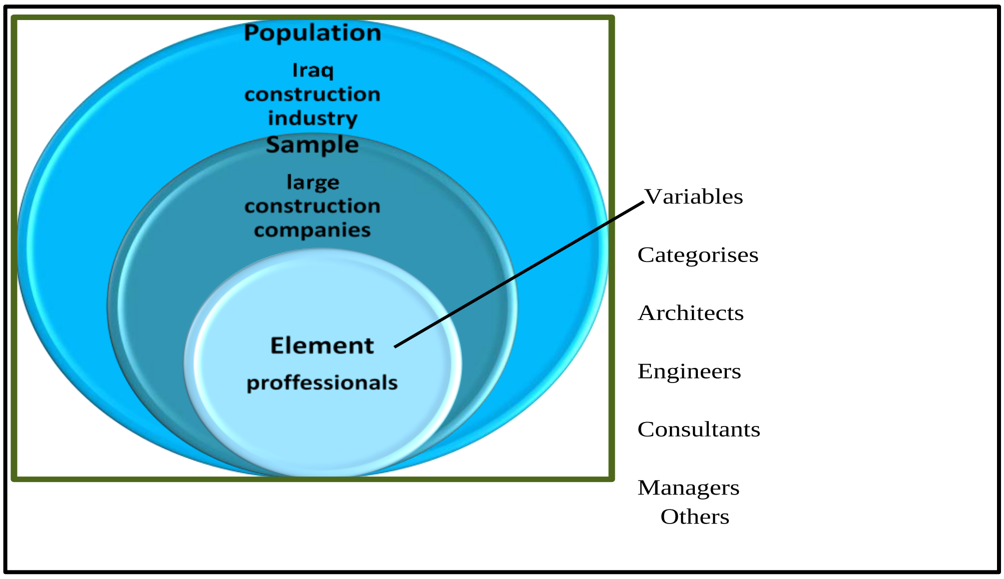


Figure 3-3: Construction companies' sample

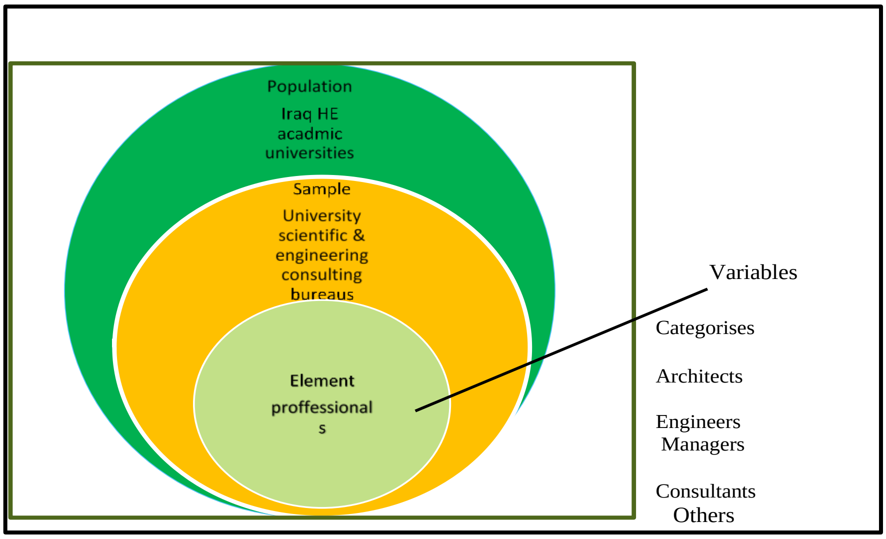


Figure 3-4: USECB sample

Some authors encountered a similar situation when collecting data, such as Alkinani (2013) who conducted a survey in the Iraqi construction industry during an unstable security situation. As such, he used stratified random sampling, which only used secure locations. He collected 239 responses from eight construction companies from a total of 317 issued copies. Similarly, Allali (2016) conducted a survey strategy with construction companies in Libya during less security-intensive circumstances, and was only able to secure 38.50% of the actual sample size. Moreover, Bendi (2017) was only able to secure 49% valid response rate from the actual target sample for a study on OSC. Similarly, in his OSC survey, Yunus (2012b) was able to achieve 115 valid responses from 300 issued copies. In addition, Al-Mutairi (2015) was able to collect 136 out of 174 issued copies for a study on developing an OSC strategy in Saudi Arabia. Like this study, the researcher distributed the questionnaire to large government construction companies, although based in Iraq.

Moreover, to gather a sample of interviewees, the researcher used a combination of purposive and snowballing methods to approach participants from construction companies and the academic field who were experts in OSC. The researcher used a semi-structured interview with eight participants face to face and six through Skype. As such, the total number of interviewees was 14. The minimum size for non-probability sample for semi-structured interviews is shown in Table 3-5.

Table 3-5: Minimum Size for Non-Probability Sample (Source: (Saunders et al., 2016, p. 297)

Nature of Study	Minimum Sample Size
Semi-structured/In-depth interviews	5-25
Ethnographic	35-36
Grounded theory	20-35
Considering a homogenous population	4-12
Considering a heterogeneous population	12-30

3.11 Unit of analysis

A unit of analysis indicates the main subject under study and represents an important element in research design (Yin, 2014). The unit of analysis denotes what or who is being investigated, which could be an individual, group, organisation, industry, or programme (Collis & Hussey, 2013; Saunders et al., 2016). Common units of analysis include the individual, group (e.g., family, friendship group), social category (social class, gender, race), social institution (e.g., religion, education), society (e.g., nation, a tribe) and organisation (e.g., corporation, company).

In this study, the units of analysis are the organisation's prime activity (discipline) and professionals both from the public and private sector. Furthermore, in order to test the hypotheses and fulfil the research objectives, Iraqi HE institutions were also targeted (academia). By selecting the unit of anaylsis, the researcher was able to investigate the factors affecting the use of OSC in Iraq. The data was analysed through comparison and synthesis when explaining the findings, and by discussing the subjects investigated.

3.12 Ethical Issues

In order to protect the rights of participants involved in this research, there are several ethical issues that need to be addressed when collecting data. Ethical issues are usually connected to the participant's voluntary involvement, offering informed consent, confidentiality and anonymity. Regarding voluntary disclosure, the researcher gave participants the freedom of choice to take part in the research questionnaire.

Participants were informed about the procedures and risks involved in the research before they chose to take part. The researcher introduced participants to the research topic, procedures, and purpose of the questionnaire, after which the researcher asked the participants whether they gave permission to partake in this research. Also, the researcher took the participants' privacy seriously to avoid any harm or risk, and as such, the researcher kept their information confidential. Moreover, the participants remained anonymous throughout the research, particularly those who completed the questionnaire. Thus, the researcher pointed out in the cover letter that the participant's name should not be included in the questionnaire. In addition, the questions in the questionnaire just related to the research subject, which means there were no personal questions, which could risk making the participants feel uncomfortable. It is important to note that the researcher completed the ethical approval forms for this research before collecting the data, which contains the above ethical issues and the data collection procedures. The Research Governance and Ethics Committee at the University of Salford approved this form.

3.13 Validity and Reliability

To ensure quality of the research, its validity and reliability needed to be considered in the design and analysis stages. Yilmaz (2013) offers a description of both validity and reliability. Reliability is a *"consistency or the degree to which a research instrument measures a given variable consistently every time it is used under the same condition*"; however, validity denotes the *"accuracy of research data"* (Yilmaz, 2013, p. 318). Hence, a study needs to satisfy specific standards when collecting and measuring data in order to ensure validity and reliability.

The reliability of the questionnaire survey data is tested using quantitative techniques. SPSS software offers Cronbach's Alpha Test, based on an 'internal consistency' coefficient, which is the most frequently used reliability coefficient test (Cho & Kim, 2015). Thus, the afore-mentioned test was conducted to confirm the reliability of the quantitative data of this research. Evidence concerning the reliability of the questionnaire will be explored in sections 4.6.1 and 4.7.1.

When addressing the validity for a quantitative instrument, various methods exist, which includes; internal validity, content validity and construct validity (Saunders *et al.,* 2009). However, Yin (2014) refers to the application of construct validity, internal validity and external validity in social research when testing the quality and reliability of a study.

- **Content validity**: is established through the judgment of adequate coverage of the investigated questions through a number of ways, such as the careful definition of research through the literature reviewed and, where appropriate, prior discussion with external experts. This determines whether the items or questions are representative of the construct investigated (Creswell & Clark, 2011; Saunders et al., 2009).
- ***Internal validity:*** this describes the ability of a questionnaire to measure what the researcher intends to measure. The findings of casual relationships between drivers and barriers are explored through statistical analysis in this research; they are validated by the literature review, and by an independent panel of experts.
- **Construct validity:** this determines the most appropriate operational measures that need to be employed when collecting the data regarding the study subject (Yin, 2014).
- **External validity:** refers to whether a study's findings are generalisable beyond the immediate case study. Yin (2014) added that, in survey research, a sample is intended to generalise to a larger population, while a single case studies offers poor generalisation. Thus, the researcher should be careful when selecting a representative sample size from the whole population (Saunders *et al.*, 2012). Therefore, the researcher chooses the survey method when adopting data collection in order to be able to achieve validity and generalisation, focuses on inviting a sample to participate at this stage, checks they form a representative sample, and thus confirms a high degree of external validity at the qualitative and quantitative stage. Indeed, when collecting the data, the researcher consulted two types of sample; Iraqi construction companies including three large construction companies who has an experience of OSC application, and the Iraqi academic field from three USECB. The researcher used random sample to collect data and then achieved good response rate from both samples and thus enables generalisation. In addition, the interviewees were also collected from Iraqi construction companies and the academic field who were experts in OSC.

In this study, choosing a suitable research design and appropriate data collection tool enhances the validity of the process. Furthermore, triangulating the data collection methods and conducting the pilot study can enhance reliability. Moreover, the questionnaire is developed to include factors (drivers and barriers) that affect the use of OSC in Iraq. These factors were identified from various empirical research in current literature, and therefore considered valid for testing. A panel comprising four experts from various segments in the Iraqi construction industry reviewed the questionnaires. This aimed to ensure that the instrument generated in this research measured what it was supposed to and to evaluate the content validity of the instrument. Experts were asked specifically to review each of the items according to (1) how the item represented the effected factors in content, and (2) whether they think the Likert scale assigned was applicable to each item in meaning. The comments and concerns raised by this panel of experts during this review process have been acknowledged and incorporated to improve the questionnaire instrument for use in the data collection stage.

For the qualitative method, a pilot study was conducted to review the interview questions; this was achieved by consulting experts to ensure suitability and clarity. To ensure the reliability, interviews were conducted with participants from different organisations including construction companies and those from the academic field with different levels of experience in the construction industry. Moreover, to increase the reliability of the semi-structured interviews, the researcher developed a list of research themes and information regarding the subject of the research; this list was distributed to participants to inform them of the researcher's interest, and at the same time this offered the chance for participants to feel prepared for the interviews. Finally, in order for the interview questions to be reliable and comprehensive, the researcher combined open and investigating questions. Furthermore, comparisons were made with the literature review and data gathered from the quantitative method to ensure confirmability.

In addition, to ensure the solidity of this research, the researcher consulted multiple sources for the data collection methods by adopting a mixed-method explanatory parallel research design. The construct validity in this research was considered when selecting this mixed method of data collection that included questionnaires and interviews. The process was followed to ensure the questions were designed and asked correctly. Therefore, the construct validity was based on the findings that emerged from the different data sources, including the literature review, which focused on the concept and aspects of OSC, along with the findings gathered from the mixed methods used for this research, which informed the final strategic guideline to improve the use of OSC in Iraq. Moreover, the design of the questionnaire aimed to increase the study’s validity by structuring the format of the questions to focus on the objectives of this research.

3.14 Outcome of the Research and Validation

A strategic guideline that enables the enhancement of OSC in Iraq is the intended outcome of this research. The final strategic guideline was developed based on the outcomes of the data analysis. The strategic guideline (see Chapter 7) lists the drivers and their challenges to the use of OSC in Iraq and the suggested indicative actions to eliminate these challenges; it also detailed the barriers that affect the use of OSC and the suggested indicative actions for each barrier. The guideline was validated for authenticity and credibility through consulting a group of expert interviewees. Relevant details of this second group of experts are presented in Chapter 8. Thus, the final guideline was updated after its validation by experts.

3.15 Summary

The main aim of this chapter was to highlight how and why this research was conducted in accordance with a specific methodological approach. It examined several aspects of research methodology, presented the journey of this research, and described the validation and reliability considerations of this study.

This chapter highlighted and justified the research philosophy, approaches, procedures, strategies and techniques that were used to achieve the research objectives and test the hypotheses. Based on the 'Research Onion' model, this research adopted the (interpretivism) epistemological stance. In addition, it incorporated subjectivism (ontological consideration) and (value-laden) axiology stance. This research is based on both deductive and Indicative approaches. In the deductive approach, the research subject was generated from the general to specific; this was gathered from the available data and literature and followed by the key factors for testing. At the same time, the research also adopted an Indicative approach to develop an in-depth perspective of OSC in Iraq.

The researcher firstly gathered secondary data from a literature review and then collected primary data generated through the adoption of a mixed methods research strategy, namely questionnaires and semi-structured interviews. The questionnaire aimed to provide the researcher with a general perspective about the factors affecting the use of OSC. At the same time, semi-structured interviews were held with experts in order to develop an in depth understanding of the drivers and barriers to using OSC. Subsequent to, and informed by, these steps, the researcher developed a strategic guideline to enhance the use of OSC in Iraq.

Chapter 4 Questionnaire analysis

4.1 Introduction

This chapter presents the findings from the questionnaire survey used in this research. The researcher has analysed data and identified factors affecting the adoption of OSC in Iraq from both groups of construction companies and USECB. The author of this thesis has documented the descriptive data results and discussed the findings of the statistical tests conducting using the Chi-Square for Independence, Spearman and Kruskal-Wallis tests.

4.2 Questionnaire survey of current research

The survey questionnaire was planned as the research tool for the first stage of this study. It aims to understand the present status of OSC in Iraq. The primary objective of this questionnaire was to determine the nature and extent of current OSC practices in Iraqi construction organisations. It focused on the views of construction companies, including architectural, engineering and construction professionals and universities' scientific and engineering consulting bureau, regarding OSC current practices and the delivery of OSC projects in Iraq. The second objective of this survey was to identify the key factors influencing the adoption of OSC in Iraqi construction industry.

4.3 Overview of the questionnaire

The results from the literature review were presented in Chapter 2 and directed to the content of the current questionnaire survey. The questionnaire consisted of three sections; section one consisted of general information about the respondents. Question 1 including their current job title in the company/ university. Questions three and four sought information regarding the respondents' experience in the OSC industry and the major subsectors in which their organisation is involved. For instance, these sub-sectors included hospitals, industrial, educational establishments, and housing, etc. Questions four to seven sought information on their current experience in OSC projects, namely their current and future opinions on the use of OSC in Iraq and types of systems they used/use. The second section included the factors that encourage the use of OSC (drivers), while third section included the factors that inhibit the use of OSC (barriers).

4.4 Measurement and Scaling

The questionnaire was designed to identify the factors affecting the use of OSC in order to develop a strategic guideline for its implementation in Iraq. The survey was a self-administrated questionnaire with five-point Likert scale questions, which were used to measure opinions and attitudes. Likert scales often use a five or seven-point scale to assess the strength of agreement about statements, from which the results are stated as a summated rating scale (Hair, Wolfinbarger, Money, Samouel, & Page, 2015). The reply options ranged from "strongly disagree" to "strongly agree" and from "not satisfied at all" to "extremely satisfied". The Likert scale can also measure other concepts, such as importance, and the responses ranged from very unimportant to very important. Hair *et al.* (2015) describe rating scales as the use of statements on a questionnaire accompanied by pre-coded categories; respondents select one to specify the extent of their agreement or disagreement with a given statement. Moreover, in the delivery and collection questionnaires, the five-point rating scale, allowed respondents to tick the middle "neutral" or "not sure", which was potentially less negative than having to admit they "do not know". By using this type of scale, it became easy for the researcher to determine and assess the impact of drivers and barriers identified from the literature on OSC.

4.5 Descriptive Analysis of the Questionnaire

Descriptive statistics refer to the description of the main features of the data in a quantitative (numeric) manner. In this study, the researcher use frequency (i.e. the number of participants per answer) along with the percentage (%) of participants per answer. Based on the frequency and percentage, the items within the questionnaire were be ranked in terms of importance (or highest agreement). Such descriptive statistics (i.e. frequency, percentage, rank) are chosen due to the assumption that the scale followed in the questionnaire is ordinal (i.e. a five-point Likert scale), and hence such statistical tests are most effective when describing the data. The first part of the descriptive analysis introduces the reliability test, participants' personal and organisational background information, and then: (1) the drivers for using OSC techniques; (2) the barriers for using OSC techniques, and the systems of using OSC. The questionnaire was distributed to two types of groups which are construction companies and universities scientific engineering consultants' bureaus. The descriptive analysis will be discussed for each group in the next sections.

4.6 Universities Scientific and Engineering Consulting Bureau (USECB) Sample

This sample selection was demonstrated in chapter 3. The target sample was for Universities Scientific Engineering Bureaus. The participants work in this Bureaus have experience in different types of construction projects including planning and design and sometimes implementing.

4.6.1 Cronbach's Alpha

The first reliability test was performed by using SPSS to check the reliability of the data for the Universities Scientific and Engineering Bureau sample concerning the drivers and barriers which presented 16 items. The result of Cronbach's alpha indicated 0.726, which is above 0.7 and thus considerable as an acceptable level of consistency and reliability in the literature. See Table 4-1: Cronbach's Alpha for USECB

Table 4-1: Cronbach's Alpha for USECB

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.726	.707	16

4.6.2 Personal and Organisation Background

This section outlines the general personal and organisational characteristics shared by the respondents to the questionnaire. All respondents were asked to state the following: (1) Participants' Job Titles; (2) Main Sub-Sectors Projects (3) Participants' satisfaction towards OSC in Iraq (4) their experience in OSC; (5) OSC Systems.

4.6.2.1 Job title

The participants in the Scientific and Engineering Consulting Bureaus predominantly answered the questionnaire survey. Table 4-2 and Figure 4-1 demonstrate the distribution of participants in terms of numbers; thus, 45 consultants participated in this survey. Furthermore, 23 architects, 12 civil engineers and 14 managers also completed the survey, while other six participants were 3 technicians and 3 electrical engineers.

Table 4-2: Job title of USECB respondents

Job title					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Consultant	45	45.0	45.0	45.0
	Manager	14	14.0	14.0	59.0
	Civil Engineer	12	12.0	12.0	71.0
	Architect	23	23.0	23.0	94.0
	Others	6	6.0	6.0	100.0
	Total	100	100.0	100.0	

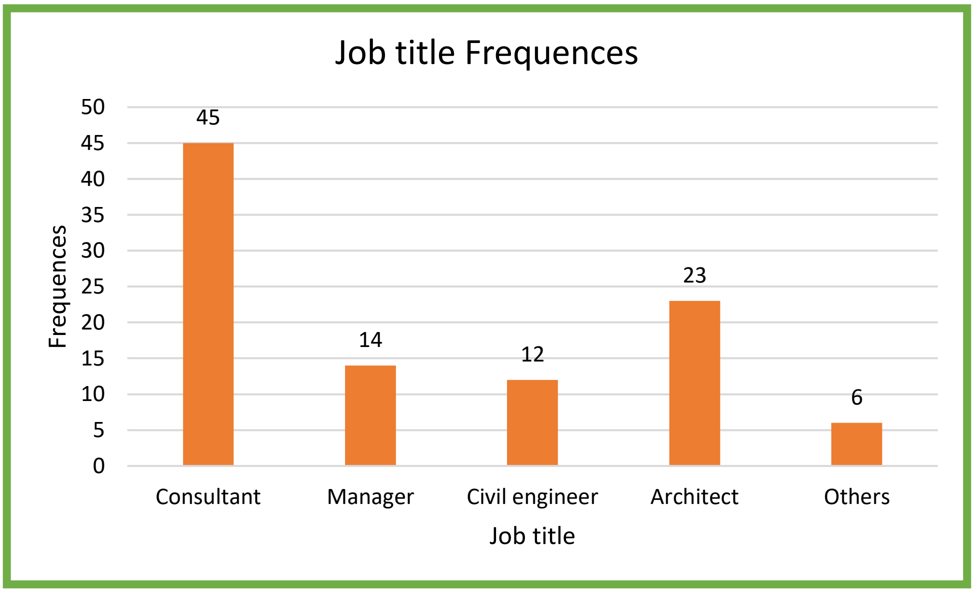


Figure 4-1: Job title of USECB respondents

4.6.2.2 Experience in OSC

Among the respondents, 34 members had less than 5 years' experience in the construction industry, which comprises 34% of the sample. Secondly, 26 members have 5-10 years of experience, whilst 16 members have 16-20 years of experience and 14 participants have more than 20 years' experience in using OSC in Iraq. However, only 10 members have 11-15 years of experience in the OSC industry. Table 4-3: Experience in OSC and Figure 4-2 show the experience of respondents in the field of construction,

Table 4-3: Experience in OSC

Experience in OSC					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	< 5 years	34	34.0	34.0	34.0
	5-10 years	26	26.0	26.0	60.0
	11-15 years	10	10.0	10.0	70.0
	16-20 years	16	16.0	16.0	86.0
	> 20 years	14	14.0	14.0	100.0
	Total	100	100.0	100.0	

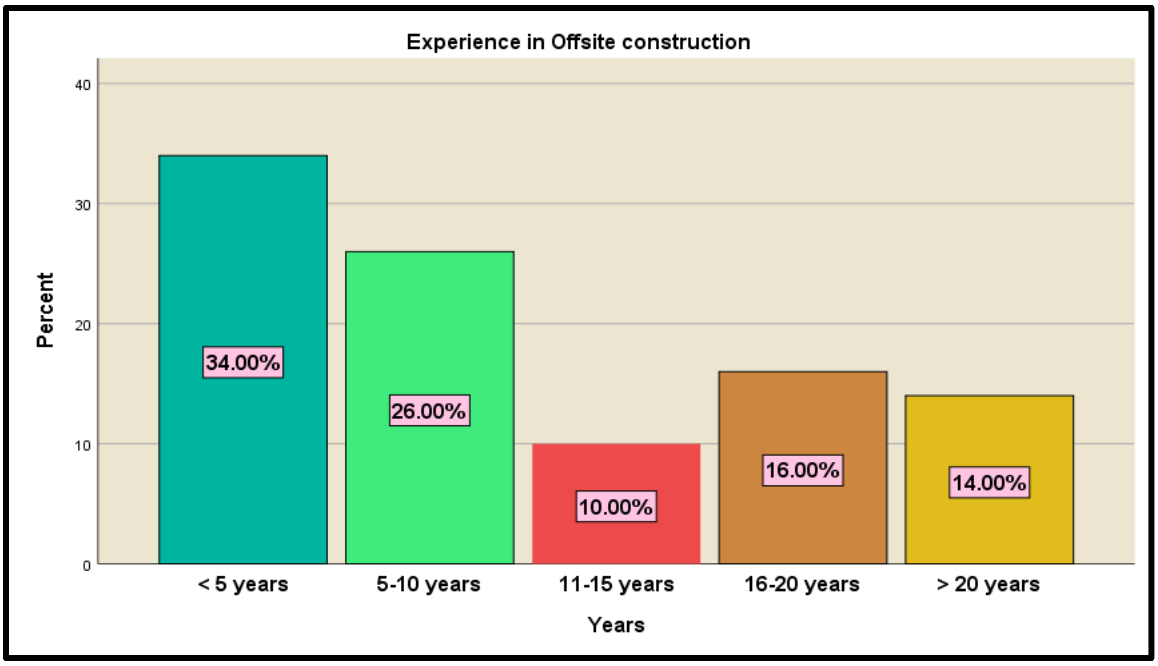


Figure 4-2: USECB respondents' experience in OSC

4.6.2.3 Participant Satisfaction

- **Question 1/ Increasing the use of OSC in the Future**

The respondents were asked, do you expect that the use of OSC will increase in the forthcoming years? In total, 84 respondents expected that the use of OSC would increase in the forthcoming years, while only 16 members do not expect to increase the use of OSC in Iraq. See Table 4-4 USECB respondents' expectations of OSC's future

Table 4-4 USECB respondents' expectations of OSC's future

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yes	84	84.0	84.0	84.0
	no	16	16.0	16.0	100.0
	Total	100	100.0	100.0	

- **Question2/ Considering** OSC

The respondents asked: Would you consider offsite methods if you had the opportunity?

A reasonable percentage of respondents (58%) were willing to use OSC in their projects if they had the chance, while only 40% considered that they might use it. Only 2% of respondents did not want to use it, as shown in table 4-5.

Table 4-5 USECB Considering using OSC

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yes	58	58.0	58.0	58.0
	may be	40	40.0	40.0	98.0
	no	2	2.0	2.0	100.0
	Total	100	100.0	100.0	

- **Question3/ Supporting Using OSC**

The third question was: do you support the use of OSC in Iraq? The predominant positive answer shows the strong support amongst Iraqi academic participants for the use of OSC in Iraqi construction industry. Thus, 96% of respondents support the use of OSC in Iraq whilst only 4% do not support such methods in Iraq. See table 4-6;

Table 4-6: USECB responses for supporting the using OSC in Iraq

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yes	96	96.0	96.0	96.0
	no	4	4.0	4.0	100.0
	Total	100	100.0	100.0	

4.6.2.4 Main Sub-Sectors Projects

What are the main sub-sectors that your organisation deals/has dealt with?

Academic respondents are mostly involved in residential projects according to 25% of respondents. Also, members who are working in scientific and engineering consultation bureaux deal substantially with educational and government projects at 22.5% and 20.3%, respectively; furthermore, industrial (13%) and commercial (11%) projects are similarly handled by these academic bureaux members. The lowest percentage of their consultation work seems to be amongst hospitals at 7% response of the sample population. See table below: -

Table 4-7: USECB responses for main sub-sectors' project

Sectors Frequencies				
		Responses		Percent of Cases
		N	Percent	
Sectors work	Residential	70	25.4%	70.0%
	Industrial	36	13.0%	36.0%
	Commercial	32	11.6%	32.0%
	Educational institution	62	22.5%	62.0%
	Government institution	56	20.3%	56.0%
	Hospitals	20	7.2%	20.0%
Total		276	100.0%	276.0%
a. Dichotomy group tabulated at value 1.				

4.6.2.5 Systems of OSC

The respondents were asked: What are the systems that you used/use in your OSC projects? The results in Figure 4-3: OSC System (USECB) responds towards OSC System revealed that 55%of USECB respondents used or use modular building system in their projects, whilst 40% preferred to use the hybrid system in their application. Finally, only 30% of respondents are likely to use volumetric preassembly.

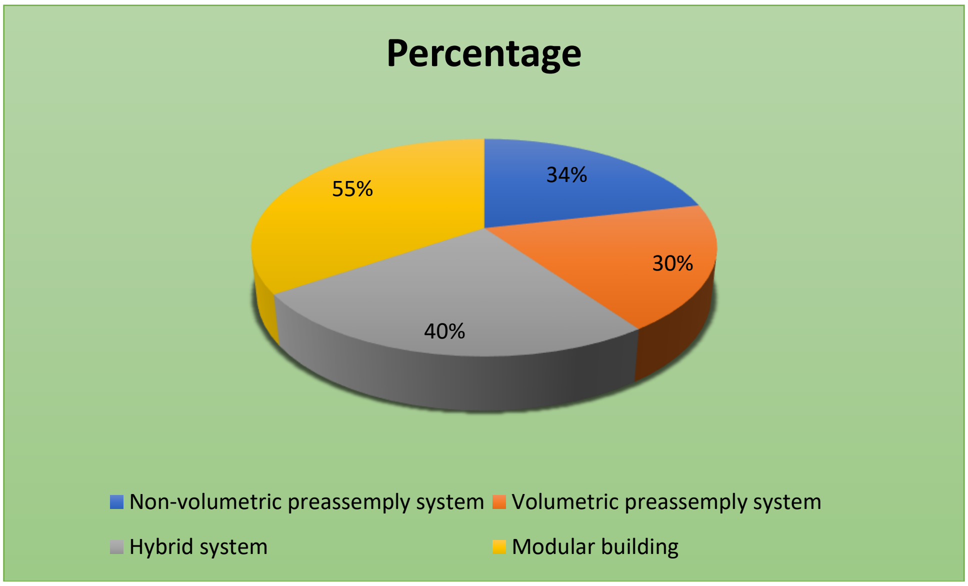


Figure 4-3: OSC System (USECB)

4.6.3 Drivers to the use of OSC in Iraq for USECB

For section 2 of the questionnaire, the researcher prepared a list of variables (drivers) from the literature review, and respondents from Universities Scientific & Engineering Consultant Bureaux (USECB) were asked to rate the influence of each variable by selecting from strongly agree/agree/neutral/strongly disagree/disagree, which were indicated on a five-point Likert scale. This aimed to investigate respondents’ perceptions of the drivers for using OSC in Iraq, which aimed to achieve objective 2 of this study.

In general, most respondents selected strongly agree or agree to the influence of all drivers on the use of OSC in Iraq. Thus, most respondents strongly agreed or agreed with the following drivers: reduced overall project time; high volume of mass units in a short time; improved labour productivity performance; higher speed of construction; addressing the housing shortage in Iraq, and quality control review during the manufacturing process and site assembly. In comparison, respondents did not agree as strongly with the following drivers: the revision to building regulations to support OSC; government promotion and support, and the availability of a legal standards and a code framework to cover all stages of the project. However, more than half of the respondents agreed that the variables concerning policy are drivers to the use of OSC in Iraq.

According to the data obtained, 96 participants agreed or strongly agreed that a reduction in the overall project time and the production of a high volume of mass units in a short time strongly influences the use of OSC practices in Iraq. In comparison, 22 participants disagreed or strongly disagreed that the availability of codes and standards encouraged the adoption of off-site practices in Iraq. Moreover, a significant number of respondents neither agreed nor disagreed with the drivers relating to social factors; indeed, 45 participants selected neutral towards the reduction of accidents onsite whilst 40 participants selected neutral towards employment opportunities for local communities with greater long-term security for individual workers. This may be attributed to the perception that people in academic work are less likely to be involved in construction sites and may therefore be unsure about their answers.

Figure 4-4 shows the graphical representation of the USECB participants' responses concerning the drivers for using OSC in Iraq by using 5-likert scale. In this graph, each driver represents three answers: the first combines the responses under strongly agree and agree; the second includes both strongly disagree and disagree, whilst the third represents neutral. Details of the drivers and their answers are also shown in Table 4-8.

Table 4-8: Statistical representation of respondents rating of drivers of using OSC in Iraq (USECB)

Factors	Sub-Themes Drivers	Strongly Disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly Agree (5)	Strongly disagree to disagree	Strongly agree to agree
Time	Reduce the overall project time	0	0	4	66	30	0	96
	High speed of construction	0	0	7	59	34	0	93
	Ensuring time certainty	0	2	24	61	13	2	74
Quality	Achieving high quality	0	0	31	51	18	0	69
	Quality control review during manufacturing process and site assembly	0	0	5	80	15	0	95
	OSC products are less defects than traditional construction products	0	0	21	71	8	0	79
Cost	Minimizing maintenance and replacement cost	0	0	28	55	17	0	72
	Reducing construction cost	0	0	16	71	13	0	84
	Minimizing overall life-cycle cost	0	0	16	74	10	0	84
	Reducing accidents onsite	0	8	45	36	11	8	47

Social	Offers employment opportunities for local communities with greater long-term security for the individual worker	0	8	40	42	10	8	52
	Improves working conditions for workforce and industry	0	4	27	59	10	4	69
Policy	Revision to building regulation to support OSC	2	7	17	38	36	9	74
	Government promotion and support	5	8	27	29	31	13	60
	Availability of legal, standards and codes framework to cover all stages of the project	6	16	17	39	22	22	61
Productivity & Market	Improve overall project productivity	0	0	12	70	18	0	88
	Addressing the problem of housing shortage in Iraq	0	3	5	29	63	3	92
	High volume production of mass units in short time	0	0	4	37	59	0	96
	Providing affordable housing	0	7	10	40	43	7	83
Environmental	Decrease the energy use during construction and building usage	0	5	25	46	24	5	70
	Reduce materials waste	0	0	14	52	34	0	86
	Reducing environmental impact during construction	0	2	23	61	14	2	75

Labour	Reduces labour required for onsite construction	0	0	17	63	20	0	83
	Improve labour productivity performance	0	0	6	72	22	0	94
	Improves management and coordination among workers at the site	0	0	16	72	12	0	84

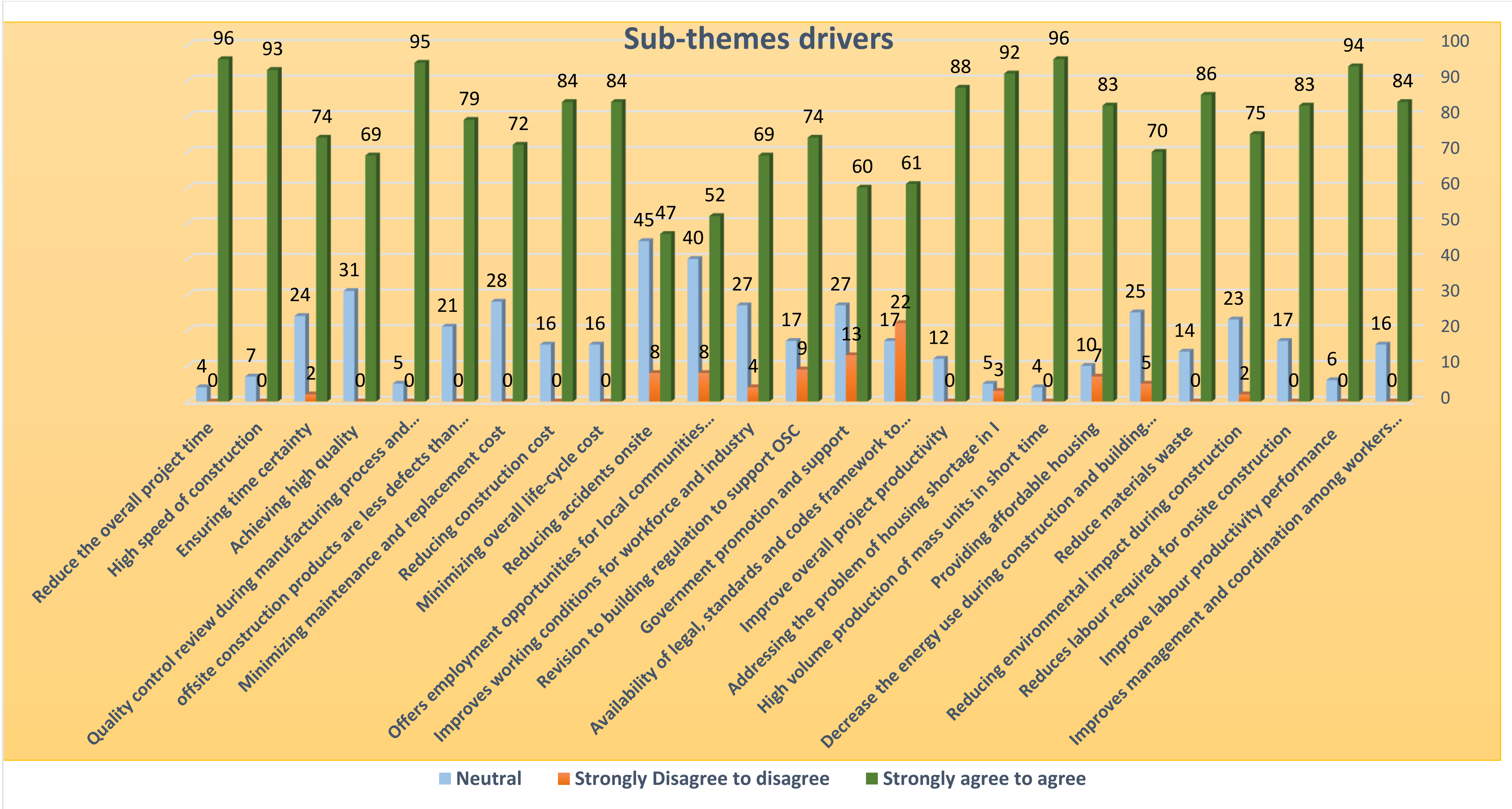


Figure 4-4:Graphical representation of drivers for using OSC in Iraq (USECB)

4.6.4 Barriers to the use of OSC in Iraq for USECB

Further to addressing the drivers towards the adoption of OSC in Iraq, the researcher prepared a list of variables (barriers) from the literature review, and the USECB respondents were asked to rate the influence of each by selecting strongly agree/agree/neutral/strongly disagree/disagree. This represents section three of the questionnaire data.

Based on these responses, many academic respondents agreed or strongly agreed with the barriers related to the supply chain & procurement factor, including the limited capacity within industry to supply diverse varieties of OSC, and the firm control of a supply chain when using OSC. Based on responses from USECB participants, the following represent barriers to the use of OSC in the Iraqi construction industry: higher transportation costs when long distances are involved; a lack of knowledge and awareness; a lack of previous experience and skills; the inability to make changes in the field by using OSC, and difficulties in obtaining formal approval for this type of construction. However, many academic respondents disagreed that the following barriers hindered the use of OSC in Iraq: OSC is more expensive than traditional construction, and unsafe sites are restricted from external parties.

Amongst the variables, 78 participants agreed that the following discourage the adoption of OSC techniques in Iraq: the limited capacity of the Iraqi industry to supply diverse varieties of OSC, and OSC requires a firm control of the supply chain. Furthermore, 70 respondents agreed that higher transportation costs when long distances are involved, whilst 68 participants agreed that a lack of previous experience and skills is a barrier, and 66 agreed that a lack of knowledge and awareness also acted as an impediment to the adoption of OSC. In addition, 66 participants agreed that the following hinders the use of OSC in Iraq: the inability to change design in the field, and difficulties in obtaining formal approval (financial insurance) for this type of construction. However, 38 respondents disagreed that OSC is considered to be more expensive than traditional construction, whilst 32 participants disagreed that the restriction of unsafe sites to external parties represents a barrier. On the other hand, half of the respondents selected neutral for building regulations/legal framework barrier. Figure 4-5 shows a graphical representation of the USECB responses regarding the barriers to adopting OSC in Iraq by using 5- Likert scale. In the graph, each barrier is represented by three answers: the first combines the strongly agree and agree responses; the second includes strongly disagree and disagree, whilst the third represents the neutral responses. Details of the barriers and responses are also shown in Table 4-9.

Table 4-9: Statistical representation of respondents rating barriers for using OSC in Iraq (USECB)

Barriers	Sub-theme barriers	Strongly disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly agree (5)	Strongly Disagree to disagree	Strongly agree to agree
Logistic & site operation	Unsafe sites restricted by external parties	7	25	22	31	15	32	46
	Restricted site layout, space size, access, storage and site location	2	18	28	48	4	20	52
	Difficulties in transporting of materials and components from factory to site	2	24	26	34	14	26	48
Project complexity	Complex and limited design options	6	20	40	22	12	26	34
	Inability to make changes in the field by using OSC.	2	12	20	60	6	14	66
	Building regulation/legal framework requirement	2	20	50	18	10	22	28
	Higher transportation cost where long distance is required	6	6	18	62	8	12	70

Cost	OSC is often considered more expensive compared to traditional methods	2	36	36	18	8	38	26
	Higher initial cost	2	20	32	34	12	22	46
Political & economic	Unstable security situation	4	12	22	34	28	16	62
	Financial status fluctuation	6	14	18	32	30	20	62
	Unstable Current market condition	6	8	30	28	28	14	56
Industry and market culture	Clients desire traditional construction and custom made	0	12	26	38	24	12	62
	Negative image from past attempts of the application of OSC may limit acceptance	4	14	18	42	22	18	64
	Difficult to obtain formal approval (financial- insurance) for this type of construction.	0	10	24	34	32	10	66
Skills & Knowledge	Lack of knowledge and awareness	2	16	16	42	24	18	66
	Lack of R&D in OSC	2	22	18	54	4	24	58
	Lack of previous experience and skilled workforce	2	20	10	36	32	22	68

Supply chain & procurement	Industry capacity to supply diverse varieties of OSC is limited due to lack of infrastructure support and resources	2	6	14	38	40	8	78
	The use of OSC requires firm control of supply chain which can involves high risks.	**2**	**8**	**12**	**56**	**22**	**10**	**78**
	More complex payment terms & cash flows process and financial administrations where mixed offsite and onsite components are required	**6**	**14**	**22**	**38**	**20**	**20**	**58**
Management	Delay of decision making from the leadership.	**2**	**14**	**24**	**42**	**18**	**16**	**60**
	Absence of effective communication between project team members	**2**	**10**	**40**	**44**	**4**	**12**	**48**
	Deficiencies and corruption in dealing with managing project	**6**	**8**	**38**	**28**	**20**	**14**	**48**

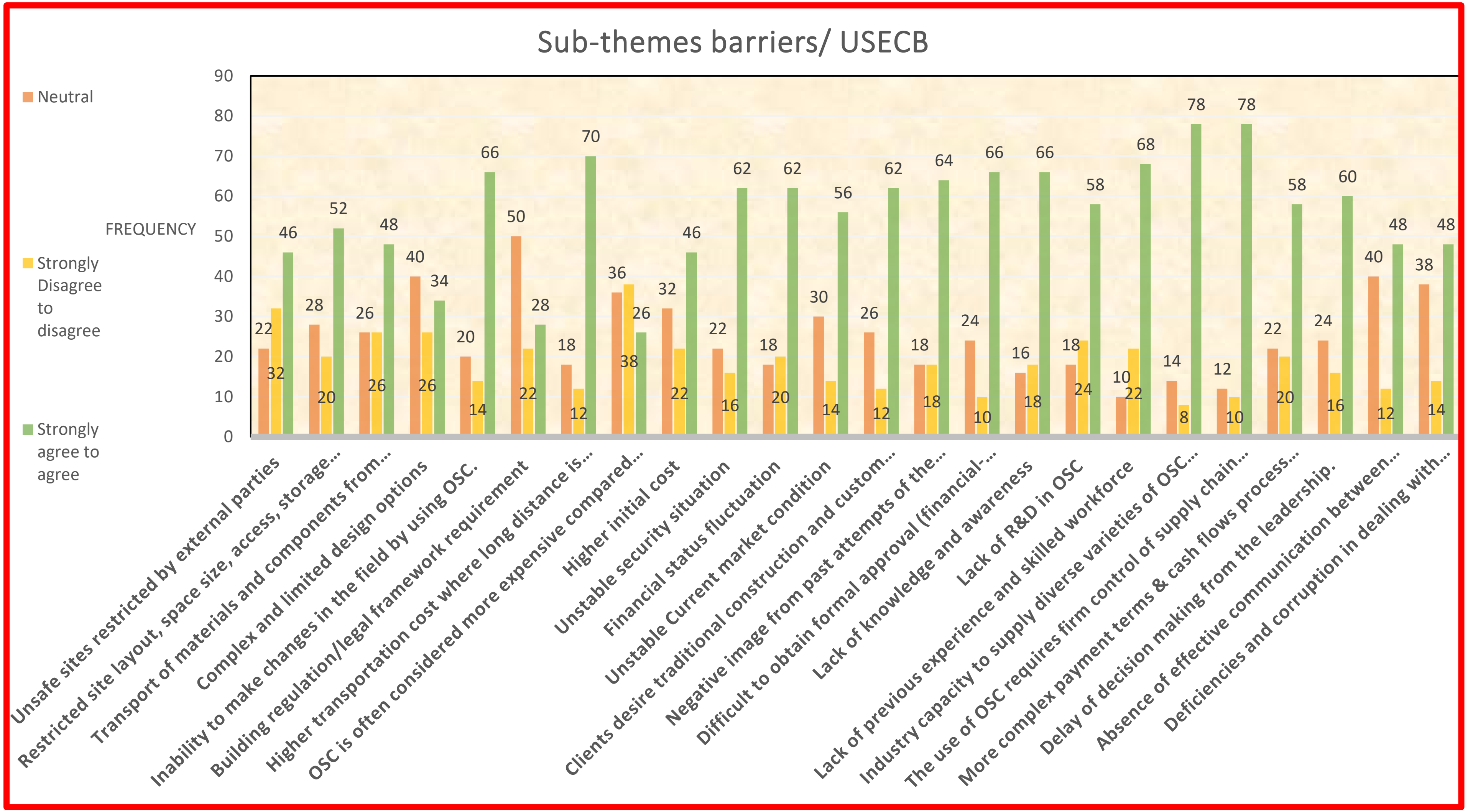


Figure 4-5: Graphical representation of respondents rating of Barriers for the Use OSC in Iraq (USECB)

4.6.5 Summary of findings for USECB sample

This element of the study targeted participants from Universities' Scientific & Engineering Consultant Bureaux. The majority of these participants are consultants and architect engineers. It was found that 34% of participants had less than five years of experience within the field of OSC application whilst 14% experience had more than 20 years. This may be explained by the fact that construction in Iraq was halted several times due to wars and embargoes, which lead to the elimination of construction projects and the transferral of existing experience and expertise to other fields. Nevertheless, OSC re-emerged in Iraq a few years ago although with limited application, which potentially explains the number of participants with less than five years' experience.

Moreover, from the findings, and with a high response rate of 84%, it was noted that the USECB group believe that the use of OSC will increase in Iraq over the forthcoming years. Also, a significant percentage of this group (58%) were willing to use this type of construction if there was the opportunity. The findings also indicated that participants were more involved in residential projects than any other type of construction. Furthermore, most respondents strongly agreed or agreed with the following drivers: reduced overall project times; the production of a high volume of mass units in a short time; improved labour productivity performances; greater construction speeds; the opportunity to address the housing shortage in Iraq, and opportunities to quality control review during the manufacturing and site assembly processes.

However, respondents within this group indicated the following significant barriers to the adoption of OSC in Iraq: limited capacity within the industry to supply a diverse range of OSC; the need for firm control over a supply chain when using OSC; higher transportation costs when long distances are involved; the lack of previous experience and skills in OSC; the lack of knowledge and awareness; an inability to make changes in the field by using OSC, and difficulties in obtaining formal approval (financial-insurance) for this type of construction.

4.7 Data analysis of the Responses from the Construction Companies Sample

This sample selection was demonstrated in chapter 3. The target sample was for construction companies in Iraq. The participants work in these companies have experience in different types of construction projects including OSC. The total numbers of participants were 100.

4.7.1 Reliability test

The reliability test was established to determine the reliability of the data for the construction company sample concerning the drivers and barriers represents 16 items. The result of Cronbach's alpha is shown in Table 4-10: Cronbach's Alpha for Construction Companies

Table 4-10: Cronbach's Alpha for Construction Companies

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.751	.783	16

The result of the reliability test is 0.751, which is above 0.7 and thus indicates an acceptable level of consistency and reliability. Researchers, such as Field (2013); Pallant (2005) recommended that the value of alpha should be 0.7 or higher to ensure greater consistency.

4.7.2 Personal and Organisational Background

This section outlines the general personal and organisational characteristics shared by the respondents to the questionnaire. All respondents were asked to state the following: (1) Participants' Job Titles; (2) Main Sub-Sectors Projects (3) participants' satisfaction towards OSC in Iraq (4) their experience in OSC; (5) OSC Systems.

4.7.2.1 Job Titles

Participants predominantly answered the questionnaire survey from construction companies. Figure 4-6 demonstrates the distribution of participants by number, showing that 32 civil engineers participated in this survey, followed by 30 managers (including project, general and procurement mangers). Moreover, 24 consultants were interviewed comprising 20 chief engineers (including two mechanical engineers, three electrical engineers, 10 civil engineers, two environmental engineers and three architects' engineers) and four general directors. Moreover, the research also included construction companies, interviewing eight architects and six others who classified their role as 'technicians'.

Figure 4-6 and *Table 4-11* illustrate this breakdown by role.

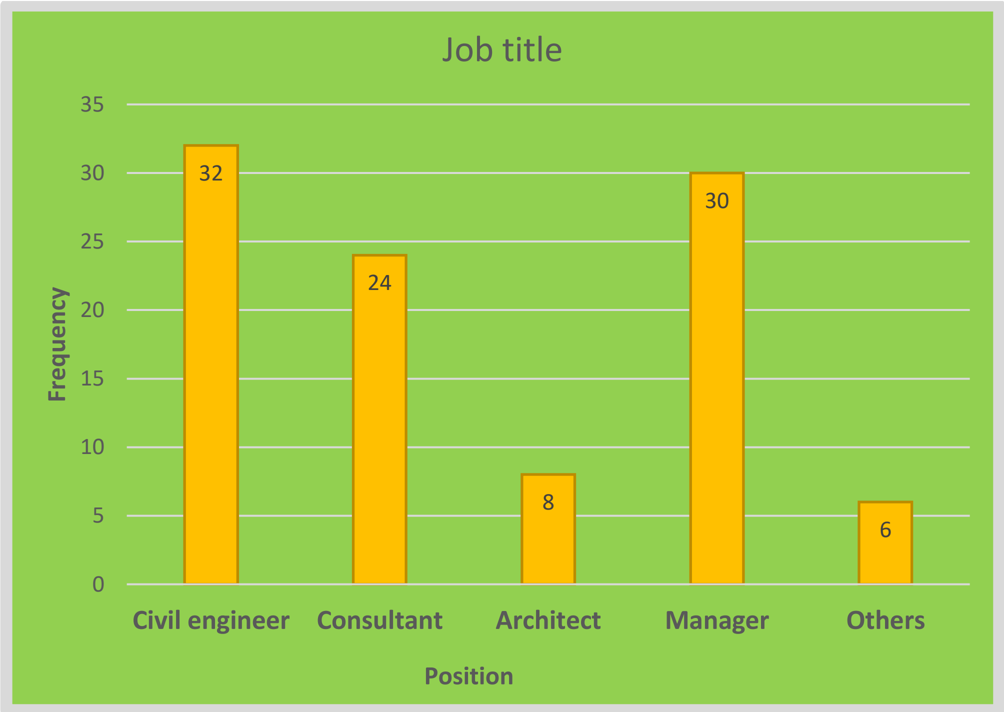


Figure 4-6: Job title of construction company respondents

Table 4-11: Job Title (Construction Companies)

Job title

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Civil engineer	32	32.0	32.0	32.0
	Consultant	24	24.0	24.0	56.0
	Others	6	6.0	6.0	62.0
	Architect	8	8.0	8.0	70.0
	Manager	30	30.0	30.0	100.0
	Total	100	100.0	100.0	

4.7.2.2 Experiences of OSC in Iraq

Among the respondents, 38 (38%) members had less than 5 years' experience in the construction industry. Secondly, 34 members have 5-10 years of experience, whilst 16 members have 16-20 years of experience, and 14 participants have more than 20 years' experience in using OSC in Iraq. Moreover, 8 members have 11-15 years of experience in the OSC industry and only 6 respondents have between 16-20 years' experience. Table 4-12 and Figure 4-7 illustrate the experience of respondents in the field of OSC.

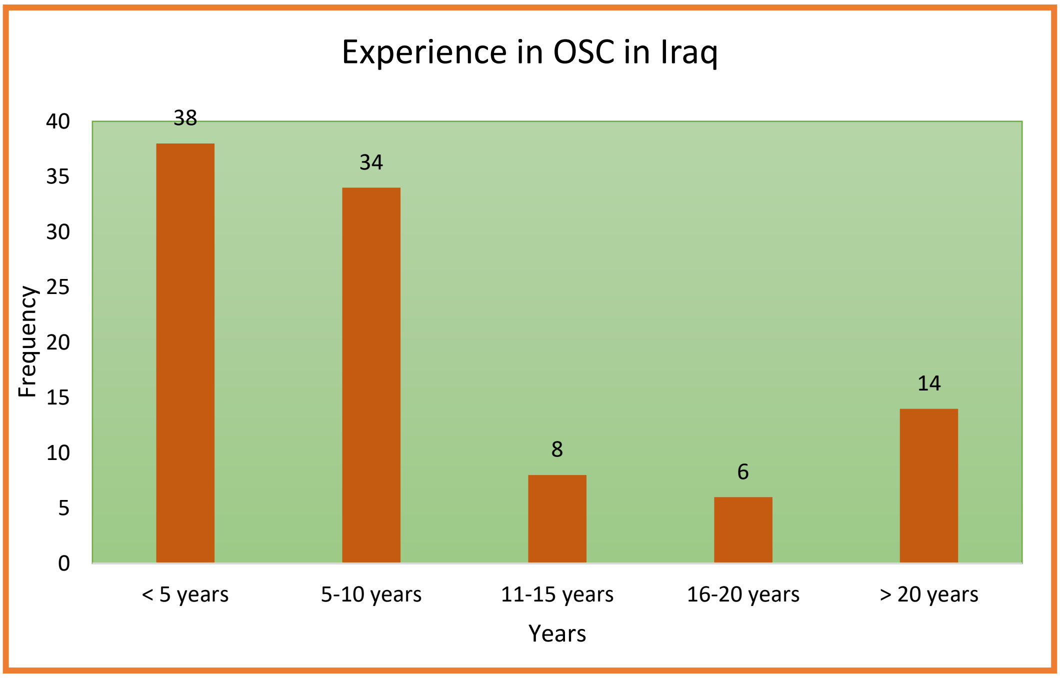


Figure 4-7: Experience Of Construction Companies Respondents In OSC

Table 4-12: Experience in OSC

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	< 5 years	38	38.0	38.0	38.0
	5-10 years	34	34.0	34.0	72.0
	11-15 years	8	8.0	8.0	80.0
	16-20 years	6	6.0	6.0	86.0
	> 20 years	14	14.0	14.0	100.0
	Total	100	100.0	100.0	

4.7.2.3 Participant Satisfaction

- **Question1/ Increasing the use of OSC in the Future**

The respondents were asked: Do you expect that the use of OSC will increase in the coming years? In response, 62 respondents confirmed that they would expect its use to increase in the coming years, while only 38 members disagreed that it would become more prevalent in Iraq. See Table 4-13.

Table 4-13: Construction Companies respondents' expectation of OSC future

Responses					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	62	62.0	62.0	62.0
	2	38	38.0	38.0	100.0
	Total	100	100.0	100.0	

- **Question 2: Considering the use of OSC in Iraq**

The respondents asked the following question: Would you consider offsite methods if you have the opportunity? In response, a high percentage of respondents (48%) indicated they were willing to use OSC in their projects if they had the chance, while 44 % indicated that they might use it. Only 8% of respondents indicated that they would prefer not to use it. Table 4-14 illustrates the breakdown of these responses.

Table 4-14: Construction Companies Consideration of using of OSC

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	48	44.0	44.0	44.0
	2	44	48.0	48.0	92.0
	3	8	8.0	8.0	100.0
	Total	100	100.0	100.0	

- **Question 3: Supporting the using OSC in Iraq**

A further question asked: Do you support the use of OSC in Iraq? In response, the predominately positive answer shows a high level of support amongst the Iraqi construction companies in the sample, confirming they would encourage the use of OSC in Iraqi construction. In comparison, 88% of respondents moderately supported the use of OSC in Iraq whilst only 12% of respondents did not support the method at all. Table 4-15 shows the breakdown of responses to this question.

Table 4-15: Construction Companies Responses for supporting the using OSC in Iraq

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	88	88.0	88.0	88.0
	2	12	12.0	12.0	100.0
	Total	100	100.0	100.0	

4.7.2.4 Main Sub-Sectors Projects

Construction companies were asked the following question: What are the main sub-sectors that your organisation deals/has dealt with? The results show that 26% of the construction companies in this sample are mostly involved in residential projects. Moreover, this sample is also undertaking educational (19.7%) and government institutions' (16.5%) projects. Industrial projects are also currently performed by these construction companies, as selected by 15% of the sample. In contrast, commercial (at 11% of the responses) and hospitals (at 11.8%)

represent the lowest percentage of the construction work. Table 4-16: Main sub-sectors projects (Construction Companies) shows the breakdown of these results.

Table 4-16: Main sub-sectors projects (Construction Companies)

		Responses		
		N	Percent	Percent of Cases
Sub-sectors	Residential	66	26.0%	66.0%
	Industrial	38	15.0%	38.0%
	Commercial	28	11.0%	28.0%
	Educational institution	50	19.7%	50.0%
	Government institution	42	16.5%	42.0%
	Hospitals	30	11.8%	30.0%
Total		254	100.0%	254.0%

a. Dichotomy group tabulated at value 1.

4.7.2.5 OSC Systems

Figure 4-8 illustrates the use of OSC systems in Iraq from the perspective of construction company respondents. The respondents were asked to indicate the system that they had used or were using in their project; the responses show that 65% used/use modular buildings system, whilst 50% use a hybrid system. The less used/in use systems in Iraq are volumetric and non-volumetric, which were selected by 40% of the sample. Figure 4-8 illustrates these responses.

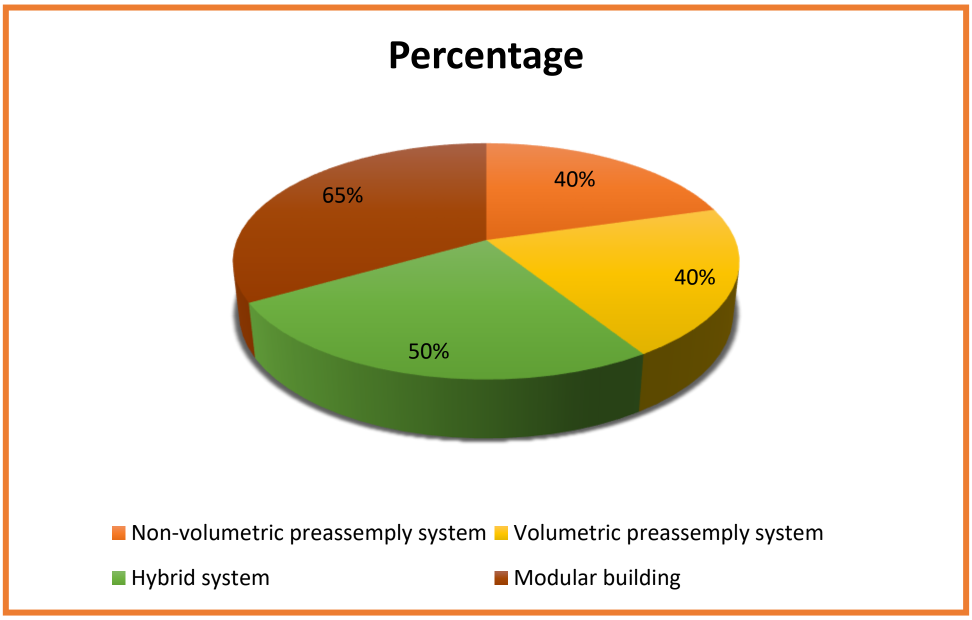


Figure 4-8: OSC Systems in Use/Used within Iraq (Construction Companies)

4.7.3 Drivers to the use of OSC in Iraq for Construction Companies

An examination of the area delineated by the second objective of this research (to investigate perceptions towards the drivers for using OSC in Iraq) also required the researcher to disseminate the list of variables (drivers from the literature review) amongst respondents from construction companies, who were similarly asked to rate the influence of each by selecting strongly agree/agree/neutral/strongly disagree/disagree.

In total, 96 participants strongly agreed that the following represents drivers to the adoption of OSC in Iraq: reducing the overall project time; addressing housing shortages in Iraq; enabling a high volume production of mass units over a short period of time, and the provision of affordable housing. In addition, 95 respondents positively rated the speed of construction. However, some respondents disagreed with the following drivers to the use of OSC in Iraq: reductions to the amount of labour required for onsite construction (n=19), and the availability of legal, standards and a code framework to cover all stages of the project (n=15). Nevertheless, a large percentage of participants agreed on the following drivers: the reduction of labour required for onsite construction (73%), and the availability of legal, codes and a framework to cover all stages of the project (68%). Moreover, 37% of the sample neither agreed nor disagreed with the reduction of accidents onsite, whilst 31% selected neutral to the OSC driver ‘minimizes overall life-cycle cost’.

Figure 4-9 and table 4-17 show the sample participants' responses regarding the drivers for using OSC in Iraq by using 5- Likert scale. Each driver in Figure 4-9 is represented by three answers: the first combines the responses under strongly agree and agree; the second includes strongly disagree and disagree, whilst the third answers show the neutral responses. The last two columns in table 4-17, comprises the answers of strongly agree to agree in one column, and strongly disagree to disagree in one column in order to enable draw figure 4-9.

Table 4-17: Statistical representation of respondents rating Drivers for the Use of OSC In Iraq (Construction Companies)

Factors	Drivers	Strongly disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly agree (5)	Strongly disagree to disagree	Strongly agree to agree
Time	Reduce the overall project time	0	2	2	60	36	2	96
	High speed of construction	0	2	3	62	33	2	95
	Ensuring time certainty	0	2	29	46	23	2	69
Quality	Achieving high quality	0	2	18	48	32	2	80
	Quality control review during manufacturing process and site assembly	0	1	9	57	33	1	90
	OSC products are less defects than traditional construction products	0	1	31	52	16	1	68
Cost	Minimizing maintenance and replacement cost	4	7	11	48	30	11	78
	Reducing construction cost	0	0	25	44	31	0	75
	Minimizing overall life-cycle cost	0	0	31	35	34	0	69
Social	Reducing accidents onsite	2	4	37	50	7	6	57
	Offers employment opportunities for local communities with greater long-term security for the individual worker	0	2	8	82	8	2	90

	Improves working conditions for workforce and industry	2	3	29	37	29	5	66
Policy	Revision to building regulation to support OSC	0	0	10	51	39	0	90
	Government promotion and support	0	4	13	48	35	4	83
	Availability of legal, standards and codes framework to cover all stages of the project	0	15	17	50	18	15	68
Productivity & Market	Improve overall project productivity	0	0	11	45	44	0	89
	Addressing the problem of housing shortage in Iraq	0	2	2	37	59	2	96
	High volume production of mass units in short time	0	0	4	43	53	0	96
	Providing affordable housing		1	3	56	40	1	96
Environmental	Decrease the energy use during construction and building usage	0	0	29	56	15	0	71
	Reduce materials waste	0	0	13	62	25	0	87
	Reducing environmental impact during construction	0	0	22	54	24	0	78
Labour	Reduces labour required for onsite construction	10	9	8	41	32	19	73
	Improve labour productivity performance	1	4	8	52	35	5	87
	Improves management and coordination among workers at the site	0	0	23	57	20	0	77

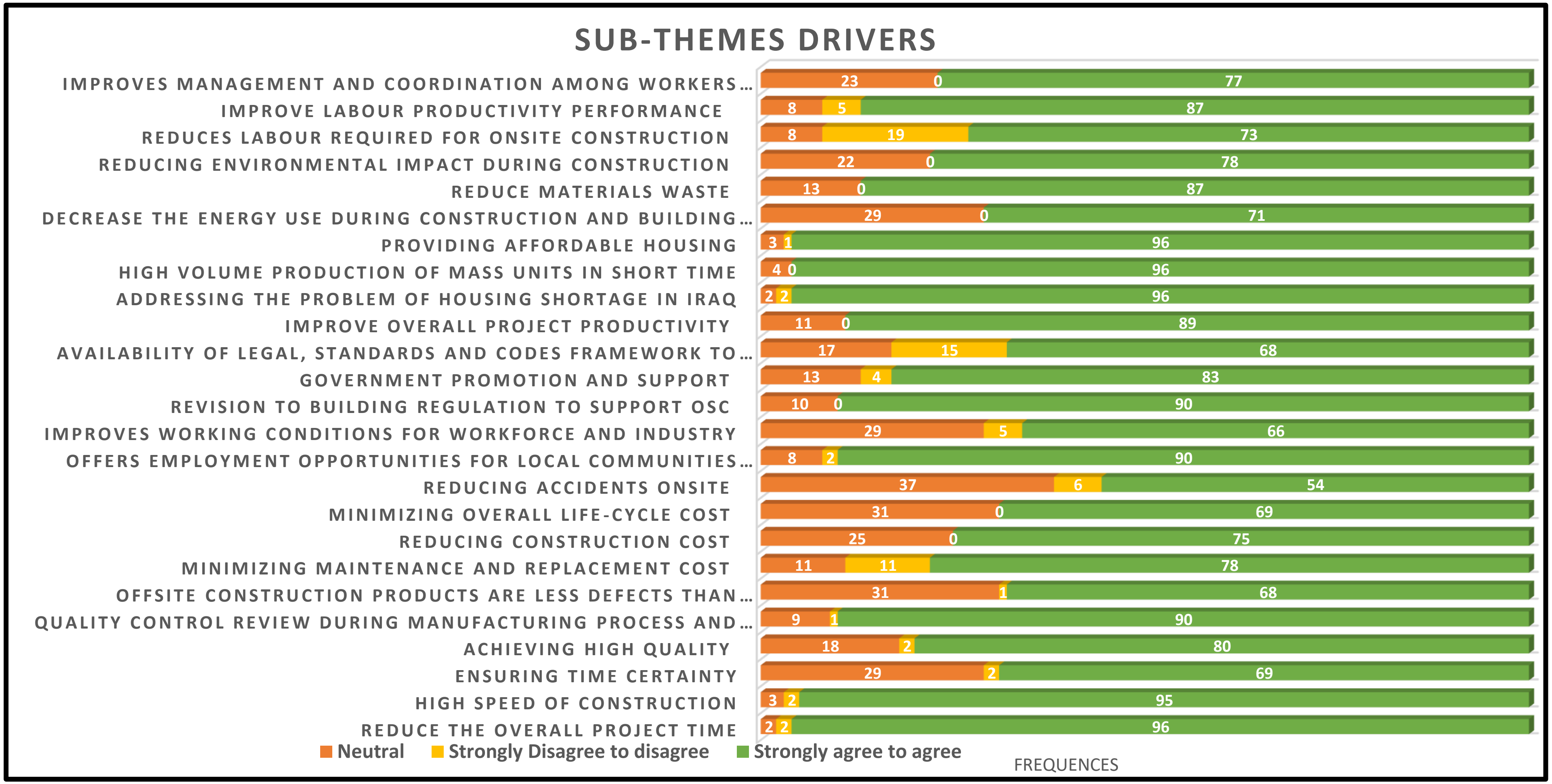


Figure 4-9: Graphical representation of respondents rating drivers for the use of OSC In Iraq (Construction Companies)

4.7.4 Barriers to the use of OSC in Iraq for Construction Companies

As with the USECB sample, and to achieve the second objective of this research, the researcher disseminated a list of variables (barriers) from the literature review amongst respondents from construction companies. Again, respondents were asked to rate the influence of each variable by selecting strongly agree/agree/neutral/strongly disagree/disagree. Figure 4-10 and Table 4-18 show the range of construction company respondents' responses towards the factors that inhibit the use of OSC in Iraq. Most respondents selected the following as barriers to the use of OSC in Iraq:

- Barriers related to the industry & market culture: the client's desire for traditional construction and custom-made products (80 respondents) and a negative image from past attempts (72 participants).
- Barriers related to politics & economics: unstable market conditions barrier (76 participants) and fluctuations in financial status (74 participants).
- Barriers related to skills & knowledge: a lack of knowledge and awareness (78 participants) and both a lack of experience & skills and lack of R&D (74 participants).
- Higher transportation costs when long distances are required (72 participants).

In comparison, participants strongly disagreed that the following factors inhibit the adoption of OSC in Iraq: it is more expensive than traditional methods (58 respondents); it has complex and limited design options (54 participants), and there is the need for a firm control over the supply chain (half of the respondents). However, 42 participants selected neutral to deficiencies and corruption with the management of projects, whilst 30 selected neutral for unsafe sites restricted by external parties. Each barrier in Figure 4-10 is represented by three (clustered) answers: firstly, strongly agree and agree are combined; secondly, strongly disagree and disagree are amalgamated, whilst the third answer represents neutral. Details of the barriers and the range of responses are demonstrated in Table 4-1

Table 4-18: Statistical representation of respondents rating of using OSC in Iraq (Construction Companies)

Barriers	Sub-themes barriers	Strongly disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly agree (5)	Strongly disagree to disagree	Strongly agree to agree
Logistic & site operation	Unsafe sites restricted by external parties	**4**	**22**	**30**	**18**	**26**	**26**	**44**
	Restricted site layout, space size, access, storage and site location	**10**	**20**	**20**	**46**	**4**	**30**	**50**
	Transport of materials and components from factory to site	**2**	**12**	**32**	**48**	**6**	**14**	**54**
Project complexity	Complex and limited design options	**14**	**40**	**16**	**26**	**4**	**54**	**30**
	Inability to make changes in the field by using OSC**.**	**20**	**14**	**16**	**44**	**6**	**34**	**50**
	Building regulation/legal framework requirement	**2**	**26**	**18**	**48**	**6**	**28**	**54**
	Higher transportation cost where long distance is required	**2**	**12**	**14**	**66**	**6**	**14**	**72**

Cost	OSC is often considered more expensive compared to traditional methods	**24**	**34**	**14**	**28**	**0**	**58**	**28**
	Higher initial cost	**22**	**22**	**18**	**28**	**10**	**44**	**38**
Political & economic	Unstable security situation	**0**	**16**	**14**	**34**	**36**	**16**	**70**
	Financial status fluctuation	**0**	**8**	**18**	**36**	**38**	**8**	**74**
	Unstable Current market condition	**0**	**8**	**16**	**42**	**34**	**8**	**76**
Industry and market culture	Clients desire traditional construction and custom made	**0**	**6**	**14**	**40**	**40**	**6**	**80**
	Negative image from past attempts of the application of OSC may limit acceptance	**0**	**16**	**12**	**36**	**36**	**16**	**72**
	Difficult to obtain formal approval (financial- insurance for this type of construction.	**4**	**16**	**16**	**30**	**34**	**20**	**64**
Skills & Knowledge	Lack of knowledge and awareness	**0**	**14**	**8**	**68**	**10**	**14**	**78**
	Lack of R&D in OSC	**2**	**14**	**10**	**58**	**16**	**16**	**74**
	Lack of previous experience and skilled workforce	**0**	**16**	**10**	**60**	**14**	**16**	**74**

Supply chain & procurement	Industry capacity to supply diverse varieties of OSC is limited due to lack of infrastructure support and resources	**4**	**28**	**12**	**42**	**14**	**32**	**56**
	The use of OSC requires firm control of supply chain which can involves high risks.	**18**	**32**	**16**	**18**	**16**	**50**	**34**
	More complex payment terms & cash flows process and financial administrations where mixed offsite and onsite components are required	**6**	**28**	**22**	**20**	**24**	**34**	**44**
Management	Delay of decision making from the leadership.	**20**	**6**	**22**	**42**	**10**	**26**	**52**
	Absence of effective communication between project team members	**16**	**22**	**22**	**36**	**4**	**38**	**40**
	Deficiencies and corruption in dealing with managing project	**2**	**6**	**42**	**42**	**8**	**8**	**50**

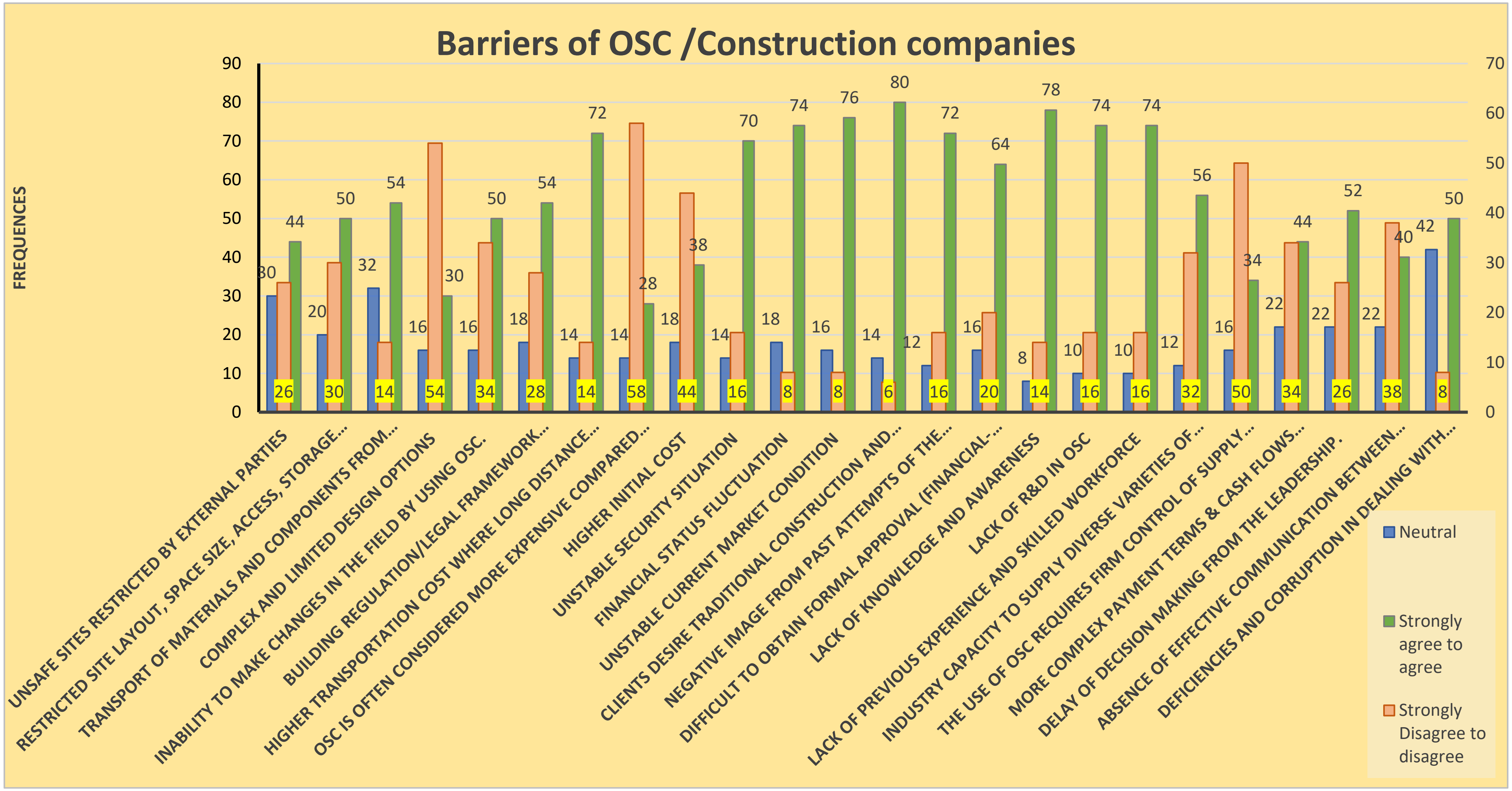


Figure 4-10: Graphical representation of respondents rating the barriers to the use of OSC in Iraq (Construction Companies)

4.7.5 Summary of descriptive analysis for the construction companies' sample

The findings of this group indicated that 66% of construction company participants believed that OSC would increasingly be used in the forthcoming years. However, 48% were willing to use OSC if they had a chance. The construction company participants agreed on supporting the use of OSC in Iraq; moreover, they also tended to use a modular building system and to apply OSC more to residential projects than any other type of construction project. Furthermore, the descriptive analysis illustrated that most respondents significantly agreed that the following drivers encourage the use of OSC in Iraq: reducing the overall project time, producing a high volume of mass units in short time; ensuring a faster rate of construction; addressing the problem of housing shortages in Iraq, and providing affordable housing.

However, participants from this group also strongly agreed that following represent barriers to the use of OSC in Iraq: the client's desire for traditional construction and custom-made products; current unstable market conditions; fluctuations in financial status; a lack of OSC knowledge and awareness, and lack of OSC skills and knowledge. In comparison, the majority of interviewees refused to consider that OSC is more expensive than classic construction and thus poses a barrier to the use of OSC in Iraq.

4.8 Inferential statistics

4.8.1 Introduction

This section presents the results of the statistical tests undertaken on the data collected. The responses to the survey questions will be presented and discussed in this part. A comprehensive inferential statistical analysis is carried out for the data obtained from the questionnaire method for two expert groups, namely construction companies and academic consultants within universities. The questionnaire data contains four parts, which are: the background of respondents, drivers to the uptake of OSC in Iraq, barriers to the uptake of OSC in Iraq, and the systems of OSC**.** The researcher used a Likert scale to summarise the responses to several key questions. Thus, the researcher computed variables into one variable by using the mean; for example, the time factor has three Likert scale elements for analysis, therefore these three items are computed into one variable by applying the mean ranking response.

Three types of analysis are used for both the drivers and barriers to the use of OSC in Iraq, which are as follows:

1. Chi-square statistical approach test
2. Spearman statistical approach test
3. Kruskal-Wallis statistical approach

Moreover, the results are explained and analysed under the following headings:

1. Construction companies: Chi-square test analysis of the drivers to the OSC in Iraq
2. University Academic Consultants: Chi-square test analysis of the drivers to the use of OSC in Iraq
3. University Academic Consultants: Chi-square test analysis of the barriers to the use of OSC in Iraq
4. Construction companies: Chi-square test analysis of the barriers to the use of OSC in Iraq
5. University Academic Consultants: Spearman rho test analysis of the drivers to the use of OSC in Iraq
6. Construction companies: Spearman rho test analysis of the barriers to the use of OSC in Iraq
7. University Academic Consultants: Spearman rho test analysis of the barriers to the use of OSC in Iraq
8. Construction companies: Spearman rho test analysis of the drivers to the use of OSC in Iraq

9. Comparison of the drivers for both groups using the Kruskal-Wallis test
10. Comparison of the barriers for both groups using the Kruskal-Wallis test

4.8.2 Chi-square for Independence Test

Rana and Singhal (2015) confirm that the Chi-Square Test is nonparametric and used for two specific reasons: (a) To test the hypothesis of no association between two or more groups, population or criteria (such as checking the independence between two variables); and (b) to test how likely the observed distribution of data fits with the distribution that is expected (i.e., to test the goodness-of-fit). The test is used to analyse categorical data but is not meant to analyse parametric or continuous data. Also, Pallant (2005) stated that there are two types of Chi-Square Test, and both involve categorical data: firstly, the Chi-Square for Goodness of Fit, explores the proportion of cases that fall into the various categorises of a single variable and compares these with hypothesised values. Secondly, Buckalew and Pearson (1982) state that the Chi-Square Test of Independence consider two variables, such as groups and conditions/categories, and tries to determine whether one variable is independent of the other. When using this test, a significant Chi Square shows non-independence, which means that an association exists between the variables.

Corder and Foreman (2009); Pallant (2005) state the Chi-Square Test for Independence is used to determine whether there is a statistical relationship between two categorical variables. Also, the Chi-Square for Independence statistic can be used when two or more categories are involved for two variables. If the Exact Sig. value is less than .05 for the row labelled 'Pearson Chi-Square', there is a significant relationship between the two examined variables (Field, 2013; Corder & Foreman, 2009; Field, 2009; Pallant, 2007).

SPSS can be used to conduct the Chi-Square test for Independence and adopts the following steps:

1. Obtain a chi-square statistic by opening the crosstabs dialog (analyse > descriptive statistics > crosstabs).
2. Select one variable as the row variable, and the other variable as the column variable.
3. Click Statistics. Check Chi-Square, then click Continue.
4. Click OK.

The adoption and reporting of the Chi-Square for Independence test results for this study followed the guidance outlined by Corder & Foreman (2009), Field (2009) and Pallant (2005).

The third objective of this research is establishing the relationships and interdependencies between factors that impact on the implementation of OSC in Iraq. Therefore, the application of the Chi-Square for Independence test is appropriate to find the relationships between the factors (in this case, barriers and drivers affecting the use of OSC in Iraq).

4.8.2.1 Construction companies: Chi-square test analysis of the drivers to the use of OSC in Iraq

This section explains the results of the Chi-Square for Independence Test for drivers of using OSC in Iraq that obtained from the construction companies' participants. It principally examines each factor alongside seven other factors; for example, it tests the relationship between the time drivers' factor and quality, cost, and social, policy, labour, productivity, and market and environmental factors. The results of Chi-Square for Independence are demonstrated in table 4-19. Thus, according to Chi-Square Test, if the calculated p-value is under 0.05, then the null hypothesis is refused, and the alternative hypothesis is accepted. However, if the calculated p-value is > 0.05 then the null hypothesis is accepted. It is worth mentioning that all results determined in table 4-19 show a significant relationship between all the factors This is because the calculated p-value for all hypothesises is < 0.05.

The null hypothesises are as follows:

Hypothesis A1: there is no relationship between time & quality drivers.

Hypothesis A2: there is no relationship between time & cost drivers.

Hypothesis A3: there is no relationship between time & social drivers.

Hypothesis A4: there is no relationship between time & policy drivers.

Hypothesis A5: there is no relationship between time & labour drivers.

Hypothesis A6: there is no relationship between time & productivity & market drivers

Hypothesis A7: there is no relationship between time & environment drivers.

Hypothesis A8: there is no relationship between quality & cost drivers

Hypothesis A9: there is no relationship between quality & social drivers

Hypothesis A10: there is no relationship between quality & policy drivers

Hypothesis A11: there is no relationship between quality & labour drivers

Hypothesis A12: there is no relationship between quality, & productivity & market drivers

Hypothesis A13: there is no relationship between quality & environmental drivers

Hypothesis A14: there is no relationship between cost & social drivers

Hypothesis A15: there is no relationship between cost & policy drivers

Hypothesis A16: there is no relationship between cost & labour drivers

Hypothesis A17: there is no relationship between cost, & productivity & market drivers

Hypothesis A18: there is no relationship between cost & environmental drivers

Hypothesis A19: there is no relationship between social, & policy drivers

Hypothesis A20: there is no relationship between social, & labour drivers

Hypothesis A21: there is no relationship between social, & productivity & market drivers

Hypothesis A22: there is no relationship between social, & environmental drivers

Hypothesis A23: there is no relationship between policy & labour drivers

Hypothesis A24: there is no relationship between policy & environmental drivers

Hypothesis A25: there is no relationship between policy, & productivity & market drivers

Hypothesis A26: there is no relationship between labour, & productivity & market drivers

Hypothesis A27: there is no relationship between labour & environment drivers

Hypothesis A28: there is no relationship between environmental & productivity & market drivers

Table 4-19: Chi-Square for Independence Drivers for the Use of OSC in Iraq: Construction Companies Group

Hypothesis	Pearson chi-square value	df	Asymp. Sig. (p-Value)	Decision
Hypothesis A1/Time &Quality drivers	219.461	49	0.000	Reject
Hypothesis A2/Time & Cost drivers	116.664	56	0.000	Reject
Hypothesis A3/Time & Social drivers	193.574	63	0.000	Reject
Hypothesis A4/Time & Policy drivers	81.819	49	0.002	Reject
Hypothesis A5/Time & Labour drivers	130.175	63	0.000	Reject
Hypothesis A6/Time & Productivity & Market drivers	166.868	49	0.000	Reject
Hypothesis A7/Time & Environmental drivers	98.657	42	0.000	Reject
Hypothesis A8/Quality & Cost drivers	114.015	56	0.000	Reject
Hypothesis A9/Quality & Social drivers	282.691	63	0.000	Reject
Hypothesis A10/Quality & policy drivers	118.653	49	0.000	Reject
Hypothesis A11/Quality & Labour drivers	144.777	63	0.000	Reject
Hypothesis A12/Quality & Productivity & Market drivers	182.932	49	0.000	Reject
Hypothesis A13/Quality & Environmental drivers	85.281	42	0.000	Reject
Hypothesis A14/Cost, & Social drivers	161.281	72	0.000	Reject
Hypothesis A15/Cost & Policy drivers	131.668	56	0.000	Reject
Hypothesis A16/Cost & Labour drivers	165.196	72	0.000	Reject

Hypothesis A17/Cost, & Productivity & Market drivers	77.868	56	0.028	Reject
Hypothesis A18/Cost & Environmental drivers	73.619	48	0.010	Reject
Hypothesis A19/Social & Policy drivers	115.492	63	0.000	Reject
Hypothesis A20/Social, & Labour drivers	222.301	81	0.000	Reject
Hypothesis A21/ Social & Productivity & Market drivers	178.462	63	0.000	Reject
Hypothesis A22/Social & Environmental drivers	149.719	54	0.000	Reject
Hypothesis A23/Policy & Labour drivers	91.063	63	0.012	Reject
Hypothesis A24 Policy & Environmental drivers	82.474	42	0.000	Reject
Hypothesis A25/Policy & Productivity & market drivers	111.518	49	0.000	Reject
Hypothesis A26/Labour & Productivity & Market drivers	165.100	63	0.000	Reject
Hypothesis A27/Labour & Environmental drivers	81.996	54	0.008	Reject
Hypothesis A28/Productivity & Market & Environmental drivers	92.148	42	0.000	Reject

4.8.2.2 USECB: Chi-square test analysis of the drivers to the use of OSC in Iraq

This section illustrates the results of the Chi-Square for Independence test for the drivers in using OSC in Iraq. It specifically addresses the results from the university scientific & engineering consulting bureau participants, by examining each factor with the seven other factors. For example, it tests the relationship between the time factor and quality, cost, social, policy, labour, productivity & market, and environmental factors. The results of the Chi-Square for Independence are illustrated in Table 4-20. Thus, according to the Chi-Square test, if the calculated p-value is under 0.05, then the null hypothesis is rejected, and the alternative hypothesis is accepted. However, if the calculated p-value is > 0.05 then the null hypothesis is accepted. It is noted that all results within Table 4-20 show a significant relationship between most factors, because the calculated p-value of most hypothesises is < 0.05. However, because the p-values for these relationships are above 0.05, there are no relationships between: quality and environmental, policy and labour, and cost and environmental factors. So, accept hypothesis B23, B13 and B18.

The null hypothesis of this section is explained below:

Hypothesis B1: there is no relationship between time & quality drivers.

Hypothesis B2: there is no relationship between time & cost drivers.

Hypothesis B3: there is no relationship between time, & social drivers.

Hypothesis B4: there is no relationship between time & policy drivers.

Hypothesis B5: there is no relationship between time & labour drivers.

Hypothesis B6: there is no relationship between time, & productivity & market drivers.

Hypothesis B7: there is no relationship between time & environmental drivers.

Hypothesis B8: there is no relationship between quality & cost drivers

Hypothesis B9: there is no relationship between quality & social drivers

Hypothesis B10: there is no relationship between quality & policy drivers

Hypothesis B11: there is no relationship between quality & labour drivers

Hypothesis B12: there is no relationship between quality & productivity & market drivers

Hypothesis B13: there is no relationship between quality & environmental drivers

Hypothesis B14: there is no relationship between cost & social drivers

Hypothesis B15: there is no relationship between cost & policy drivers

Hypothesis B16: there is no relationship between cost & labour drivers

Hypothesis B17: there is no relationship between cost & productivity & market drivers

Hypothesis B18: there is no relationship between cost & environmental drivers

Hypothesis B19: there is no relationship between social & policy drivers

Hypothesis B20: there is no relationship between social & labour drivers

Hypothesis B21: there is no relationship between social & productivity & market drivers

Hypothesis B22: there is no relationship between social, & environmental drivers

Hypothesis B23: there is no relationship between policy & labour drivers

Hypothesis B24: there is no relationship between policy & environmental drivers

Hypothesis B25: there is no relationship between policy & productivity & market drivers

Hypothesis B26: there is no relationship between labour & productivity & market drivers

Hypothesis B27: there is no relationship between labour & environmental drivers

Hypothesis B28: there is no relationship between environmental & productivity & market drivers

Table 4-20: Chi-Square for Independence Drivers for the Use of OSC in Iraq: USECB Group

Hypothesis	Pearson Chi-Square value	df	Asymp. Sig. (p-Value)	Decision
Hypothesis B1/Time & Quality drivers	79.202	24	0.000	Reject
Hypothesis B2/Time & Cost drivers	92.967	24	0.000	Reject
Hypothesis B3/Time & Social drivers	54.030	30	0.005	Reject
Hypothesis B4/Time & Policy drivers	108.950	66	0.001	Reject
Hypothesis B5/Time & Labour drivers	66.673	24	0.000	Reject
Hypothesis B6/Time & Productivity & Market drivers	104.044	42	0.000	Reject
Hypothesis B7/Time & Environmental drivers	92.820	42	0.000	Reject
Hypothesis B8/Quality & Cost drivers	70.550	16	0.000	Reject
Hypothesis B9/Quality & Social drivers	41.838	20	0.003	Reject
Hypothesis B10/Quality & Policy drivers	72.833	44	0.004	Reject
Hypothesis B11/Quality & Labour drivers	44.358	16	0.000	Reject

Hypothesis B12/Quality & Productivity & market drivers	91.953	28	0.000	Reject
Hypothesis B13/Quality & Environmental drivers	24.615	28	0.649	Accept
Hypothesis B14/Cost & Social drivers	52.606	20	0.000	Reject
Hypothesis B15/Cost & Policy drivers	68.124	44	0.011	Reject
Hypothesis B16/Cost & Labour drivers	40.303	16	0.001	Reject
Hypothesis B17/Cost & Productivity & Market drivers	48.774	28	0.009	Reject
Hypothesis B18/Cost & Environment drivers	38.124	28	0.096	Accept
Hypothesis B19/Social & Policy drivers	80.274	55	0.015	Reject
Hypothesis B20/Social & Labour drivers	67.333	20	0.000	Reject
Hypothesis B21/ Social & Productivity & Market drivers	65.791	35	0.001	Reject
Hypothesis B22/Social & Environment drivers	61.570	35	0.004	Reject
Hypothesis B23/Policy & Labour drivers	50.014	44	0.247	Accept
Hypothesis B24/Policy & Environmental drivers	151.167	77	0.000	Reject
Hypothesis 25/Policy & Productivity & Market drivers	216.143	77	0.000	Reject
Hypothesis B26/Labour & Productivity & Market drivers	52.263	28	0.004	Reject
Hypothesis B27/Labour & Environmental drivers	59.200	28	0.001	Reject
Hypothesis B28/Productivity, & Market & Environmental drivers	134.215	49	0.000	Reject

4.8.2.3 Construction companies: Chi-square test analysis of the barriers to the use of OSC in Iraq

The results of the Chi-Square for Independence for the construction companies sample regarding barriers in using OSC in Iraq is revealed in Table 4-21**.** All results determined in this table shows significant relationships between all factors. This is because the calculated p-values for all hypothesises are < 0.05, which means the null hypotheses are rejected and the alternative hypotheses are accepted.

The null hypotheses are as follows:

- D1= there is no relationship between logistic & site operation & project complexity barriers
- D2= there is no relationship between logistic and site operation & cost barriers
- D3= there is no relationship between logistic & site operation & political &economic barriers
- D4= there is no relationship between logistic& site operation, & industry & market culture barriers
- D5= there is no relationship between logistic& site operation & skills & knowledge barriers
- D6= there is no relationship between logistic & site operation, & supply chain & procurement barriers
- D7= there is no relationship between logistic& site operation & management barriers
- D8= There is no relationship between project complexity & cost barriers
- D9= There is no relationship between project complexity, & political & economic barriers
- D10= There is no relationship between project complexity, & industry and market culture barriers
- D11= There is no relationship between project complexity, & skills & knowledge barriers
- D12= There is no relationship between project complexity, & supply chain & procurement barriers
- D13= There is no relationship between project complexity& management barriers
- D14= There is no relationship between cost, & political & economic barriers

- D15= There is no relationship between cost, & industry and market culture barriers
- D16= There is no relationship between cost, & skills & knowledge barriers
- D17= There is no relationship between cost, & supply chain & procurement barriers
- D18= There is no relationship between cost & management barriers
- D19= There is no relationship between political & economic issues, and industry & market culture barriers
- D20= There is no relationship between political & economic, & skills & knowledge barriers
- D21= There is no relationship between political & economic, and supply chain & procurement barriers
- D22= There is no relationship between political & economic, & management barriers
- D23= There is no relationship between industry & market culture, and skills & knowledge barriers
- D24= There is no relationship between industry & market culture, and supply chain & procurement barriers
- D25= There is no relationship between industry & market culture, & management barriers
- D26=There is no relationship between skills & knowledge, and supply chain & procurement barriers
- D27= There is no relationship between skills & knowledge, and management barriers
- D28= There is no relationship between supply chain, & procurement & management barriers

Table 4-21: Chi-Square for Independence barriers for the Use of OSC in Iraq: Construction Companies Group

Hypothesis	Pearson chi-square value	df	Asymp. Sig. (p-Value)	Decision
Hypothesis D1/logistic and site operation & project complexity barriers	244.332	80	0.000	Reject
Hypothesis D2/logistic and site operation & cost barriers	290.957	100	0.000	Reject

Hypothesis D3/logistic and site operation & political &economic barriers	191.662	80	0.000	Reject
Hypothesis D4/logistic and site operation & industry &market culture barriers	268.453	80	0.000	Reject
Hypothesis D5/logistic and site operation & skills & knowledge barriers	326.346	90	0.000	Reject
Hypothesis D6/logistic and site operation & supply chain & procurement barriers	362.995	100	0.000	Reject
Hypothesis D7/logistic and site operation & management barriers	318.642	90	0.000	Reject
Hypothesis D8/project complexity & cost barriers	193.816	80	0.000	Reject
Hypothesis D9/project complexity & political & economic barriers	201.872	64	0.000	Reject
Hypothesis D10/project complexity & industry and market culture barriers	240.825	64	0.000	Reject
Hypothesis D11/project complexity & skills & knowledge barriers	272.155	72	0.000	Reject
Hypothesis D12/project complexity & supply chain & procurement barriers	257.912	80	0.000	Reject
Hypothesis D13/ project complexity & management barriers	223.517	72	0.000	Reject
Hypothesis D14/cost & political & economic barriers	237.557	80	0.000	Reject
Hypothesis D15/cost & industry and market culture barriers	224.931	80	0.000	Reject
Hypothesis D16/cost & skills & knowledge barriers	331.282	90	0.000	Reject
Hypothesis D17/cost & supply chain & procurement barriers	269.013	100	0.000	Reject
Hypothesis D18/cost & management barriers	256.435	90	0.000	Reject
Hypothesis D19/political & economic & industry and market culture barriers	235.924	64	0.000	Reject
Hypothesis D20/political & economic & skills & knowledge barriers	300.956	72	0.000	Reject

Hypothesis D21/political & economic and supply chain & procurement barriers	167.553	80	0.000	Reject
Hypothesis D22/political & economic & management barriers	178.956	72	0.000	Reject
Hypothesis C23/industry & market culture & skills & knowledge barriers	224.432	72	0.000	Reject
Hypothesis D24/industry & market culture and supply chain & procurement barriers	256.291	80	0.000	Reject
Hypothesis D25/industry & market culture & management barriers	224.958	72	0.000	Reject
Hypothesis D26/skills & knowledge and supply chain & procurement barriers	171.827	90	0.000	Reject
Hypothesis D27/skills & knowledge and management barriers.	158.362	81	0.000	Reject
Hypothesis D28/supply chain & procurement & management barriers	309.737	90	0.000	Reject

4.8.2.4 USECB: Chi-square test analysis of the barriers to the use of OSC in Iraq

This section illustrates the Chi-Square Independence test for the barriers to OSC. The section specifically focuses on the results from the university scientific & engineering consulting bureaus (USECB). The results of this test revealed significant relationships between all barriers in the use of OSC in Iraq in which Table 4-22 illustrates these relationships. This is because the p-value result for these relationships is under 0.05, which means the null hypotheses are rejected and the alternative hypotheses are accepted.

Table 4-22: Chi-Square for Independence barriers for the use of OSC in Iraq: USECB group

Hypothesis	Pearson chi-square value	df	Asymp. Sig. (p-Value)	Decision
Hypothesis C1/Logistic and site operation & Project complexity barriers	289.701	72	0.000	Reject
Hypothesis C2/Logistic and site operation & Cost barriers	342.041	99	0.000	Reject
Hypothesis C3/Logistic and site operation, & Political & Economic barriers	281.451	99	0.000	Reject

Hypothesis C4/Logistic and site operation, & Industry & Market Culture barriers	193.203	72	0.000	Reject
Hypothesis C5/Logistic and site operation, & Skills & Knowledge barriers	319.962	81	0.000	Reject
Hypothesis C6/Logistic and site operation, & Supply Chain & Procurement barriers	351.382	81	0.000	Reject
Hypothesis C7/Logistic and site operation & Management barriers	377.978	90	0.000	Reject
Hypothesis C8/Project complexity & Cost barriers	275.265	88	0.000	Reject
Hypothesis C9/Project complexity, & Political & Economic barriers	253.623	88	0.000	Reject
Hypothesis C10/Project complexity, & Industry & Market Culture barriers	185.067	64	0.000	Reject
Hypothesis C11/Project complexity & Skills & Knowledge barriers	319.792	72	0.000	Reject
Hypothesis C12/Project complexity, & Supply Chain & Procurement barriers	237.800	72	0.000	Reject
Hypothesis C13/Project complexity & Management barriers	284.796	80	0.000	Reject
Hypothesis C14/Cost, & Political & Economic barriers	433.013	121	0.000	Reject
Hypothesis C15/Cost & Industry, & Market Culture barriers	285.087	88	0.000	Reject
Hypothesis C16/Cost, & Skills & knowledge barriers	321.431	99	0.000	Reject
Hypothesis C17/Cost, & Supply Chain & Procurement barriers	314.757	99	0.000	Reject
Hypothesis C18/Cost & Management barriers	341.202	110	0.000	Reject
Hypothesis C19/Political & Economic & Industry and Market Culture barriers	251.328	88	0.000	Reject
Hypothesis C20/Political & Economic & Skills & Knowledge barriers	354.501	99	0.000	Reject
Hypothesis C21/Political & Economic and Supply Chain & Procurement barriers	358.620	99	0.000	Reject

Hypothesis C22/Political & Economic and Management barriers	337.424	110	0.000	Reject
Hypothesis C23/Industry & Market Culture, & Skills & Knowledge barriers	265.161	72	0.000	Reject
Hypothesis C24/Industry & Market Culture, & Supply Chain & Procurement barriers	215.946	72	0.000	Reject
Hypothesis C25/Industry & Market Culture, & Management barriers	260.894	80	0.000	Reject
Hypothesis C26/Skills & knowledge& Supply Chain & Procurement barriers	395.925	81	0.000	Reject
Hypothesis C27/Skills & knowledge, & Management barriers	326.246[a]	90	0.000	Reject
Hypothesis C28/Supply Chain & Procurement, & Management barriers	333.821[a]	90	0.000	Reject

The null hypotheses are as follows:

- **C1=** there is no relationship between logistic and site operation & project complexity barriers
- **C2=** there is no relationship between logistic and site operation & cost barriers
- **C3=** there is no relationship between logistic and site operation, & political & economic barriers
- C4= there is no relationship between logistic and site operation, & industry & market culture barriers
- **C5=** there is no relationship between logistic and site operation, & skills & knowledge barriers
- **C6=** there is no relationship between logistic and site operation, & supply chain & procurement barriers
- **C7=** there is no relationship between logistic and site operation & management barrier
- C8= There is no relationship between project complexity & cost
- C9= There is no relationship between project complexity & political & economic barriers
- C10= There is no relationship between project complexity & industry and market culture barriers

- C11= There is no relationship between project complexity & skills & knowledge barriers
- C12= There is no relationship between project complexity & supply chain & procurement barriers
- C13= There is no relationship between project complexity & management barriers
- C14= There is no relationship between cost & political & economic barriers
- C15= There is no relationship between cost & industry and market culture barriers
- C16= There is no relationship between cost & skills & knowledge barriers
- C17= There is no relationship between cost & supply chain & procurement barriers
- C18= There is no relationship between cost & management barriers
- C19= There is no relationship between political & economic, and industry and market culture barriers
- C20= There is no relationship between political & economic, and skills & knowledge barriers
- C21= There is no relationship between political & economic, and supply chain & procurement barriers
- C22= There is no relationship between political & economic, and management
- C23= There is no relationship between industry & market culture, & skills & knowledge barriers
- C24= There is no relationship between industry & market culture, and supply chain & procurement barriers
- C25= There is no relationship between industry & market culture, & management barriers.
- C26= There is no relationship between skills & knowledge, and supply chain & procurement barriers
- C27= There is no relationship between skills & knowledge, and management barriers.
  C28= There is no relationship between supply chain & procurement, and management barriers.

4.8.2.5 Summary of the chi-square for independence test

Chi-square is a non-parametric test applied to explore the relationships between categories of factors. In this study, it was applied to determine whether there are relationships between the drivers for using OSC in Iraq between both samples (CC & USECB), as aligned with objective three of this study. The Chi-Square result for Independence test for the CC sample revealed significant relationships between all drivers. However, the Chi-Square result for the USECB only indicated a significant relationship for most drivers. Thus, the results indicate that the (USECB) participants believe there is no significant relationship between the environmental and quality factors, and the environmental and cost factors. Also, the USECB participants believe there is no significant relationship between the labour and policy factors. On the other hand, findings from the Chi-Square for Independence test for both groups found significant relationships between all barriers.

4.8.3 Spearman Test

A Spearman test is non-parametric and based on ranked data; furthermore, the Spearman's rank-order correlation (often abbreviated to Spearman's correlation) calculates a coefficient, *rs*, (Field, 2013). This test determines the strength of the association between two continuous variables (Pallant, 2005), which could be interval, ordinal or ratio (Weaver, Morales, Dunn, Weaver, & Godde, 2017). The coefficient value ranges between -1 and +1 with a negative value reflecting a negative relationship and a positive value reflecting a positive relationship. The value sizes closer to -1 and +1 indicate a strong or perfect relationship between the variables, while the value size close to 0 indicates a linear relationship (no relationship) (Weaver et al., 2017; Field, 2013; Pallant, 2005). However, Pallant (2005) used Cohen (1988) guidelines, which are illustrated below; these enable an interpretation of the value results between 0-1. This guideline is also mentioned by (Corder & Foreman, 2009), and is also addressed in (Cohen, 2013).

small	r=.10 to .29
medium	r=.30 to .49
large	r=.50 to 1.0

(Adopted from: (Pallant, 2007, 2005)

Also, Field (2013) indicated that the correlation coefficient is a commonly used measure of the size of the effect in which the values ±0.1 represent a small effect, ±0.3 is a medium effect, and ±0.5 denotes a large effect. Therefore, based on these illustrated measures, the researcher used and interpreted the Spearman test results to examine the relationships among the drivers for both sample groups. Also, it applied the same test for the barriers from participants of both groups. Moreover, it should be noted that an alpha level below 5% reflects a significant relationship ($p<0.05$); in contrast, a value above reflects a lack of any relationship (Weaver et al., 2017).

The third objective of this research is to establish the relationships and interdependencies between the factors that impact on the implementation of OSC in Iraq. Therefore, a Chi-Square for Independence was first conducted to help identify the relationships (between the barriers and drivers) that affect the use of OSC in Iraq. However, in order to determine the strength of the association between two continuous variables, a Spearman Rho test was applied. This test was conducted on results from both groups to clarify the strength of the (driver and barrier) relationships affecting the use of OSC in Iraq.

4.8.3.1 USECB: Spearman rho test analysis of the drivers for using OSC in Iraq

The analysis of the data was conducted by applying a non-parametric (Spearman test) to explore the correlation between the drivers towards the uptake of OSC in Iraq. Therefore, table 4-23 shows the Spearman correlations between the drivers according to USECB groups' point of view. The most positive significant correlation is between the time & cost factors at rho=0.668, p=0.000. Meanwhile, the most significant negative correlation is between the policy and labour factor at rho= (-0.042). The results indicate that time, quality and cost are the most important factors for the uptake of OSC in Iraq. This is due to a high positive relationship between each factor, and a medium or low positive relationship with other factors. Time is the most significant drivers, according to the USECB respondents. This is because time has the strongest positive significant correlation with the cost factor, where Spearman rho=0.668. Also, time has another important positive relationship with the quality driver at rho= 0.580. The time factor also has a medium relationship with labour (rho= 0.479), and social (rho=0.491), $p<0.05$. Meanwhile, a low positive relationship is explored with environmental factor, at rho=0.181, and with policy factor, at rho= 0.204.

According to the academic respondents, another two important drivers for the uptake of OSC in Iraq are quality and cost which have significant positive relationship with time. Interestingly, both the cost & quality factors have a strong positive relationship with each other, at rho=0.611. Moreover, the cost & quality drivers have a low positive relationship with the productivity & market factor (Spearman rho=0.172), and with productivity & market (rho= 0.196). Moreover, the cost factor has another two medium positive relationships, which are the labour and social drivers (at rho=0.448 and rho=0.495 respectively). Furthermore, the cost factor has another two low positive relationships with the environmental and policy factors, at rho=0.123 and rho=0.235 respectively. The quality factor has a low positive relationship with social (rho=0.256, p=0.010), labour (at rho=0.263, p=0.008) and environmental, (rho=0.024). However, two medium positive relationships are found between quality and policy factors (at rho=0.334) and quality with social (at rho= 0.314).

According to the academic consultants, the productivity & market factor is an important driver for the use of OSC in Iraq. This factor has a significant positive relationship with the environmental factor (rho=0.581, p=0.000). The productivity & market factor also has a medium positive relationship with time (rho= 0.303) and policy factor (rho=0.307). Moreover, the productivity & market factor has a low positive relationship with the remaining factors.

Furthermore, the labour, and social have a medium-positive relationship, at rho= 0.446. Indeed, they have also a medium significant association with the time and cost factors. In addition, both the social and labour factors indicated a low positive relationship with productivity & market and with environmental factors. Interestingly, both the labour, and social factors have a significant low negative relationship with the policy factor (at rho=-0.042 and -0.020 respectively).

The environmental factor has a strong positive relationship with the productivity & market factor, although it has low positive relationships with the remaining factors, and this may signify that it is influential on the uptake of OSC in Iraq. Furthermore, two negative relationships between policy and social, and policy and labour may indicate that this factor is less important in driving the use of OSC in Iraq. However, the policy factor has medium and low positive relationships with the other factors.

Table 4-23: Spearman USECB drivers for using OSC in Iraq

			Time drivers	Quality drivers	Cost drivers	Labour drivers	Policy drivers	Productivity & market drivers	Social drivers	Environmental drivers
Spearman'	Time drivers	Correlation Coefficient	1.000	.580**	.668**	.479**	.204*	.303**	.491**	.181
		Sig. (2-tailed)	.	.000	.000	.000	.042	.002	.000	.071
		N	100	100	100	100	100	100	100	100
	Quality drivers	Correlation Coefficient	.580**	1.000	.611**	.263**	.334**	.196	.314**	.024
		Sig. (2-tailed)	.000	.	.000	.008	.001	.050	.001	.811
		N	100	100	100	100	100	100	100	100
	Cost drivers	Correlation Coefficient	.668**	.611**	1.000	.448**	.235*	.172	.495**	.123
		Sig. (2-tailed)	.000	.000	.	.000	.018	.087	.000	.224
		N	100	100	100	100	100	100	100	100
	Labour drivers	Correlation Coefficient	.479**	.263**	.448**	1.000	-.042	.297**	.446**	.193
		Sig. (2-tailed)	.000	.008	.000	.	.679	.003	.000	.055

		N	100	100	100	100	100	100	100	100
	Policy drivers	Correlation Coefficient	.204*	.334**	.235*	-.042	1.000	.307**	-.020	.202*
		Sig. (2-tailed)	.042	.001	.018	.679	.	.002	.847	.044
		N	100	100	100	100	100	100	100	100
	Productivity & Market drivers	Correlation Coefficient	.303**	.196	.172	.297**	.307**	1.000	.281**	.581**
		Sig. (2-tailed)	.002	.050	.087	.003	.002	.	.005	.000
		N	100	100	100	100	100	100	100	100
	Social drivers	Correlation Coefficient	.491**	.314**	.495**	.446**	-.020	.281**	1.000	.033
		Sig. (2-tailed)	.000	.001	.000	.000	.847	.005	.	.747
		N	100	100	100	100	100	100	100	100
	Environmental	Correlation Coefficient	.181	.024	.123	.193	.202*	.581**	.033	1.000
		Sig. (2-tailed)	.071	.811	.224	.055	.044	.000	.747	.
		N	100	100	100	100	100	100	100	100

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

4.8.3.2 Construction companies: Spearman rho test analysis of the drivers to the use of OSC in Iraq

Table 4-24 shows the correlation between the drivers for OSC according to construction companies' views. The highest correlation is between the time and quality factors in which Spearman rho=0.693. While, the lowest correlation is found between the environmental and policy factor, at rho=0.-0.051, it recorded as a negative relationship.

The factors that have more significant positive relationships are the most influential factors on the uptake of OSC in Iraq. For example, time, quality, cost, social and labour are the most significant factors on the uptake of OSC in Iraq. This is because each of these factors has four significant positive relationships.

The time and social factors have a high positive relationship with each other, at rho=0.666, and this correlation is the second-highest positive relationship amongst the other correlations. Interestingly, the time and social factors have three other strong positive relationships with the same factors, including quality, cost, and labour. The rho results can be found in table 4-24.

Similarly, the labour and cost factors have a strong positive relationship, at rho= 0.593, p=0.000. The labour and cost factors also have strong positive relationship with time, at rho=0.553 and 0.626 respectively. In addition, the labour and cost factors share another significant relationship with the social factor and almost the same rho, which is equal to 0.595 and 0.547 respectively. Nevertheless, the labour factor has a medium-positive relationship with the quality driver, at rho=0.391, p=0.000, and a low-positive relationship with the policy driver, at rho=0.215, p=0.032.

The quality factor does not only have a strong correlation with time factor, but also has another three significant positive relationships, with cost, social, and policy. The relationship between quality, and social is the second highest positive relationship amongst the quality relationships, where rho=0.583. Furthermore, the quality factor has three medium-positive relationship with productivity & market, environmental and labour factors. The rho results are shown in table 4-24.

Another medium influential factor on the uptake of OSC in Iraq is the productivity & market factor. The productivity & market factor has a significant positive relationship with the labour factor, at rho=0.573. The productivity & market factor also has a medium-positive relationship with five factors, including time, quality, cost, social and environmental. Although, one low-positive relationship is found between the productivity & market and policy factors, at rho=0.227, p=0.023

Interestingly, the policy factor has one strong-positive relationship with the quality factor at rho= 0.540 and one low-negative relationship with the environmental factor, at rho=0.-051. This factor also has three medium-positive relationships with time, cost, and social. Moreover, the policy factor has a low-positive relationship with labour, productivity & market, and environmental factors.

Environmental factor has a medium relationship with the remaining factors, excepting the policy factor, which indicates a negative relationship. Therefore, it appears from the results that the factors of time, cost, quality, labour and social are influential to the uptake of OSC in Iraq as these factors have four strong-positive correlations.

Table 4-24 : Construction companies: Spearman rho test analysis of the drivers to the use of OSC in Iraq

Correlation

			Time drivers	Quality drivers	Cost drivers	Social drivers	Policy drivers	Labour drivers	Productivity& Market drivers	Environmental drivers
Spearman's rho	Time drivers	Correlation Coefficient	1.000	.693**	.626**	.666**	.387**	.553**	.319**	.429**
		Sig. (2-tailed)	.	.000	.000	.000	.000	.000	.001	.000
		N	100	100	100	100	100	100	100	100
	Quality drivers	Correlation Coefficient	.693**	1.000	.515**	.583**	.540**	.391**	.400**	.385**
		Sig. (2-tailed)	.000	.	.000	.000	.000	.000	.000	.000
		N	100	100	100	100	100	100	100	100
	Cost drivers	Correlation Coefficient	.626**	.515**	1.000	.547**	.475**	.593**	.303**	.422**
		Sig. (2-tailed)	.000	.000	.	.000	.000	.000	.002	.000
		N	100	100	100	100	100	100	100	100
	Social drivers	Correlation Coefficient	.666**	.583**	.547**	1.000	.344**	.595**	.311**	.384**
		Sig. (2-tailed)	.000	.000	.000	.	.000	.000	.002	.000

		N	100	100	100	100	100	100	100	100
	Policy drivers	Correlation Coefficient	.387**	.540**	.475**	.344**	1.000	.215*	.227*	-.051
		Sig. (2-tailed)	.000	.000	.000	.000	.	.032	.023	.613
		N	100	100	100	100	100	100	100	100
	Labour drivers	Correlation Coefficient	.553**	.391**	.593**	.595**	.215*	1.000	.573**	.489**
		Sig. (2-tailed)	.000	.000	.000	.000	.032	.	.000	.000
		N	100	100	100	100	100	100	100	100
	Productivity & market drivers	Correlation Coefficient	.319**	.400**	.303**	.311**	.227*	.573**	1.000	.337**
		Sig. (2-tailed)	.001	.000	.002	.002	.023	.000	.	.001
		N	100	100	100	100	100	100	100	100
	Environmental drivers	Correlation Coefficient	.429**	.385**	.422**	.384**	-.051	.489**	.337**	1.000
		Sig. (2-tailed)	.000	.000	.000	.000	.613	.000	.001	.
		N	100	100	100	100	100	100	100	100

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

4.8.3.3 USECB: Spearman rho test analysis of the barriers to the use of OSC in Iraq

Table 4-25 illustrates the correlation results between the barriers affecting the use of OSC in Iraq in accordance with the view of the academic scientific and engineering consulting bureau respondents. The table reveals that the strongest positive correlation is between the skills & knowledge and project complexity factor, at spearman rho= 0.677, sig(2-tailed) = 0.000. Instead, the lowest negative correlation is between the cost & management barriers, at rho= -0.165, sig(2-tailed) =0.100.

Table 4-25 clarifies that, from the perspective of academic respondents, the supply chain & procurement factor is the most significant barrier to the use of OSC in Iraq. This is because the factor has four significant positive correlations, which are with project complexity (Spearman's rho= 0.608), with politic &economic issues (rho=0.601, with skills & knowledge (rho=0.655), with industry & market culture (rho= 0.511), at p< 0.05. Also, the supply factor has a medium-positive relationship with the management factor (at rho= 0.322). It also has a low-positive correlation (rho=0.198) with the logistic & site operation factor.

Similarly, the second influential factor to constrain the use of OSC in Iraq is the skills & knowledge factor as this barrier has a strong relationship with project complexity (rho= 0.677, p = 0.000) and at the same time this is the strongest positive relationship among all the factors. In addition, the skills & knowledge factor has other two significant positive relationships, with the supply chain & procurement factor (at rho= 0.655, p= 0.000) and with the industry & market culture factor (at rho = 0.644, p=0.000). Furthermore, the skills & knowledge factor shows a medium-positive relationship with the cost factor, at rho= 0.450, p<0.05.

A low-positive relationship is found between the skills & knowledge factor and the political & economic factor, at rho 0.255, p= 0.010. Similarly, the management, and skills & knowledge factors show a low-positive association, at rho 0.019. In contrast, a low-negative relationship is demonstrated between the skills & knowledge and logistic factors, at rho=-0.112 and p= 0.230.

The third most influential factors are project complexity, and industry & market culture as both have two strong-positive relationships with same factors, which are: skills & knowledge and supply chain & procurement. Also, the project complexity and industry culture factors have a positive-low relationship with the remaining factors. Furthermore, the project complexity and industry culture sharing factors represent another significant positive relationship and alongside the supply chain & procurement factor (rho value explained previously).

The political barrier seems to have a reasonable impact on the decision to use OSC in Iraq, as it only has one strong-positive relationship with the supply factor, at rho=0.601, p= 0.000. Furthermore, the political factor has low-positive relationships with the logistic, project complexity and cost factors, at rho= 0.403, 0.386 and 0.394 respectively. Also, a low-positive relationship occurs between the political and management factors, at rho= 0.164. Indeed, the lowest positive relationship related to the political factor is with the industry & market culture barrier, at rho= 0.076, p= 0.451.

The cost factor does not show a strong-positive relationship with other factors. Instead, it shows medium and low-positive relationships with almost all factors, except for the low-negative relationship with management factor (at rho= -0.165). The cost factor, for example, has a medium-positive relationship with the project complexity (rho=0.456) and with the political & economic factor (at rho=0.394). Instead, it has a low-positive relationship with the supply chain factor, at rho=0.287, p=0.004.

According to the academic respondents, the lowest two influential factors that may constrain the use of OSC in Iraq are logistic & site operation, and management factors as both demonstrate low-negative relationships with other factors. The logistic & site operation factor has a low-negative relationship with industry & market culture and skills & knowledge factors (at rho= -0.056) and with the skills factor (at rho=-0.112). Instead, the management factor has a low-negative association with the project complexity and cost factors (at rho= -0.121 and rho= -0.165 respectively). Furthermore, the logistic & site operation and management show a medium-positive relationship, at rho= 0.332, $p<0.05$. The management factor has the same Spearman rho value =0.332 with the supply chain & procurement factor.

Table 4-25: USECB: Spearman rho test analysis of the barriers to the use of OSC in Iraq

Correlations										
			Logistic & site operation barriers	Project complexity barriers	Cost	Political & economic barriers	Industry & market culture barriers	Skills & Knowledge barriers	Supply chain & procurement barriers	Management barriers
Spearman's rho	Logistic & site operation barriers	Correlation Coefficient	1.000	.168	.098	.403**	-.056	-.112	.198*	.332**
		Sig. (2-tailed)	.	.095	.334	.000	.582	.266	.048	.001
		N	100	100	100	100	100	100	100	100
	Project complexity barriers	Correlation Coefficient	.168	1.000	.456**	.386**	.227*	.677**	.608**	-.121
		Sig. (2-tailed)	.095	.	.000	.000	.023	.000	.000	.230
		N	100	100	100	100	100	100	100	100
	Cost barriers	Correlation Coefficient	.098	.456**	1.000	.394**	.169	.450**	.287**	-.165
		Sig. (2-tailed)	.334	.000	.	.000	.093	.000	.004	.100
		N	100	100	100	100	100	100	100	100
	Political & economic barriers	Correlation Coefficient	.403**	.386**	.394**	1.000	.076	.255*	.601**	.164

		Sig. (2-tailed)	.000	.000	.000	.	.451	.010	.000	.104
		N	100	100	100	100	100	100	100	100
	Industry & market culture barriers	Correlation Coefficient	-.056	.227*	.169	.076	1.000	.644**	.511**	.228*
		Sig. (2-tailed)	.582	.023	.093	.451	.	.000	.000	.023
		N	100	100	100	100	100	100	100	100
	Skills & knowledge barriers	Correlation Coefficient	-.112	.677**	.450**	.255*	.644**	1.000	.655**	.019
		Sig. (2-tailed)	.266	.000	.000	.010	.000	.	.000	.852
		N	100	100	100	100	100	100	100	100
	Supply chain & procurement barriers	Correlation Coefficient	.198*	.608**	.287**	.601**	.511**	.655**	1.000	.322**
		Sig. (2-tailed)	.048	.000	.004	.000	.000	.000	.	.001
		N	100	100	100	100	100	100	100	100
	Management barriers	Correlation Coefficient	.332**	-.121	-.165	.164	.228*	.019	.322**	1.000
		Sig. (2-tailed)	.001	.230	.100	.104	.023	.852	.001	.
		N	100	100	100	100	100	100	100	100

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed)

4.8.3.4 Construction companies: Spearman rho test analysis of the barriers to the use of OSC in Iraq

This section considers the perspectives of construction company respondents by explaining the results of the Spearman correlation between the barriers to the uptake of OSC in Iraq. The strongest positive correlation is found between the political & economic and logistic & site operation factors, at rho=0.640, p=0.00. Instead, the strongest negative correlation is between the management, and industry & market culture factors, at rho=-0.514, p=0.00.

It appears that the industry & market culture, and political & economic factors represent the most significant barriers to the uptake of OSC in Iraq. This is because both factors have three strong positive relationships, at rho = 0.559. Secondly, they have a significant positive association with logistic & site operation. Furthermore, Spearman rho value is 0.531 for industry & market culture with logistic & site operation, whilst the spearman rho for the political logistic factors is 0.640. The third positive-significant relationship for both the political & economic, and industry & market culture factors is with the skills & knowledge factor, at rho = 0.547 (political & skills) and rho= 0.532 (industry & skills).

Moreover, the skills & knowledge and logistic & site operation factors seem to represent another two important obstacles of the use of OSC in Iraq. This is because these two factors have two a strong-positive relationship with industry & market culture, and political & economic issues. Moreover, the skills & knowledge and logistic factors have medium positive relationships with each other, at rho=0.374. They also share a medium-positive relationship with the supply chain factor, rho= 0.489 (supply plus logistic), rho=0.320 (supply plus skills). However, both the skills and logistic factors share a low-negative relationship with the management factor, at rho= -0.283 (management & skills) and rho= -0.242 (management & logistic).

The supply chain and project complexity factors have a strong positive relationship with each other, rho=0.509, p=0.00. Both factors have a medium to low positive relationship with the following factors: skills, logistic, political, industry and management. However, while the project complexity has a low positive correlation with the cost factor, the supply chain & procurement barrier has a low-negative relationship with the cost factor, at rho= -0.064. These correlation results signify that the project complexity and supply chain factors have a medium impact as barriers to the uptake of OSC in Iraq.

Although the cost factor has four low-medium positive relationships with the project complexity, industry & market culture, skills & knowledge and management factors, it also has three negative relationships with political & economic issues, logistic & site operation, and supply chain & procurement. Therefore, it may be concluded that this factor is less effective in constraining the use of OSC in Iraq.

Similarly, the management factor is most likely to be considered the least influential factor in constraining the uptake of OSC in Iraq. This is because the factor has a negative relationship with the logistic & site operation, political & economic issues, industry & market culture and skills & knowledge factors. However, management barriers has three low-positive relationships, with project complexity, cost, and the supply chain & procurement factors. All these details are illustrated in Table 4-26.

Table 4-26: Construction companies Spearman rho test analysis of the barriers to the use of OSC in Iraq

Correlations										
			logistic & site operation barriers	Project complexity barriers	Cost barriers	Political & economic barriers	Industry & market culture barriers	Skills & Knowledge barriers	Supply chain & procurement barriers	Management barriers
Spearman's rho	logistic & site operation barriers	Correlation Coefficient	1.000	.437**	-.256*	.640**	.531**	.374**	.489**	-.242*
		Sig. (2-tailed)		.000	.010	.000	.000	.000	.000	.015
		N	100	100	100	100	100	100	100	100
	Project complexity barriers	Correlation Coefficient	.437**	1.000	.200*	.455**	.351**	.244*	.509**	.024
		Sig. (2-tailed)	.000		.046	.000	.000	.014	.000	.815
		N	100	100	100	100	100	100	100	100
	Cost barriers	Correlation Coefficient	-.256*	.200*	1.000	-.146	.108	.271**	-.064	.309**
		Sig. (2-tailed)	.010	.046	.	.147	.285	.006	.528	.002
		N	100	100	100	100	100	100	100	100
	Political & economic barriers	Correlation Coefficient	.640**	.455**	-.146	1.000	.559**	.547**	.477**	-.298**

		Sig. (2-tailed)	.000	.000	.147		.000	.000	.000	.003
		N	100	100	100	100	100	100	100	100
	Industry & market culture barriers	Correlation Coefficient	.531**	.351**	.108	.559**	1.000	.532**	.193	-.514**
		Sig. (2-tailed)	.000	.000	.285	.000	.	.000	.054	.000
		N	100	100	100	100	100	100	100	100
	Skills & Knowledge barriers	Correlation Coefficient	.374**	.244*	.271**	.547**	.532**	1.000	.320**	-.283**
		Sig. (2-tailed)	.000	.014	.006	.000	.000		.001	.004
		N	100	100	100	100	100	100	100	100
	Supply chain & procurement barriers	Correlation Coefficient	.489**	.509**	-.064	.477**	.193	.320**	1.000	.090
		Sig. (2-tailed)	.000	.000	.528	.000	.054	.001		.373
		N	100	100	100	100	100	100	100	100
	Management barriers	Correlation Coefficient	-.242*	.024	.309**	-.298**	-.514**	-.283**	.090	1.000
		Sig. (2-tailed)	.015	.815	.002	.003	.000	.004	.373	.
		N	100	100	100	100	100	100	100	100

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

4.8.3.5 Summary of the spearman test

The non-parametric Spearman Rho test was applied to investigate the strength between the factors affecting the adoption of OSC in Iraq. This test was conducted for both groups on the drivers and barriers to adopting OSC in Iraq. For the USECB group, the strongest relationships were found amongst the time, cost and quality drivers. Also, a high positive, significant correlation was found between the time and cost factors, while a low negative correlation was found between the policy and labour factors. In comparison, findings from the construction companies revealed that the highest correlation was found between time and quality, whilst the lowest correlation was noted between environmental and policy. It was found that time, quality, cost, labour, and social are important drivers for the adoption of OSC in Iraq as they have highly significant relationships with other factors.

Furthermore, from the perspective of USECB respondents, the supply chain & procurement factor was found to be the most significant barrier to the adoption of OSC in Iraq. The results revealed that the strongest positive correlation was found between skills & knowledge, and project complexity, whilst the lowest negative correlation was found between cost & management.

Moreover, according to results from construction company participants, it was found that industry & market culture, and political & economic factors represented the most significant barriers to the uptake of OSC in Iraq. Also, the strongest positive correlation was found between political & economic, and logistic & site operation factors. In contrast, the strongest negative correlation was noted between management, and industry & market culture factors.

4.8.4 Kruskal Wallis test

The Kruskal-Wallis H test is the nonparametric alternative to a one-way between groups analysis of variance; it can be used to compare the scores on some continuous variables for three or more groups (Field, 2009; Pallant, 2005). Scores are converted to ranks and the mean rank for each group is compared. Basically, the Kruskal-Wallis test is an extension of the Mann-Whitney test with a design involving more than two independent sample; thus, when k (number of groups)=2,the Kruskal-Wallis one way analysis of variance by rank will yield a result that is equivalent to that obtained by the Mann-Whitney (U) test (Sheskin, 2003; Kruskal & Wallis, 1952). In addition, the Kruskal-Wallis test is applicable to two groups (Broota, 1989). Furthermore, (Weaver et al., 2017) stated that the Kruskal-Wallis test is a common non-parametric test that uses two or more samples and is considered to be similar to the Mann-Whitney U test as it performs comparisons or analyses of independent samples. Weaver et al. added that the Kruskal-Wallis test is most applicable when comparing two or more samples; it aims to determine whether there is an overall difference among various sampling groups, but it lacks the ability to determine where the difference lies between groups (Weaver et al., 2017).

According to Field (2009) and Pallant (2005), the output of this test needs the following pieces of information, which are: the Chi-Square value, the degree of freedom (df), and the significant level (presented as Asymp.sig.). Moreover, if a p-value (Asymp. Sig) is below or equal to 0.05 in the Kruskal-Wallis test, this indicates that there is a significant difference between the groups of participants concerning the affected variable, at a 95% confidence level. Any p-value above 0.05 indicates that there is no significant difference among the groups (Weaver et al., 2017; Field, 2013; Corder & Foreman, 2009; Field, 2009; Pallant, 2005) .

Based on these references, the researcher applied a Kruskal-Wallis test to determine whether there is a significant difference between the sample of construction companies and the sample from the universities' scientific & engineering bureau concerning the drivers and barriers in using OSC in Iraq aligned with objectives of this research.

4.8.4.1 Comparison of the drivers to the use of OSC for both groups using the Kruskal-Wallis test

Table 4-27 illustrates the Kruskal-Wallis non-parametric test that investigates whether there are any differences between the two samples (construction companies' and universities scientific & engineering consulting bureau) regarding the drivers of using OSC in Iraq. The Kruskal-Wallis null hypothesis is determined as follows:

E1= there is no significant difference between the two groups of participants on the affected variable time factor at a 95% confidence level

E2= there is no significant difference between the two groups of participants on the affected variable quality at a 95% confidence level

E_3 = there is no significant difference between the two groups of participants on the affected variable cost factor at a 95% confidence level.

E4= there is no significant difference between the two groups of participants on the affected variable productivity& market factor at a 95% confidence level

E5= there is no significant difference between the two groups of participants on the affected variable labour factor at a 95% confidence level

E6= there is no significant difference between the two groups of participants on the affected variable social factor at a 95% confidence level

E7= there is no significant difference between the two groups of participants on the affected variable environmental factor at a 95% confidence level

E8= there is no significant difference between the two groups of participants on the affected variable policy factor at a 95% confidence level

Table 4-27: Comparison of the drivers to the use of OSC for both groups using the Kruskal-Wallis test

No.	Factors	Mean rank		Kruskal-Wallis H	Asymp. Sig./ p value	Accept or reject null hypothesis
		Sample 1 (USEC B)	**Sample 2 (CC)**			
Hypothesis E1	Time drivers	99.15	101.85	0.116	0.733	accept
Hypothesis E2	Quality drivers	91.78	109.23	4.889	0.027	reject
Hypothesis E3	Cost drivers	97.15	103.85	0.699	0.403	accept
Hypothesis E4	Productivity & Market drivers	93.04	107.97	3.431	0.064	accept
Hypothesis E5	social drivers	87.42	113.59	10.697	0.001	reject
Hypothesis E6	Labour drivers	97.71	103.29	0.496	0.481	accept
Hypothesis E7	Environmental drivers	100.25	100.75	0.004	0.949	accept
Hypothesis E8	Policy drivers	93.76	107.24	2.766	0.096	accept

According to the results, there are no significant differences between the two samples regarding the following factors: time, labour, cost and policy, environmental and productivity & market drivers. This is because the (Asump. Sig) of the Kruskal-Wallis test for all these factors is > 0.05 and this means that both groups agree on the significance of these factors in driving the use of OSC in Iraq. However, there are significant differences between both samples for the quality and social factors as the p-values are below 0.05.

The Kruskal -Wallis result for the time factor is x^2 (1) = 0.116, p=0.733. As p (0.733) >0.05, which means the participants in each group agreed on the importance of the time factor in driving the use of OSC in Iraq. It is worth noting that the mean rank of the time factor for construction companies' respondents is quite close to that of the academic respondents' group, which are 101.85 and 99.15 respectively. The agreement of both groups on the time certified the drivers that the factor can offer in terms of decreasing the overall project time, promoting a rapid construction time and enabling greater certainty on the completion time.

Another significant factor on which both groups agreed its importance is the cost factor. The Kruskal-Wallis test result is x^2 (1) =0.699, p=0.403, the calculated p-value is > 0.05 level. This illustrates that there is no significant difference between the participants from construction companies and academic respondents regarding the cost factor as a driver to the uptake in using OSC in Iraq. Also, the mean rank of the cost factor is close for both groups: 103.85 construction companies and 97.15 academic scientific & engineering consulting offices. This also clarified the importance of cost related drivers, including minimising maintenance and replacement costs, reducing construction costs and minimising the overall life-cycle cost in driving the use of OSC in Iraq.

Furthermore, the Kruskal-Wallis results for the labour factor is x^2 (1) = 0.496, p=0.481> 0.05. This means both groups agree on the labour factor as a driver for using OSC in Iraq. In addition, the mean rank of the academic groups is close to the mean rank of the construction company group, which are 97.71 and 103.29 respectively. This result certified the drivers that a labour factor can offer to OSC in Iraq, such as the increased productivity of labour when using OSC. Also, the use of OSC leads to a reduction in the number of workers for onsite construction activities and improves the management and coordination among people at the site.

The other influential factor driving the use of OSC in Iraq is policy. The policy related drivers include the importance of revisions to building regulations to support the use of OSC, and the government promotion and availability of standards and codes to cover all stages of the project.

According to the Kruskal-Wallis test, the policy factor shows an agreement amongst both Iraqi construction companies' respondents and academic participants as a driver for using OSC in Iraq. The results of the Kruskal- Wallis test is x^2 (1) = 2.766, p=0.096 which is > p (0.05).

Similarly, environmental, is found as significant factor driving the use of OSC in Iraq. The Kruskal-Wallis value for the environmental factor is x^2 (1) = 0.004, p=0.949, as the p-value is above 0.05 which indicated that there is no significant difference between the two examined groups about the environmental factor. OSC can largely reduce the waste of materials as it mainly adopts factory manufacturing and can reduce the use of resources onsite, such as water usage. Also, the use of OSC can reduce the impact to the surrounding environment, such as reducing dust and noise during construction as a result of prefabricated materials and a reduction of the activities required on-site. Moreover, the adoption of this method of construction can lead to a decrease in the energy required during construction and throughout the building usage

Furthermore, the Kruskal-Wallis test results for productivity & market factor is x^2 (1) =3.431, p=0.064 since the calculated p-value is above 0.05. Therefore, this illustrated that there is no significant difference between two examined groups concerning the productivity & market factor. The issues associated with housing shortages are increasing globally and particularly in Iraq. Such housing problems is usually caused by increased population, a drop in supply, an inability to provide affordable housing. However, in Iraq, the shortage of housing is not only impacted by these reasons, but also as a result of the disasters that have impacted the country; this has exacerbated the housing shortage problems in this country. OSC can overcome this problem due to its ability to mass produce housing in a short time, which may also offer affordable houses. Therefore, the agreement on the productivity & market factor was high from both groups of participants.

The other remaining drivers include quality, and social shows a difference between participants from both groups. For example, the quality factor is x^2 (1) = 4.889, p=0.027, which is less than 0.05; this means that there is a significant difference between the two groups of participants on the affected variable, namely the quality factor, at a 95% confidence level. However, the lack of agreement between the two groups regarding the quality factor does not mean that this is not a driver of OSC in Iraq, as this can reflect in people opinions, which often accord with their experiences. Also, the slight difference between the mean ranks for both groups, which are 91.78 (academic) and 109.23 (construction companies), do not show a huge disagreement between the two groups. Moreover, x^2 (1) =10.697, p=0.001, since the calculated p-value < 0.05, this means that there is a significant difference between the two groups about the social driver.

Thus, the lack of agreement amongst the factors from both groups does not mean that these factors are not important in driving the use of OSC in Iraq. The results of the Kruskal Wallis test only illustrate whether there is a difference in a particular factor among the selected groups. At the same time, the mean rank associated with this test shows the agreement on a particular factor, but sometimes the amount of agreement is not as much as the other group. Also, this can be supported by this argument that there are no major differences to the mean ranking for both groups regarding the insignificant factors determined by the Kruskal- Wallis test.

4.8.4.2 Comparison of the barriers to the use of OSC for both groups using the Kruskal-Wallis test

This section describes the outcomes of the Kruskal-Wallis test regarding the barriers to the use of OSC in Iraq by combining the views of the two groups, namely the construction companies and USECB.

According to the results of Kruskal-Wallis test shown in Table 4-28, there are no significant differences between the various stakeholders in both groups regarding the significance of the following barriers: logistic & site operation, industry & market culture, and skills &knowledge. This is because the calculated p-value for these factors is above 0.05. Moreover, the null hypotheses of Kruskal-Wallis test for the barriers are as follows:

F1 = there is no significant difference between the two groups of participants on the affected variable logistic & site operation factor at a 95% confidence level

F2 = there is no significant difference between the two groups of participants on the affected variable project complexity at a 95% confidence level

F3 = there is no significant difference between the two groups of participants on the affected variable cost factor at a 95% confidence level.

F4 = there is no significant difference between the two groups of participants on the affected variable political & economic factor at a 95% confidence level

F5= there is no significant difference between the two groups of participants on the affected variable industry & market culture factor at a 95% confidence level

F6= there is no significant difference between the two groups of participants on the affected variable skills & knowledge factor at a 95% confidence level

F7= there is no significant difference between the two groups of participants on the affected variable supply chain and procurement at a 95% confidence level

F8 = there is no significant difference between the two groups of participants on the affected variable management factor at a 95% confidence level.

Table 4-28: Comparison of the barriers to the use of OSC for both groups using the Kruskal-Wallis test

No	Factors	Mean rank		Kruskal-Wallis H	Asymp. Sig./ p value	Accept or reject null hypothesis
		Sample 1(USECB)	**Sample 2 (CC)**			
Hypothesis F1	Logistic & site operation barriers	97.16	103.84	.677	.411	accept
Hypothesis F2	Project complexity barriers	115.94	85.06	14.857	0.000	reject
Hypothesis F3	Cost barriers	111.74	89.26	7.692	0.006	reject
Hypothesis F4	Politic & economic barriers	91.60	109.40	4.933	0.026	reject
Hypothesis F5	Industry & market culture barriers	94.56	106.44	2.144	0.143	accept
Hypothesis F6	Skills & knowledge barriers	97.32	103.68	0.637	.425	accept
Hypothesis F7	Supply chain & procurement barriers	122.56	78.44	29.587	0.000	reject
Hypothesis F8	Management barriers	108.84	92.16	4.247	.039	reject

Regarding the logistic & site operation, the Kruskal-Wallis test result is x^2 (1) =0.677, p= 0.411, which is > 0.05. This means that the there are no significant differences between the two groups of participants for the logistic and site operation barriers. It also indicates that, when there are unsafe places to consider, this can restrict external parties and thereby hinder the use of OSC. It can also be noted that other restrictions, such as site layout, space size, access and storage, may impede the use of OSC in Iraq. Moreover, it shows that the difficulties in transporting the components from factory to site can cause problems in processing or implementing, and thus can delay the use of OSC in Iraq.

According to Kruskal-Wallis test, another significant barrier is the industry and market culture barrier, which is shown by the chi-square value, which is x^2 (1) = 2.144, p=0.143, thus > p (0.05). Therefore, this clarifies that there is no significant difference between the two samples for the industry & market culture barrier. The participants from both samples agreed on the limited of acceptance of OSC, which may be due to a negative image that developed from past attempts to apply OSC. Also, another barrier be impacted by clients who may hinder this type of construction as they prefer traditional finishes and custom-made products Also, difficulties in obtaining a formal approval for this type of construction seems to impede the use of OSC in Iraq.

The skills & knowledge factor is a significant barrier that was agreed by both groups. Thus, x^2 (1) =0.637, p=0.425, which >0.05. The mean rank for the academic group of respondents was 97.32, which is quite close to mean rank of 103.68 for the construction companies' group. According to this result, there is no doubt that a lack of knowledge, awareness and experience has an important effect on hindering the use of OSC in Iraq. Also, the lack of research and development for this type of construction can impede its use. In addition, a lack of skilled workforce hinders its implementation in Iraq.

In contrast, there is a significant difference between the two groups of participants concerning the following variables: project complexity, cost, political & economic, supply chain & procurement and management. This is because the p value of the Kruskal-Wallis test for these factors is below 0.05. Although there is disagreement on these factors between both groups, it does not mean that they are not barrier; instead, it may signify that the degree of impact is different between the selected groups.

It is worth to mentioning that there is a significant difference between the groups for supply chain & procurement barrier: x^2 (1) = 29.587, p= 0.00, which is < p (0.05). Therefore, the null hypothesis F7 is accepted. This difference can be also noticed between the mean rank of both groups for which the academic respondents mean rank at 122.56 is much higher than that for the construction companies' respondents, at 78.44. This means that academic participants consider the supply chain more of a barrier to the use of OSC than construction companies. Thus, from theoretical and practical side, the supply chain & procurement can represent an important barrier if not dealt with effectively. This is because every activity in an offsite project is related to the others, so any defects resulting from one activity could lead to delay and risk in completing the project. In addition, in some cases, the industry's capacity to supply diverse OSC materials is limited due to a lack of infrastructure and materials and the occasional mixing of OSC and onsite work in one project, which can generate complex financial administration. Nevertheless, in the Iraqi industry, there is a significant difference in opinion between the selected groups about the supply chain & procurement as a barrier.

However, the management factor shows a close mean rank between two groups, namely 108.84 for the academic consultants' group and 92.16 for the construction companies. However, the Kruskal-Wallis test result is x^2 (1) =4.247, p=0.039, which is < 0.05. This means that there is a significant difference between the two groups of participants on the management factor. There is no doubt that ineffective management can lead to risks in processing any project. The results from the construction companies indicate a bit of disagreement on this factor, which indicates that the academic consultants seem to be more concerned that management hinders the use of OSC in Iraq. This difference may be because construction companies are keener on the financial than the management aspects.

Similarly, the political & economic factor Kruskal-Wallis result is x^2 (1) = 4.933, p=0.026, which is less than 0.05. This means that there is a significant difference between the two groups of participants on the political & economic factor at a 95% confidence level. However, it is noticeable that the mean rank for both groups is close. Also, it is noted that the construction companies group scores a higher mean rank than the academic consultants' group, namely 109.40 and 91.60 respectively. Usually, people who are more involved in the whole project and especially in onsite operations are the most likely to be affected by political and economic issues in the industry; this may explain why construction companies are slightly more likely to consider this factor as a barrier

The results for the cost factor not only show the significant differences between the participants of both groups in terms its effectiveness as a barrier, but also indicate a lower acceptance amongst construction company participants than USECB participants. The construction company participants are likely to be more familiar with the complete process of an offsite-manufacturing project than academic participants. The results are indicated as follows: x^2 (1) = 7.692, Asymp. sig= 0.006, which is < p (0.05). Moreover, the mean rank for the cost factor, amongst construction companies' respondents is 89.26, which is less than the 111.74 mean rank for academic consultant respondents.

Lastly, according to Kruskal-Wallis results, a significant difference is shown between the two groups for the project complexity factor. The result is x^2 (1) = 14.857, p=0.00, which is less than 0.05. The construction companies' group mean rank is 85.06, which is less than mean rank of 115.94 for the academic consultants 'group. Thus, this difference could be explained by considering that the role of academic consultants may mainly on design issue. Also, a project's legal framework requirements may not represent a big issue for some big construction companies related to the government in the Iraqi industry.

4.8.4.3 Summary of Kruskal Wallis test

A Kruskal-Wallis test was applied to determine whether there are any differences between both participant groups regarding drivers and barriers to the adoption of OSC in Iraq. The findings of the test indicate that there were no significant differences for construction companies and USECB participants regarding the following factors: time, cost, environment, labour, productivity & market, and policy. However, the results show differences between both groups regarding social and quality factors, as construction companies gave more positive responses than the USECB. This could be attributed to their different types of engagement with the sector, as the CC group is more likely to be involved in the practical side of construction than the USECB group. Moreover, drivers related to the social and quality factors are most likely to be affected by the construction team and by the nature of such companies. Thus, if construction companies are reliable and demonstrate relevant expertise, this will help to enhance the project performance in terms of its cost, time, quality, safety and environmental. Moreover, the existence of trustworthy leadership and skilled teamwork with a high level of cooperation and skills between members of a team can improve safety, quality, cost and time performances.

Furthermore, the Kruskal-Wallis test revealed no significant differences between the construction company and USECB groups on the following barriers: logistic & site operation, industry & market culture, and skills & knowledge. The other barrier's factors, including political & economic, management, cost, supply chain & procurement and project complexity, show differences between the groups. Construction companies are more likely to be affected by barriers related to political & economic and cost factors than the USECB, as these factors need to be aligned throughout the whole project. Therefore, construction companies are more familiar with the whole project than their academic counterparts, whose responsibilities may perhaps focus more on the design stage.

The other factors related to supply chain & procurement and management demonstrated a greater level of agreement for the USECB than for the construction companies. The USECB responses can be evaluated from a logical perspective in that, from both a theoretical and practical view, the supply chain & procurement factor represents an important barrier if not dealt with effectively. Thus, every activity in an offsite project is related to the others, so any defects resulting from one activity could lead to delay and risk in completing the project. Moreover, in order to achieve optimal results, an efficient management system is very important in any construction project. The lower level of agreement from construction companies may attributed to an understanding that management is not as important as other factors, such as cost and people acceptance. However, the barriers related to this factor may still hinder the use of OSC in Iraq, as any deficiencies and mismanagement when dealing with OSC project can lead to negative results, which in turn can increase the negative image of this type of construction. Finally, there were differences between both groups for project complexity, which could be explained by the assumption that a project's legal framework requirements may not pose a big issue for some big construction companies working with the Iraqi government

4.8.5 Conclusion

This chapter revealed the descriptive and statistical results of the questionnaire data analysis. The researcher conducted a questionnaire survey to explore the nature and extent of current OSC practices in construction organisations in Iraq. The researcher approached two groups, construction companies and universities scientific & engineering consultants bureaus (USECB) for their involvement in the survey. The first section of the chapter discussed the descriptive results of the data collection and included the profiles of the participants for each group.

From the findings, and with a high responses rate of 84%, it was noted that the USECB group believe that the use of OSC will increase in Iraq in the forthcoming years. Also, a good percentage of this group (58%) were willing to use this type of construction if they had a chance. The participants from this group were involved more in residential projects than in any other type of construction. This group also used modular building more than other system of OSC. Moreover, 66% of construction company participants also believed that the using of OSC would increase in the forthcoming years. However, 48% were willing to use OSC if they had a chance. The construction companies' participants agreed with the USECB participants in supporting the use of OSC in Iraq. Similar to USECB group responses, the construction companies also tended to use a modular building system and to applied OSC more to residential projects than any other construction.

Moreover, the descriptive analysis illustrated that most respondents from both groups agreed that the following factors encourage the use of OSC in Iraq: reducing the overall project time, producing a high volume of mass units in short time, and ensuring a speed of construction.

Furthermore, both groups agreed on the following barriers to the use of OSC in Iraq such as higher transportation costs for OSC when long distances are involved, and barriers related to skills & knowledge. However, the USECB respondents agreed on the following barriers to the adoption of OSC in Iraq: a limited industry capacity to supply diverse varieties of OSC, the need for a firm control of supply chain when adopting OSC, and. In comparison, most of the construction companies' respondents indicated that variables, such as a client's desire for traditional construction and custom-made products, unstable market conditions and financial fluctuation represent barriers to the use of OSC in Iraq. Nevertheless, the respondents from both groups less agreed that the following represented a barrier to the use of OSC in Iraq: which is OSC is more expensive than traditional construction.

To further analyse the statistical results, the Chi-Square for Independence test was implemented to investigate the significance of the relationships between the factors affecting the use of OSC in Iraq. Findings from the Chi-Square for Independence test for construction companies indicated a significant relationship between all the drivers. In comparison, USECB believe that there is no significant relationship between environmental and the quality and cost & environment factors. Also, they believe there is no significant relationship between the labour and policy drivers. However, findings from the same test found significant relationships between all the barriers for both groups.

The Spearman test was also conducted for both groups on the drivers and barriers of using OSC in Iraq. For the USECB group, the Spearman test for the drivers, found the strongest relationships amongst the time, cost and quality factors. Also, the most positive significant correlation was found between the time and cost factors, while the most significant negative correlation was found between the legislation and labour factors. In comparison, findings from the construction companies revealed that the highest correlation was between the time and quality factors. Meanwhile, the lowest correlation was noted between the environmental and policy factors. It was found that time, quality, cost, labour and social are important drivers for using OSC in Iraq.

Furthermore, and from the perspective of USECB respondents, the supply chain & procurement factor was found to be the most significant barrier to the use of OSC in Iraq. The results from this group revealed that the strongest positive correlation was between the skills & knowledge and project complexity factors. Instead, the lowest negative correlation was found between the cost & management barriers.

Moreover, according to the construction companies' results, it found that the industry & market culture and the political & economic factors represented the most significant barriers to the uptake of OSC in Iraq. Also, the strongest positive correlation was found between the political & economic, and logistic & site operation factors. In contrast, the strongest negative correlation was noted between the management, and industry & market culture factors.

Finally, a Kruskal-Wallis test was applied to determine whether there are any differences between both groups of analysis regarding the drivers and barriers in using OSC in Iraq. The findings of the test indicated that there were no significant differences between the construction companies and the USECB regarding the following factors for the use of OSC in Iraq: time, cost, environmental, labour, productivity & market, and policy. Moreover, the Kruskal- Wallis test revealed that that there are no significant differences between the construction companies and USECB on the following barriers to the use of OSC in Iraq: logistic & site operation, industry & market culture, and skills & knowledge. Next chapters will analysis the interview results, then after, a discussion chapter will be applied to explain the drivers and barriers of using OSC in Iraq and their relationships in more details.

Chapter 5 Qualitative analysis

The previous chapter presented the quantitative data analysis findings with regard to the construction industry's perception and concerns with regard to OSC. However, the quantitative data analysis was mainly concerned with the breadth rather than the depth of this study. Therefore, this chapter will gain a deeper understanding about the drivers of using OSC in Iraq and the potential barriers regarding its uptake. It will also be explored some good practise to enhance the OSC implementation. This chapter presents the qualitative data analysis from a primary data sources represented by 14 open-ended interviews, which were carried out with individuals holding various positions and with varying levels of experience. A list of the participants is provided (initials are used to ensure confidentiality).

The researcher arranged to meet interviewees in quiet and familiar locations that were conducive to reflective thought. All interviewees possessed previous knowledge of OSC. Following a brief introduction concerning the research background and its primary objectives, the researcher commenced the interviews, which were also audio-recorded. All interviews were then transcribed and analysed within NVIVO. The interview data was analysed, and a number of themes and sub-themes were revealed in relation to the drivers and barriers to using OSC in Iraq. Also, the interviews explored interviewee recommendations regarding the development of the use of OSC in Iraq.

Profile of the Interviewees

The following table outlines the information concerning the interviewees who took part in the semi-structured face-to-face interviews or through Skype. The 14 individuals collectively represent various levels of management. Their job title and experience in construction also is illustrated in table 5.1

Table 5-1: Description of Sample Interviewees

Code	Job	Experience (years)	Educational and Employment Backgrounds
E1	Director and Contractor	38	PhD Mechanical Engineering: Private company, Baghdad
E2	Design Manager	39	PhD Civil Engineering: Manufacturing Design Manager, Government company, Baghdad and Mosul

E3	Consultant	40	Masters: Energy Engineer Manager, Government company
E4	Director	30	PhD in Civil Engineering: Director of a private company, Basra
E5	Contractor and Manager	18	Civil Engineer, Basra
E6	Supervisor Engineer	20	Master's in mechanical engineering, Messan/ South Iraq
E7	Consultant	34	PhD Civil Engineer/Academic: Baghdad University
E8	Consultant	35	PhD Civil Engineer/Academic: Technology University
E9	Consultant	37	PhD Civil Engineer/Academic: Baghdad University
E10	Contractor	32	Civil Engineer: Private company, East Iraq
E11	Engineer	17	Civil Engineer: Tikrit
E12	Consultant and Contractor	30	Civil Engineer: Government company, Baghdad
E13	Engineer	20	Civil Engineer/Academic: Technology University
E14	Contractor	22	Engineer: private company, Baghdad and South West Iraq.

5.1 The Drivers for using OSC in Iraq

This section will discuss the drivers of using OSC in Iraq according to the interviewee's responses. The figure 5.1 illustrated the drivers of using OSC investigated for this research

DRIVERS

Name	Files	References
Policy drivers	14	66
Social drivers	14	46
Productivity & Market drivers	14	45
Environmental drivers	14	33
Labour drivers	14	33
Cost drivers	14	32
Quality drivers	14	31
Time drivers	14	22

Figure 5-1: Drivers for using OSC in Iraq

5.1.1 Time related drivers

Time related drivers' being mentioned in the literature and investigated in this research are: Reduce the Overall Project Time, High speed of construction and ensuring time certainty. All participants agreed on the importance of time related drivers in enhancing the adoption of OSC in Iraq. Figure 5-2 illustrated time drivers investigated in this research.

Name	Files	References
Time drivers	14	22
Reduce the overall project time	9	10
Speed of construction	10	10
Ensuring time certainty	8	8

Figure 5-2: Time drivers

One of the key implications for OSC is speed; Interviewee E13 indicated that, "*The primary objective of using OSC is to accelerate construction*". Furthermore, interviewees E1, E2, E4, E5, E11 and E12 indicated that the implementation process within a construction unit is very quick compared to traditional construction. Meanwhile, interviewee E4 declared that, "*Time is [a] very important factor as a promoter of the use of* OSC *because of the speed in the* *implementation of all kinds of buildings, especially if the customer needs quick solutions, time will be an important factor in the project*". Although, interviewee E8 agreed with the advantage of speed construction when using OSC compared to traditional construction, he argued that, "*the speed of construction can only achieve if the construction elements, like slabs, columns, are available and their supply ... continues; then the erection will be fast. Otherwise [you] need to wait for production*".

Moreover, the reduction of the overall project time drivers is also agreed by the interviewees. Interviewee E10 stated that a "*fast implementation is achieved when using OSC because the required stages of work are [fewer], and savings in ... time of a project reach[es] up to 50% compared to ... normal construction method, and thus in turn made OSC a successful alternative solution to the more costly and long-term traditional construction*". Interviewees E6 and E14 attributed the short schedule duration to the pre-fabrication of OSC products under quality control environment which means less defects can occurred onsite which in turns lead to enhance time performance, whilst interviewee E6 stated that, "*less duration is achieved for OSC compared to [the] classic one as the last depends on some factors like market and the availability of workers.*"

The interviewees have some different argument about the driver of time certainty, E3 and E6 indicated that the certainty regarding the completion time could be only achieved when there was an existing, reliable plan with appropriate cash flow. E3 commented that, "*the completion date of the project can be ensured if an organised effective plan of work have been made previously*". Also, E2 added that, "*to ensure the timely completion of the project, it needs initial preparation like a site preparation done by the site engineer and experienced technical staff*".

However, interviewee E9 thought that the predication of the completion time would be achieved when using OSC "*because the processes of OSC activities are clear and organised and repetitive*". Moreover, E14 declared that, "*the duration of [the] project schedule can be planned and achieved so that the project ends in the time agreed unless uncontrolled conditions can ... occur*". In the same way, E13 pinpointed that "*even if there are unexpected events in [the] work of OSC, they are few and calculated, while the traditional construction [has] 50 unexpected events per hour, the length of the normal construction [is] longer and unplanned events are more and unexpected*". He added that, "*Originally, if we want to stick to time, we will use* OSC". Interviewee E8 also mentioned that "we can control the time in OSC more than … in the classic one".

Indeed, one participant (E7) stated that "*time is one of the important three principles in the construction industry which are time, cost and quality factors*". This finding resonates with those from the literature review in that stakeholders in the construction industry mainly focus on time, quality and cost as priority factors in construction projects.

Accordingly, the time-related drivers investigated in this study are generally agreed by most of the interviewees. The speed of construction is an important driver for the use of OSC in Iraq. Another important driver emphasised by interviewees is the reduction of overall project time; they believe that an OSC project schedule is shorter than that for traditional construction. They justified this by explaining that the use of OSC requires fewer stages due to less risk of defects occurring onsite as a result of the high-quality products manufactured in closely controlled environments. Another driver is greater time certainty; although interviewees did not mention it as a driver, they believe that this time certainty is enabled through the mandatory, previously arranged optimal plan for a project. Moreover, some believe that unexpected events within this construction method are less likely than traditional construction and are most likely to be controlled. One of the interviewees believed that certainties in time completion are achieved due to the repetitive and organised process of activities associated with OSC.

Hence, interviewees agreed that time enhances the drive to adopt OSC in Iraq. In fact, as found in the literature review, Iraq requires time related drivers in its rehabilitation stage in order to meet the need for houses, schools, hospitals, and so forth. However, in order to achieve this time performance, stakeholders need to investigate any obstacles that can negatively affect this performance.

5.1.2 Quality related drivers

The other important elements in the construction project is quality. There are some quality related drivers that affect the use of OSC being explored in the literature including: achieving high quality; Quality control review during manufacturing process and site assembly, OSC products are less defects than traditional construction products.

Accordingly, Figure 5.3 demonstrated the quality drivers of using OSC in Iraq.

Quality drivers	14	31
Durability	13	27
Acheiving high quality	13	22
Quality control review	8	10
OSC products are less defects	8	8

Figure 5-3: Quality drivers of using OSC in Iraq

Almost all interviewees ascertained the driver of achieving high quality of products when using OSC. Interviewees E1 and E3 believed that the organised and effectively calculated steps with proper time for implementing them, both in a factory and onsite, lead to high quality gains of OSC project. Interviewee E1 stated that, *"the high quality will be obtained [by] using OSC, contrary to ordinary construction in which more stages are involved and each stage is more complex than other, so you need to be very accurate in the implementation of ... traditional construction, while the stages of OSC are regular and known; ... technicians and workers are trained and experienced, therefore the quality is better."* Interviewees E3, E5 and E13 further believe that the high quality of OSC products relate to their manufacture to particular, *"technical and engineering plans and specifications"*. Interviewee E3 pointed out,

> *"... the obtaining. of high quality of products when using OSC as a result of manufacturing according to special measurements and systems, like ... mixing ratios of materials ... within carefully calculated engineering measures, which is unlike traditional construction; the mixing process is done for the purpose of casting".*

In similar way, interviewee (E10) mentioned that *"There is high efficiency [within] the construction unit because it is pre-installed in factories under the control of high quality and designed under high technology".* E2 further justified the high quality of products in the *"... products of OSC manufactured without any industrial defect; they do not have a tendency and do not require a spray process and plastering, therefore, OSC products ensures high quality."* Although this opinion has been noted within the literature, this cannot be true all the time, as faults can occur in any type of product. However, a high percentage of faults or defects can be eliminated due to the manufacturing process, which involves greater control and thus increases the likelihood that faulty products will be rejected before transportation. It is worth mentioning that the interviewee who suggests this is a Design Manager of OSC manufacturing, who may strongly believe that faulty products are rejected in the factory.

E8 and E3 emphasised that the effective environment in a factory, like safety manuals, quality control and security manuals lead to the achievement of high-quality products. E8 explained that, *“,,, the construction elements ... made in a factory are under high control and the environment conditions in there are suitable for good achievement, more than [in] traditional construction, so we get high quality”.* However, E8 believed that there is a lack of quality monitoring from the implementation team. He clarified that,

> " *Actually, we do not monitor the quality of products perfectly, as sometimes some products are coming with defects because there is no observed engineer in the factory and usually the factory is owned by a contractor. So we need to have an observed engineer appointed from the owner of the work to stay in a factory and be responsible for monitoring quality so he can refuse the defective products in a factory before it [is] transported to the site to avoid increase cost[s] and delay[ed] work”.*

In similar way, E4 mentioned that “*The quality of the OSC is better than normal construction but depends on the management team ... high quality, good durability and good final finishes can be obtained when good training for the executing staff is provided*”. This can be explained the contrasting opinion offered by E11, who stated that “*the quality of OSC is good, but in Iraq the attempts are poor because some companies import the worst products and the method of implementation they use is not good and the workers have not got good experience in this area*".

Most of the interviewees indicated that OSC products have fewer defects than traditional construction. E6 stated that,

> *“... the products of OSC [have] less defects than ... old construction because it [is] manufactured in advance in the factories according to specifications and measurements of precision engineering, and the fact that [there is] the intervention of machines and equipment in the manufacture of them and not human hands.*”

Moreover, E11 agreed that OSC products have fewer defects than traditional construction products; however, they also stated that, “… *it must be subject to the standards and specifications approved*”. In the same way, E7 indicated that, “*defects are less than [in] ... classical construction, but other technical problems can happen, but it can deal with different treatments, especially joints*”. However, interviewee E12 also pinpointed that,

> *“Generally, OSC projects require minimum finishing requirement[s] for the walls and roofs due to the good quality control and immediate repair in the factory. Mostly, such walls and roofs will have only paints as a finishing item. The most important finishing item in precast concrete is the joints, especially in the exterior wall. This requires special care in the selection of proper types of sealant, width of the joints, time of the year for filling the joint with the sealant (generally the coldest period of the year when the*

> *concrete has contracted and the real size of the joint is achieved so the right depth to width relation of the sealant is met. So, if the joints treated carefully by good cadres the predictability of good quality and performance will be high".*

E5 also illustrated that, "*we can have good finishing when using OSC as some activities like plastering is not need; however, the joints have to be treated carefully to prevent any defects [that] can occur… and the problem of joints [can] start… to be solved by closing the gaps and using good treatment*".

The predication of the time and quality performance of the project can be high. E13 believed that, *"... it is possible to predict the result of the project because its highly controlled and the uncertainty and risk is low with using an OSC system*". Interviewees E6, E9, E10, E12 and E14 confirmed that the quality and time performance results are predictable and improved due to the fact that OSC steps are implemented through organised work that involves clear repetitive processes and high quality products which in turns leads to productivity improvement.

Interviewee E5 illustrated that "*One of the advantages of OSC is it's previously calculated and organised; it is more organised than classic construction. According to this, and with the availability of reliable companies with trained cadres, we can expect performance quality and the life cycle of the building*". E1 also declared that, *"... if the implementation companies are reliable and solid and their cadres are highly trained, you can expect the quality and time performance results which consequently enhancing the performance of project productivity*". The availability of well-trained cadres is also illustrated by E9 who insisted that, "… *the results of time performance and quality improvement can be expected by 90% if such cadres are available for implementation*". Meanwhile, E3 insisted that, "*we can predict the results 100% because the quality is under control, the steps are previously known, organised and controlled and repetitive*". E2 justified the ability to predict the performance of the project; *"... in the design stage, we can make the required plan to obtain the good quality and performance, and the life cycle is predictable as well"*.

However, interviewee E4 has a different opinion.

> "*In Iraq it is difficult to expect anything because you need a crystal ball to do that as you do not know what changes are possible to happen. For example, the Ministry agrees with you for doing a project, then the Minister changes and a new one comes who has a different view, and so on. Unfortunately, nowadays there is no clear vision*".

Durability and strength are drivers related to the quality mentioned by the interviewees in which durability is the ability to last for a long time without significant deterioration. E2 participant believes that *"… precast concrete is very a strong material that has a long life span*"; however, the only associated problem is that it is hot during summer especially in Iraq, so that the factories starts to include insulation but the insulation is expensive, so that they use light weight concrete to overcome cost. Interviewee E12 also highlighted the high durability of precast concrete

> "*… because it is generally subjected to good quality controls in the factory. Also, due to the use of concrete admixtures, which improve its workability and ensure proper consolidation, this enables its density and permeability. Thus, concrete itself is a durable product but its durability can be further improved with water repellent paints, like acrylic, but I do not think it is resistant to earthquakes*".

However, E1, E5, E6, and E14 believe that OSC products are durable and resistant to disasters, such as earthquakes, but need to be implemented by reliable and sufficient companies. E6 further added that, *"…the structure of offsite products is usually very good quality and its resistance to weather conditions, like strong wind, and the associated insulation is very good*" E6, E8 and E13 attributed the high durability of such products to high quality control; therefore, it needs less maintenance. E8 further added that, *"… the implemented companies need to have experience in dealing with joints, so needs high skills in implementation*". E4 and E9 agreed on the durability of precast concrete and E4 further indicated that the "*durability of precast concrete is better than traditional construction because of the high quality and accuracy*". In the same way, E10 pinpointed that,

"*These buildings can endure for decades without any problems, and the tests proved steadfast when they are built in a wet environment with a lot of rain and thus provide citizens with a lot of money that may be spent in the process of restoration and repair. The use of prefabricated construction in the construction of houses instead of the traditional method … as these methods give buildings strength, durability, flexibility and resistance to combustion and adaptation to climate change*".

E5 and E8 illustrated another point, where the products of OSC can be designed to face natural disasters, fire, explosions, and this depends on the materials included in the insulation. E5 commented that the "*precast concrete or steel walls and panels are usually resistant to fireworks and the life cycle of precast is longer than it would be in traditional construction*". E14 further indicated that, *"… the durability and strength in OSC is usually better than classic construction, and if we need very high durability and strength, the cost will be increased, the construction can be designed according to the desire of the clients … OSC buildings … done in Iraq in 70s are still in existence and strong*"

E7, E11 and E12 highlighted an important point on which they agreed that OSC products, especially precast concrete and steel, are durable and strong but they should be not misused; with appropriate use, this product can have a life cycle of up to 80 years. Moreover, E11 and E12 believe in the durability of OSC buildings, but they have concern on its use. They noted that, in Iraq, there is, *"… a problem of [a] lack of knowledge and awareness about this type of buildings and its requirements [in order] to … survive for a long time, so the less knowledge people have about it, the more they misuse it*".

Therefore, it seems that interviewees in the Iraqi construction industry acknowledged the related drivers of quality when using OSC. These include achieving high quality through quality control reviews within the manufacturing and site assembly processes; thus, OSC products tend to have fewer defects than traditional construction and thereby offer more durable products. As the literature review shows, the construction industry worldwide has called for new methods of construction to enhance quality; therefore, quality can be a significant driver for the use of OSC in Iraq, and address deficiencies in the quality performance of classic construction. However, according to both interviewees and the literature review, in order to achieve the best quality performance results, some aspects need to be addressed, such as, reliable companies for implementation, skilled labour and a well-planned and managed project. Moreover, special care has to be taken with the joints between components, whilst teamwork requires the selection of appropriate materials to fill the joints and scheduling at the appropriate time of the year, otherwise problems can occur that affect the quality of the finished product. Also, it is recommended that the owner allocates an observer engineer to monitor products in the factory before transporting.

Furthermore, interviewees indicated another driver related to quality, which is the durability and strength of OSC to withstand environmental impact. However, some indicate that, in order for these buildings to survive for a long time, users have to understand how to appropriately engage with them.

5.1.3 Cost related drivers

The cost related drivers obtained from the literature are: Minimizing maintenance and replacement cost, reducing construction cost and minimizing overall life-cycle cost.

Accordingly, the cost related drivers of using OSC in Iraq demonstrated in Figure 5.4

Cost drivers	14	32
Less maintenance cost	8	10
Minimizing overall life-cycle cost	7	10
Reducing construction cost	10	10
Accessibility of infrastructure	1	1

Figure 5-4: Cost drivers of using OSC in Iraq

Interviewee E7 identified three key elements for every construction industry, which are time, quality, and cost.

> "*Generally, time, quality and cost are better when we use OSC; however, we have a triangle consisting of three elements: time, quality and cost and these elements are controlled and rotated by us. So, if we want excellent quality, more time and cost are required; however, if we want time as [the] head of this triangle, it will be [at] the expense of the other two elements*".

Interviewees E1, E2, E3, E4, E5, E6, E7, E8, E10 and E14 emphasised that the cost in using OSC is less than the cost of traditional construction that employs 'mass production'. However, E1, E10 and E14 agreed that the cost can be reduced by around 30% less than for traditional construction. This is also in line with literature review in which believe that the use of OSC can be less than onsite construction by 50%. E1 confirmed that,

> *"The cost of prefabricated construction is less than the traditional construction by 20-30% in [the] case of mass production, as the initial cost of OSC is high and the templates are costly. So, it is recommended[ed], for example, to produce 1000 units by using the template, [rather] than 100 units, otherwise it will be more expensive than traditional construction when no mass production is required, In Iraq most of OSC experience although they are few, but most of them were volume production"*.

Interviewee E2 also illustrated that "*The cost will be less in the process of … implementing OSC if there is a quantity unit rather than a small project, as in this case, the cost will be close to the cost of using … classic construction*". Some reasons for the cost reduction were also identified by interviewees E3, E6, E8, E9, E12 and E13; these reasons were repetitive production, fewer onsite workers required, short project schedule time. etc. E12 clarified that,

> "*It requires [a lower] number of skilled workers and machinery, minimum waste of materials, shorter construction time, and minimal finishing items leading to cost reductions. I do not think there are high costs in the transportation, installation and storage of residential projects using (Precast Panels), because such projects must be subject to the careful planning of the stages of production, transport and installation*".

E13 further indicated that, "… *one of the motivation factors towards the using OSC is reduction in cost, so when the housing unit is cheap, [it] encourage[s] people to buy and accept it and* *people's acceptance has a key role in spreading these kinds of construction"*. He further added that most of the projects had done in Iraq were volume production.

However, E1 and E5 (who are both contractors) feel that some factors affect the cost; both agreed on factors that affect the cost, such as the location of the project, the type and volume of the project, the distance between the site and the factory. Interviewee E5 stated that*, "… the cost value depends on if the location of the project in the city or countryside, and whether the use of OSC is practical or not, so the priorities here will vary".* He also added that,

> *"I mean, to execute the building in the city, the cost will be high because the conditions and requirements are more, like transportation costs … more attention is needed to interior and exterior design and all this will require a high quality and this leads to high costs. While, usually, if the project is in the countryside and it is required to build a school, the school will be used for eight hours, [unlike] for example, a home [which is] used for 24 hours. Then, using … OSC is cheaper than the normal building because the requirements are less in this case while the traditional building will be more expensive because they should bring raw materials and bricks and workers and takes months to implement, while with using OSC will be cost saving".*

Interviewee E1 agreed with E5, but added another factor that can affect the cost; *"… another factor that affects cost is the availability or accessibility of infrastructure because if the infrastructure [is] far and hard to get to the implementation site, the cost will be high*". E5 concluded that, "*If the desired project is economical and not fancy, the cost is lower, and the precast is originally designed for this thing because it is faster and less expensive*".

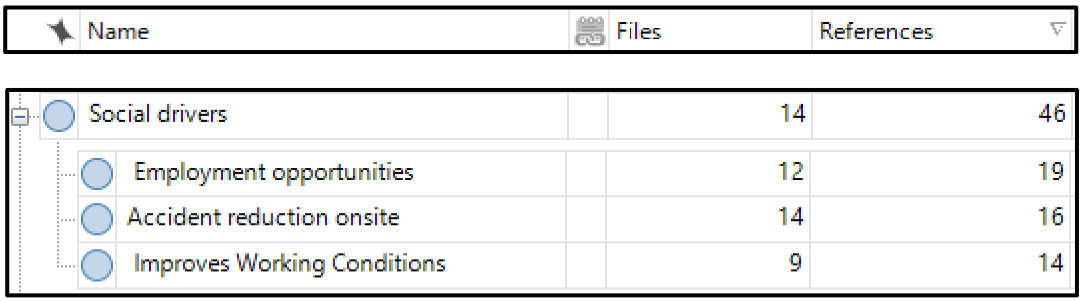
Furthermore E1, E6, E8, E9, E12, E13 and E14 emphasised that the cost of OSC maintenance is less than it would be for traditional construction and minimised overall cost life cycle. E6 pinpointed that, *"… the OSC does not need a lot of maintenance compared to ordinary construction because the products of OSC [are] made under … high controls in the factory and the details and waste in such construction [are] less than traditional construction, and this leads to minimised costs and improved overall life cycle cost performance*". Although, E5 agreed with this but he also stated that,

"*The cost of maintenance can be more than normal construction; in [the] case of internal extensions inside the wall, the maintenance … becomes more expensive, but if the extensions are external the cost of maintenance is usually less. The maintenance requirement of a precast concrete building is longer than … with traditional buildings, as the precast is stronger than ordinary construction. The life span of the precast is longer. This is for structural maintenance. Other maintenance costs, such as pumps or heat changes, can be made but will be expensive. It* *is necessary to ask the consultant when a hole may need to be made in the wall and this wall can be [a] load-bearing wall and thus can be expensive".*

Although interviewees believe that reductions in overall cost can occur if there is mass production, they still emphasise the related cost drivers, including reductions to onsite labour, less need for maintenance, and minimised overall life cycle costs. Also, interviewees illustrated that other factors can affect cost in OSC, including the location of the project, the type and volume of the project, and the distance between the site and factory. One of the interviewees highlighted that the availability or accessibility of infrastructure can also affect the cost. Interviewee E5 believes that overall cost is reduced when there is mass production, concluding, "*If the desired project is economical and not fancy, the cost is lower, and the precast is originally designed for this thing because it is faster and less expensive*". Hence, it appears that cost can be positively or negatively affected by other factors; in the case of Iraq, stakeholders still believe that mass production decreases cost, which accords with findings from the literature review, especially in developing countries where this construction method is still not well established. It is worth noting that most OSC applications in Iraq were for large projects. Therefore, in order to access cost benefits, it is important to understand the drivers related to this factor and obstacles that can negatively affect its performance.

5.1.4 Social related drivers

Drivers related to social factor indicated in the literature and to be investigated in this research are reducing accidents onsite, offers employment opportunities for local communities with greater long-term security for the individual worker and improves working conditions for workforce and industry. Figure 5.5 shows these social related drivers for using OSC indicated by the interviewees by using NVivo.



Name	Files	References
Social drivers	14	46
Employment opportunities	12	19
Accident reduction onsite	14	16
Improves Working Conditions	9	14

Figure 5-5: Social related drivers

OSC can increase the on-site safety record by decreasing the exposure of labourers to severe climates, heights and hazardous operations, and this can also mean fewer accidents on-site Interviewees E1, E3, E5, E6, E7, E9, E10, E13, E14 agreed that the accidents onsite when using OSC are less than when using traditional construction and this in turns save time and cost. Interviewee E1 pointed out that,

> *"... using ... OSC reduces accidents on the site because the stages of implementation are few and deliberate, and everything is subject to a plan. The OSC, in our experience, is an iterative process; for example, the transfer of the panels by crane is a repetitive process, so workers will be more familiar with risks [that] can occur and the repetitive process reduces risks".*

Interviewee E9 agreed with E1 and added that, *"... with traditional construction, every day we have new methods that are difficult to control. The problems that [the] crane goes up and down, workers working up and down, all processes [are] difficult to control and lead to increased ... accidents".* In the same way E5 indicated that *"... using OSC reduces accidents on-site because the activities are less, and all project steps are set under a trustworthy and organised plan"*. Also, E8 and E13 believed that there are fewer details with OSC, whilst E6 mentioned that there are,

> *"... reduced accidents that occur on site because the OSC does not need to pour ceilings and ... develop ... a wooden formwork, which can collapse and cause accidents in normal construction; while in the OSC, the walls and ceilings [are] prepared and manufactured in advance and this can result on saving time".*

This is also supported by E11 who agreed with E6 and E13 and stated an example of the accidents that occur when using normal construction,

> *"... certainly, ... OSC is better in reducing accidents onsite because the events are less, while in traditional construction there is a greater risk. For example, an incident occurred two years ago at the University of Tikrit at the work site where there was a group of workers in the process of pouring the ceilings and after the completion of the process ... it collapsed on the workers and caused an accident"*.

However, E1, E5 and E10 agreed that OSC can be risky when applied to high rise buildings. E5 confirmed that,

> *"... the OSC is usually safe especially if the company follows the H&S procedure; however, in some projects, the installation is more difficult and more serious than [in] traditional construction because it needs cranes to transport products to [a] high level, [and] people up there to fix beams with columns. Some of the installations are [more] dangerous, such as airports and large projects, such as multi storey buildings, than*

> *ordinary construction and the height of traditional construction [is] between 3.5-4 metres while the height in OSC possibly reaches up to 15 metres".*

Interviewee E8 highlighted another important point, that, *"... if the labourers have good skills to deal with OSC products, then the accidents decrease; the OSC requires high technical skills, so if these skills [are] available, the risks reduce".* In the same way, E3 asserted that, *"... using OSC reduces accidents because this construction is always subject to a specific and systematic method of work and the people are well-trained; there is no random work. Workers know very well the current step and next step. It is a chain of organised and calculated steps, so the accidents decrease".*

Another opinion was highlighted by E4, that *"... in any work, if workers do not follow health and safety standards or do not have enough skills, accidents can occur"*. Likewise, E2 declared that,

> *"... the rate of accidents is equivalent between traditional and OSC because of using cranes for high level to raise the wall and place it in the desired location and workers need to ascent to dismantle and tighten these walls and this represents a danger to the worker and therefore must be trained well in how to deal with this matter and there should be courses and awareness of the worker"*

Another point highlighted by interviewees was that OSC provides a safe environment for workers. Interviewees E1, E2, E3, E5, E8, E9, E10, E13 and E14 believe that most work occurs in a factory environment under quality control, and health and safety standards, and this protect the workers from bad weather conditions. E1 mentioned that, *"... using OSC provides [a] safe work environment in a factory and onsite, as in a factory there are clear and repetitive processes and the problems are limited or disappear and this lead to enhance safety performance"*. This was also supported by E3 and E8 who emphasised the advantage of quality control in a factory and safety standard *"... there is always a quality manual, safety manual, and security manual, and workers already [have] training on that, so that the health and safety standards are [more] highly controlled in a factory than [in] traditional construction which involves less organised steps"* (E3). E12 also supported E3's opinion and added that; "*the OSC system is clean, safe, less noisy to the surrounding environment*". Likewise, E2 further added that, *"to provide safe jobs in the factory, the worker must be a trainee technician because the work is carried out using machines. However, in comparison with normal construction, the nature of the work in a factory is safe because it [is] performed inside a closed control environment"*. Moreover, E5 added that, *"usually, OSC provides a safe environment for workers, especially if the factory follows a health and safety standard".*

Furthermore, in considering the reduced exposure to weather conditions, E3 ascertained that,

> *"One of the main factors why people use OSC is that people [do not] work at extreme conditions, as these conditions can be controlled through fewer activities and less time required on-site. Even when there is an installation onsite, they choose the appropriate time with the highest productivity, while in a conventional project if the temperature is high or cold, they must stop and wait for several weeks".*

Moreover, the speed of construction has an advantage when using OSC, as it reduces the exposure to bad weather conditions, as highlighted by E1 and E14; therefore, it *"reduces the duration of exposure to bad weather conditions as a result of performing most of the work in a factory and the speed of the construction" (E14).*

In addition, E1, E2, E3, E5, E8, E9 and E11 indicated that OSC offers opportunities for local workers through longer-term, secure jobs. For example, E10 stated that *"... OSC provides job chances to local workers and this is an advantage as it leads to reduced unemployment problems in Iraq".* Similarly, E11 stated that, *"...OSC offers jobs for local communities as well as helping to [offer] experience for everyone in this field, while in the traditional construction the tasks assigned to the workers are multiple."* Interviewee E7 commented that, *"... using OSC, the contractors can get job chances and get their money faster than it would be in normal construction".* Meanwhile, some interviewees, such as E1, E3, E9 and E13, have different opinions regarding the offer of job opportunities to local contractors.

> *"...OSC needs skilled and experienced people, as it offers opportunities for local contractors, but it can be double-edged sword; ... if the local contractor has experience and skilled workers, the OSC results ... will be good; however, if the contractor has not got enough experience and his mind is affected by traditional construction, the results will be bad".* (E1)

Interviewee E12 also believed that, *"... it provides jobs for local companies and for local workers, but in such situations, [it] requires use by the best execution companies, so they know this type of construction very well, as insecure companies will respond badly if implemented".* Moreover, E9 confirmed that, *"... it offers secure long-term jobs for local workers in a factory, while in traditional construction once the job finished on-site, they leave. In-terms of contractors, very few contractors have a production factory, so the OSC cannot offer them jobs until it is distributed widely in the country".* In similar way, E3 believed that,

> *"it serves the local communities as it provides more secure jobs and social services for them than traditional construction; it offers job chances for local contractors, when the OSC will be more economical than traditional construction and when it gains momentum and when people use it and gain experience".*

Interviewee E8 also made another important point when he mentioned that *"... the OSC not only offers job opportunities for the local community, including contractors, but also helps the contractor to improve himself in OSC, so that when there is an advertisement about an OSC project, the contractor will improve himself and his staff to get this contract; this ,in turn, will reduce the competition for projects in the construction industry"*. In contrast, E13 mentioned that, *"the use of OSC will not provide economic jobs for contractors because it is becoming a monopoly. It means that four contractors can monopolise the method of OSC, while in traditional construction cannot be denied it because all contractors know how to work with such construction". The monopoly* may or may not occur for some time, but even if a it occurs, it will most likely be eliminated when OSC spreads widely in Iraq.

Consequently, the interviewees seem to agree with social related drivers including reduced accidents onsite, employment opportunities for local communities with greater long-term security for the individual worker, and improved working conditions for the workforce and industry. However, there are differing opinions about these drivers, such as reduced accidents onsite; most interviewees agreed on this driver and stated some reasons, such as fewer stages required onsite, more organised work, and work is usually done by skilled labour. However, some indicated that OSC should be implemented by reliable companies that follow health & safety procedures and the work must be undertaken by skilled expert workers. Others feel that this kind of construction may be riskier than traditional construction for high-rise buildings. Interviewees emphasised a driver for improving labour working conditions as most work is conducted in a controlled environment within a factory, which means conditions are less affected by adverse weather than onsite construction. When the stakeholders decide to use OSC, they usually adopted according to well-plan such as choosing the appropriate time for implementation to prevent exposure to bad weather. Furthermore, most interviewees believe that this type of construction offers employment for local communities and thus can reduce unemployment in Iraq.

5.1.5 Labour related drivers

As OSC products are prefabricated, there is less need for workers onsite than for classic construction. Thus, regarding overall labour, E1, E3, E4, E5, E6, E7, E8, E9, E10, E11, E12, E13 and E14 confirmed a common perception, that OSC requires less labour onsite. Figure 5.6 shows labour related drivers.

Name	Files	References
Labour drivers	14	33
Labour reduction	14	19
Labour productivity	13	13
Coordination improvement	7	7

Figure 5-6: Labour drivers for the use of OSC in Iraq

E1 explained that, *"... the reduction in labour is a result of the OSC products being prefabricated, so some activities are removed offsite lead to less time and workers required onsite. It also depends on the size of the project and capacity of the work and implementation. However, it still the normal construction of ten thousand housing units need more workers than if it implemented by an OSC method"*. In the same way, E4 pinpointed that, *"A large part of the work will be carried out in the factory, so that the number of workers required on site is less as a result of less activities which means less time".* Another reason for the labour reduction is due to the greater reliance on machinery and equipment, as identified by E3 and E9. Although, E5, E6 and E12 also agreed on the labour reduction, they emphasised that the workforce must be trained well and skilled when using OSC. In addition, E6 believed that *"the cost can be minimised to 30% [less] than normal construction as a result of the labour reduction"*. The literature review also indicated that the use of OSC lead to cost reduction as a result of less labour required onsite. Another opinion was offered by E10, who believed that *"OSC needs skilled labour in fewer numbers than required for traditional construction, so that minimises the problem of skilled labour shortages*". This view was also supported by E14.

Thus, most interviewees believed that the number of labourers required on site is less than in normal construction; E1 emphasised that the number of workers required in a factory depends on its volume of the production. However, E2 believed that the number of labourers required in traditional construction is similar to that needed for OSC, *"... in OSC, the labour is divided into labour in a factory and on-site, while in traditional construction the labour is only required onsite. Therefore, in my opinion, I believe that the number is equal in both types of construction".* Interviewees E1, E3, E4, E6, E7, E8, E9, E10, E12 and E14 believed in the increasing labour productivity when using OSC. The reason for that is due to the fact that it is "repetitive work" (a view mentioned by E1, E3, E4, E6, E7, E9, E12 and E14); *"... in OSC, the work is repetitive, like you have a training workshop in which the second time is better than the first time and so on, but in traditional construction the work is not necessarily repetitive" (E1).*

Another reason of increasing the productivity of labour, according to interviewee E9, is due to, *"the high-quality control in a factory [that] leads to increased labour productivity in contrast with traditional construction, which may be implemented in a remote area and this leads to difficulties in monitoring quality"*. In the same way, E12 emphasised that, *"the work with OSC is difficult at the beginning but when the work becomes continues to be repetitive, the labour productivity and skills will increase"*. In contrast, E5 had a different opinion, and believed that *"… it is not necessarily the productivity of labour [that] increases when using OSC because, if the worker starts to implement work wrongly, he will continue in similar way. Therefore, it is vital to implement OSC by skilled labour and if they are not skilled enough, [the company] has to provide them with suitable training"*. E2 had a similar opinion, *"… in a factory, machines are used in the production process; there is no income for the worker in improving productivity. Also, in an onsite workplace the productivity depends on the nature of the worker and his temperament, so there is a productive worker and there is unproductive or grumbling worker"*.

In general, some interviewees, including E1, E6, E9, E13 and E14 believed that OSC improves the coordination and management of teamwork. Interviewee E6 attributed it to the understanding that, *"the stages of the work are previously well-known and organised and there is the ability to control these stages"*. Accordingly, the interviewees agreed the labour related drivers that developed from the literature include: Reduced labour for onsite construction, improved labour productivity performance, and improved management and coordination among workers onsite. The reduction of labour onsite is achieved as a result of the prefabrication of products in a factory. This means greater dependence on machines and faster construction with fewer stages required onsite resulting in fewer workers per hour. Moreover, most interviewees believe that labour productivity increases when using OSC construction due to the adoption of repetitive processes. However, two of the interviewees believe that productive and unproductive workers exist, and although this could be said to be true, the greater dependency on machines and repetitive processes in OSC are more likely to lead to increased productivity. The interviewees also believe that this type of construction can enable better coordination and management onsite. This is may be due to fewer activities and less interfacing onsite; this is due to the nature of this construction method, which involves more organised work than classic construction. The reduction in labour leads to reduced costs and is similarly supported in the literature.

5.1.6 Productivity & Market related drivers

The productivity & market related drivers conducted from the literature review are: Improve Overall Project Productivity, Addressing the Problem Of Housing Shortage In Iraq and High Volume Production Of Mass Units In Short Time and providing affordable housing. These drivers are illustrated in figure 5.7.

Productivity & Market drivers	14	45
Housing shortage	14	16
Overall productivity improvement	13	15
Mass production	11	15
Affordable houses	11	14

Figure 5-7: Productivity & market related drivers

In recent years, the construction industry has continued to experience pressure to raise productivity and improve the housing supply rate. Interviewee E3 believed that the reasons behind improving the overall productivity when using OSC is due to, quality control, quality insurance and the health and safety system provided in the factory and improved time performance. Furthermore, E4 ascertained that, "*the use of OSC offers high quality and productivity, as there is no need for skimming, plastering and painting* ", whilst E7 indicated that "*the productivity is improved significantly, as some difficult activities move off-site, and the wet trades reduce and thus means reduce overall project time* ". However, E9 believed that; "*the use of OSC will increase the overall productivity; but sometimes in Iraq this can be the opposite because either the project is assigned to un-reliable companies or an inexperienced contractor*".

However, E1 and E5 believed that the productivity increases were because of "*the use of machines to make more products than worker hands and this has also led to the ability to produce a mass production*". E8 also stated that "… *daily production is increased and there is an ability to work with more than one activity in the same time*", whilst E13 attributed the increase in overall productivity when using OSC to good quality, reduced activities and limited interference between them. This view was also supported by E6, E2 and E14. Furthermore, E6 declared that *"… productivity is an important factor that can enhance the use of OSC because, within this construction, there is an advantage of improving the overall productivity of the project, a few stages of work … overlaps between trades and provides the possibility of large quantitative production and hence results on faster construction and improve safety performance and environmental performance* ". E4 emphasised that, "… *using OSC provides a massive mass* *production in less time of implementation, like fencing made from precast concrete as I implemented a 19 km fencing with three-metre height in five days*". Also, E8 also indicated the large volume of production in a factory when applying this type of construction.

Nevertheless, all interviewees emphasised the ability of OSC to solve the housing shortage in Iraq because of the advantages of mass production including shorter time and less cost. The advantages of mass production through the use of OSC were indicated by E1, E3, E5, E6, E8, E9, E13 and E14. E1 and E5 emphasised that the main objective of OSC is to meet society's need for housing through the mass production offered by OSC. Moreover, E1, E7 and E11 further indicated that Iraq currently needs to provide 4-5 million housing units, and this cannot be achieved by traditional construction due to the long-time associated with this method. Therefore, interviewees E1, E5 and E12 confirmed that OSC is the best solution for Iraq. Similarly, E7 agreed that *"... as OSC solves the problem of the housing shortages worldwide; it will solve this problem for Iraq as well*". In the same way, E9 stated that "… *the use of OSC is indispensable in Iraq. All the projects for residential complexes built in Iraq were from precast construction like al-Salam complex and Bisamayia complex*". According to E1, E6, E11, E12 and E14, this is because OSC provides the mass production of housing in a short period of time. As such, *"... the country is thirsty for such projects because the crisis is severe, especially housing, but projects are slow due to the country's circumstances".* (E14)

E10 emphasised that, "… *the entry of prefabricated environmentally friendly construction technology can be considered a safe haven at present to solve the housing crisis in Iraq, under difficult economic and security conditions*". Similarly, E4 and E10 indicated that Iraqi people, particularly those on a low income, need houses regardless of their specification and make. However, E4 and E6 identified that the awareness and culture of the community have not yet realised this type of construction despite the urgent need for housing. E4 clarified that, "… *unfortunately, the nature of the existing environment related to the Government's views, the legal environment, and the culture of society, prevent the contractor from finding good opportunities to apply OSC. Therefore, to support the use of OSC, there is a need to create a cultural environment by the Government and its Ministries".*

Additionally, E12 highlighted that "… *OSC is the best solution to solve the housing deficiencies in Iraq; however, this can be achieved through reliable, experienced foreign investors and supported with the latest technology in this field to provide low cost, durable, proper housing units".* E3 and E4 highlighted a vital point that OSC is the best solution to solve crises or disasters, like housing shortages, war disasters, and flood and earthquakes. E4 stated that, *"the OSC establish to face such disasters and crises, some Europe countries use it as a solution to face some natural disasters …"*. E3 also added that, *"OSC is working as strategic rescue projects to face disasters"* and gave an example of the housing crises in Iraq; "… *in order to meet housing needs, the solution is to build residential complexes with all facilities".*

Providing affordable housing for low to medium income people was illustrated by E1, E2, E4, E5, E6, E7, E8, E9 and E10. E8 further indicated that, *"… OSC is recommended for low income people because of the advantages it can provide in terms of producing low-cost housing".* However, E1 and E5 indicated that, low cost prefabricated housing is possible when there is mass production. Meanwhile, E7 declared that, *"… there are several ways for OSC production that can lead to get low-cost unit, like light weight concrete or galvanised steel structured units. We usually choose the one that is light, less expensive and fast to get for low-cost housing".* E4 suggested a new idea which saw the construction of a structural unit that mixes offsite and traditional construction at the same time; E4 explained that,

> *"… as the weather conditions in Iraq are very cold in winter and very hot in summer, there is no ability to construct OSC units without insulation, and this insulation is expensive and will lead to increases in the weight and thicknesses of the components and this will cause difficulties in transporting, storage and installation … I suggested the use of insulated walls made from traditional construction with prefabricated roofs as the casting roofs, which need time, and thus enables a reasonable cost"* (E4).

Nevertheless, E10 illustrated that the OSC has many advantages for those who are looking for economical housing units; *"including reducing the costs of construction and heating as well as reducing the time required to complete the project".* He added that *"… OSC projects are completed in two months at a low cost and thus are a radical solution for those with limited income"* (E10).

Accordingly, the productivity and market factor has related drivers found within the literature, which are: improved overall project productivity, addressing the housing shortage in Iraq, the high volume production of mass units in a short time, and providing affordable housing. Interviewees within the Iraqi construction industry agreed on these drivers. Interviewees believe in improving the overall productivity of OSC projects for many reasons, including time performance, quality performance, and cost and social performance. On the other hand, the ability for mass production can lead to cost reductions, increased safety performances, reduced time and improved environmental performances. In fact, interviewees also emphasise the ability to address the housing shortage in Iraq as OSC enables mass production in less time. Moreover, the interviewees agreed on OSC's ability to provide affordable housing due to its mass production and the use of economical materials to reduce cost. Nevertheless, to gain the best quality and productivity performance results, OSC needs to be implemented by expert-skilled contractors and reliable companies

5.1.7 Policy related drivers

OSC, like any other system, would need to comply with numerous regulations, for example, safety, thermal insulation codes, contract, and quantities bills and so forth. The policy related drivers investigated in this research are: revision to building regulation to support OSC, government promotion and support, availability of legal, standards and codes framework to cover all stages of the project. These drivers are illustrated in figure 5.8.

Name	Files	References
Policy drivers	14	66
Government support	14	42
Revision regulation	12	12
Codes	10	12

Figure 5-8: Policy drivers of using OSC in Iraq

Some interviewees, namely E1, E2, E3, E5, E10, E11, E12 and E14 indicated that the lack of regulation for the use of OSC meant there is a need to re-view these regulations carefully. Interviewee E1 believed that, "… *the lack of regulations regarding OSC is one of the main problems that I face, in addition there is no desire from the supervisor engineers to use this construction as a result of the lack of regulations and specifications that they can rely on which in turns delay our project*". Interviewee E11 has a similar view and added that,

> "… *the lack of regulations that support OSC in Iraq leads to the reluctance of most companies to engage in this field. For example, the President of the University of Tikrit contacted the Ministry of Higher Education with the purpose of obtaining the necessary approvals for the construction of classrooms by OSC where the need was urgent for this subject and the Ministry's response was to refuse to use this construction technology because they do not have knowledge and quantities schedules for this type of construction*".

Moreover, E14 stated that, *"… as the construction system adopted in Iraq is traditional construction, therefore it is the role of the Ministry of Planning to implement such regulations for OSC"*. In a similar way, E5 ascertained the need to review regulations to support the use of OSC and gives an example of that,

> "*… as there is a shortage of schools in Iraq, the Ministry of Education has to cooperate with consultation bodies in establishing legislation to work through OSC, as a result of benefits gained from this type of construction, including speed, quality, cost saving. In fact, all Ministries in Iraq have to establish such legislation to enhance the use of OSC in Iraq*".

Another important point highlighted by E10 is, "*… in addition to the technical and organisation obstacles, like the lack of codes, standards, and tenders for OSC, we are suffering also from the large expansion of investment without careful plans. Therefore, the review of legislation for this system is vital as it will organise and facilitate the work of companies*". E4 similarly stated that, "*… there was some successful experiences of OSC, but after difficulties and suffering because of the lack of regulation and delay of funding; therefore, it is important to review it*". In contrast, interviewee E13 commented that,

> "*We do not need to review the regulations and laws for OSC because it is the same regulations that apply to the requirements of the engineering contract for engineering works. The first and second sections are taken from the terms of the Egyptian contract that taken from Fedics, so there is legislation that supports the use of OSC".*

Furthermore, E8 emphasised *"... the importance of including special chapter for OSC into the general conditions contract related to the Ministry of Planning"*.

Regarding codes and specifications, interviewees E1, E2, E5, E6, E9, E10 and E11 agreed that there are no Iraqi codes. E5 emphasised, *"... the need for Iraqi codes for OSC, as when products are finished and delivered, they have to be subject to Iraqi codes, and sometimes, the consultant body determines the codes that company has to follow to facilitate the work and implementation"*. E6 believed there is an absence of Iraqi codes, in stating that,

> "*… the codes are a basis for everything in construction. Until now, engineers have suffered from the lack of codes in Iraq for OSC, specifically for the project preparation and design, and there are no tenders as well. There is no standardisation and specification to organise the work of observed engineering, so it is vital to have all of that".*

Interviewees E3, E8, E9 and E12 believe that there are no Iraqi codes regarding OSC; however, they emphasised the opportunity to use global code, such as those by the British or American. Interviewee (E9) suggested that *"There is no specific code in the legislation that binds everyone from using any construction method; there is no or incomplete Iraqi codes and therefore the engineers are concerned. Therefore, we always use global codes."* In a similar way, E8 mentioned that, "*Iraq is not prevented from using any global codes, like American or British, and there is a trend to provide such codes ... I was involved in the establishing of Iraqi thermal insulation code for OSC*". Significantly, E3 stated that he was advised to use global codes until this type of construction improves in Iraq, at which point Iraqi codes could then be established. He explained that,

> *"... most of the Iraqi construction companies who implement OSC are importing equipment and products from abroad. The know-how is from abroad and the knowledge and training is from abroad, so it is very important to rely on the American and British international codes and after improving the use OSC in Iraq, the Iraqi codes will come automatically"*

All interviewees agreed on the importance of government support to enhance this type of construction. E8 noted that *"... the government role in enhancing the use of OSC in Iraq is vital. In fact, the Iraqi government motivated in calling on construction companies to use OSC in their projects for the speed of implementation, reducing costs and meeting housing needs".* The drivers related to policy explored in the literature review are: Revisions to building regulations to support OSC, government promotion and support, and the availability of legislation, standards and a codes framework to cover all stages of the project. The interviewees emphasised that there is a lack of regulation to support the use of OSC in Iraq, and they emphasised the importance of reviewing such regulations. However, while some believe that there are no Iraqi codes or standards for OSC, others recommend the use of British or American codes until Iraqi codes are developed. These would be particularly important when this type of construction has spread widely in Iraq. Government support is highly emphasised in the literature as a motivation for using OSC. The interviewees also strongly agreed with the importance of government support as a driver. The role of the government could be to support contractors by allocating funding, providing lands for construction, and so forth. Consequently, the policy drivers have an important role in enhancing other drivers.

5.1.8 Environmental related drivers

The environmental drivers of using OSC in Iraq are highlighted in the figure 5.9. These are demonstrated and discussed through the interviews process

Environmental drivers	14	33
Waste reduction	14	16
Decrease energy usage	12	13
Recycling	10	10
Reducing environmental impact	8	8
Protecting infrastructure	1	2

Figure 5-9: Environmental drivers of using OSC in Iraq

Energy consumption is perceived as essential, with an increasing emphasis on thermal insulation. In this respect, energy consumption is required to be minimal during utilisation and construction. Interviewees E1, E2, E3, E5, E6, E8, E11 and E13 believed that the energy required when using OSC is less than in traditional construction. This is because of the good insulation provided and the quality of the finished products can reduce the energy consumption during building usage and due to less activities and speed of construction reduce energy during construction. E1 and E3 divided the energy consumption into two types: consumption during construction, and consumption during the use of the building. E3 stated that, "... *using OSC reduces the energy consumption during the use of the building because of the thermal insulation and the quality finishing of the products which is generally highly standard. It also reduces energy use during construction because of the organised clear activities and the speed of production. Therefore, the energy use is less than the energy requires in traditional construction*". E1 also had the same opinion and added that, "… *energy use reduces in [OSC] construction because of the activity reduction compared to traditional construction and this in turns reduce cost*". In a similar way, E11 indicated that, "*the use of OSC is useful for Iraq because it has thermal insulation which is useful for winter and summer and due to the high percentage of improving of the quality performance of finishing products such as the efficiency of the pre-assembled mechanical and electrical systems which performs much better than those being assembled and commissioned onsite."* Interviewee E1 agreed with this opinion and added that classic construction in Iraq usually does not involve thermal insulation

Indeed, in Iraq there is a large consumption of energy as a result of the climate and geographical location of Iraq, but with this system of construction the energy use is less". This was also supported by E10 and E14 who indicated that there are energy crises in Iraq**.**

"*The use of OSC saves 70% of the electrical energy. People in the world are moving towards the use of green buildings to reduce the complications of CO2 and to save of energy. If we have 1000 housing units, it will use the electricity of 300 housing units (saving 70%), and thus benefit other housing complexes and save cost"*. (E10). This interviewee seemed motivated to decrease energy as a driver; moreover, the literature review supported their opinion to decrease energy use during building operations. Although this can lead to cost savings, it is not achieved to the same level (percentage) indicated by interviewee (E10).

Moreover, E8 declared that, *"the use of insulation and improved fabric and structural quality of the finished products in OSC became binding to reduce energy and work towards sustainable* *buildings"*. E7 also stated that, *"I introduced a project of low-cost precast concrete housing in Iraq, with a solar energy system to minimise the crisis of energy by insulation and solar system"*. E2 believed in the importance of using insulation with precast concrete to save energy; however, he believed that *"... insulation is expensive; therefore, I suggest using lightweight concrete with insulation to reduce costs or invent cheap thermal insulation".*

Regarding the environmental impact, E3 described the term 'environmental impact' during construction as the extent of influence of construction on water, air, soil…etc. Accordingly, E1, E3, E5, E8, E12 and E13 highlighted the improvements to the environmental impact during OSC. E3 attributed this to;

> "*… the OSC system [which] is highly controlled and monitored and more environmentally controlled which lead to productivity improvement. While traditional construction is random and can affect badly on the environment such as explosions of gas or gas pollution or water pollution but in OSC the observers account every step carefully with less time of implementation and less waste to protect the environment and surroundings and save cost".*

In the same way, E12 stated that, *"I would consider it friendly to the environment in comparison with normal construction due to minimum pollution outcomes from waste of material and construction and reduce emissions"* Indeed, all participants agreed that OSC significantly reduces the waste of materials, whilst E1, E5 and E13 declared that it meant waste was almost non-existent which means save overall project time and cost and improve productivity and safety performance. This is due to fact that OSC products are prefabricated in the factory (E6, E10, E11) and these products have a good accuracy (E4).

Furthermore, E14 stated that OSC protects the environment from the risk of waste. This was also clearly explained by E3 who suggested that OSC could protect the infrastructure,

> "*… no destruction of the infrastructure when using OSC as there is no throwing of waste of materials, which lead to the blockage of sewers, no random drilling and the design processes are specific and well-known. There is no random work as every worker knows when to drill, to install columns and the roof height is accounted for previously. The height of electricity wires is also accounted for to prevent cutting during the transporting of materials. The width of the bridges to transport materials by lorries is accounted for. While in traditional construction, confusion with other services and follow ups by the council and restrictions prevent some activities by closing the roads. Whereas in OSC, the work is organised, the supply chain is controlled, organised, knows when production, transportation and installation [will occur]".*

Regarding the recycle of materials, the majority of participants agreed that there is a possibility of recycling the OSC products; however, E1, E5 and E6 stated that it is expensive whilst E4 declared that, *"It is possible to use second grade precast concrete in some less important areas or to sell at a reduce cost. In some countries, they crashed it and used it as aggregate"*.

E3 also stated that, *"... it can crash the products; however, the rejection of fault products or panels in OSC is very few compare to traditional construction, which involves more faulty products and cannot to re-used"*. In the same way, E7 confirmed that, *"when the project is completed and some extra panels are left for some years and are not stored correctly, they crash, and they have to re-use them. However, it has not happened yet in Iraq, but it has been done in some countries"*. Moreover, E9 indicated that, *"the crashing and recycle is usually made in a factory"*.

Accordingly, the literature review widely addressed the related environmental drivers. Some of these drivers also investigated in this research are: Decreased energy use during the construction and building usage phases, reduced material waste, and reduced environmental impact during construction. The interviewees within the construction industry in Iraq agreed on these drivers. In fact, the reduction of energy use during construction overlaps with other factors, such as less time required onsite. Moreover, the reduction of energy usage during the building operation emerges as a result of the high quality of finished products. Although this may be true to a large extent, the final quality depends on the construction team. Also, the use of thermal insulation within this construction method enhances energy saving as traditional construction in Iraq does not usually incorporate thermal insulation.

Furthermore, interviewees strongly agreed on the reduction of material waste which can lead to time and cost reductions and protect the infrastructure. The literature review revealed that there is a big problem associated with material waste in traditional construction in Iraq; therefore, this type of construction can play an important role in decreasing this problem. The other driver was to reduce environmental impacts during construction, which is also emphasised by the interviewees and justified by the reduced time required onsite; this includes reduced pollution, noise, emissions and so forth. Some interviewees highlighted another driver under the environmental factor, namely that OSC materials can be recycled. Moreover, another interviewee highlighted the protection of infrastructure as a result of waste reduction and organised work, which they confirmed as a driver.

5.2 Barriers towards the use of OSC in Iraq

This section will discuss the interviewees' responses regarding the barriers towards OSC in Iraq. These barriers are illustrated in Figure 5.10.

BARRIERS

Name	Files	References
Skills & knowledge barriers	14	49
Project complexity barriers	14	42
Logistic & site operation barriers	14	41
Industry & market culture barriers	14	40
Management barriers	14	31
Cost barriers	14	26
Political & economic barriers	14	26
Supply chain & procurement barriers	14	22
Non-working days barriers	2	4

Figure 5-10: Barriers of using OSC in Iraq

5.2.1 Logistics and site operations related barriers

The site selection, including the location and layout, is very important in construction projects worldwide as it can act as a barrier in some cases. In considering the site location, interviewees E1, E2, E4, E9 and E10 believed that if the site of the project is located in an unsafe location, like site controlling by unauthorised external parties like militias, or occupied illegally by some of people would negatively affect the use of OSC projects, as it would either, *"… increase costs in the case of extortion from militias"* (E10) or "*Halt the projects*" (E1). This recently occurred in Mosul city (in the north of Iraq) due to the entry of ISIS. Figure 5.11 shows logistic related barriers including:

- Unsafe sites restricted by external parties
- Restricted site layout, space size, access, storage and site location
- Difficulties in transporting of materials and components from factory to site

Logistic & site operation barriers		14	41
Difficulties in transporting of materials		14	24
Unsafe sites		14	15
Restricted site layout, space size, access		7	8

Figure 5-11: Logistic & site operation barriers of using OSC in Iraq

Interviewee E3 considered that unsafe sites affect OSC more significantly than traditional construction and attributed this to the fact that, *"... the use of OSC needs freedom as sometimes needs to be observed by international observers, or the machines need repairing by international workers*". Therefore, it essential that it is safe and uncontrolled by external parties. However, interviewees E6, E7, E11, E12, E13 and E14 ascertained that an unsafe location does not only stop an OSC project, but also traditional construction projects. E7 indicated that if "*… the area is not controlled by the government but by clans, it will halt any construction project".* E6 illustrated that, "*This problem exists in all types of construction and affects them all because of the security situation in Iraq as some work sites are unsafe but can be solved*". He emphasised the necessity of calculating the risks before the implementation of a project. For example, people who are illegally occupying the site can be evacuated before the implementation of the project. E9 mentioned an important point, that extortion can be also occur during the transportation to the site in which OSC needs continuous flow of transporting products. He confirmed that the Bisamaya project overcame this problem by employing security forces to protect the project. Moreover, E4 agreed that there are some unsafe sites, but that he managed this risk through production in his factory and that clients were then responsible for any transportation and erection. In contrast, E13 declared a different opinion, that implementing OSC in unsafe sites was easier than in traditional construction because, "*the use of OSC involves only erection on-site with less activities, while traditional construction [involves] more activities and its materials will be liable for theft*". Accordingly, unsafe sites significantly affect the performance of construction projects; these can also halt a project and can affect all types of construction. Moreover, some interviewees believe that the impact of this barrier on OSC is more significant than for classic construction. This is because international workers and experts are involved in OSC. Moreover, OSC needs a continued flow of transported resources. Therefore, risk assessments are recommended in early stages of projects and sites should be protected by guards to prevent any terrorist attacks that may occur.

Regarding site layout and storage, E3 believed that, in Iraq, site layouts are big and there are only a few restricted site layouts. Furthermore, E6 and E1emphasised that a site layout could be an advantage and disadvantage in the use of OSC. Indeed, E1 indicated that "*Fewer activities required on site enhance coordination and reduce interfaces; however, the use of OSC may requires special large cranes to transport large components which in turn can be difficult for restricted site layout and access."* They recommended that OSC is not used when the site layout is narrow or when there are difficulties in reaching the site, either because of the road routes or because of heavy traffic. Moreover, E11 stated that, "if the site layout is tight, this would affect the transportation of products". In addition, E9 confirmed this would affect any type of construction, especially when the project needs to be implemented in crowded areas. Thus, difficulties associated with moving vehicles and loading products can pose obstacles to the use of OSC within restricted site layouts, as special large cranes may be required to transport large products.

The transportation factor was widely acknowledged by interviewees as an essential consideration in OSC, and that this sometimes constrains the project. The delay in receiving the OSC products is one of the factors highlighted as a barrier by interviews. For example, (E1, E5, E7, E10) attributed this to, "… the large number of government checkpoints as a result of the security situation" (E10) that it is vital to facilitate the passage of loaded trucks to avoid delay. In the same way, interviewees E2, E4 and E13 highlight that delays result from congestion or the number of checkouts. For example, E4 stated that, "*Currently, there are new laws on weight and security examination scans and checks when the lorries enter the city because it can create congestion*". Another important point highlighted by interviewee E4, E14 and E9 is the transportation difficulties that result from an insufficient road network. E14 stated that, *"... the road network in Iraq is old and has only existed since the 1980s, despite the increasing the population and cars*". E9 stated that the road network can present an obstacle for the transportation of materials,

> "*… some OSC projects are small and far away, and the network road nearby is either not good or unable to hold the loads of materials on the lorries and this leads to an inability to reach the site, Therefore, I do not recommend the use of OSC in this case because it will not be practical to use alternative routes for small or single buildings".*

In addition, E4 also highlights the concern regarding insufficient road networks, and added that "… as a result of wars, some bridges suffered from fracture, so humps can lead to breaks in products; therefore, it is necessary to transport materials by special lorries to avoid any damage or cracks". E2 and E6 also highlighted this and emphasised the importance of managing transportation when using OSC, as it requires special caution when moving in order to avoid cracks. Moreover, E2 indicated that, "… the products need to be held by special trucks and there must be enough knowledge about the product's dimensions in order to put them correctly on the trucks to avoid any damage during transportation". (E3) highlights the importance of accounting for everything before transporting materials, like bridge capacities, heights, and product weights, to avoid any problems may occur.

E14 recommended the necessity of improving the roads network in Iraq, whilst E6 and E14 recommended implementing OSC housing projects outside cities to avoid traffic congestion. Furthermore, E6 interviewee recommended to use local factories or small factories onsite for making the products on-site to avoid transportation, as this is what Bisamaya residential housing project did. Finally, E12 pinpointed that,

> *"Generally, it is recommended that the distance from transporting the products from a factory to the site is within a circle of radius 50 km. But it will affect the cost if the distance is longer than this, or it may lead to delays arrival because of complicated safety check points around cities in Iraq".*

It appears that interviewees find transportation issues an effective barrier that can halt or delay OSC projects in Iraq. Indeed, there is a problem with transporting products in Iraq, especially when importing products from other countries, due to delays at border checking points. Also, extra security checking points can pose obstacles to the delivery of materials. Moreover, the existing Iraqi road network is insufficient which can cause delays, and cracking in products. Therefore, this barrier needs particular attention by assessing bridge capacities, heights, and product weights to avoid problems that may arise. Also, stakeholders need to provide suitable equipment, cranes and special transport vehicles to lift and transport products. Furthermore, the interviewees offered some recommendations, such as implementing OSC outside cities to avoid congestion, using local factories, and restricting transportation distance from factory to site to within a 50 km radius.

5.2.2 Project complexity related barriers

The majority of interviewees agreed that OSC products are designed in the factory according to engineering standards and specifications and are ready to install onsite. Therefore, it is difficult to make changes to products on-site (E1 and E14).

E1 pinpointed that

"… it is difficult to make changes onsite and if it happens, it will be costly". E7 emphasised that the changes are difficult when using precast concrete, while other types may be easier. In contrast, E4 and E6 emphasised that, although the design is made previously, changes can made in the

finishing. However, E9 had a different opinion, as he believed that the inability to make changes cannot act "*as a barrier as some consider it a driver because it plans securely and in advance*".

Accordingly, the project complexity related barriers for the use of OSC in Iraq after investigating the interviewees responses are illustrated in Figure 5.12

Project complexity barriers		14	42
Lack of comitment		8	14
limited design options		12	12
Lack of building regulation		7	12
no change in the field		10	10

Figure 5-12: project complexity barriers affecting the use of OSC in Iraq

The design of OSC is not considered a barrier by most interviewees. E4 stated that, "*Whenever a simple design is available, it is more preferred by the people because it will facilitate the work onsite*". E8 indicated that, *"… the design of OSC products is typical and standardised and easy, it must be standardised to produce standard components*". However, E12 noted that,

> "*…there is nothing that cannot be designed, even if it is out of the standard, but certainly it will affect the cost of the project. In many sophisticated buildings where it requires merging cast in situ with precast decorative panels the cost will be affected so I do not think there is limited design with OSC*".

E13 explored an important point; when the project is complicated , there is a preference for traditional construction; he added that, *"… the design options of OSC are easy; it can only be complicated when it needs to produce a lot of pieces that are opposite to each other; in this case we use traditional construction*". Most of the interviewees emphasised that the design of OSC products is typical and standard; therefore, they believe that there should be no limited and complex design associated with OSC products. However, they still believe it is not possible or difficult to make alterations onsite. Thus, the idea persists amongst interviewees that OSC products require early agreement on the design to produce the products required, Therefore, any later changes, particularly onsite, may either be impossible or costly. This may not meet the preferences of clients who often request later alterations. However, one of the interviewees found this a driver rather a barrier because this could leverage a secure project performance in terms of quality, time, cost and overall productivity as the design decision-making is confirmed early on. This is typically important for big projects, and particularly for housing complexes.

Most of the interviewees agreed that there is a need for the revision of regulations that support the using of OSC (as previously noted mentioned in the section on drivers). E9 commented that,

"*… there is no or insufficient regulation that support OSC like establishing a rule to use thermal insulation when using precast concrete because the insulation is hard to include in traditional construction. Therefore, if such regulation was established, people will be encouraged to use OSC*". Furthermore, there are no engineering specifications, regulations and standards for this type of construction. According to Interviewee E6, this has led to reluctance in using this type of construction and increased project duration. Therefore, revisions to regulations to support the use of OSC, the availability of Iraqi codes, and the availability of engineering specifications (such as tables of quantities in contracts) are important factors that influence the best adoption of OSC in Iraq.

The interviewees were also concerned with commitment amongst stakeholders to construction projects. Furthermore, E3 suggested that legal issues and commitment are the main problems in construction. For example, a financier might commit to half of the project due to mistakes in the accounting, whilst the contractor may take on more than one project, but he is unable to finish on time. Moreover, the Government might delay payments to contractors, whilst finance or administrative corruption may arise, and the lack of strong management could also impact. E3 added that,

> "*… as a result of dissonant contractor interests that are not compatible with the employer, and where the employer wants to lower the cost and the contractor wants to increase the cost, everyone wants to profit …. Therefore, it needs the establishment of clear regulations and legislation, good project management, fines for any type of construction, and more specifically for OSC"*

A lack of commitment is a vital barrier that hinders the successful performance of any construction project. Therefore, this barrier needs strong management, regulations, and fines to prevent or eliminate the negative impact of this barrier on OSC projects. Otherwise, poor performances resulting from a lack of commitment will not only affect the project performance but also may lead to a poorer image of this type of construction.

5.2.3 Cost related barriers

Interviewees E1, E3, E4, E5, E6, E7, E8, E9 and E14 emphasised that the cost in using OSC is less than the cost in traditional construction when there is mass production. E1, E5 and E14 agreed that cost can be reduced by 30% over traditional construction, whilst A stated that as,

> *"The cost of prefabricated construction is less than traditional construction by 20-30% in case of mass production, [and] as the initial cost of OSC is high and the templates are costly, it is recommended, for example, to produce 1000 units by using the template [rather] than 100 units, otherwise it will be more expensive than traditional construction when no mass production is required".*

The cost related barriers of using OSC in Iraq according to interviewees' responses are shown in Figure 5.13.

Cost barriers		14	26
Higher transportation cost		12	15
OSC is more Expensive than traditional construction		8	8
Higher initial cost		6	6

Figure 5-13: Cost barriers of using OSC in Iraq

Similarly, E3, E8 and E12 believe that the cost will depend on the size of the project; if the number of construction units is very large and symmetrical, it will be cheaper than a classic construction project. E3 attributed that,

> *"... the cost reduction will reach 50% cheaper than onsite construction because the production will be symmetrical and we will move the molds from place to place and experiences from place to place and this leads to increased productivity and shortened time, but if it is single unit, the cost of OSC increases*".

Meanwhile, E4 declared that, *"... sometimes OSC is either an equal cost to classic construction or more expensive because there is extra money for transportation, erection and the skilled workforce*". He explained that OSC needs factories, machines and engineers for production, special trucks for loading products, skilled workers for erection, special treatment for joints and all this can increase the cost. However, the same interviewee also confirmed that *"... the cost depends on the size of project, so if there is mass production, the cost is reduced, otherwise there will be a high initial cost"*.

Accordingly, the initial cost of implementing OSC is high as it requires the establishment of factories, which involves installing machines and employing engineers, offsite and onsite labour skills, special trucks and treatment, and transportation. Therefore, interviewees believe that the cost of OSC can largely be cheaper than traditional construction when there is a mass production, and some believe this could reach up to 50%. This is due to the symmetry of production, the ability to move molds from place to place, using the same molds to produce symmetrical products, and shifting experiences from place to place. This leads to reduced costs, increased productivity and shortened times.

Regarding transportation costs, most interviewees believed that the cost of OSC increased when there were long distances between the site and factory. E7 illustrated that, if the factory is within the area of the project, there is no extra cost, while if it is outside the site the cost increases. Another advantage highlighted by E1 confirmed that, *"… when the distance is close between the factory and site, it will ease the transporting and handing of materials as sometimes the products are heavy and need specific lorries and this will increase costs if the distance is far*". He added that, when there is big project, they use a factory within the area of the project. Interviewees E8 and E3 agreed with E1 in emphasising the importance of having the factories close by the projects as these factories can be moved from place to place. E3 stated that,

> *"… there is always the organisation of the work in OSC; the factory can move from place to place, as the transport process is always complicated and can be costly when long distances are involved; however, if OSC spreads in Iraq, there will be a factory in each city, and then the distance will be close".*

He also added that, sometimes, they mix offsite with onsite when they cannot transport large components, like bridges that require prefabricated columns with in-situ castings of the bridge. While E1 highlights another important point that,

> *"… if there is government support and the referral of large projects, then investors can build factories inside Iraq … as the security and political situation has led to the reluctance of many investors to build factories for ready-made buildings in Iraq, the protection plan is required and the existence of factories within a reasonable distance can minimise damages and defects to products that can occur during transportation".*

Finally, E12 ascertained that, "*OSC [is] generally is cheaper if the sites are within a specified distance from the factory, generally within of a circle radius of not more than 50 km from the factory, hence no over costs in transportation*".

Transportation cost can be high when using OSC, particularly when long distances are required. Therefore, the existence of local factories is vital within the construction industry in Iraq. Meanwhile, they recommend reasonable distances from the site to the factory, specifically within of a circle radius of not more than 50 km. Indeed, a large project usually involves the establishment of factories within, or close to, the site. Hence, the government play an important role in supporting investors in OSC by referring large projects and providing security measures to protect such projects.

5.2.4 Industry and market culture related barriers

It is important to have acceptance among people in the use OSC in Iraq, otherwise it is unlikely that its adoption will increase. While some interviewees (E1, E2, E6,E7,E8 and E13) emphasised that the "*there is a lack of acceptance and desire among people including clients and contractors to use this type of construction*".

Figure 5.14 shows Industry & market culture barriers of using OSC in Iraq including:

- Clients desire traditional construction and custom made
- Negative image from past attempts of the application of OSC may limit acceptance
- Difficult to obtain formal approval (financial- insurance) for this type of construction.

Industry & market culture barriers	14	40
Past application	14	17
Clients desire traditional construction	10	15
Difficult to obtain formal approval	11	15

Figure 5-14: industry & market culture barriers of using OSC in Iraq

Interviewees E1 and E7 attributed this to a lack of knowledge, whilst another cited reason was that contractors prefer to use traditional construction (E2, E7 and E8). E8 explained that the contractor and its workers usually have a good knowledge of traditional construction, whereas "*OSC needs accuracy on work, specialised people, and therefore, the contractor is avoided*". He emphasised the importance of improving of society's culture and added that the Ministry of Planning should introduce a chapter about OSC in the General Conditions for Contracting. E7 also illustrated that, "*the contractor himself cannot adopt this kind of construction for small projects; it needs government support and large companies' involvement to build and bring in people to live*".

Another reason explored by E2 and E10 was that people do not yet trust this type of construction. E10 attributed that to the view that, "*as an Iraqi society, [we] are used to defending classical methods in any matter, whether social, economic or even urban*". There are those who see a difference in the cost between traditional and OSC, as well as those who believe that OSC is not safe under the prevailing conditions in the country. E2 added that, *"... people, especially in the Middle East, believe that this type of construction is not good or has limited lifetime"*. He added another important view that the people in Iraq are accustomed to changing the shape of houses from time to time; this is not applicable to OSC. Another reason was identified by interviewee E6, that Iraqi society and culture are different from others as people in Iraq *"... do not like the vertical buildings; however, Iraq can take advantage of the large land available by constructing OSC multi-story buildings*".

However, interviewees E9, E12 and E14 believed that the society's negative cultural thinking towards OSC is starting to change as some successful projects have recently been completed in Iraq, like Bisamaya city in Baghdad. E9 stated that the society's culture about OSC started to *change in favour of OSC*. E14 agreed with E9 and added that there is not only a positive improvement in society's thinking towards OSC, but also towards vertical buildings. E9 declared that, "*the improvement of people's thinking towards this type of construction will occur when it spreads out through the successful application from reliable companies as these companies usually adequate efficient design and implemented successfully"*. In the same way, E12 thought that, "*… people are now more aware about this type of construction as few successful offsite projects have been done; however, there is still much to do for this type of construction to spread around Iraqi cities as development is still considered slow compared with other developed countries*".

However, some interviewees, such as E1, E2, E3, E4,E5,E6,E8,E10,E11 and E13 believed that the reason behind people's lack of desire to use this type of construction was a result of the negative image from insufficient past applications of OSC. E3 stated that, *"... because OSC is relatively new, has entered Iraq randomly and has been implemented from inefficient contractors, this has lost trust amongst people for this construction*". Interviewees E1,E4,E5,E8 and E6 also indicated that, *"... the past applications of OSC were implemented from non-reliable and inefficient companies*". E4 clarified that by *"... the negative image comes from the past experience of implementing OSC by insufficient companies; unfortunately, there are still some unreliable and incompetent companies implementing OSC with bad quality and this increase the bad image about it*". Interviewees E7 and E13 highlighted an important point, namely the problem with past negative experiences in 1970s, which caused problems in joints and a lack of insulation and not because of the structure of the building. E7 emphasised that the problems with joints have since been solved due to technological improvements and insulation nowadays is used with OSC products. He also ascertained that, *"... the main idea is to be implemented by trustful and efficient companies that improve the cultural thinking towards this construction*". In the same way, E10 believed that there were some negative applications of OSC that led to people losing their trust in this type of construction; however, there have been some single successful applications as a result of government and bank supports, like Bisamaya residential complexes. This is also supported by E9 who highlights Bisamaya as a recent successful OSC project.

Most of the interviewees believe that there is cultural resistance or an avoidance of OSC. The interviewees attributed this to several reasons, including the following:

- OSC requires accuracy and a specialised workforce, thus the contractor and his team may be more familiar with traditional construction.

- Societies are used to defending established thinking in many aspects of the life, which can explain the difficulties in shifting thinking to any new technology. However, the interviewees suggested that the negative thinking amongst society in Iraq has started to change in favour of this method of construction. Nevertheless, this change is slow and as such, this method needs time to spread.
- Past, or even recent applications, of OSC by unreliable construction companies or implemented without using insulation with joint problems have increased both the negative image of OSC and the loss of trust amongst people. However, technologies are now improving and now insulation is used with most OSC application, whilst more technologies require treatment of the joints.

Therefore, interviewees recommend that the government and large construction companies adopt this construction method to promote its spreads throughout the country. They also emphasised the importance of trustful and reliable companies implementing this type of construction, as a good project performance by these companies will leverage trust and acceptance among clients and end users. Other important good practise is to include a chapter dealing with OSC in Iraqi general conditions contracts.

Interviewees E1, E6, E10, E11 and E14 agreed on the difficulties of getting formal approval from the authorities. Interviewees E1,E3, E4 and E6 attributed that to the "lack *of knowledge, desire and experience of the responsible people in this field"* and there are no engineering specifications, regulation and standards for this type of construction; this has led to reluctance in using this type of construction and increase the project duration (E6). In the same way, E14 emphasised *"... the difficulties in obtaining formal approval and financial support as a result of ineffective regulation which lead to long lead time; therefore, the government and banks have to support this construction financially*". E8 stated that, "… the local authorities and decision makers need to have enough knowledge about OSC in order to support its use administratively and financially, otherwise it will increase the project time*"*. He added generally, that if an OSC project tender is introduced effectively and clearly, the government will support it, as the government is now more familiar with the benefits of OSC, such as cheap cost and the speed of implementation. Nevertheless, E7 had a different opinion; *"... if the tender is introduced by the engineering offices to be built by OSC, there is no need to get formal approval*". Instead, E9 and E13 believed that it would be easy to secure formal approval. E9 emphasised that *"... nobody will oppose the contractor in building OSC; the people, including decision makers, have a clear vision about OSC in terms of cost and time saving*"

Some interviewees recommended particular actions in order to confront industrial, market and cultural barriers. E2 recommended that, *"…academic consultants and experienced people have to provide awareness, research and studies, and lectures in order to spread knowledge and to change culture and society's thinking*". E13 also recommended the importance of education and building good models, whilst E12 recommended applying it through proven, trusted and reliable companies.

The difficulties in obtaining formal approval for this type of construction were mainly declared by contractors or supervisor engineers, whilst academic consultants mostly believed that there was no problem with this. This difference can be attributed to contractors reflecting on the practical side of the project while academic consultants reflect on the theoretical. Moreover, the interviewees attributed this difficulty to a lack of knowledge or desire by the authorities responsible for approval, which in turn leads to project delays and can increase cost. Also, some interviewees attributed these difficulties or delays to obtaining formal approval, due to lack of regulations that support this type of construction.

Hence, interviewees believe that the industry & market related barriers include client reluctance, bad image, and delays on formal approval, which still exist in Iraq. Therefore, some actions noted by the interviewees include:

- Reliable companies are required to efficiently implement OSC in order to reduce client reluctance and improve trust.
- Academic consultants and experienced people promote awareness, research and studies to spread knowledge and thus change both culture and society's thinking.
- Establish good models
- Government bodies are responsible for providing regulations to support the use of OSC in Iraq.
- Producing a chapter that deals with OSC in the Iraqi general conditions contract.

5.2.5 Political and economic related barriers

Iraq has suffered from a major economic crisis that has negatively impacted the country's affairs and people. Although Iraq is the richest country in the world with natural resources, such as oil, natural gas, mineral materials, abundant water and land fertility, this wealth is not exploited due to financial issues, administrative confusion and failures in planning. Thus, as a result it fails to achieve the progress and prosperity of the state. Figure 5-15 illustrated Political & economic barriers of using OSC in Iraq indicated by the interviewees.

Political & economic barriers		14	26
Unstable Current market condition		8	17
Unstable security situation		9	13
Financial status fluctuation		9	10

Figure 5-15: Political & economic barriers of using OSC in Iraq

There is agreement on the importance of this factor and its impact on the use of OSC; however, some interviewees believe that this factor affects all kinds of construction. E4 stated that the political and economic factor is, ‘a major player in the market’. Meanwhile, interviewees E1, E7, E8, E5, E10, E4, E9, E6 and E13 ascertained that the unstable political, security and economic issues significantly affected the use of OSC. Interviewees E8, E9 and E13 attributed that to, *“the fear of venture”.* E8 criticised this, stating that *“... the stakeholder will not run a risk and build a factory during an unstable situation in the country where is no demand, as the cost of the factory is expensive*”. E9 confirmed that and added that the contractor cannot be involved in this type of construction without ensuring contracts and continued demand otherwise they will lose money. E10 also stated that another important point, in addition to the fear of adventure, that *“ ...this type of construction needs financial support and may need to import materials, so if there is political and financial conflict, companies will not take a risk by adopting it, especially if it still has not achieved the desired confidence amongst Iraqi individuals*”. The economic factor is a highly important factor, as indicated by E5; *“... when there is no demand or fluctuation in demand for OSC units, the contractors will be afraid to use it*”.

Although E2, E3, E11 and E14 believed that this factor affects construction in general, whether traditional or offsite, M had a different opinion, namely that the political and financial factor does affect OSC construction than it would be in traditional construction, This is because *“... the financial budget of traditional construction is smaller than the financial budget of OSC, in which the person can control and finish his project because the factors influencing it are less than they would be with OSC, which requires financial support and demand because it involves large project*”.

Moreover, issues with financial and administrative mismanagement that reportedly occurred after the 2003 war started to affect all sectors of the country, including the construction industry.

While some interviewees, including E3, E4 and E7 agreed on the existence of this phenomenon in Iraq and its affected on OSC others clarified how it affected the use of OSC. E1,E5, E8 and E9 illustrated that, as a result of financial and administrative corruption in Iraq, some OSC projects have been referred to as unreliable and inefficient companies, which in turn creates a bad association about OSC because of poor performance of whole project . Interviewee E1 suggested another example of mismanagement, where some committees who refer a project allegedly require a share of the profits. In the same way, E8 explored another type of issue where some faulty OSC components were reportedly accepted due to financial mismanagement.

In fact, successive policies and wars that have passed through the country, and the control of external forces over the decisions and resources of the country have led to the aggravation of the housing crisis in Iraq and the decline of its infrastructure. Interviewee E12 suggested that, it was widely understood that, if the Iraqi Government seeks a loan, it should reduce any infrastructure expenditure. This includes health, education, transportation, electricity, water, roads and housing projects, and potentially impacts the availability of public hospitals, public schools, public housing projects, and public electrical project station. However, it was suggested that such projects should be left for private sector investment.

Iraq suffers from political and economic issues as a result of many wars. This situation has affected all aspects of life in this country, particularly amongst construction in which it has experienced problems in performance and even halted some projects. Although some interviewees believed that this issue could affect all types of construction, some believe that it would affect the adoption of OSC more than classic construction. This is due to the fear of risk, as OSC requires substantial financial support compared with classic construction, and sometimes means the import of materials. The other reason is that the contractor will not risk building a factory if there is no specific demand, as it has not achieved the desired confidence amongst Iraqi individuals or continued project contracts.

The mismanagement of administrative and financial aspects has meant the referral of some OSC projects to unreliable companies, which in turn creates a negative impression of OSC that stems from poor project performances overall. In addition, as a result of corruption, some committees require profit shares or accept bad quality products from unreliable companies due to bribery. This barrier needs attention by government bodies who could establish policies to protect construction companies and offer loans to support clients.

5.2.6 Supply chain and procurement related barriers

The management of supply chain shall include a full understanding of the roles of different parties, clear communication and knowledge between the people involved and resources need to work towards desired outcomes; this enables the project timeline to finish close to the deadline.

Figure 5.16 Illustrated supply chain & procurement barriers of using OSC in Iraq

Supply chain & procurement barriers		14	22
Industry capacity to supply diverse varieties of OSC is		9	12
The use of OSC requires firm control of supply chain		10	12
More complex payment terms where mixed offsite an		6	6
Different payement terms		5	5

Figure 5-16: Supply chain & procurement barriers of using OSC in Iraq

When there is no capacity amongst the Iraqi construction industry to introduce a variety of OSC products, this will pose a barrier in the adoption of OSC and lead to import from other countries. This can cause different problems, including legal conflicts between both countries; interviewees (E1, E12, E9, E14 and E5) noted this point. E12 highlighted that, "*It is a barrier when the capacity of Iraqi factories to produce offsite products is insufficient as this leads to imports from outside Iraq, and hence the control of the supply chain is not easy*". He added that, supply requires firmer control because there will be regulatory conflicts between Iraq and other importing countries, especially for regulation regarding transportation issues. E1 also supported interviewee E12's thinking and added that, *"... any defect in the arrival of imported products from different countries can cause a delay of the project and that was what we had in our project as there is lack of sufficient infrastructure in Iraq especially roads and this sometimes cause a defect sand cracks of the products"*. He added that, in order for OSC to finish on time with cost savings, it requires all required information and products on time and a firm control over the steps of the supply chain (E1 and E9). In the same way, E9 emphasised that, "*the existence of the factory in another country is not practical*". He confirmed that,

> *"... the products of OSC have to be under the quality control of the owner, so how can the observing engineer monitor the products when the factory is in a country and the construction is in another country, as problems can occur because of the long distance of transportation especially there is poor road network, and legal and administrative problems at the borders between the counties which in turns lead to long lead time that can affect the completion of the project*".

E6 and E14 also illustrated another point, that the importation of OSC products as a result of an incapacity to provide OSC products in Iraq can lead to additional payments, including taxing of importing materials, transporting and the delayed entry of materials as a result of closing the borders from time to time, this is in turns may explain reluctance of some contractors regarding this construction . This was also highlighted by E10 who suffered from the need to "*pay tax and customs on raw materials, although the raw materials are exempt from customs and tax in all countries of the world*".

Furthermore, E4 indicated that, *"... there is a problem in the supply chain, especially transporting issues; even though this means transporting materials inside Iraq, because the lorries need to access long inspections for security reasons, and we must pay commission for each lorry*". E3 and E4 emphasised *"... the importance of closely managing the steps of OSC and the importance of continued communication between the stakeholders to ensure the receipt of the products by the clients*". In fact, E8 illustrated that the project can be stopped in case of delays to essential items that are required in the installation of OSC products. E8 also gave an example of legislation differences between Iraq and the export country regarding transportation "*The difference is that the cargoes are guarded by cargo laws in the export country ... but in Iraq, there are insufficient cargo safety checks. For example, the products are loaded into three lorries from the export country, but while entering in Iraq [they are] carried in two lorries to double the cargo ... and favour the contractors in Iraq*".

Instead, interviewees E7 and E13 believed that there are no difficulties on the procurement of OSC products, especially when cash flow is available (E7). In the same way, E2 stated that,

> "*It is possible to supply different types of OSC products because the resources, like raw materials, exist in Iraq, but the lack of support, whether governmental or private, limits this process. There is no new or complex expenses or administrative problems when mixing the ready and ordinary ground floor and the cost is included in the calculation*".

Moreover, interviewee E12 commented that,

> *"... the supply chain parties have to work together perfectly to implement the project with the time scheduled and budget agreed; but the managing of the supply chain may be easier when factories are available in Iraq within reasonable distances and varieties of product design".*

Accordingly, the supply chain & procurement barriers indicated by the interviewees are:

- *Industry capacity to supply diverse varieties of OSC is limited due to lack of infrastructure support and resources*

- *The use of OSC requires firm control of supply chain which can involves high risks.*
- *More complex payment terms & cash flows process and financial administrations where mixed offsite and onsite components are required*
- *Different payment terms.*

Interviewees confirmed the supply chain and procurement barriers. Indeed, the lack of capacity to provide different types of construction could have a negative impact on the project. This is because countries unable to provide different types of OSC products will be obliged to import from international countries which can cause conflicts in legislation, delays to materials due to checks at borders, taxes for the import of materials and long lead times. Therefore, all these problems can negatively affect the performance of the project, like increased cost and delays to the completion of projects. On the other hand, the supply chain requires a firm control and management of its steps when using OSC as any disturbance can lead to delays or disturbances in other phases. Also, the cooperation and proper communication amongst the different parties involved in the project are essential for the success of a project. Hence, local factories are fundamental in avoiding any disturbance or delay to the supply chain within a reasonable distance. Engineers in local factories also monitor the products in the factory and can refuse any faulty product before transportation.

Transportation is another issue in the supply chain that interviewees recommended was addressed; they advised the transportation of materials within reasonable distances whilst the development of local factories would help to avoid the delays and commissions that lorries require to pass cargo across borders between export and import countries. Whenever, the distance is long the materials will be liable to many security checks points which causes delay and sometimes requires commission to pass. This means another type of project payment that can explain the contractor's resistance and low uptake to this type of construction. The other problems that can occur, particularly when there is a long distance between the site and the factory, is delay or defects to the products due to the insufficient road network in Iraq.

More complex payments are involved when both onsite and offsite work are required, which can be a problem in the supply chain. However, some interviewees believe that, if cash flow is available, this would not matter.

5.2.7 Skills and knowledge related barriers

There is little industrial knowledge on OSC in the Iraqi construction industry. Most interviewees agreed that there is a lack of knowledge and awareness about OSC in Iraq. Interviewee E7 illustrated an important point, namely that the engineer, when finishing university and starting employment in a company, is only familiar with traditional construction. Thus, when a company wants to become specialised in using OSC, they need well-trained and experienced engineers and technical workers. Figure 5.17 demonstrated skills & knowledge barriers of using OSC in Iraq indicated by the interviewees.

Name	Files	References
Skills & knowledge barriers	14	49
Lack of previous experience and skilled workforce	14	31
Lack of knowledge and awareness	10	17
Lack of R&D in OSC	9	9

Figure 5-17: Skills & knowledge barriers of using OSC in Iraq

Therefore, E7 stated "*I suggest that there will be an association for OSC in order to spread the knowledge and awareness among people through meetings, workshops, international training as the real problem is the lack of knowledge about this type of construction in Iraq that lead to poor manufacturing capacity in Iraq*". E1,E3,E5 and E12 also supported E7 on the lack of knowledge; furthermore, E1 highlighted that, *"... the knowledge and awareness among people is one of the drivers that support OSC, but unfortunately, Iraq suffered from a shortage in knowledge, shortage in research and development, insufficient knowledge, experience and future planning on supporting the use of it and this lead to poor application and production of OSC* ". E8 also supported E1's thinking by noting that, "As *well as the lack of adequate awareness of this type of construction, this is considered a large problem; existing research is mainly in engineering design issues, like precast concrete. There must be research focusing on construction management engineering related to OSC*"

This was also indicated by E6, who further added that the, "*awareness and culture of the community did not absorb this type of construction despite the urgent need for housing*." In the same way, E4 noted another important point, that, "*there were very rare tenders declared using OSC as a result of limited engineering knowledge about this construction as well as limited research about it*". E8 believed that people are resistant to this type of construction as a result of their lack of awareness about it. E8 commented that, "*Iraq was using OSC since the 60s; there were some negative attempts, however, at the same time there are positive attempts as well, but the community knowledge about it is limited*".

Finally, interviewee E11 believed that the lack of knowledge is an essential factor that can largely affect the use of OSC in Iraq, and added that, " *Currently and in the near future, I do not imagine that such a kind of construction is applied due to its absence in the general culture of the society, weak government support for this type of construction, and the absence of factories operating in this field*".

Moreover, it seems that the construction industry in Iraq suffers from a lack of a skilled and experienced available workforce. Interviewee E12 raised criticisms, that,

> *"Since the Iraqi-Iranian eight years' war, Iraq has lost many of its skilled labourers in war, and those who survived had no interest in their former career, being tired and getting old and due to a shortage of projects because of the embargo imposed on Iraq after 1991 war. This led to stop the transfer of knowledge to the new generation of labour. As a result, there is a shortage in all the skilled labours in general and among them in OSC".*

All participants identified the lack of an experienced and skilled workforce. Interviewee E1 highlighted this factor, "*the availability of a skilled workforce is a very important driver for using OSC in Iraq; but unfortunately, currently the Iraqi industry market suffers from a shortage of this factor and will requires good financing to cover this barrier by providing training and awareness. The other shortage is the existence of expert companies in dealing with this factor*". E9 attributed this to the "*shortage of this type of construction leads to less availability of an expert skilled workforce and this in turn will lead the contractor hesitates to use it*". To overcome this lack E3, E7 and E10 stated that Iraq needs foreign labour to train domestic workers on the system. E3 added that,

> *"… the availability of a skilled workforce needs a time to spread out in Iraq, as the foreign labour needs to train the local workers , and if skilled and expert labour will be available, the use of OSC will increase, and if this happens, it reacts as an economic factor as the OSC will be competitive to classic construction due to its advantages".*

Although, OSC needs foreign workers to train a local workforce, the process of attracting them is difficult, as it entails a long process and formal approval is needed, as illustrated by E4 and E10. Moreover, E6, E8 and E14 agreed that there is a lack of skilled and experienced workforce in OSC; however, the interviewees emphasised that this factor is not difficult to overcome when the labourers learn to use it, as it is repetitive work.

Interviewee E2 ascertained that there is, "*a fact of a labour skills shortage in Iraq and Arabic countries in the construction industry*". However, E12 and E14 noted that using OSC could help to overcome the problem of shortage of skilled labour in Iraq. Interviewee E12 stated that, *"…the use of OSC can lead to a reduced need for a skilled workforce as the amount of skilled workforce required onsite in OSC is less than traditional construction and therefore, helps to overcome this shortage*".

Although, E12 did not agree that this factor is a barrier as training labourers does not need a long time to achieve; however, it is a barrier to interviewees E2 and E13. Meanwhile, E13 confirmed that, "*if the labour needs to be expert, and expert needs training, this is currently unavailable in Iraq*". In the same way, E2 identified that, *"… the shortage of skilled labour and experience in using OSC is a strong factor that can be a barrier to the use of OSC.*" He further explained that,

> "*Manpower must be skilled both in the process of manufacturing including design or in the process of implementation or the construction of the offsite unit because the worker will work with advanced technology and software and must have the experience, and this can be achieved through continuous training even though increase cost and if such a workforce is available, it will increase production and demand*."

Therefore, most interviewees believed that the availability of skilled labour and experience in using OSC is a driver towards its use. Interviewee E5 stated that, "*Work experience and the existence of skilled workers engineers for design and implementation of OSC will lead to the success of this construction*".

Accordingly, it is clear that there is a lack of knowledge, skills and experience of OSC in the Iraqi construction industry. This is can be a significant barrier that inhibits the use of OSC in Iraq and affects its performance. In order to overcome this barrier time and financial support are needed to provide training courses for labour and to leverage awareness among society. The wars and embargoes suffered by Iraq have led to a shortage of skilled labour, which has halted construction and stopped the transfer of skills to new generations. However, some interviewees noted that this construction can help to overcome the problems associated with labour shortages as OSC requires fewer skilled labourers than classic construction. Although the literature review also mentioned this, it does not mean that this type of construction does not need skilled labour onsite and in the factory. In fact, generally the use of OSC requires a lower number of labourers onsite as products are produced in the factory thus requiring fewer activities onsite. This barrier needs to be overcome by providing training for Iraqi labour by providing courses or workshops or by hiring expert labour to train local workforces. Government support is fundamental for the success of this construction and the availability of skills and awareness is essential to promote the adoption of this construction and achieve project performance.

5.2.8 Management related barriers

Manging construction projects can be challenging and stressful because it involves many steps. Thus, successful and efficient project management will ensure that the client receives a finished product that meets their expectations. Interviewees E2, E11 and E12 believe that management and leadership is a very important factor that can affect any construction project. Moreover, E2 added that, "*if any weakness or imbalance in management occurs, it can lead to a delay in the project and increase the possibility of extra cost*". However, interviewees E3 and E13 believed that there are problems when the decision is delayed by senior leaders as there are particular project timings that must be adhered to because "*any imbalance in the supply and transport chain is problematic and can lead to delay and cost overruns*". Therefore, E3 emphasised *"the importance of providing good training and a high level of management in dealing with OSC projects"*. In the same way, E1 and E10 believed in the importance of clear and continuous communication between the work team. Figure 5.18 shows management barriers of using OSC in Iraq

Name	Files	References
Management barriers	14	31
Deficiencies in dealing with managing project	8	13
Delay of decision making from the leadership	10	12
Absence of effective communication between project	7	9

Figure 5-18: Management barriers of using OSC in Iraq

Delays in making decision by management can be connected to different reasons, which are illustrated by some of the interviewees. E1 and E5 attributed this to the view that, "*there is some leadership that has not absorbed this type of construction yet*". Interviewees E4 and E10 also supported this view and further explained that, *"the problem is the existence of inefficient persons in the position of decision-making"*. Interviewee E4 added that, this is impacted by inefficient leadership, which does not address the potential for political and management corruption. Moreover, there is limited knowledge about this type of construction, and thus the involvement of an untrained person can delay important decisions.

Interviewees E3, E7, E8 and E9 also noted the issues in project management, as E7 illustrated that,

> *"... there are many reasons for difficulties in taking decisions, including management [issues], a lack of knowledge in dealing with such projects, a lack of communication between the manager and the team, and a fear of decision-making to avoid any responsibility. Therefore, they make a consultant responsible for making decision [may be] too afraid to take such decisions; therefore, this leads to delays ..."*

E9 also emphasised the potential impact of financial and management issues in Iraq, which can include the referral of OSC to untrained, unknown or unreliable companies, which can lead to the failure of some projects; for example, the schools projects in Iraq, which was reportedly not completed and the funding allegedly disappeared which in turns increase the bad image about OSC. Instead, E8 illustrated another opinion, that managerial and financial issues can either go against or with OSC, so through such problems, the contractor can persuade the decision-maker to accept this system. E9 identified another reason behind delay in decisions,

> *"In Iraq, the decision has been to withdraw from the resident site engineer, while globally he has a power and mandate in taking decisions. But nowadays the resident engineer has to consult the higher decision-makers in Ministries, and they must be convinced of his opinion, then he can make the decision after their acceptance"*.

Interviewees E5, E8, E9 and E10 emphasised the importance of clear and continuous communication among the teamwork. E9 stated that,

> *"... if there is no appropriate communication between the teamwork, it will cause deficiencies in the OSC project more than it would be in the traditional construction, for example, the lack of communication between the supplier and the team work onsite can halt the project as sometimes the site supplied by columns while it needs beams then columns go to the different site as a result of communication absence"*.

Therefore, E9 strongly recommended, "*the importance of clear communication between the teamwork of the project, the teamwork and suppliers, even the different sites with each other when they have the same factory supplier*". Finally, E6 and E14 believed that *"If the legal answer is not delayed, and if the solutions are available for this type of construction, then there are no problems, and it can be implemented without any problems. There will be no delay in making the decision"*.

A proper management system, the existence of reliable and strong leadership and effective communication are important factors for the success of any project. Furthermore, OSC in particular requires proper planning and supervision. However, interviewees believe that, in Iraq, there is a lack of sufficient projects management due to corruption and political issues. These problems, as well as the lack of efficient leadership, can lead to cost and time overruns. In Iraq, decision-making has been withdrawn from the site engineer, which means he has to consult government bodies resulting in delays. Corruption within or against OSC, can include occasions when a contractor becomes liable to pay commission to some committees if he wants to use this method. However, as a result of corruption, some committees can give a contract to unreliable companies or may accept bad quality products. Therefore, the interviewees recommended providing good training for project teams, particularly for leadership, and to provide a high level of management when dealing with OSC projects. Moreover, they emphasised the need for clear communication and cooperation amongst the teamwork in order to enhance the use of OSC.

5.2.9 Non-working days related barriers

There is another obstacle in Iraq that the OSC suffered from, namely that there are a lot of events that require road closures. Figure 5.19 demonstrated non-working days barriers of using OSC in Iraq.

Non-working days barriers		2	4

Figure 5-19: Non-working days barriers of using OSC in Iraq

Two of the interviewees pinpointed that non-working days as an important barrier in up taking of OSC in Iraq. One of these are the religious, which especially occur in south and middle of Iraq and thus would cause more delays in OSC projects than in traditional construction (as illustrated by E9). The interviewee attributed this to the fact that, "*in OSC, a project needs continuous supply of products, while traditional construction does not, as you can load all materials and stock them on site. Therefore, religious holidays, which may take more than a week, will delay the completion schedule of the OSC project*". Thus, E9 added, "*to avoid such problems in the large OSC projects, the factory is built either close or beside the site, like Bisamaya project. But built such a big factory is not practical for small projects, like schools in different sites*". Moreover, Interviewee E1 also illustrated this point and further added that "*religious and national non-working days in Iraq negatively affect the continuity of the project activities as a result of delay, difficulties in transportation and disturbance of the supply chain which in turns causing delay time and increase cost and affect negatively the quality performance of the final building which in turns can increase the bad image about OSC application in Iraq."* Indeed, both interviewees E1& E9 emphasised that this barrier could increase mismanagement in construction projects and particularly in OSC. Therefore, vital measures have to be taken in order to address this problem such as government support and leverage awareness amongst the stakeholders. Indeed, both interviewees emphasised that this barrier could increase the mismanagement in construction project specifically in OSC, therefore, vital measures have to be taken in order to face this problem. Hence, it is clear that the phenomenon of non-working days in Iraq due to the large number of national and religious events can be a barrier to using OSC in Iraq as this type of construction requires a continuous supply. Moreover, this barrier can negatively affect other factors, such as increased mismanagement and time and cost overruns. Using local factories close to, or within, the site can decrease this problem, however, this solution is not practical for small projects or different sites. Therefore, vital measures are required to overcome this barrier, such as government support to establish laws that reduce the number of non-working days or prevent road closures during such events.

5.3 Recommendations

This section presented the interview results of the analysis regarding the best practices for enhancing the use of OSC in Iraq. Figure 5-20 illustrated the interviewees recommendations. Most of these recommendations could play a vital role in enhancing the drivers and reducing or overcoming the barriers.

RECOMMENDATIONS

Name	Files	References
Association	12	15
Building regulations & codes	8	11
Effective strategy	7	10
Enhance knowledge & awareness	12	22
Enhanced support from construction professionals	7	8
Existence of reliable companies	9	15
Government support	14	27
Integration	14	22
Others	2	2
Ready models	8	12
Risk management	6	6
Technology	7	8

Figure 5-20: Recommendations for enhancement of OSC in Iraq

5.3.1 Government support

Interviewees were asked to demonstrate their recommendations to enhance the use of OSC in Iraq, and all participants emphasised the role of the Iraqi government in enhancing the use of OSC and getting best project outcomes performance. Some interviewees, such as E4, E5, E6, E7, E10, E13 and E14, demonstrated that the role of the government is important in allocating of lands for OSC for investors. E7 indicated that "*the government's role is allocating land, obliging the proposed contracts to use OSC, supporting the idea of value for money …*". E3 also supported the idea of value for money by advocating, *"… getting reliable, trust-worthy companies to implement OSC projects perfectly…*". E8 highlighted that, "*the government does not prevent work offsite … but its role will be on prioritising the work through OSC instead of classic when they announce a tender and accelerate funding to improve time performance*". E9 supported E8's view and added that, "*the contractor taking the tender must provide proof of his ability to do it like having a factory that produces offsite products, not just vows to do it in order to get the tender*". In the same way, E5 and E14 added that, "*the government has to establish regulations that support the using of OSC and protect the investors from [issues from] irregular parties*". E5 further added that, "*the government's role is to*

accelerate the process of establishing regulations for people who want to work in this sector, like tender regulations and monitoring their work by supervisory bodies". E4 also emphasised the importance of providing large lands for investors in stating that, "*in order to have mass production to save cost, the nature of OSC projects are big and such projects are not recommended for implementation inside cities as the services are difficult …, therefore, the government's role is to provide large areas of investment outside cities*".

E10 and E13 illustrated another important point, that the Government should provide financial support. Moreover, E6 and E10 recommended that the Government provides the raw materials for OSC and reduces its taxes. In the same way, E9 illustrated the importance of lending, "*as money is a problem for some citizens, the government's role is to find a way to lend to citizens in order to enable them to buy housing units in large housing complexes. So, I highly recommend providing a system of lending for citizens*". E14 also agreed with E9 on the importance of lending to citizens and further added that "*… banks have a great role in supporting the investor and financing projects to improve time performance and … have a role in supporting the citizen by granting loans with small benefits to enable him to buy a house in such projects, and this cannot be achieved without Government support*".

Iraq is currently in need of private and international investors as a result of many disasters it has faced that have caused an increase in housing shortages and infrastructure deficiencies. Some interviewees highlighted this important point, which is the role of the government in supporting ‘investors. E5 noted that,

> "… *in countries with a weak financial economy, like Iraq, they need external investors to enhance the economy. The government must subsidise the investors through giving them certain lands to perform their projects or provide them with raw materials at subsidised prices; for example, reducing the value of electricity by 50%. It is necessary to allocate specific areas to establish OSC factories in industrial areas and not beside residential areas to protect people and environment, so all kinds of support will result on improving the overall performance of the project"*.

In the same way, E10 emphasised "*encouraging the private sector to raise the national economy, develop a proper organisational plan for the investment budget and give priority to local, reliable, good reputation Iraqi construction companies, support investors by reducing the cost of utility bills*". E12 also emphasised the importance of encouraging the private investment sector in Iraq and to support them by "*exempting them from customs and taxes, giving cheap lands, and subsidising the price of raw materials"*. Moreover, E3 supported E12's views but highlighted that,

> *"… if this construction wants to be successful in Iraq, it needs to be implemented by reliable, experienced companies, so before choosing, any foreign companies must visit these companies and visit their past projects and ask the end-user about it and have a clear knowledge on how the unit can be treated if any problems occur, and if that happened in past projects who did they deal with. Ensuring trustful companies in implementing OSC is vital issue"*

E12 advocated, "… *reliable, experienced foreign investor companies supported by the latest technology in this field and providing low cost, durable, proper housing units to solve housing shortage problem*". Another important point highlighted by E10 was that, *"… the government should facilitate the bringing of foreign workers to train internal staff in Iraq in terms of facilitating entry visas and symbolic amounts*".

Accordingly, government support has a strong role in enhancing the drivers and addressing the barriers to using OSC in Iraq; for example, accelerating funding can enhance time and cost performances. Moreover, the existence of funding for investors and loans for end users can reduce the capital cost of implementing OSC and increase demand. Providing regulations to support the use of OSC in Iraq would enhance project performances in terms of time, cost, quality social impacts and productivity. The support starts from bids as government bodies can introduce bids to implement OSC projects. Moreover, it is also essential to focus on value bids rather than lower bids. Indeed, the negative image of this type of construction results from bad implementation by unreliable companies. Therefore, to enhance this construction method, bids should be referred to reliable companies and supervisory bodies must monitor work. The government's role is also important in encouraging the private sector by providing funding to establish factories, and lands; moreover, they could lower the price of materials and utility bills for factories producing OSC materials.

Furthermore, government decision-makers have a role in easing the work of international companies and expert labour who may need to train local labour. At the same time, the government has to protect investors from irregular parties or perhaps support them against terrorist attacks.

5.3.2 Reliable companies

Reliable companies are those providing good quality products with a high durability and with experience and a well-known reputation in the market. The existence of such companies is vital to successful use of OSC in Iraq. The majority of the interviewees (E1, E3, E5, E6, E7, E10, E11, E12 and E14) recommended the need for such companies implement OSC in Iraq in order to enhance the performance of the project. E1 suggested that, in order to ensure good project process and performance results, the project needs to be implemented by reliable companies. This was also supported by E7, whilst E14 recommended *"... encouraging reliable companies in the adoption of such construction, as these companies have the ability to spreading out such construction in positive way in order to solve housing problems and rehabilitate infrastructure and enhance labour productivity*"

In the same way, E6 highlighted,

> "*… the vital need for reliable Iraqi companies committed to the implementation of OSC in Iraq to achieve good results because Iraq has suffered from the lack of such companies in this area, the problem of poor implementation from past attempts, lessened desire and confidence of the community in such construction*".

Interviewee E5 explained the importance of implementing OSC by reliable companies to achieve overall appropriate results as, "*reliable companies adopt specifications, quality control, supervisory and advisory bodies, providing after sales services; therefore, the clients will be motivated to deal with them*". E12 also supported that and demonstrated that *"... successful projects outcomes can be met once we establish a truly experienced certified company specialised in each stage, including design, manufacturing and the erection of offsite products*". Moreover, E12 added that there is, *"... still much to do for this type of construction to spread* *around Iraqi cities as the development is still considerably slow compared with other developed countries. Therefore, we need more robust, trustful companies to implement such construction*". In the same way, E1 recommended that, "*If a suitable roadmap is developed and supported by the government and implemented by specialised, trusted companies, this construction will succeed in Iraq*".

Therefore, it seems that there is agreement between interviewees about the importance of implementing OSC projects by using reliable companies. These companies usually adopt specifications, quality control, supervisory and advisory bodies, and provide after sales services. Therefore, the existence of such companies will attract clients, enhance the performance results of projects, and play an important role in enhancing all the drivers. These companies can spread this type of construction in Iraq and help to dispel its existing negative image.

5.3.3 Ready good models

Some interviewees recommended undertaking ready good models of OSC units in order to enable people to see it (E1, E3, E5, E7, E8, E9, E13 and E14). E13 believed in the importance of doing ready good models before the implementation to ensure the success of the project and to enable people to see examples before buying. E3 and E14 similarly attributed the importance of having ready models to enabling clients to see them and develop their awareness of the unit. E3 also illustrated another benefit from ready models, in which "*the feedback can benefit the companies to understand the public needs and preferences, and to improve the company and to prevent mistakes*". In the same way, E7 noted, "*The need for doing pilot models and inviting experienced consultants and ordinary citizens to give their views on this model in order to develop the production of companies and protect them from the impact of mistakes*". E8 also recommended "*the need to adopt models open to the public, especially international exhibitions and major scientific events, to enable people see them*". However, E9 believed that, *"... the using of models is important although the good reputation of the project attracts people to the project*". This action is important in enhancing the use of OSC in Iraq. Indeed, people need to see prepared models in order to be sufficiently satisfied to purchase. This will be fundamental to the success of any OSC project and increase the production of such construction. These models will not only benefit end users, but also the companies themselves by gathering feedback from clients, consultants and experts in order to avoid any mistakes in the future. This kind of action is important to eliminate the barrier of industry and market culture, as good models can highlight the culture of resistance to this type of construction. At the same time, this action will enhance the awareness and knowledge about this type of construction.

5.3.4 Enhancing Knowledge and awareness

The lack of knowledge and awareness about OSC in Iraq is one of the barriers towards improvements in its use. Therefore, most interviewees emphasised the importance of enhancing the awareness about it (E1, E2, E3, E4, E5, E6, E7, E8, E10, E11, E12 and E13). E4 stated that, *"… to improve the use of OSC, the government and ministries need to create cultural awareness and improve workers skills*". E3 agreed with E4 as he believed that,

> *"… this type of construction benefits many Ministries in Iraq; the Ministry of housing (by decrease the problem of housing shortage), the Ministry of Labour and Social Affairs (by providing jobs for people and enhance labour skills), the Ministry of Municipalities and Public Works (by protecting the infrastructure). Therefore, the Government and Ministries, in their interest to encourage the use of OSC, they can play an important role in promoting its use and leverage the awareness".*

E2 pinpointed that, to enhance the use of OSC, there is a need "*To establish awareness campaigns and educate people about the advantages and disadvantages of OSC in Iraq and acknowledge that this construction is the best solution in Iraq*". E11 also held the same view, and further emphasised that, *"… the need to build the knowledge in people that this type of construction has less cost than traditional, and the same effectiveness as the traditional*".

Moreover, interviewees E7, E8 and E11 illustrated another important point on developing curricula to study OSC. E4, E5, E7 and E11 suggested make these curricula similar to engineering fields in universities, as *"… graduate engineers are more familiar with classic construction than OSC*" (E7). Moreover, E5 emphasised the role of education in teaching OSC within universities in order to "… *have an educated, cultured generation about this type of construction*". Furthermore, both E6 and E8, emphasised the importance of *"… starting leverage awareness and studying this type of construction from secondary school and universities as well*" . E11 attributed the importance of such awareness to building cadres and workers within this area, and this is important in enhancing the use of OSC, therefore *"…the Ministry of higher education needs to provide OSC materials in universities as we need trained cadres and skilled workers in this field*" (E6). In the same way, E2 demonstrated that, in order to have a bright future for OSC, *"… we need good knowledge, research, studies; there must be trained cadres, architects, supervisors and labour to ensure the success of this construction*".

A lack of knowledge and skills is a barrier to the adoption of OSC in Iraq. The interviewees emphasised the importance of developing skills and knowledge about this type of construction. The interviewees asserted the importance of ministries in developing skills and awareness; moreover, this type of construction will benefit all such ministries, including the Ministry of Housing which could address the housing shortage, and the Ministry of Labour and Social Affairs, by providing job opportunities for workers. Indeed, the Ministry of Education also has an important role in developing curricula in universities and colleges that incorporates OSC; this will help to create a new generation that is familiar with the improvements in construction technologies. Awareness is important as this construction method needs trained cadres, architects and supervisors to ensure the success of such construction. Accordingly, developing skills and awareness is fundamental to enhance the drivers for using OSC, for example, good quality needs good skilled and trained cadres. Moreover, to achieve optimal project performance results, the relevant skills and awareness need to be available among stakeholders. Leveraging awareness of the benefits of OSC can also help to alter resistance to this type of construction.

5.3.5 Association

Some interviewees agreed on the importance of developing an association with OSC in Iraq. Interviewee E4 stated that,

> *"… the attempts of implementing OSC are individual, so I believe that we need bond, to gather all companies that want to work in OSC, like American Association. So, I suggest having an association of OSC in Iraq for many benefits: gathering companies, promotion through advertisement and media, coordination with universities to spread out knowledge, evaluation work through expert people".*

This was also agreed with E3, who further added that,

> *"This kind of association will serve the industrial renaissance as it provides … these associations an exchange of experience between companies, holding specialised conferences, dealing with international companies, setting laws and proposals and referring them to the legislative and executive councils in Iraq and the Ministries, based on the advancement of the profession, such as what the Union of Engineers became. We have the profession of ready-made work on a higher and better field and provide training for cadres. Supervising the training schools that run courses and seminars, working conferences calling for international conferences".*

E5 agreed with E3 and E4 about the importance of existence such associations, "*the role of association is helping for creativity, supporting reliable companies, encouraging universities to teach this construction, awareness campaigns for people and companies about OSC*".

Another important benefit from establishing such associations was illustrated by E8, who believed that "*this is a good proposal to help the exchange of information and to disseminate knowledge, as well as the optimal exploitation of existing equipment. For example, a person who wants equipment can take it from his colleague for a few months and then return it back instead of importing it*".

Interviewees E1, E10 and E14 illustrated another benefit, namely that establishing this association will help in facilitating the work of construction companies, especially in getting formal approval and hence encouraging companies to invest as they feel safe and it improve awareness. E1 further added that this association can help in improving skills, whilst E7 also strongly agreed with the other interviewees on the importance of establishing such associations for the benefits previously demonstrated. He commented that, *"... it is a great step in improving such construction as it is protects the investors and helps companies present and organise their offers and exchange experience between companies; this in turns will support the economics of the country*"

In comparison, E9 neither agreed nor disagreed with the importance of such associations in Iraq, as *"... the association will be gathering the contractor companies, which are not a lot, and there is a competition between them, so they will not benefit each other*". E2 and E13 also believe that there is no need for such association. Interviewee E13 states that, *"... it is a project and, in the end, [only] one contractor will take it*". However, E12 believed that a good suggestion is to have an OSC association in Iraq, although he highlighted that, *"... where are these companies to be gathered and what became of those former precast factories after all these wars Iraqi faced? What is to be achieved is needing time and big efforts from all parties starting from the highest leadership in the Government and Ministries to the smallest contractor companies*".

Most of the interviewees agreed on the importance of establishing associations, such as Buildoffsite in the UK. Indeed, due to the benefits that stakeholders can gain, the existence of such associations in Iraq could play an important role in enhancing the use of OSC. This includes:-

- Sharing knowledge and experience.
- Providing training courses and workshops.
- Providing tools.
- Assisting construction companies to secure formal approval from government authorities.
- Enhancing the economy of the country.

- Supporting reliable companies, encouraging universities to teach this construction method, developing OSC awareness campaigns for individuals and companies. Gathering companies, promoting through advertisement and media
- Setting laws and proposals and referring them to the Ministries, and legislative and executive councils in Iraq

Hence, such action represents good practise in enhancing the drivers for using OSC in Iraq and reducing the impact of the barriers; for example, minimising the lack of knowledge and awareness by providing training workshops and encouraging universities to teach such construction. Moreover, easing the process to obtain formal approval for construction companies will enhance time and cost performances.

5.3.6 Integration

The researcher asked the interviewees about their opinion on the cooperation between stakeholders in Iraqi projects. The interviewees ascertained the importance of good and continued cooperation in order for a project to succeed. E3 believed that this cooperation is important and needs a productive culture; however, the main aim is to ensure proper project management that is organised between the project team, including the contractor, designer, sponsor, authorities responsible for the infrastructure and consultants in order to a project to succeed to achieve time performance. E4 also agreed with E3, and added that *"… the consultants and designers have to be in contact with the producer from the first point and be continue in communication until they agree on the ability to produce such designs and to find out ways to be less costly, and the end products have to meet end user requirements because the sponsor will not pay until satisfied*". In the same way, E1 and E2 agreed on the significance of such cooperation between the stakeholders of a project and indicated the important role of the landowner of the project in ensuring that there is "no under groundwater" (E2) and no, "… oil pipeline inside it or an archaeological area" (E1). Moreover, E1 added that,

> *"… cooperation is vital to the success of a project, especially in big projects and this cooperation in Iraq is minimal, and each person has a role, like the consultant's role in explaining and advising the need for OSC specifications according to the Iraqi climate culture, like using insulation. The contractor has to ensure he is able to implement a design and take advice on design, as he is more familiar with Iraqi culture and clients' desires. The manufacturing team have to ensure their ability to produce such products, the sponsor's role is to ensure the success of his project and when he is able to profit from it".*

E14 also agreed with E1 and E2, and noted the importance of cooperation in *"… reducing or facing any problems in the project, so all the project team have to cooperate and communicate regularly and I suggest participation from the Ministries of Planning and Housing in Iraq as there are infrastructures, which belong to the government that must be agreed upon*". E3, E5 and E9 agreed with E1 in terms of weak cooperation between the stakeholders of a project in Iraq and they attributed that to the *"… lack of legal framework in controlling this cooperation*". Meanwhile, E3 indicated that, "*the lack of regulation and commitment and corruption are the main issues that affect the relationship between the stakeholders, and the interests of contractors and owners are inconsistent*". E9 emphasised the *"… importance of having a legal framework that control the relationship between all the project team, and he sheds a light on the consultant [who] should be appointed by the supervising engineer and not by the contractor when the consultant may justify the contractor's mistakes*". In the same way, E5 agreed with E3 and E9 on the weaknesses of the cooperation in the teamwork for Iraqi projects, *"… there is a weak and unclear unwritten cooperation between the team that facilitates the dealing between them and I suggest having a supervisor engineer in the factory to ensure the process of the work according to the design agreed and to refuse any faulty products in the factory before transporting*". The importance of having an engineer supervisor employed by the owner is also highlighted by E8. Furthermore, although E11 illustrated that this cooperation was almost non-existent in Iraq, E13 believes that "*there is cooperation between the teamwork in Iraq and in many cases this cooperation is fruitful*". However, for E8 and E10 the stakeholders are available but there is "*no continuous communication between them*" and this may lead to the failure of the project or the owner being unable to finish the project. E8 explained this was because "*they do not account the budget correctly, so the coordination between the team and owner is important to advise him to work according to his financial ability as always the owner is ambitious to do many things*".

E5 and E8 pinpointed that another important party has to be involved in the project from the first step, namely the maintenance and follow up party. E8 believed that, *"… four parties have to be involved and cooperate in the project, which are: the implementing party with the contractors, the benefit party (owner), the design team with consultants, [and] the maintenance and follow-up team*". However, E8 emphasised

> *"… the lack of a maintenance and follow*-up team in Iraq, *although there is importance in their involvement at the early stages of the project, especially in the planning stage, as they work as consultants during implementation and as the monitor and maintenance team during use; for example, advising the designer of the best place to put boilers, or the depth and width of pumps to ease its maintenance and monitoring, so whenever monitoring and discovery mistakes occur early, this will reduce the running cost*".

In the same way, E5 illustrated that,

> *"… 'till nowadays there is nothing clear about maintenance; therefore the government have to establish regulations about maintenance and the contract has to be clarified whether the maintenance has to be [done] by the owner or the factory, if the factory supply maintenance guidelines with the products, or [there is an] allocated team for maintenance after completing projects at reasonable prices agreed by all stakeholders".*

Finally, E12 commented that,

> "*… cooperation is important in any construction project, especially the OSC, because to be successful, it requires firm management and cooperation from the first step of the project because it is a series of steps and any disturbance in one of the steps affects the subsequent steps. The problem is that, in the absence of the supervisory bodies monitoring the executing of the work, the government must allocate such supervisory bodies and make regulations for this*"

Therefore, E7 and E6 agreed on the importance of integrating all stakeholders in the project decision-making process as early as possible and improving the cooperation and communication between them. E6 attributed this importance to enabling the existence of cooperation, *"... to enable share needs, information, ideas and knowledge and harmonise the objectives of individual parties and reduce conflict*".

The integration and cooperation between project teamwork are very important in order to obtain the optimal project performance results through sharing needs and information. OSC requires firm management and cooperation from the first step of the project, as this method involves a series of steps and any disturbance in one affects the subsequent steps. However, the lack of regulation, commitment and corruption are the main issues that affect the relationships between stakeholders. Therefore, establishing such regulations could enhance the working environment, as the stakeholder will be forced to follow these regulations, or otherwise face a fine. Moreover, it is important for the government to establish supervisory bodies to monitor the execution of the work in order to avoid or reduce problems. The interviewees specified each stakeholder role, such as the consultant who is responsible for design aspects, the contractor, who has to ensure they are able to implement a design and take advice on design; in particular, the contractor is generally more familiar with Iraqi culture and clients' desires. The manufacturing team have to ensure their ability to produce such products, whilst the sponsor has to ensure the success of the project and when they are able to profit from it. Interviewees also explored other important roles, such as the maintenance and follow up teams, and emphasised that their roles should be included in the project from the first step to advise on the best design option to ensure better future maintenance. Hence, a decision-making consensus among authorities and their continued cooperation and communication is important to ensure the OSC project success.

5.3.7 Establish Iraqi building Codes

A building code is a set of rules that specify the standards for constructed pieces such as buildings and nonbuilding structures. Buildings must conform to the code to obtain planning permission. For example, Iraqi materials specifications used, Iraqi standard dimensions of each components used, Iraqi types of insulation used. Some interviewees emphasised the importance of establishing Iraqi codes for OSC. E1 commented that,

> *"… there is no Iraqi code, so each international experience in implementing OSC use their own codes and specifications, like the German and Turkish experience, and, for example, the weather and people's preferences are different in Iraq. Therefore, it is vital to establish Iraqi codes and specifications, a table of quantities and standardisation to ease the work of companies and to protect public health, safety and general welfare*".

E5 also agreed with E1 on the importance of having Iraqi codes to facilitate the work and implementation; he further added that, "It is vital to have an Iraqi code, as finishing and receiving the project will be subject to this code, as the government stated to build offsite. However, there are no legal and specific codes that the companies commit to, so sometimes the companies implement according to their specifications, regardless of quality, to save cost, then the results are negative". E9 advised, *"… establishing an Iraqi code issued by the Iraqi Central Organisation for Standardisation and Quality Control and adopted by the Ministry of Construction and Housing to prevent companies from adopting their own specification and codes and committed to Iraqi code*". E8 attributed the use of other international codes to a *"… few applications of OSC in Iraq, so there is no specific system and code to cover this type of construction; therefore, companies use other international codes when they apply it*". Therefore, E1, E6 and E14 emphasised the re-vision of regulations that support the use of OSC and establishing Iraqi code for this system. E6 stated, *"… there is an urgent need for an Iraqi code as specifications need codes*". However, E3 believed that, *"… we always use American or British codes when using OSC and when this type of construction is increased, the Iraqi codes will establish automatically*". Instead, E5 noted that, *"… there are no American or British codes that companies adopt in their application, because if there is, the building will be perfect. These codes are only adopted for big and important projects as the consultation party forces the companies to follow codes mentioned previously*". E5 also illustrated an important point as an example for inclusion in the Iraqi code, *"… the delivery of the item must not be less than the maintenance period of five years, including the guarantee of the internal parts of the substance of the establishment; continuous follow-up is necessary to follow the casting*".

Hence, interviewees emphasised the importance of establishing regulations to support the use of OSC in Iraq. Indeed, the existence of such regulations will ease the work for contractors and protect them. In addition, the interviewees' recommendations regarding codes are significant; the lack of Iraqi codes prevent companies from using established codes that consider the preference of Iraqi clients and relevant weather consideration. Although the use of international codes may suit some countries, they may not be suitable for the Iraqi context which can lead to problems in project performances and in turn increase the negative image of this type of construction. However, some interviewees recommended the use of American or British codes, although they may not suitable for Iraq and may be only used by big companies. Thus, small companies may not commit to any codes until Iraqi codes are established. Hence, this action can reduce the barriers, such as reducing design conflicts and enhance the performance of drivers.

5.3.8 Enhancing support from construction professionals

Interviewees E1, E2, E8, E9, E11 and E13 emphasised the role of the architect in encouraging the use of OSC. E1 explained that, *"… when the architect gives an uncomplicated and accurate design, the implementation like erection will be quick and easy taking into account of commitment of the design and minimise change by clients"*. E2 also demonstrated that,

> *"The architects are the basis in the design and planning process and therefore must be fully knowledgeable about OSC and they are a key factor in the success of this subject and should know that ready-made construction is the best solution and eliminates uncertainty in such construction on themselves. Hence, they will create the design and simplify the design options".*

E11 agreed with E1 and E2 about the role of architect in OSC in simplifying design and speed implementations. E11 further added that, "*the architect will choose the shape of the component and on this basis, the make and type of components will be produced according to his advice*". E9 further commented that, *"… it is important because the work starts according to his plan and decision*", whilst E8 supported E9's view and further added, *"… the architect's role is designing identical and repeated components for OSC*".

Another important engineering role is indicated by E8 who emphasised that,

> *"… as there is a problem in quality control in Iraq, [it is] recommended to have a supervisor engineer related to the owner in the factory to monitor production, so in terms of any deficiency the product is refused at the factory to save cost, compared to, if there is no such supervisor, a faulty product will be transported to the site then refused, which will lead to increased cost and delayed work*".

This is also supported by E5 who recommended *"… having a supervisor engineer in the factory specially for vital projects; however it's costly, but the supervision and monitoring is important in guaranteeing all stakeholders of the project to avoid any problems that can occur*".

The role of professionals, such as engineers, is important in implementing and enhancing the use of OSC. As the architect believes that this type of alternative construction has many advantages, the most likely will create different types of design that are not complicated and cheap. The commitment of design could enhance the reputation of OSC. Having an accurate and simple design will enhance the performance of drivers for using OSC in Iraq. Nevertheless, interviewees indicated another important point, namely allocating a supervisor engineer who is related to the owner to monitor production. This will enable the refusal of any faulty products before transportation to site, which in turn could enhance the quality, time and cost performances.

5.3.9 Technology

From a technological view, Interview E1 recommended the use of

> "*… environmentally friendly materials and special insulation for thermal and humidity [aspects], taking into account the weather conditions in the country with the importance of providing financial budget to protect the environment. The insulation comes from oil, so when the price of oil is cheap the cost of insulation decreases. A simple design is required to ease the implementation*".

E3 also agreed with E1 and added that, "*… using light weight concrete, simple designs and a small area is recommended for OSC because it is easier and the dimensions are more accurate; for example, the studio because it is difficult to be done by traditional construction"*. E2 and E11 also highlighted the use of environmentally friendly materials; E11 pinpointed that *"... we largely need such materials, especially after severe pollution has happened in Iraq as a result of the war, as such materials can be recycled*". E2 recommended *"... developing the types of insulation to get the more cost effective one*". Moreover, E13 noted that, *"… the factory must supply details of the design as a manufacturing catalogue to the contractor and consultant to understand how to connect the components with each other and how it looks*". Another point was indicated by E8, *"… using Building Information Modelling as a tool to help the engineers and consultants in understanding the steps of the project*". In addition, E12 illustrated that,

> "*That the best way to build residential complexes [with a] quick implementation and low cost and … a reasonable degree of acceptability and sustainability is the adoption of the insulated aluminium panels. But [this] requires attention to the type of construction, especially for internal services, and the site and levels, [as well as the] infrastructure and roads to achieve and ensure the sustainability of this type of construction. It also requires*

the encouragement of national investment in the production of this type of board and with high quality and different thicknesses to achieve insulation".

Interviewees emphasised the importance of using environmentally friendly materials to reduce pollution and enhance recycling which in turn enhances the environment performance. The thicknesses and materials used for thermal insulation should be chosen carefully due to Iraq's special humidity and weather. A special financial budget is recommended to enhance environmental related drivers. Technologies, such as building information modelling and design for manufacturing and assembly, need to be considered in order to enhance the drivers and reduce the barriers to using OSC. For example, the use of BIM in construction projects enhances coordination between teams and helps to better control the supply chain. Providing a design for the manufacturing and assembly catalogue can ease the erection onsite. Hence, it is important to choose OSC technologies that achieve and ensure the sustainability of this type of construction.

5.3.10 Effective Strategy

Interviewee E1 highlighted that *"... if a suitable roadmap is developed and supported by the government and implemented by specialised, reliable companies, this system will be successful in Iraq.*" E7 also agreed with E1 and added that,

> *"...if a properly plan is developed for the future, it is possible for this construction to largely compete with normal construction and possibly to overshadow it, especially in some areas in Iraq that suffered from comprehensive destruction, which need the reconstruction of buildings and infrastructure and this cannot be solved by only normal construction because this can take a long time.*"

E9 also supported that, a *"... country like Iraq needs a lot of construction work and this cannot be achieved by onsite construction. It is a fact that Iraq is in need of such construction; however, it needs an effective plan".* E2 stated that, "*There must be a clear and correct planning based on scientific foundations and there should be support and government incentives for this type of construction through the dissemination of knowledge and research and* attraction students to learn such construction*".* E2 also highlighted that, *"... optimal coordination and planning is needed to facilitate all issues and ensure success for the project*". Nevertheless, E4 and E9 stated that there is "*... no roadmap or strategy or guidelines to improve the use of OSC in Iraq*".

E4 attributed this barrier to the *"... the unstable situation in Iraq caused unclear vision or incredibility in developing a specific strategy to promote this type of construction".* Interviewees noted the lack of strategies or guidelines to promote the adoption of this type of construction. This occurred for two reasons; limited academic research related to the concept of OSC in Iraq, and reluctance amongst decision makers to adopt such construction due to the unstable political and financial situation. However, the existence of such strategies or guidelines can help stakeholders in the construction industry to understand this construction and enable effective adoption.

5.3.11 Risk Management

Interviewee E13 believed that, *"... it is possible to predict the result of the project because it's highly controlled and the uncertainty and risk is low with using an OSC system*". Interviewees E3 and E1 agreed with E13; however, E1 reported that *"as Iraq shows unstable security and financial fluctuations [it is] recommended to the construction companies to apply risk management prior to their projects. They have to understand how to take advantage of transferring and sharing risks by employing a professional team or professional subcontractors"*. E3 agreed with E1 but added that *"[a] risk assessment is required for the whole project, such as delays of transportation, cash flow difficulties, poor site conditions and delay decision in order to tackle risks or minimize its impact". Moreover, E7, E8 and E9 emphasised on the importance of using risk management when using OSC project to enable the project team in establishing actions to overcome any risks can occur.*

Hence, risk management is a fundamental measure that needs to be taken by project stakeholders to enhance OSC drivers and overcome or reduce its barriers. Some risk management measurements were explored by the interviewees, which included: employing security forces to protect the project site and prevent access to illegal external parties who may cause problems to the project during its implementation. Others manage the risk of extortion during transportation or avoid involvement in unsafe sites by developing their own factory and making the customer responsible for transportation and onsite erection.

5.3.12 Others

a) Transportation system: E2 recommended improving the transportation process, such as transport via the railways. E14 added that, *"... there should be a good road network and projects need to be done outside the cities because the cities are densely populated and have not enough areas for such projects*". This is quite an important recommendation that should be considered by decision makers within government bodies. The interviewees cited poor road networks in Iraq, which can lead to supply chain disturbances that affect the project's time, quality and cost performances.

b) Service after selling: Interviewee E5 confirmed that *"... companies have to provide service after sales and provide a customer service options*." This is a valuable point, as it can build and strengthen trust between the end user and companies, and challenge existing negative images to leverage a good perception of OSC.

5.4 Conclusion

This chapter presented the qualitative analysis conducted with experts in the construction industry in Iraq. The analysis was facilitated through the use of NVivo software, whilst a thematic analysis was used to identify themes and patterns. The analysis of participant responses commenced with classifying the interview questions into three main themes that affect the use of OSC in Iraq.

The interview results from the first section confirmed that the same drivers developed from the literature review enhance the use of OSC in Iraq. In comparison, results from the second section confirmed the barriers developed from the literature review, which were corroborated by the interviewees as inhibiting the use of OSC in Iraq. Moreover, one new barrier found to be an effective factor within OSC in Iraq is non-working days, due to numerous national and religious events. Significantly, this factor has a negative impact on the other factors. The third section identified the best practices in using OSC in Iraq. In this section, the interviewees presented their recommendations in order to develop the adoption of OSC in Iraq. These recommendations will be beneficial in developing the guidelines introduced later in this research.

Chapter 6 **Findings and Discussion**

This chapter presents the findings of the questionnaire survey and expert interviews. The discussion is based on the analysis of results presented in Chapters four and five. Drivers and barriers will be discussed. A Schematic diagram of relationships between the drivers of using OSC in Iraq will be provided. Furthermore, schematic diagram of relationships between the barriers of using OSC in Iraq will be illustrated. These findings will be combined to build the final guidelines in the next chapter.

6.1 Drivers for using OSC in Iraq

This section will discuss the results of the quantitative and qualitative data of this research regarding the drivers to using OSC in Iraq. Figure 6-1 presents the different drivers examined in this research.

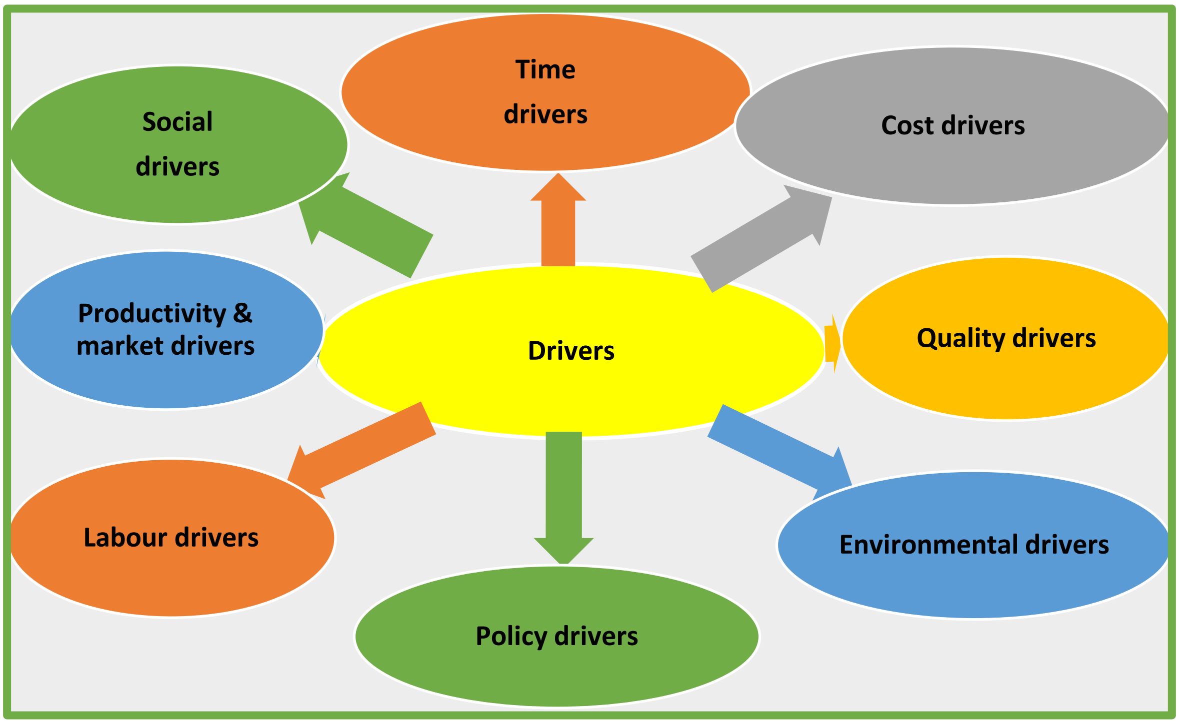


Figure 6-1: Drivers for using OSC in Iraq

6.1.1 Time Drivers

The construction companies aim to finish the project on time in order to gain competitive advantages. However, time overruns and project delays remain a critical phenomenon in most construction industries worldwide particularly when using onsite construction. Moreover, onsite construction is relatively inflexible to meet demand in the short run. As such, the construction sector recognized the need for a technique that could offer more certainty in time and speed in construction like OSC. The time-related drivers when using OSC investigated in this study are:

- Minimising the overall project duration,
- Speeding up construction, and
- Reducing the overall project time.

In considering the views obtained from the questionnaire and interview responses, it was clear that time related drivers are one of the drivers that enhances the use of OSC in Iraq. The descriptive analysis of the questionnaire results, involving construction companies and the Universities Scientific & Engineering Consultants Bureau (USECB), confirm these drivers (sections 4.6.3 and 4.7.3). The time-related drivers are supported by Bendi (2017); Al-Mutairi (2015), whilst the results of the Kruskal-Wallis test (section 4.8.4.1) reflected no significant difference between the groups concerning time-related drivers. Furthermore, the interviewees confirmed that time-related drives are one of the most important drivers for using OSC in Iraq (section 5.1.1). This can be attributed to the speed of construction that result from reducing activities onsite; it also enables the concurrent performances of more than one activity. Indeed, Hairstans et al. (2014) also emphasise the scheduling of activities, which take place at the same time instead of sequentially, like modules being manufactured for 'just-in-time' delivery during the completion of site infrastructure and foundations, hence results on the reduction of the construction time.

The interviewees similarly revealed a greater level of certainty over project completion times when using OSC. However, this can only be achieved if a reliable and effective plan of work has previously been established. Hwang, Shan, and Looi (2018) support this in OSC; most construction activities are applied in factories; therefore, OSC demands the early confirmation of design, construction detail, and construction arrangements to avoid fruitless work that is costly and time-consuming. The interviewees highlighted that the time- related drivers in OSC plays an important role in some projects, such as prisons, schools and hospitals. This is also supported by the literature review, and particularly by Krug and Miles (2013); Gibb and Isack (2003). The analysis of the statistical approach for both groups of construction companies and the USECB revealed significant relationships between time-related drivers and the other related-drivers for (quality, cost, social, labour, productivity, policy and environmental). The interviewees also support these findings. The relationships with the time factor will be discussed individually in detail over the following sections.

6.1.1.1 Time - quality drivers' relationship

The findings of the data analysis in Chapter Four (sections 4.8.2.1 and 4.8.2.2), in particular those using the chi-square test for independence, shows a significant relationship between time-related drivers and quality related drivers for both groups involved in this research (the construction companies and the USECB). Furthermore, the correlation coefficient ranking highlighted this relationship revealing a value of (rho=0.693) for the construction company group, and a value of (rho=0.580) for the USECB group (sections 4.8.3.2 and 4.8.3.1). This finding is supported by Yunus, Abdullah, Yasin, Masrom, and Hanipah (2016) who noted a significant correlation between higher quality products and time performances.

Moreover, according to the qualitative data analysis (sections 5.1.1 and 5.1.2), interviewees demonstrated that, when using OSC, higher quality products, and repetitive processes and operational activities leads to improvements in the time performance, which creates greater certainty about the project completion. This finding reflects those of Fenner, Razkenari, Hakim, and Kibert (2017); Alazzaz and Whyte (2014), confirming that a greater certainty of achieving construction deadlines when using OSC is greater than that in classic construction. It is also indicated in the literature Gan et al. (2017) that the imposition of inadequate time for construction, design and production by clients affects the quality of OSC projects. This indicates that an appropriate time allocation for all OSC processes enhances the quality of a project. Therefore, it can be concluded that quality related drivers play a substantial role in improving the time performance during the implementation of OSC.

6.1.1.2 Time drivers – cost drivers relationship

The chi-square test for independence, which was conducted in Chapter Four (sections 4.8.2.1 and 4.8.2.2), confirmed the significant relationship between cost and time for both groups (construction companies and USECB). Moreover, this relationship is illustrated by the correlation coefficient rank which scored rho=0.626 for the construction companies. A similarly high value of rho=0.668 was obtained for the USECB (sections 4.8.3.1 and 4.8.3.2). This relationship was highlighted in the literature review Fraser, Race, Kelly, and Winstanley (2015), confirming that reductions to time lead to cost savings. This was also supported by interviewees who stated that cost savings can occur as a result of the shorter construction time required when applying OSC (section 5.1.3). Furthermore, Krug and Miles (2013); Legmpelos (2013) emphasise that cash flow returns are faster when using OSC due to the time advantages offered. However, cash flow problems during the construction stage can also lead to time overruns (Muianga et al., 2014). This suggests that the availability of cash flow helps to ensure time certainty, which is supported by the interviewees (section 5.1.1).

6.1.1.3 Time drivers – social drivers' relationship

A further relationship is illustrated between the time, and social related drivers. Results from the chi-square test indicate a significant relationship between these factors (sections 4.8.2.1 and 4.8.2.2). A highly significant correlation rank was found the mentioned factors in which for construction companies, scored rho= 0.666, while a significant correlation was noted for the USECB group, at rho=0.491 (sections 4.8.3.1 and 4.8.3.2). The data analysis of the qualitative method demonstrated this relationship; participants emphasised improvements to health and safety that result from less time onsite, a faster speed of construction, and fewer activities involved. Therefore, employees experienced less exposure to bad weather conditions and fewer accidents (section 5.1.4). This was also confirmed by Jiang et al. (2018); Krug and Miles (2013) who confirmed that a dramatic reduction to fatal injuries could be seen as a result of decreased site working hours. Also, time saving onsite was a valuable benefit when implementing projects in bad weather or in difficult site conditions (Lawson et al., 2014). Ludwig (2018) reported that creating a culture of safety is a top concern for construction projects as one serious incident can stop or close a project, and/or incur cost overruns. Therefore, improvements in the time performance of a project can be experienced when developing the health and safety system.

6.1.1.4 Time drivers – productivity and market drivers' relationship

This section will discuss the relationship between time, and productivity and market related drivers. The results from the chi-square test proved that there is a significant relationship between these factors for both groups (sections 4.8.2.1 and 4.8.2.2). The correlation test also confirmed this relationship. The correlation results showed a significant relationship for both groups; thus, the construction companies scored rho= 0.316, whilst the USECB scored rho=0.303 (sections

4.8.3.1 and 4.8.3.2). The interviewees confirmed and explained this relationship, stating that Iraq is currently in need of three to four million dwellings, which can be achieved by using OSC. This is particularly attractive due to the advantages associated with the rapid volume of production over a shorter period (section 5.1.6).

This view was also supported by the literature, which indicated that 5,413,801 housing units need to be completed in Iraq by 2020 Rahi (2015). Moreover, Mesároš and Mandičák (2015) revealed that OSC represents mass production, which can take place in factories and thus substantially shorten the construction time; they also noted the less harmful impact on the environment. The ability of OSC to address housing shortages is widely discussed in the literature (Ojoko, Osman, Rahman, et al. (2018); Al-Mutairi (2015); Elnaas et al. (2014); Pan et al. (2007). Productivity is also improved as a result of fewer activities required onsite and therefore less time is taken overall (Durdyev & Ismail, 2019). The interviewees also supported this finding (section 5.1.6). Also, the improved time performance when using OSC leads to productivity enhancements (Wuni & Shen, 2019), which was also supported by the interviewees (section 5.1.2).

6.1.1.5 Time drivers – labour drivers' relationship

The results from the chi-square test indicate a significant relationship between time and labour related drivers, for both construction companies and USECB. Furthermore, the results from the correlation coefficient rank revealed that there is a high correlation between these factors for the construction companies, at rho= 0.553, although the USECB group indicated a significant relationship, at rho=0.479 (sections 4.8.3.1 and 4.8.3.2). Moreover, the interview results (sections 5.1.1 and 5.1.5) demonstrated that, when using OSC, some onsite activities are removed, such as plastering and painting, and instead are implemented in the factory. They indicated that this led to time and labour reductions. Moreover, the interviewees added that traditional construction is highly dependent on the availability of a skilled workforce; however, OSC offers valuable advantages, such as speed and fewer essential activities, which in turns decreases the amount of skilled labour required (section 5.1.5). Furthermore, Taylor (2009) reported that, as most of the work is carried out offsite there is a reduced assembly time onsite with fewer workers required. Moreover, Fraser, Race, Kelly, Winstanley, et al. (2015) highlighted that OSC can reduce the overall programme and build time, and substantially cut the overall time and man hours required on site. These findings were also supported by Gunawardena, Mendis, Ngo, Rismanchi, and Aye (2019). The interviewees similarly indicated that the availability of skilled, well-trained labour leads to improved time performance (section 5.1.2). Indeed, Jabar, Ismail, and Mustafa (2013) found that difficulties in employing a skilled workforce on-site lead to the delay of an OSC project.

6.1.1.6 Time drivers- environmental drivers' relationship

The analysis of time and environmental related drivers indicated a significant relationship for both groups (CC&USECB), as demonstrated through the chi-square test (sections 4.8.2.1 and 4.8.2.2). The results from the Spearman Test revealed a significant correlation between time and environmental drivers for construction companies, at rho= 0.429. In comparison, a low significant relationship was found between these factors for the USECB group, at rho= 0.181 (sections 4.8.3.1 and 4.8.3.2). This finding supports those of Jaillon and Poon (2008) and Fraser, Race, Kelly, and Winstanley (2015) who report that fewer activities and less time are required onsite, which leads to a reduced impact on the surrounding environment, including less dust, noise, pollution and energy. Findings from the interviewees also supported this result (section 5.1.8). Moreover, Wuni and Shen (2019) found that reduced site disruption, such as less wasted material, leads to reduced schedule times.

6.1.1.7 Time drivers – policy drivers' relationship

Finally, the chi-square test results showed a significant relationship between time and policy related drivers for both groups (sections 4.8.2.1 and 4.8.2.2). The correlation rank order also found that construction companies noted a significant relationship between these factors, at rho=0.387. However, a low significant relationship was found by the USECB, at rho=0.204 (sections 4.8.3.1 and 4.8.3.2). Moreover, Yung and Chan (2012) clarified that delays to government funding due to excessive regulation and review hinders the scheduled completion time of a project. This suggests that accelerating government funding can potentially enhance the completion of the project in order to meet time schedules, which was supported by the interviewees (section 5.3.1). Indeed, Clark and Wolstenholme (2018) found that the aim of the partnership between industry and government is to adopt offsite manufacturing in order to meet construction sector needs for reduced times, faster construction, and reduced costs; this view was supported by interviewees (section 5.1.7). Indeed, Teen and Gramescu (2018) recommended that investors use OSC in Iraq as a quick solution to meet the urgent need for housing.

6.1.1.8 The importance of the Time-related drivers for using OSC in Iraq

Based on the results obtained, this section discusses the significance of the impact of time alongside other drivers when using OSC in Iraq. The discussion considers the following three cases:

- Case 1 indicates highly significant relationships
- Case 2 shows significant relationships
- Case 3 demonstrates moderate significant relationships

Figure 6.2 represents Case 1, which illustrates the highly significant relationships, which occur between the time, cost and quality related drivers. It shows that improvements to the quality of products lead to improvements in the time performance. Also, the allocation of adequate time can enhance the quality of a project. These relationships were reported in section 6.1.1.1. Moreover, figure 6-2 demonstrates the relationship between the time and cost drivers; thus, a reduced time when using OSC can lead to cost savings. In addition, cash flow return is faster when using OSC as a result of the advantages associated with greater time certainty, whilst the availability of a cash flow increases certainty in the time performance. These relationships are discussed in section 6.1.1.2.

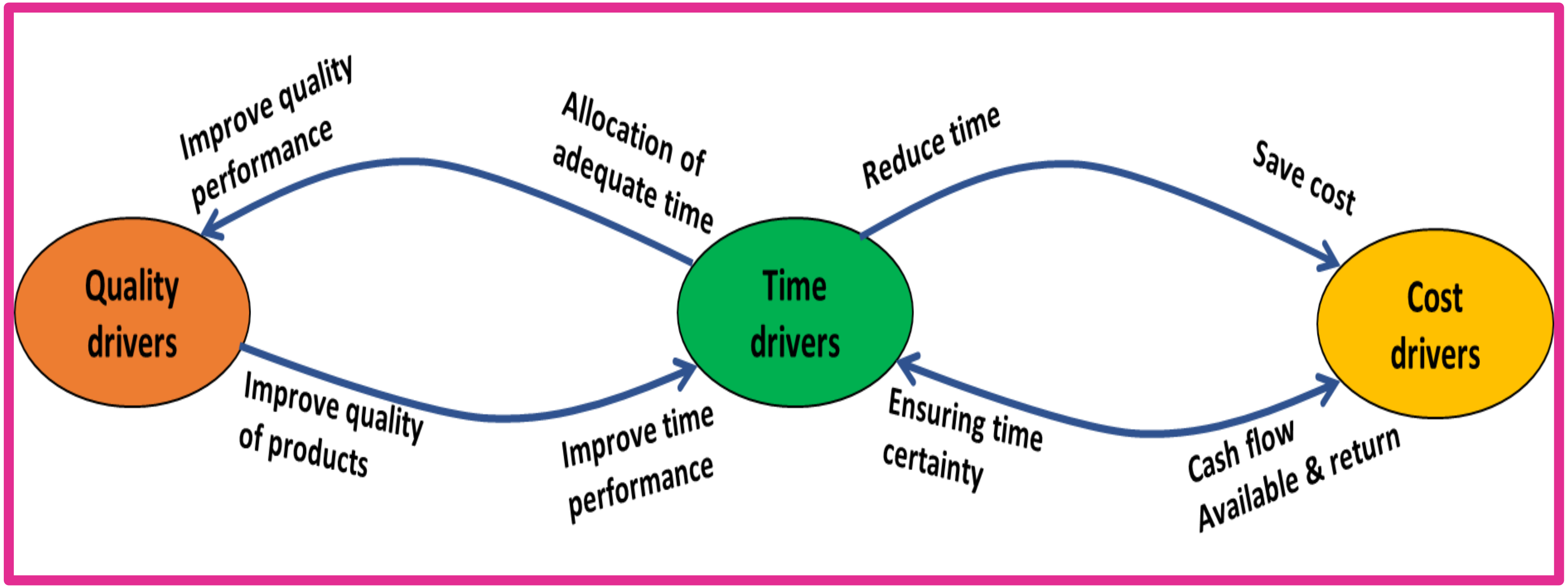


Figure 6-2: Schematic diagram of the time drivers with cost and quality drivers' relationships (Case 1)

Furthermore, Case 2 is illustrated in figure 6-3, which indicates a significant relationship between time and (productivity& market), social, and labour related drivers. This figure illustrates that improving the time performance can lead to enhancements in productivity. Also, mass production enables faster construction, which means that more homes can be completed. Similarly, the interaction between time and labour related drivers is illustrated in Figure 6.3. The availability of skilled and well-trained labour can result in improvements to the time performance; furthermore, the use of OSC can reduce the overall time taken leading to reduced onsite labour. Time related drivers also has a relationship with social related drivers, as improvements to the safety performance can lead to improvements in the time performance of a project. Also, less time is required when using OSC, which means less exposure to bad weather and difficult site conditions (Sections 6.1.1.3,6.1.1.4 and 6.1.1.5

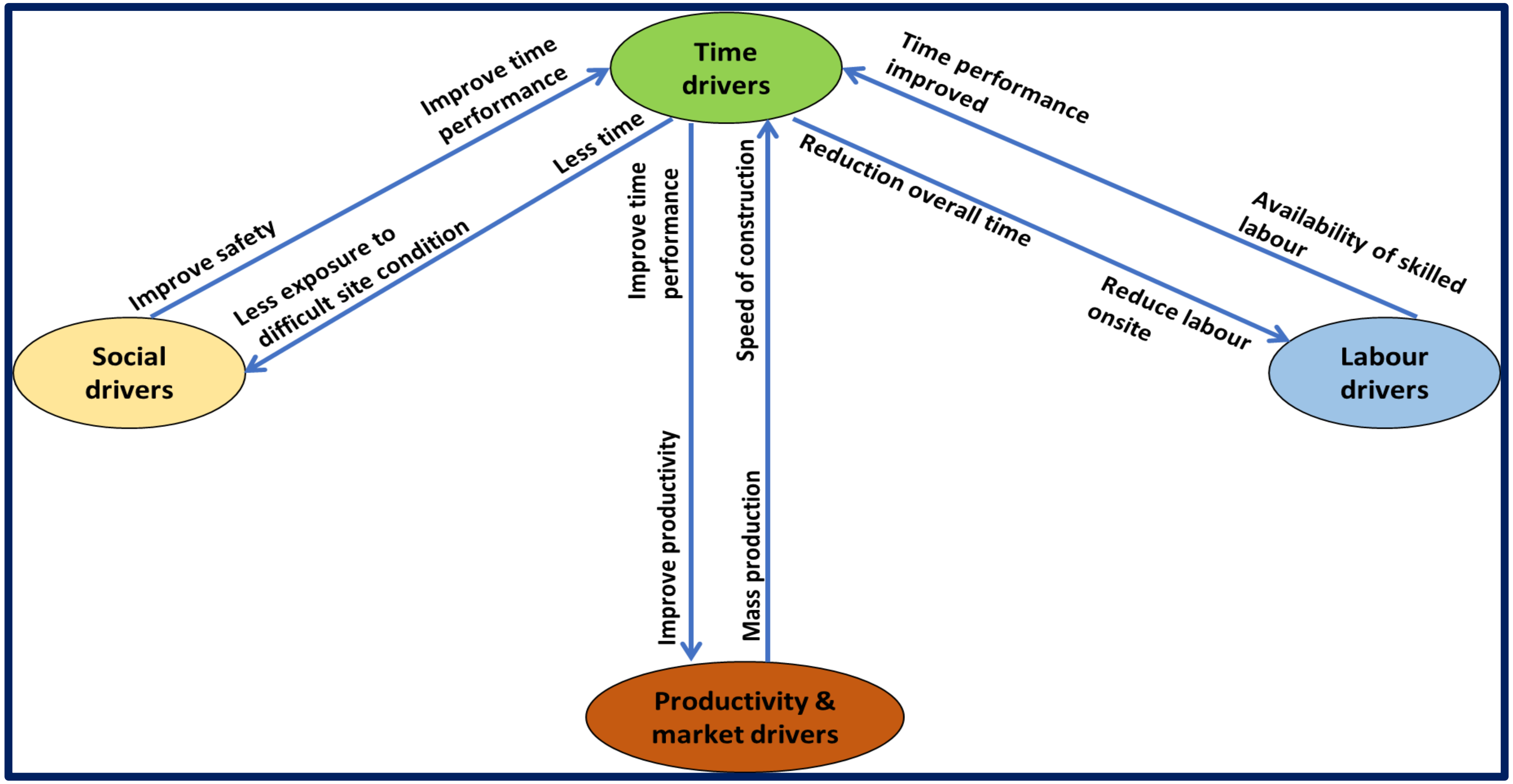


Figure 6-3: Schematic diagram of time drivers with (Productivity& Market, Labour and Social) drivers' relationships (Case 2)

Figure 6.4 illustrates Case 3, which demonstrates the moderate significant relationships. It shows a relationship between the time and environmental related drivers. Fewer disturbances onsite include less dust and noise, and minimal waste leading to reductions in time. Also, shorter completion periods can lead to a lower impact on the environment. Another relationship identified within this figure is between time and policy related drivers, where more readily available government funding leads to improved time performances. Also, the speed of construction associated with OSC encourages its adoption and support from governments worldwide. (sections 6.1.1.6 &6.1.1.7).

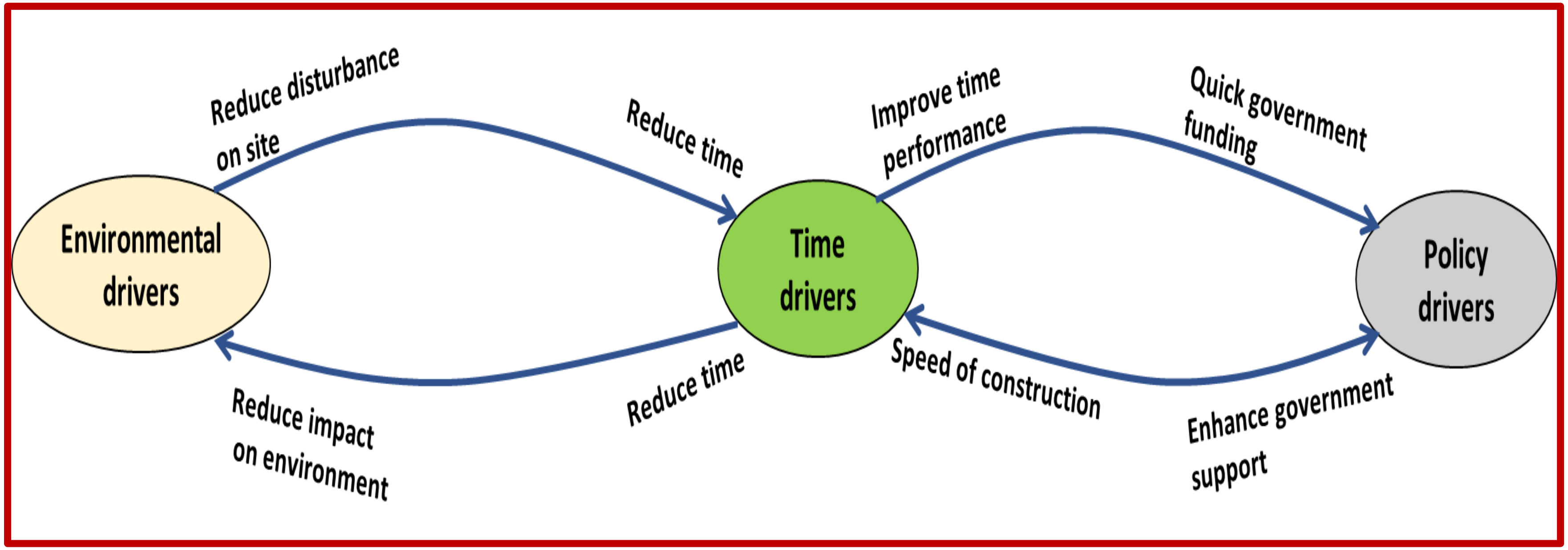


Figure 6-4: Schematic diagram of the time drivers with (Environmental and Policy) drivers' relationships (Case 3)

Finally, to demonstrate the statistical correlation carried out in Chapter Four, (sections 4.8.3.1 and 4.8.3.2), Figure 6-5 illustrates the effect of different drivers on time related drivers for both construction companies and the USECB. The results in Figure 6.5 indicate a significant correlation between the other drivers and the time drivers with regard to construction companies; this is compared with the USECB. This can be attributed to the understanding that construction companies implement work in practice, so their opinions are more likely to be accurate, while academic participants are more likely to be involved in theoretical rather than the practical experience and understanding.

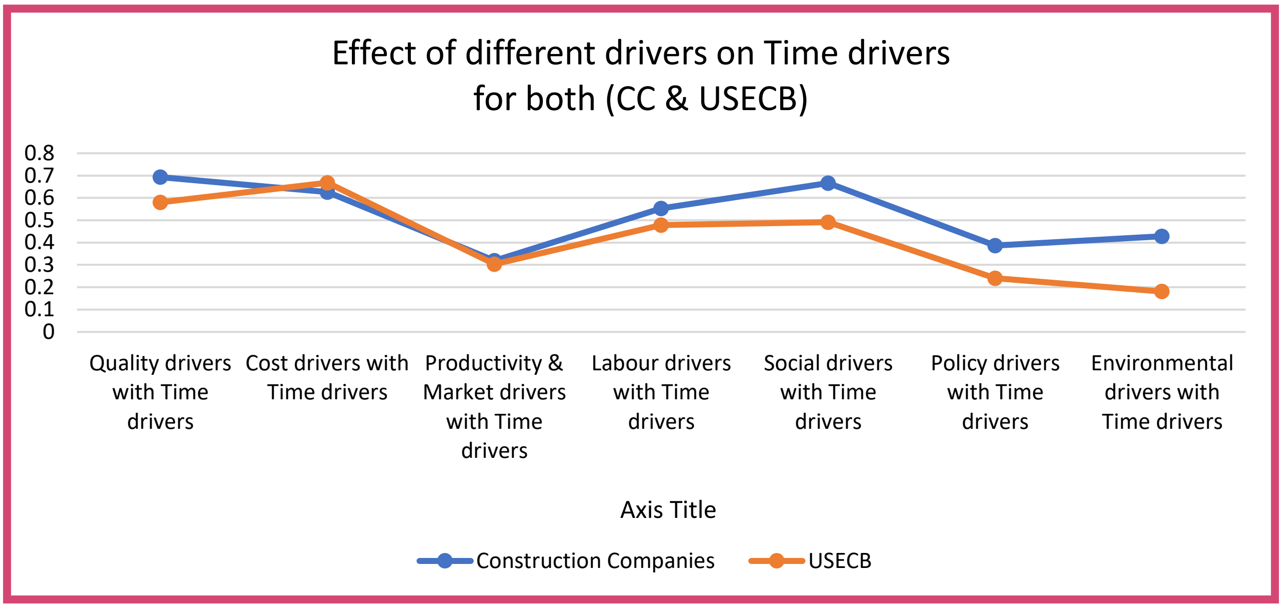


Figure 6-5: Comparison between both groups for correlation between time drivers and other drivers

6.1.2 Quality drivers

The quality factor has related drivers that include:

- Higher quality of OSC products,
- The conduct of a quality control review during the manufacturing process and site assembly, and
- Fewer defects in OSC products than in traditional construction products.

The descriptive analysis of the questionnaire results, involving construction companies and the USECB, confirm these drivers (sections 4.6.3 and 4.7.3); moreover, many researchers have emphasised the drivers associated with quality factor (Fenner et al., 2018; Musa, Mohammad, Mahbub, & Yusof, 2018).

Furthermore, the interviewees agreed that good quality can be achieved when using OSC; they attributed this to the factory environment, which considers safety and quality manuals, special measurements and systems, where the stages are better known and regular, and the technicians and workers are experienced and specifically trained. This accords with the findings of Mohamad Kamar (2011) and Al-Mutairi (2015). However, some interviewees believed that obtaining high quality end products in Iraq depends on project teamwork and reliable the construction companies to implement the work and careful treating the joints between the components. This may explain the differences in opinion between the construction companies and the USECB, which was noted when applying Kruskal-Wallis test (section 4.8.4.1), as academic consultants seem to agree less with this factor.

Moreover, interviewees believe in another driver related to quality factor, which is durability and strength of OSC products especially for the ability of precast concrete, in withstanding environmental impacts. Fenner, Razkenari, et al. (2017) indicated that, in terms of climate change and natural disasters, prefabrication has emerged as an alternative method of construction and an example of resilient design. This is because prefabricated building has specific codes and requirements for risky areas, such as hurricane-prone locations and floodplains.

The analysis of the statistical approach for construction companies and the USECB revealed significant relationships between the quality related drivers and other different related drivers (cost, social, labour, productivity& market and environmental). The interviewees also supported these findings.

6.1.2.1 Quality - cost relationship

According to the chi-square result, the quality related drivers has a significant relationship with the cost related drivers for both construction companies and the USECB (sections 4.8.2.1 and 4.8.2.2). A correlation coefficient ranking indicated a highly significant relationship between the quality and cost related drivers for construction companies, at rho= 0.515, whilst the USECB was ranked at rho =0.611 (sections 4.8.3.2 and 4.8.3.1).

Furthermore, most of the interviewees highlighted that high-quality products can be achieved when using of OSC due to the more stringent quality control in the factory. This, in turn, means less defects and maintenance, and the products are less likely to be rejected; moreover, this subsequently leads to cost savings (sections 5.2.2,5.2.3). The literature also supports these findings (Fraser, Race, Kelly, Winstanley, et al., 2015; Alistair, 1999).

Nevertheless, insufficient costs allocated for the design, production or construction stages affects the quality of OSC projects (Gan et al., 2017). Therefore, providing sufficient funding for all stages of a project leads to enhanced quality performances. Indeed, the findings of Pollack, Helm, and Adler (2018) emphasised the significant links between time, cost, and quality, verifying these concepts as vertices on the Iron Triangle.

6.1.2.2 Quality - environmental related drivers' relationship

According to the data results from the chi-square for independence test, quality related drivers has a significant relationship with environment related drivers amongst the construction companies. Although the results for the USECB group indicates that there is no significant relationship between these related drivers (sections 4.8.2.1 and 4.8.2.2). According to construction companies there is a significant correlation between quality and environmental, at rho=0.385. In comparison, a low significant relationship was found between these factors for the USECB group, at rho=0.024 (sections 4.8.3.1 and 4.8.3.2).

Moreover, an interviewee also pinpointed this advantage; *E2 '... products of OSC manufactured without any industrial defect and do not require plastering, therefore, OSC products are less defects than classic construction because of the quality control in the factory that enable to repair defects immediately and this reduce waste.'* This was also supported by Jaillon and Poon (2008) who stated that no plastering is needed onsite whilst quality control at the factory allows for the easy identification of defects and the rejection of unsuitable elements before they are transported to the site, which in turn leads to less waste on site that emerges from defects and less rebuilding. Indeed, Fraser, Race, Kelly, and Winstanley (2015) confirmed that the use of OSC can deliver better building performances for the finished product because of the high quality involved. However, Fenner, Razkenari, et al. (2017) pinpointed that quality improves as a result of the better protection of products and materials from exposure to harsh weather conditions, and that this element of production mostly occurs in a factory.

6.1.2.3 Quality - labour related drivers' relationship

The research findings show a relationship between the quality and labour related drivers. According to the chi-square result, quality has a significant relationship with the labour factor for both the USECB and construction companies (sections 4.8.2.1 and 4.8.2.2). The correlation test found a significant relationship for the construction companies, at rho=0.391. However, a low significant relationship was demonstrated between the associated related drivers for the USECB, at rho= 0.263 (sections 4.8.3.1 and 4.8.3.2).

These interviewees, who confirmed that the quality of the final product is affected by teamwork, highlighted this relationship in OSC, stating that the work is performed by skilled, trained people and leads to good quality products. This was supported by Mohammed (2016) who found that effective, skilled workers could improve the implementation of OSC in Malaysian construction projects and achieve project outcomes on time at a good quality.

Indeed, Van Tam, Huong, and Ngoc (2018) illustrated that the quality of materials and working tools, and the complexity of work affects labour productivity on a construction site. However, the interviewees stated that, when using OSC, labour productivity increases as a result of the higher quality control in a factory and the repetitive processes involved (section 5.1.5). Moreover, the findings of Al-Mutairi (2015); Mohamad Kamar (2011) supported this as OSC offers improvements in quality and productivity due to the use of factory-made products; this reduces the possibility of poor workmanship and a lack of quality control.

6.1.2.4 Quality - productivity& market related drivers' relationships

The results from the chi-square test proved that there is a significant relationship between quality and productivity & market related drivers for both groups (sections 4.8.2.2 and 4.8.2.1). The correlation test also confirmed this relationship. The correlation results showed a significant relationship between these factors for the construction companies, at rho= 0.400, whilst the USECB scored rho=0.196, which indicated a low significant relationship (sections 4.8.3.1 and 4.8.3.2). Interviewees believed that the overall productivity performance increased as a result of enhanced quality, as products are prefabricated in a factory environment under high quality control. Also, interviewees believed that automation enhances quality as it reduces the possibility of human error and the risks associated with a lack of quality control (sections 5.1.2 and 5.1.6). This accords with the findings of Javed et al. (2018) who stated that increasing the use of automated production leads to improvements in quality as the potential for rework decreases. Also, the authors found that improved quality control and assurance practices lead to productivity enhancements.

6.1.2.5 Quality - social related drivers' relationship

According to questionnaire results, the chi-square test revealed a significant relationship between quality and social (sections 4.8.2.2 and 4.8.2.1). Also, the correlation ranking revealed a highly significant relationship between the quality and social for construction companies, at rho= 0.583. In comparison, a significant relationship was found for USECB, at rho= 0.314. The interviewees justified this relationship by indicating that most of the work occurs in a factory environment under quality control, and health and safety standards, and this protects the workers from difficult weather conditions (section 5.1.4). One of the interviewees further explained that there is quality, and safety and security manuals, and health & safety standards in a factory, which ensure quality improvements. The relationship between quality and social related drivers is also recognised in the literature; indeed, Wanberg, Harper, Hallowell, and Rajendran (2013) found that there is a correlation between construction safety performance and construction quality as the recordable injury rate positively correlates to rework. The authors conclude that a project with a poor-quality performance has a higher likelihood of injury. Hence, if less rework is required, this suggests a lower probability of injury or risk. Similarly, Yunus, Abdullah, et al. (2016) found that improving safety measures leads to improved product performances.

6.1.2.6 Quality – policy related drivers' relationship

The final relationship was found between quality and policy. According to the chi-square test there is a significant relationship between these factors for both the construction companies and USECB (sections 4.8.2.2 and 4.8.2.1). With regard to the correlation test, the rho value=0.540 shows a highly significant relationship for construction companies, while a significant relationship was found for USECB, at rho=0.334 (sections 4.8.3.1 and 4.8.3.2). Indeed, the interviewees stated that establishing standards and codes for offsite products helps the manufacturer or company achieve quality performances (section 5.3.7). This accords with the findings of Gan et al. (2017). Indeed, Clark and Wolstenholme (2018) found that the aim of the partnership between industry and government is to adopt offsite manufacturing in order to meet construction sector needs by reducing time, speeding up construction, improving cost savings, and enhancing quality.

6.1.2.7 Schematic representation of the interaction between Quality and other drivers

The relationship of quality with the other drivers, as examined within the questionnaire and interviews (Chapters 4 and 5), will be discussed according to its importance. Moreover, Figure 6-6 will illustrate these relationships. According to Figure 6-6, there is a highly significant relationship between the quality and cost related drivers. It suggests that providing sufficient costs when using OSC will enhance quality. On the other hand, the high percentage of OSC products with fewer defects resulted in an overall project cost saving (reported in detail in section 6.1.2.1). Moreover, Figure 6.6 demonstrates a significant relationship between the quality, and policy and social related drivers.

With regard to the quality-policy related drivers' relationship, the good quality associated with OSC methods enhances the government's support for such construction. On the other hand, providing standards and codes will enhance the quality achievement requirement.

The relationship between the quality and social related drivers is also illustrated in Figure 6.6. Improving the performance of health & safety can lead to high quality, both in the factory and onsite. Moreover, fewer injuries are expected when using OSC as a result of the fewer defects that result from such construction and this generally improves the use of OSC. These relationships are reported in sections 6.1.2.5 and 6.1.2.6.

However, Figure 6.6 also illustrates a moderate significant relationship between the quality and (productivity, labour and environmental) related drivers. The figure indicated that the use of automation in the production of OSC could improve the overall quality. In addition, improving the quality of a construction project helps to improve productivity overall. Moreover, Figure 6.6 indicates that labour productivity is improved when there is high-quality control. However, skilled labour is required in order to achieve good quality construction projects.

It is worth mentioning that the relationship between the quality and environmental related drivers is moderate significant. Indeed, quality improvements when using OSC reduces the possibility of defects, which in turn leads to reduced waste onsite. Furthermore, the use of OSC increases the chance to protect products from environmental impact, which can improvement the quality of OSC products (as reported in sections 6.1.2.2, 6.1.2.3 and 6.1.2.4).

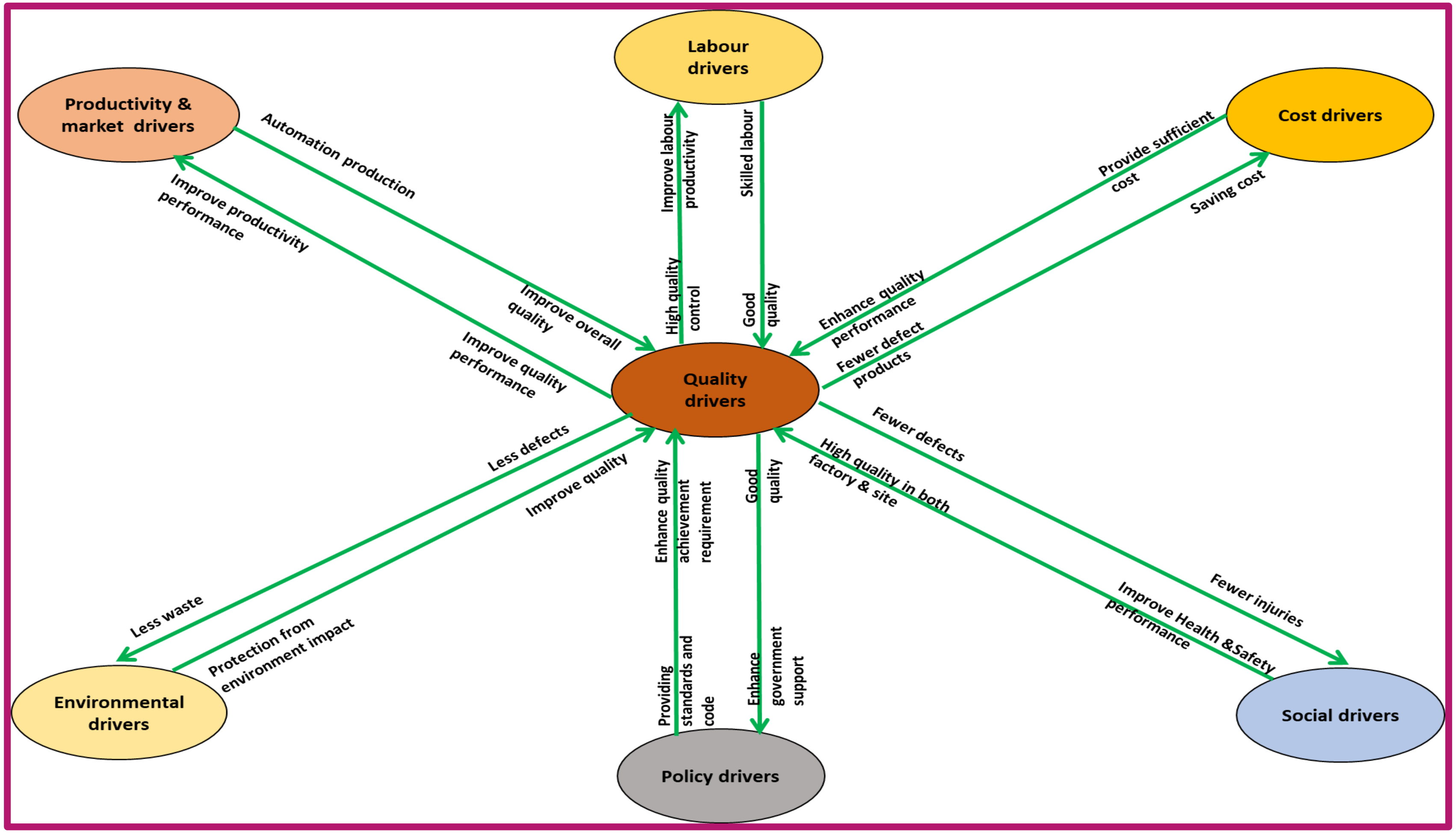


Figure 6-6: Schematic diagram of relationships between Quality drivers with other drivers and their interactions

6.1.3 Cost drivers

The drivers related to the cost factor are:

- Reduced construction cost.
- Minimised overall life cycle costs.
- Minimised maintenance & replacement costs.

These drivers were highly agreed by both groups according to descriptive analysis (sections 4.6.3 and 4.7.3). These drivers, as well as cost certainty, were frequently mentioned by researchers as drivers in using OSC (Bendi, 2017; Elnaas, 2014; Blismas & Wakefield, 2007; Blismas et al., 2006; Gibb & Isack, 2003). Moreover, the Kruskal-Wallis test shows agreement between both groups about the cost driver (section 4.8.4.1). The interview result revealed some benefits of using OSC, which leads to cost effectiveness including the speed of construction, reduced number of skilled workers, minimised materials waste and repetitive production, and minimised maintenance requirement costs. One of the interviewees indicated that a motivation to use OSC is reductions in a cost, although the reduction in cost resulted from the impact of other factors. However, most interviewees believed that the cost in OSC would be cheaper than for classic construction due to the nature of mass production. This is supported by Mesároš and Mandičák (2015) who emphasised the importance of mass production in cost savings.

On the other hand, the interviewees illustrated the other factors that can affect cost in OSC, including the location of the project, the type and volume of the project, and the distance between the site and the factory. The literature review also supported this; for example, in Australia, Blismas and Wakefield (2008, 2007) identified that using OSC could reduce costs when resources were scarce and the work was located in remote areas. Also, Vernikos et al. (2012) stated that the country and location of the project considerably affects the variances in cost. One of the interviewees indicated another important point affecting the cost of the project, namely, '*the availability or accessibility of infrastructure because, if the infrastructure [is] far and hard to get to, the implementation site, the cost will be high.*' Cost factor has a relationship with other factors explained in the following sections:-

6.1.3.1 Cost - productivity and market related drivers' relationship

The chi-square results indicated a significant relationship between cost and productivity related drivers for both groups (sections 4.8.2.1 and 4.8.2.2). Also, the spearman rho showed a significant relationship for construction companies, at rho=0.303, while a low significant relationship was found for the USECB group, at rho=0.172 (sections 4.8.3.1 and 4.8.3.2). Furthermore, the interviewees believed that a reduction in cost could be achieved when using OSC and when mass production was used. The literature review supported this finding; Lu (2009) confirmed that the use of prefabrication techniques in a project allows for cost savings at every stage of the production chain due to mass production. Similarly, Wuni and Shen (2019) found a relationship between cost and productivity related drivers whereby reduced labour demands and costs leads to improved productivity and greater demand for OSC.

6.1.3.2 Cost - labour related drivers relationship

According to chi-square test there is significant relationship between cost and labour related drivers for both groups (sections 4.8.2.1 and 4.8.2.2). Moreover, a highly significant relationship was demonstrated for the construction companies (rho=0.593), while a significant relationship was identified for the USECB, at rho= 0.448 (sections 4.8.3.1 and 4.8.3.2). The interviewees highlighted that the OSC requires fewer workers, which in turn reduces the overall cost. This accords with the findings of Elnaas (2014) and Mohamad Kamar (2011). Alternatively, Dakhil et al. (2017) states that a payment delay affects labour productivity in Iraq. The poor general financial system in Iraq causes lots of payment delays in almost all construction projects due to the different, fragmented authorities who need to approve all payments (Dakhil et al., 2017).

6.1.3.3 Cost - environmental related driver's relationship

The chi-square results revealed a significant relationship between cost and environmental amongst construction companies (section 4.8.2.1). In comparison, no significant relationship was found for the USECB (section 4.8.2.2). Although, the spearman test shows a significant relationship for construction companies, at rho=0.422, a low significant relationship was noted for the USECB group, at rho=0.123 (sections 4.8.3.1 and 4.8.3.2). Interviewees believed that the reduction in waste leads to cost savings when using OSC as well as reductions in energy requirements onsite and energy use during the life of the building, which results in decreased initial and life cycle costs (sections 5.1.3 and 5.1.8). The literature review also illustrated cost savings related to reduced energy use onsite, reduced waste and lower environmental impacts (Yunus, Abdullah, et al., 2016; Fraser, Race, Kelly, & Winstanley, 2015; Gibb & Isack, 2003; Alistair, 1999). On the other hand, applying sustainable construction project financing and policies helps encourage the distribution of green construction technologies in the construction industry (Shan et al., 2017). This is also supported by interviewees.

6.1.3.4 Cost - social related driver's relationship

The chi-square test results suggest a significant relationship between cost and social related drivers for both groups (sections 4.8.2.1 and 4.8.2.2). A highly significant correlation rank was found between cost and social for construction companies (rho=0.547), while a significant relationship was noted for the USECB (rho=0.495) (sections 4.8.3.1 and 4.8.3.2). The literature review justified this relationship where the total reduction in site hours worked associated with the use of OSC could easily lie in the range of 60-80%, whilst the reduction of workers required on site at any time could reduce the occurrence of major injury and death, which in turn could lead to greater financial benefits based on lower costs to treat injuries (Krug & Miles, 2013). The interviewees supported these findings (section 5.1.4), whilst Ludwig (2018) also found that creating a culture of safety is a top priority for many construction projects, as one serious incident can mean a project is halted, costs can overrun, and the project may close. In comparison, Cooney (2016b) highlighted that it is important for construction companies to consider cost expenditure when complying with laws related to workplace health and safety, executing plans to avoid accidents, and improving safety and work conditions onsite in order to enhance safety performance. Similarly, Yiu et al. (2019) found that sufficient expenditure on safety, and financial incentives can function as motivations for better safety system management and greater safety performances.

6.1.3.5 Cost - policy related drivers' relationship

The chi-square indicated a relationship between cost and policy related drivers (sections 4.8.2.1 and 4.8.2.2); results from the spearman test indicated a significant relationship for the construction companies rho=0.475, while a low significant relationship was noted for the USECB group, rho=0.235 (sections 4.8.3.1 and 4.8.3.2). This is supported by the findings of Gan, Zuo, Ye, Skitmore, and Xiong (2015) who found that the government's role is important in alleviating the issues associated with higher initial investment by providing more financial incentives, developing subsidy funding, and simplifying the process of funding allocation.

Also, the authors added that the development of codes and standards of technologies and materials through R&D could reduce the current high costs and promote the use of sustainable construction in the Chinese industry. Indeed, Clark and Wolstenholme (2018) found that the aim of the partnership between industry and government is to adopt offsite manufacturing in order to meet construction sector needs by reducing time, speeding up construction, saving costs and enhancing quality.

6.1.3.6 Schematic representation of the interaction between Cost and other drivers

In this section, Figure 6-7 illustrates the results obtained from Chapters 4 and 5. These will be discussed with regard to the cost related drivers and its relationship with the other factors related drivers, including labour, productivity & market, social, environmental and policy. Accordingly, there is a significant relationship between (cost and labour), and (cost and social) related drivers. These relationships can be justified by improvements to the safety performance can lead to reductions in costs when using OSC. Meanwhile, allocating sufficient cost will improve the safety performance in construction projects. On the other hand, reducing labour can lead to reductions in cost. Alternatively, if payment is to be made on time, this will improve the labour performance (sections 6.1.3.2&6.1.3.4).

Additionally, the relationships between the cost related drivers, and (productivity & market, environmental and policy) related drivers are noted as moderate significant. Indeed, savings in cost can be obtained when using the mass production methods of OSC. Also, improving the cost performance enables productivity performance. These relationships are explained in sections 6.1.3.1., 6.1.3.3 and 6.1.3.5. Regarding cost and environmental related drivers, lower waste and energy will lead to reduced projects costs. At the same time, sufficient accounting for environmental aspects enables improvements to the environmental performance of a project. In general, the cost savings when using OSC are an advantage that enhances government support. Alternatively, funding introduced by the government reduces cost.

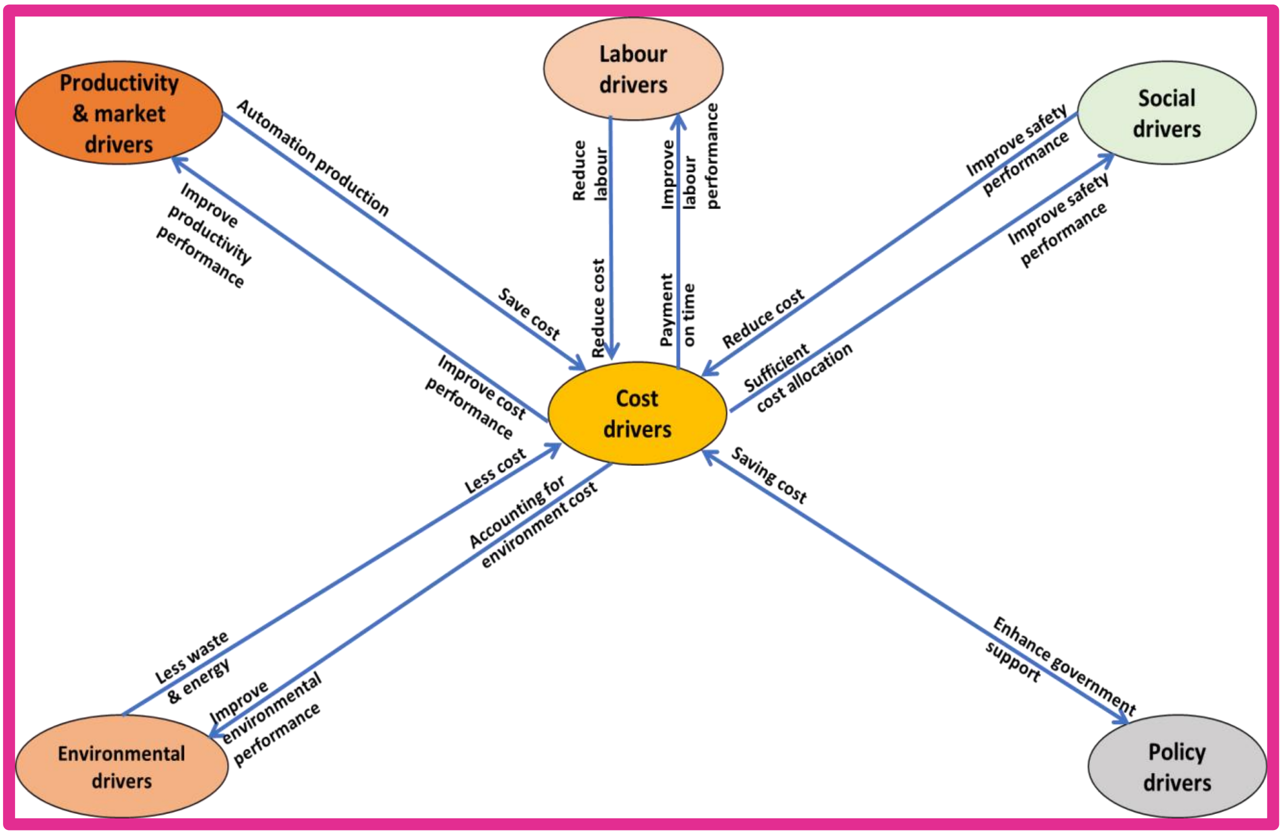


Figure 6-7: Schematic diagram of the relationship of Cost drivers with other drivers and their interactions

6.1.4 Productivity and Market drivers

The productivity and market related drivers include:

- Improving overall project productivity,
- Addressing the housing shortage in Iraq and
- Producing a high volume of units over a short period of time.
- Providing affordable housing

According to the results obtained from the descriptive analysis, participants from both groups strongly agreed to the mentioned drivers (sections 4.6.3 and 4.7.3). Moreover, the Kruskal Wallis test shows no significant differences between the construction companies and USECB groups concerning productivity and market when using OSC (section 4.8.4.1).

According to the interview results, the interviewees believe that productivity related drivers enhancing the using OSC. They mentioned that the reasons for improving overall productivity when using OSC are quality control, quality insurance and the health and safety system provided in the factory. Moreover, there is a greater possibility of mass production and fewer activities required onsite, especially within the wet trades. In the literature, Construction McGraw Hill (2011) indicate that architects, engineers and contractors believe that the primary drivers to the future usage of OSC will be the improvements that this construction can provide to the productivity elements, namely time, cost, quality, safety and waste reduction. This is also supported by (Durdyev & Ismail, 2019) who indicated that the improvements in productivity occurred when using OSC as a result of its benefits.

According to the interviewees, (section 5.1.4) the use of OSC in Iraq is essential to solve the housing crises as it can enable the mass production of units in less time. Moreover, some interviewees and sources in the literature declared that Iraq is in urgent need of such construction as there is a housing shortage of approximately four million units (Teen & Gramescu, 2018). Indeed, the use of OSC to address housing crises in different countries has been widely explored in the literature (Ojoko, Osman, Rahman, et al., 2018; Bendi, 2017; Rahimian et al., 2017; Al-Mutairi, 2015; Elnaas, 2014; Hashemi, 2009). Globally, Ojoko, Osman, Rahman, et al. (2018) stated that the adoption of OSC has been recognised as a panacea for housing delivery performances. The interviewees further added that the use of OSC could provide affordable housing, and offered some reasons including lower-cost housing through mass production, less energy and time required, and the use of reasonably priced materials. This makes homes more affordable and desirable for low to medium income families. Also, the literature supports the findings that affordable housing can be obtained when using OSC (Burwood & Poul, 2005) (Arif et al., 2012; Mohamad Kamar, 2011). Also, Mesároš and Mandičák (2015) confirm that OSC is represented by mass production in factories which significantly shortens the construction time and has a positive impact on the environment. This finding is also supported by Mohamad Kamar (2011).

Another important point highlighted by the interviewees is that OSC can offer a positive solution for a post-disaster housing solution. The literature also supported that, '*it is concluded that OSC are a highly desirable time-efficient solution to post-disaster housing reconstruction as the advantage of speed and mass production*' (Gunawardena, Ngo, Mendis, Aye, & Crawford, 2014). Fenner, Razkenari, et al. (2017) found that OSC offers an affordable and durable alternative and replaces damaged buildings quicker while providing environmental payback and improving society resilience. The productivity and market factor has relationships with other factors, which illustrated in the following sections:-

6.1.4.1 Productivity & market – social related drivers' relationship

The chi-square test indicated a significant relationship between the productivity & market and social related drivers for construction companies and the USECB (sections 4.8.2.1 and 4.8.2.2). The spearman rho test shows a significant relationship for the construction companies (rho= 0.311) and a low significant relationship for the USECB group (rho= 0.281) (sections 4.8.3.1 and 4.8.3.2). The literature review highlighted a relationship between productivity & market, and social factors; indeed, Hesapro (2013); Nahmens and Ikuma (2011) indicated that health and safety measures have a positive influence on the performance of a company's productivity & market, and its health & safety. In the same way, Durdyev and Ismail (2019); Construction McGraw Hill (2011) found that safety is one element of productivity; site safety can be improved when using OSC as less labour is required onsite for scaffolding or ladders. This also leads to an improvement in overall productivity and is supported by the interviewees who further added that the reduction of activities onsite, like wet trades and scaffolding, means a reduced overlap that can lead to fewer accidents onsite (sections 5.1.4 and 5.1.6). This finding is also supported by (McKay, 2010).

6.1.4.2 Productivity & market - labour related drivers' relationship

The chi-square test indicated a significant relationship between productivity & market and labour related drivers for construction companies and the USECB (sections 4.8.2.1 and 4.8.2.2). The correlation ranking order indicated a highly significant relationship between these factors for construction companies (who scored rho=0.573), whilst a low significant relationship was scored for the USECB group (at rho=0.297) (sections 4.8.3.1 and 4.8.3.2). This accords with the findings of Javed et al. (2018), who noted that the implementation of offsite technologies and automated production can reduce the amount of labour required for onsite operations, and thus improve productivity at the site level. The interviewees also highlighted this point as the reduction of labour comes from OSC as work is more dependent on the use of machines, which leads to reduced activities onsite (sections 5.1.5 and 5.1.6).

On the other hand, Fraser, Race, Kelly, and Winstanley (2015) found that productivity and quality are clearly linked to attitude and skills as incorrect skills impact on operation, productivity and deliverables for an OSC project. Thus, Javed et al. (2018) pinpointed that the availability of a skilled workforce leads to productivity improvements in construction. The interviewees also highlighted the need for a skilled workforce to successfully implement OSC.

6.1.4.3 Productivity & market - environmental related drivers' relationship

Results from both groups demonstrated a significant relationship between productivity & market and environmental related drivers within the chi-square test (sections 4.8.2.1 and 4.8.2.2). The spearman rho test result indicated a significant relationship (at 0.337) for construction companies, while a highly significant relationship was found for the USECB (at 0.581) (sections 4.8.3.1 and 4.8.3.2). In the literature, the relationship between environment and productivity & market related drivers was explained by (Durdyev & Ismail, 2019) who confirmed that productivity levels can be improved by reducing the waste of construction resources and that OSC has the potential to address this. Accordingly, Nahmens and Ikuma (2011) believe that, due to their construction methods, modular houses already achieve higher levels of sustainability compared with site-built homes. The interviewees also confirmed these results stating that a reduction to activities onsite leads to reduced waste, and hence improved overall project productivity (section 5.1.8).

6.1.4.4 Productivity & market – policy related drivers' relationship

A connection was found between productivity and policy related drivers, as the chi-square result revealed a significant relationship for both groups (sections 4.8.2.1 and 4.8.2.2). Moreover, the correlation rank order demonstrated a low significant relationship for construction companies (at rho= 0.227), while a significant relationship was recorded for the USECB, (at rho= 0.307) (sections 4.8.3.1 and 4.8.3.2). The findings of Javed et al. (2018) indicated that there is a relationship between the availability of policy information, such as initiatives on labour, training and regulatory requirements including the qualifications of contractors, meeting legal requirements, quality control, and compliance with new sustainability standards. This leads to enhancements in productivity in construction. However, stakeholder commitment is needed in order to achieve productivity improvements; therefore, local authorities need to provide policies and incentive schemes and promotions in order to elicit stakeholder commitment and achieve productivity (Wuni & Shen, 2019; Yunus, Suratkon, Wimala, Hamid, & Noor, 2016). The interviewees recommended government support in order to meet housing needs and emphasised the importance of codes, standards and legislation to ensure greater stakeholder commitment to a project (sections 5.1.7,5.3.1 and 5.3.7).

6.1.4.5 Schematic representation of the interaction between Productivity & Market and other drivers

This section illustrates the relationships between the productivity related drivers with other drivers, according to the results obtained from the questionnaire and interviews, and as shown in Figure 6-8 . The productivity & market factor has a significant relationship with labour and environmental related drivers (sections 6.1.4.2 and 6.1.4.3). Indeed, construction productivity improves when skilled labour is available. Although the use of automation leads to overall reductions in labour, improving productivity also leads to reduced waste and vice versa.

However, the relationship between productivity & market with social and policy related drivers is moderate significant. Furthermore, the relationship between productivity & market and social justified that the reduction of onsite activities will reduce accidents. Also, improving the safety performance enables better productivity, whilst the application of policies improves productivity and vice-versa when using OSC. These results are reported in 6.1.4.1 ------ 6.1.4.4.

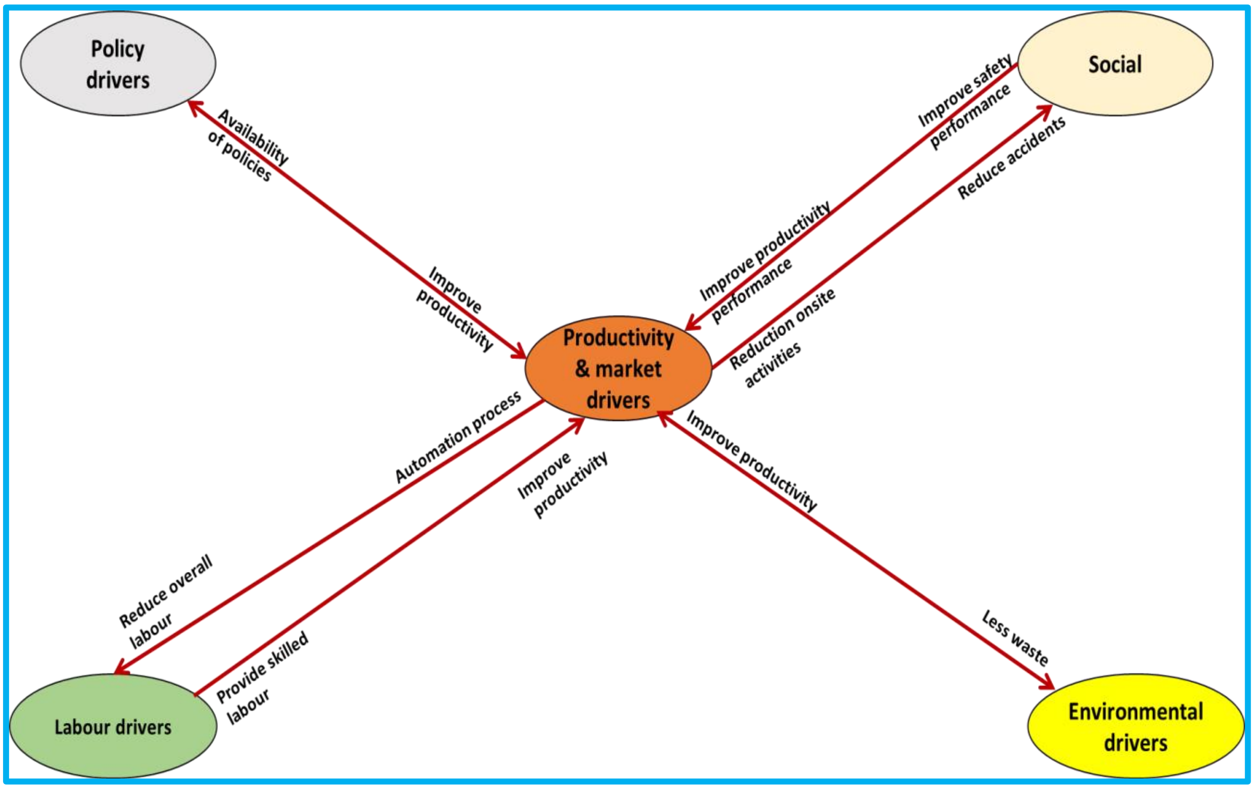


Figure 6-8: Schematic diagram of the relationship between Productivity & Market driver with other drivers and their interactions

6.1.5 Environmental drivers

According to both groups, the descriptive analysis of the drivers related to environmental factor shows agreement by both groups (sections 4.6.3 and 4.7.3). These related drivers are:

- Decreasing energy use during construction and building usage,
- Reducing the waste of materials
- Reducing the environmental impact during construction.

Moreover, the Kruskal-Wallis test revealed no differences between the construction companies and USECB groups concerning environmental (section 4.8.4.1), whilst the interviewees identified a variety of environmental benefits that could be achieved by using OSC (section 5.1.8). Firstly, they cited energy efficiency during construction due to fewer but more organised activities and a greater speed of construction. Also, the interviews believed that the energy consumption during building use is also decreased due to the thermal insulation. Interviewees stated that OSC also, ‘*reduces the energy consumption during the use of the building because of the thermal insulation and the high quality of the finished products*’; this is particularly significant due to the energy crises in Iraq. Secondly, interviewees mentioned reductions to the impact on the environment during construction, for example, less material wastage due to prefabricated products. One of the interviewees offered additional important points, namely the use of OSC has an advantage in protecting the infrastructure, such as nearby sewages, and electricity wires. This is *'because the work is organised, the supply chain is controlled, organised, knows when production, transportation and installation will occur*'. The interviewees also indicated other benefits, namely the ability to recycle materials when using OSC. The environmental drivers of using OSC are explained widely in the literature (Wu et al., 2019; Fraser, Race, Kelly, & Winstanley, 2015; Zhai et al., 2013; Taylor, 2009; Jaillon & Poon, 2008). Indeed, the top five drivers investigated by Zhai et al. (2013) related to environmental factor and included: reduced construction waste, decreased on-site dust, less noisy pollution, fewer local community disruptions, lower energy consumption, and a greater uptake of green building technologies. Therefore, the research findings in regard to environmental drivers are in a line with those in the literature which indicates that the participants in the construction industry in Iraq are aware about environmental drivers.

6.1.5.1 Environmental – labour related drivers' relationship

The findings indicated a relationship between the environmental and labour related drivers. The chi-square test illustrated a significant relationship for both groups (sections 4.8.2.1 and 4.8.2.2). The correlation test illustrated a significant relationship between these amongst construction companies (rho=0.489), whilst a low significant relationship was found for the USECB group (rho=0.193) (sections 4.8.3.1 and 4.8.3.2).

Moreover, the interviewees clarified that the labour in OSC is less likely to be exposed to bad weather conditions because most of the work is undertaken in a controlled factory environment, and, because of the speed of construction onsite, fewer activities are required (section 5.1.4). The literature review widely highlighted the benefits of using OSC to reduce the exposure to the bad weather (Al-Mutairi, 2015; Fraser, Race, Kelly, & Winstanley, 2015; Jaillon & Poon, 2008). On the other hand, the availability of skilled labour is important to achieve economically and environmentally sustainable construction (Oke, Aigbavboa, & Khangale, 2017).

6.1.5.2 Environmental – social related drivers' relationship

This section discusses the relationship between social and environmental related drivers. The chi-square test results demonstrated a significant relationship for both groups (sections 4.8.2.1 and 4.8.2.2). Thus, the results from the correlation ranking order test demonstrated a significant relationship between these factors for the construction companies' group (rho= 0.384), whereas a low significant relationship was noted for the USECB group (rho=0.033). The interviewees explained these relationships by ascertaining that most work occurs in a factory environment under quality control, and with health and safety standards. This means fewer defects onsite resulting in less waste, which in turns lead to fewer accidents (section 5.1.8). This is also indicated in the literature, as Taylor (2009) clarified that a warm, controlled and enclosed workplace using production line systems dramatically decreases the risk of accidents and ill health. Al-Mutairi (2015) also supported these findings.

6.1.5.3 Environmental – policy related drivers' relationship

According to chi-square test, there is a significant relationship between environmental and policy related drivers for both groups. The correlation test illustrated a low significant relationship for construction companies, at rho= - 0.051, whilst a low significant relationship was found for the USECB, at rho=o.202. Therefore, this relationship cannot be considered a valuable result as both groups have low contrasting opinions. Also, in this context, the interviewees did not mention the importance of this relationship.

6.1.5.4 Schematic representation of the interaction between Environmental drivers and other drivers

This section demonstrates the relationship between environmental and (labour and social) related drivers in accordance with the questionnaire and interview results obtained in Chapters 4 and 5. Again, a moderate significant relationship between these factors was found and illustrated in Figure 6-9. Indeed, the availability of skilled labour can enhance a project's consideration of environment. Also, reductions in waste and energy onsite enable a reduction to accidents onsite. These relationships are clearly explained in sections 6.1.5.1 & 6.1.5.2.

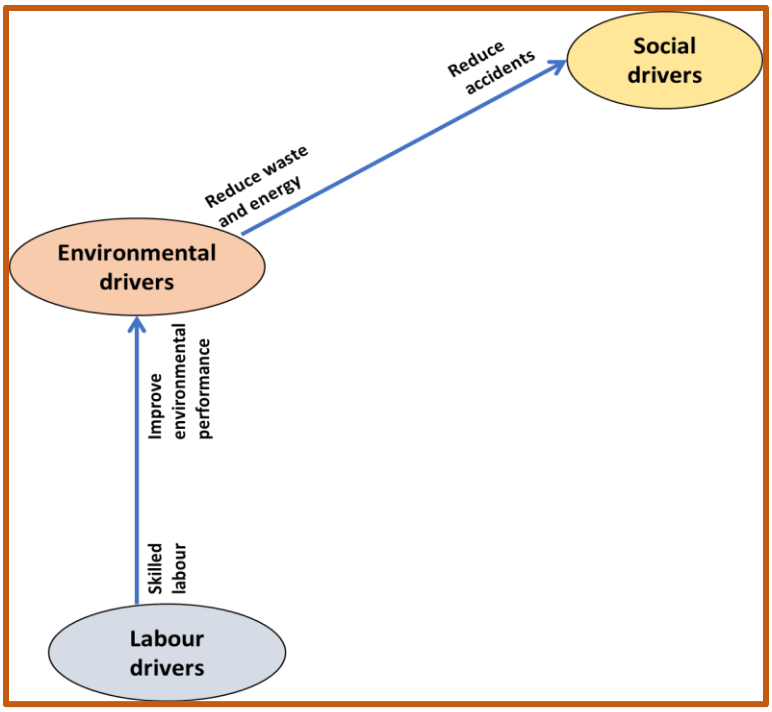


Figure 6-9: Schematic diagram of the relationship between Environmental drivers with other drivers and their interactions

6.1.6 Social drivers

The drivers related to social factor examined in this study are:

- reduced accidents onsite,
- offers of employment opportunities for local communities with greater long-term security for the individual worker,
- improved working conditions for the workforce and industry.

The descriptive analysis revealed close results for construction companies and the USECB regarding the reduction of accidents onsite, as 47% of respondents are neither agreed nor disagreed (sections 4.6.3 and 4.7.3). In addition, similar outcomes were noted for improved work conditions for the workforce and industry (69% agreement amongst the USECB and 66% agreement amongst the construction companies). However, the construction company respondents agreed more with offering employment opportunities for local communities with greater long-term security than the USECB respondents (90% and 52% respectively). Furthermore, the Kruskal Wallis test also revealed differences between both groups concerning social (section 4.8.4.1).

According to interviews results (section 5.1.4), the participants believe that the using OSC reduces accidents on site because the stages of implementation are few, everything is subject to a plan, and the process of OSC is iterative. Therefore, workers will be more familiar with the risks that can occur, while in traditional construction, some activities are difficult to control. Lawson et al. (2011) illustrated that safety on-site and in the factory is improved significantly, and it is expected that reportable accidents decrease by over 80% in comparison to classic construction.

The social related drivers when using OSC is strongly reinforced in the literature (Jiang et al., 2018; Krug & Miles, 2013; Zhai et al., 2013; Taylor, 2009; Blismas & Wakefield, 2007). However, some interviewees stated that OSC can be risky in some projects that involve high-rise buildings, such as airports, because the installation is more dangerous. This reflects other findings in the literature (Fard, Terouhid, Kibert, & Hakim, 2017), although the potential safety benefits of OSC are recognised, OSC can still be challenging and risky, for example, during the movement and installation of massive components. They recommended that fall safety protection plans should be developed and followed, which aligns with interviewees' views about the importance of such plans.

6.1.6.1 Social – labour related drivers' relationship

The chi-square for independence test shows significant relationship between social, and labour amongst construction companies and the USECB group (sections 4.8.2.1 &4.8.2.2). Moreover, the correlation ranking order indicated a highly significant relationship between these factors according to construction companies (rho=0.595), whereas a significant relationship was found for the USECB group, (rho=0.446) (sections 4.8.3.1 and 4.8.3.2).

The interviewees noted that safer working conditions onsite lead to reduced accidents when using OSC, which proves to be a more organised, tidier and safer working environment (section 5.1.4). This is supported by Mohamad Kamar (2011) findings. The interviewees added that OSC can offer job opportunities for local workers and this can minimise unemployment problems in Iraq. In the literature, job security at factories was recognised by Krug and Miles (2013), which represents stable employment with social and financial benefits. On the other hand, Yiu et al. (2019) indicated that it is important to recruit workers with a higher safety awareness in order to enhance the safety performance. Interviewees also recognised that the availability of skilled labour can enhance this performance area.

6.1.6.2 Social – policy related drivers' relationship

The chi-square for independence revealed a significant relationship between social and policy for both the USECB and construction companies' groups (sections 4.8.2.1 and 4.8.2.2). A significant relationship was found for the construction companies (rho=0.344), while low significant relationship was indicated by the USECB group, (rho= -0.020) (sections 4.8.3.1 and 4.8.3.2). Moreover, Fard et al. (2017) recommended applying safety standards and developing training programmes to improve the safety record of the OSC sector and to familiarise employees with related job hazards. Furthermore, the interviewees believed that the high safety standards associated with the use of OSC leads to enhanced safety performances (section 5.1.4).

6.1.6.3 Schematic representation of the interaction between Social and other drivers

The relationship between the social, and labour & policy related drivers is shown in Figure 6-10. As before, the results of these relationships were obtained from the questionnaire and interviews. The interaction between social and labour demonstrates a significant relationship, indicating that a good safety system helps to safeguard workers during the work implementation. If the work is carried out by labour with high safety awareness skills, this will enhance the safety performance. However, the social related drives has a moderate significant relationship with policy, suggesting that adopting safety standard rules will improve the health & safety performance. These findings are also reported in sections 6.1.6.1 & 6.1.6.2.

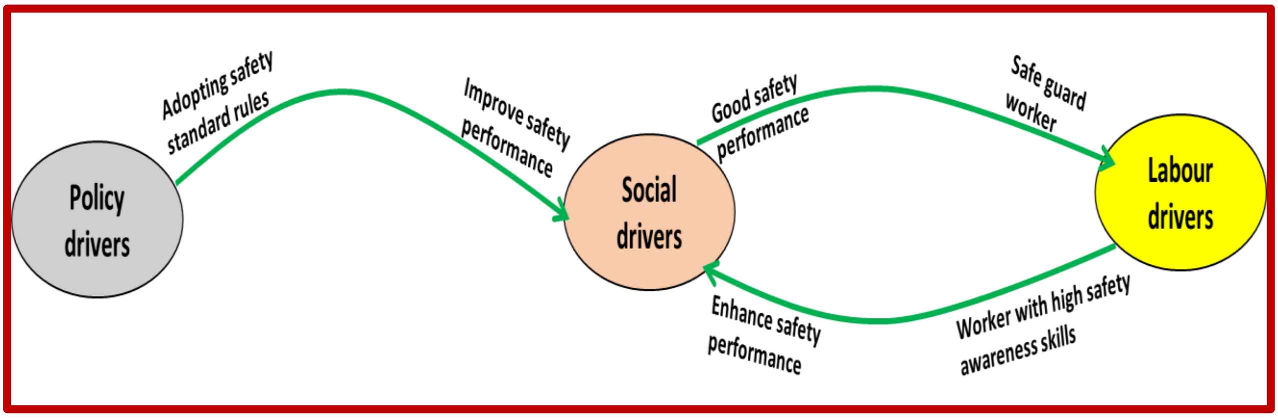


Figure 6-10: Schematic diagram of the relationship between Social drivers with other drivers and their interactions

6.1.7 Labour drivers

The descriptive analysis for the labour related drivers shows strong agreements amongst both the USECB and construction companies (sections 4.6.3 and 4.7.3). The related drivers are:

- Reduced labour required for onsite construction,
- Improved labour productivity performances and
- Improved management and coordination among workers at the site.

Moreover, the Kruskal- Wallis test revealed no differences between the groups concerning labour related drivers for the use of OSC in Iraq (section 4.8.4.1). Furthermore, most of the interviewees agreed that fewer labourers are required onsite when using OSC because most work is undertaken in a factory. However, interviewees clarified that these labourers must be skilled and well trained. They also added that that using OSC will minimise the problem of labour shortages, as OSC needs skilled labour but in lower numbers than traditional construction. The literature also supported this finding (Jiang et al., 2018; Al-Mutairi, 2015; Fraser, Race, Kelly, & Winstanley, 2015; Goodier & Gibb, 2007). Nawi, Noordin, Tamrin, Nifa, and Lin (2019) noted that the use of OSC reduces the numbers of workers; similarly, they confirmed the importance of well-trained and skilled labour when adopting OSC.

In addition, most interviewees agreed that the productivity of the labour increases when using OSC due to the repetitive work and factory environment workplace. Increased labour productivity is also confirmed within the literature (Al-Mutairi, 2015; Fraser, Race, Kelly, & Winstanley, 2015), whilst some interviewees also believed that the use of OSC improves the management and coordination between teams.

6.1.7.1 Labour – policy related drivers’ relationships

The chi-square test for independence found no significant relationship between labour and policy related drivers’ factors for the USECB group; however, there was a significant relationship between these factors for the construction companies’ group (sections 4.8.2.1 and 4.8.2.2). Furthermore, the correlation-ranking test illustrated a low significant relationship amongst construction company participants (rho=0.215), while a low significant relationship was noted for the USECB group (rho=-.0.042) (sections 4.8.3.1 and 4.8.3.2). Indeed, the interviewees emphasised the importance of government support through their ministries and in leveraging the skills of workers by providing training and education (section 5.3.4).

Furthermore, the government role is important in providing training for labour to improve their skills (Fernando et al., 2016). This relationship is illustrated in Figure 6.11.

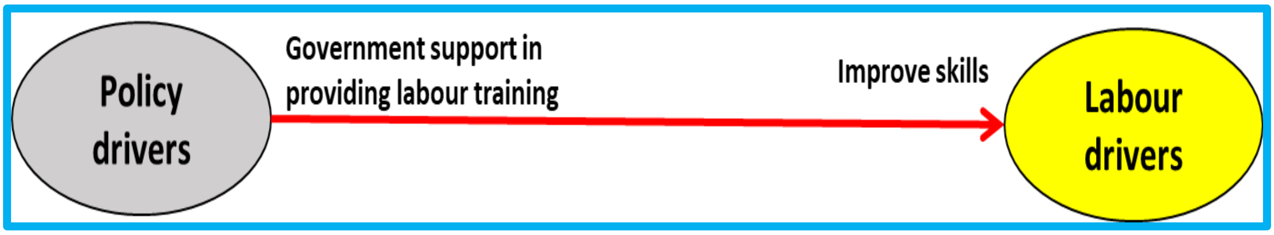


Figure 6-11: Schematic diagram of the relationship between Policy and Labour drivers

6.1.8 Policy drivers

The related drivers examined in this study are:

- The revision to building regulations to support OSC,
- Government promotion and support, and
- The availability of legal standards and a codes framework to cover all stages of the project.

According to the questionnaire descriptive result, the construction company participants were in stronger agreement than the USECB participants on these the related drivers (sections 4.6.3 and 4.7.3).

Interviewees emphasised that there is a lack of regulation to support OSC in Iraq and that it is important to re-review this issue. The interviewees believed that it is the role of ministries to establish such regulations, which would support the effective organisation of the work. Moreover, most of the interviewees believed that there are no Iraqi codes and standards to support the use of OSC; indeed, some declared that they use global codes instead. All interviewees recommended the role of the government in enhancing the use of OSC in Iraq (sections 5.1.7 and 5.3.1).

Similarly, in their study in Saudi Arabia, Al-Mutairi (2015) emphasised the importance of the government to encourage the application of regulations and codes for OSC. This also accorded with the findings of Rahimian et al. (2017) who stated that, for OSC to be adopted in Nigeria, there is a need for greater awareness, collaboration, training and encouragement from the government. Similarly, existing studies advise that the Iranian government should define a clear strategy to address the application of offsite methods in Iran (Hashemi, 2015). Indeed, the Iraqi Ministry of Planning (2018) established a national development plan for 2018-2022 that aims to address the problems that Iraq suffers in different sectors, including housing deficiencies and slums. The focus is on establishing legislation to accelerate the production of housing, by using modern methods of construction, and providing direct support to private investment companies in the field of private housing.

6.1.9 Schematic representation of the drivers factors for using OSC in Iraq according to the degree of their interaction relationships

This section demonstrates the degree of significance in the relationships between the different drivers' factors. It is based on both a statistical approach that includes the chi-square for independence, correlation test and the interview method carried out in Chapters 4 and 5. Time related drivers were found to be the main factor of importance in the use of OSC in Iraq. Figure 6 -12, figure 6-13 & figure 6-14 show schematic diagram of the relationships between drivers of using OSC in Iraq based on the degree of significance. Moreover, table 6-1, table 6-2 & table 6-3 demonstrate the values of the drivers' relationships for both construction companies and universities scientific engineering consulting bureau according to correlation test. These figures and tables are classified in the following sections: -

1 **High significant interaction relationships**

Table 6-1 illustrates the high significant value obtained from the correlation test regarding drivers of using OSC in Iraq for both groups (CC &USECB). These are time, cost, quality drivers.

Table 6-1: High significant drivers' values relationships

Factor1	**Factor 2**	**Construction companies**	**USECB**
Time	Quality	0.693	0.580
Time	Cost	0.626	0.668
Cost	Quality	0.515	0.611

Moreover, figure 6-12 illustrates the schematic diagram of the highly significant relationships, which occur between the time, cost and quality related drivers. It shows that improvements to the quality of products lead to improvements in the time performance. Also, the allocation of adequate time can enhance the quality of a project. These relationships were reported in section 6.1.1.1. Moreover, figure 6-12 demonstrates the relationship between the time and cost drivers; thus, a reduced time when using OSC can lead to cost savings. In addition, cash flow return is faster when using OSC as a result of the advantages associated with greater time certainty, whilst the availability of a cash flow increases certainty in the time performance. These relationships are discussed in section 6.1.1.2.

Moreover, there is a highly significant relationship between the quality and cost related drivers. It suggests that providing sufficient costs when using OSC will enhance quality performance. On the other hand, the high percentage of OSC products with fewer defects resulted in an overall project cost saving (reported in detail in section 6.1.2.1).

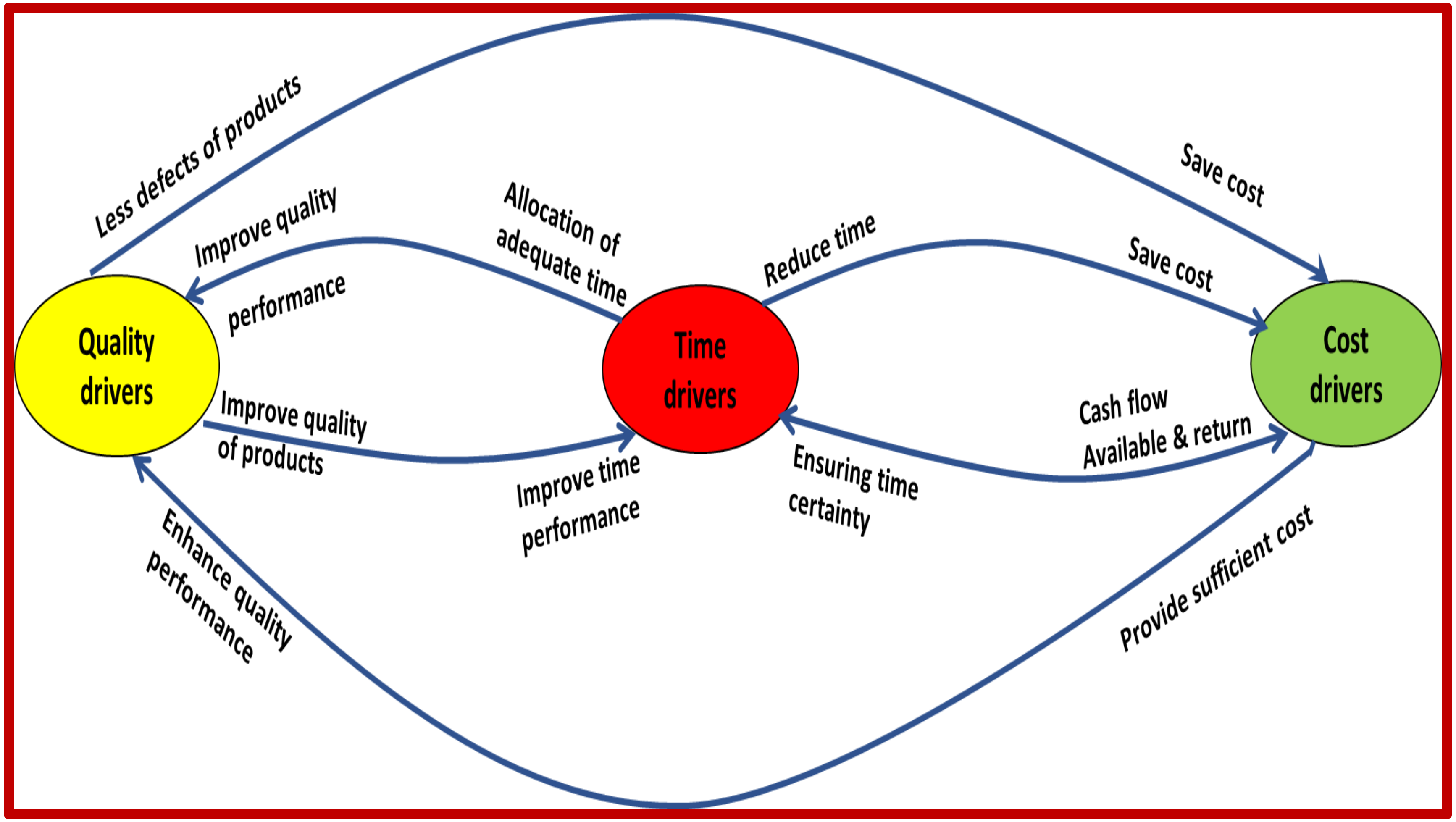


Figure 6-12*: Schematic diagram representation of high significant relationships for drivers of using OSC in Iraq*

2 *Significant interaction relationships*

Table 6-2 shows the relationships values between the drivers of using OSC in Iraq according to correlation test for both groups (CC & USECB).

Table 6-2: correlation drivers' values relationships

Factor 1	**Factor2**	**Construction companies**	**USECB**
Time	**Productivity**	**0.319**	**0.303**
Quality	**Policy**	**0.540**	**0.334**
Quality	**Social**	**0.583**	**0.314**
Cost	**Labour**	**0.593**	**0.448**
Social	**Cost**	**0.547**	**0.495**
Labour	**Productivity& Market**	**0.573**	**0.297**
Social	**Labour**	**0.595**	**0.446**
Environmental	**Productivity & Market**	**0.337**	**0.581**
Time	**Labour**	**0.553**	**0.479**
Time	**Social**	**0.666**	**0.491**

Moreover, figure 6.13 shows the schematic diagram for significant interactions relationships between the drivers of using OSC in Iraq based on quantitative and qualitative results. The figure reveals that labour and social factors have more significant relationships with other factors. The labour drivers have a significant relationship with productivity & market drivers. Indeed, construction productivity improves when skilled labour is available. However, the use of automation leads to overall reductions in labour (see section 6.1.4.2 for this relationship). Similarly, the labour has significant relationship with cost drivers in which reducing labour can lead to reductions in cost. Alternatively, if payment is to be made on time, this will improve the labour performance (section 6.1.3.2). Moreover, the interaction between social and labour demonstrates a significant relationship, indicating that a good safety system helps to safeguard workers during the work implementation. Also, if the work is carried out by labour with high safety awareness skills, this will enhance the safety performance (section 6.1.6.1). Likewise, the interaction between time and labour factors also indicates significant relationship. The availability of skilled and well-trained labour can result in improvements to the time performance; furthermore, the use of OSC can reduce the overall time taken leading to reduced onsite labour (section 6.1.1.5).

Social related drivers comprise to the second factor with a more significant relationship. This factor has a significant relationship with time factor, as improvements to the safety performance can lead to improvements in the time performance of a project. Also, less time is required when using OSC, means less exposure to bad weather and difficult site conditions (Sections 6.1.1.3). Moreover, another significant relationship is between (social and cost) factors. These relationships can be justified by improvements to the safety performance can lead to reductions in costs when using OSC. Meanwhile, allocating sufficient cost will improve the safety performance in construction projects (section 6.1.3.4). Furthermore, the relationship between the (quality and social) related drivers is also indicating as significant. Indeed, improving the performance of health & safety can lead to high quality, both in the factory and onsite. Moreover, fewer injuries are expected when using OSC as a result of the fewer defects that result from such construction and this generally improves the use of OSC. This relationship is reported in section 6.1.2.5.

This figure also illustrates that improving the time performance can lead to enhancements in productivity. Also, mass production enables faster construction, which means that more homes can be completed (section 6.1.1.4). Also, the improving productivity leads to reduced waste and vice versa (section 6.1.4.3).

Lastly, there is a significant relationship between (quality and policy) related drivers, the good quality of products associated with OSC methods enhances the government’s support for such construction. On the other hand, providing standards and codes will enhance the quality achievement requirement. This relationship is reported in detail in section 6.1.2.6

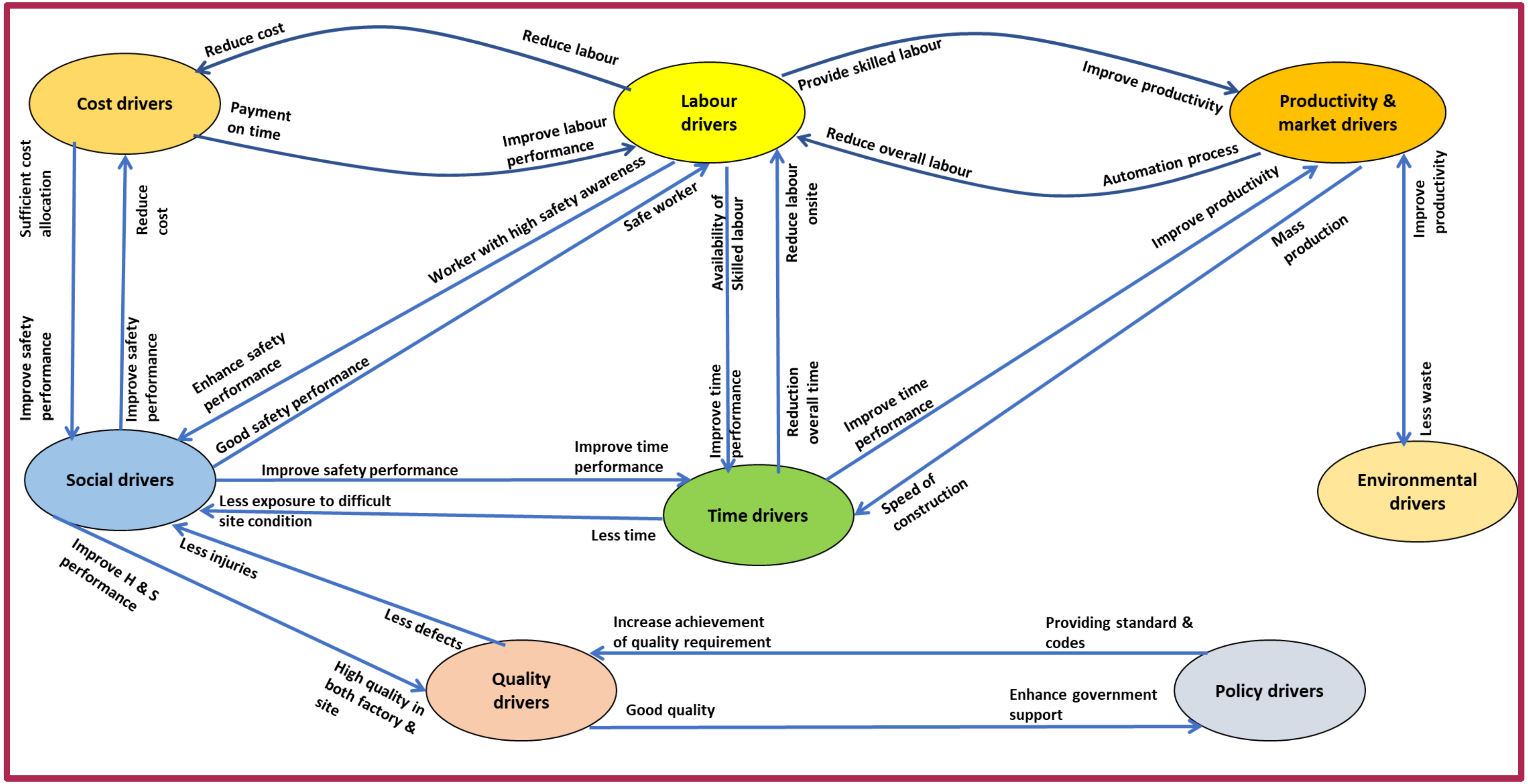


Figure 6-13: schematic diagram of the significant relationships for drivers of the using of OSC in Iraq

3 Moderate significant relationships

Furthermore, *table 6-3* shows the relationships value between drivers according to correlation test. in regard to construction companies and USECB.

Table 6-3: correlation drivers' values relationships

Factor 1	Factor2	Construction companies	USECB
Quality	Labour	0.391	0.263
Quality	Productivity	0.400	0.196
Quality	Environmental	0.385	0.024
Cost	Policy	0.475	0.235
Cost	Productivity & Market	0.303	0.172
Cost	Environmental	0.422	0.123
Labour	Environmental	0.489	0.193
Policy	Productivity & Market	0.227	0.307
Social	Productivity & Market	0.311	0.28
Social	Environmental	0.384	0.033
Time	Policy	0.387	0.24
Time	Environment	0.429	0.181
Social	Policy	0.344	-0.020
labour	Policy	0.215	-.042

The figure 6.14 shows the moderate relationships between drivers of using OSC in Iraq according to quantitative and qualitative results . The productivity & market drivers has four moderate relationships. Furthermore, the relationship between productivity & market and social justified that the reduction of onsite activities will reduce accidents. Also, improving the safety performance enables better productivity, whilst productivity& market with policy related driver's relationship justified as the application of policies improves productivity and vice-versa when using OSC. These results are reported in 6.1.4.1 and 6.1.4.4. Additionally, the relationships between the cost related drivers, and (productivity & market) related drivers are noted as moderate significant. Indeed, savings in cost can be obtained when using the mass production methods of OSC. Also, improving the cost performance enables productivity performance. These relationships are explained in sections 6.1.3.1. Moreover, the figure indicated another relationship between quality & productivity & market factors that the use of automation in the production of OSC could improve the overall quality. In addition, improving the quality of a construction project helps to improve productivity overall (section 6.1.2.4).

The figure 6-14 indicates that labour productivity is improved when there is high-quality control. However, skilled labour is required in order to achieve good quality construction projects. The relationship between the quality and environmental related drivers is justified as, the quality improvements when using OSC reduces the possibility of defects, which in turn leads to reduced waste onsite. Furthermore, the use of OSC increases the chance to protect products from environmental impact, which can improve the quality of OSC products (as reported in sections 6.1.2.2, 6.1.2.3).

On the other hand, the figure shows a relationship between the time and environmental related drivers. Fewer disturbances onsite include less dust and noise, and minimal waste leading to reductions in time. Also, shorter completion periods can lead to a lower impact on the environment. Another relationship identified within this figure is between time and policy related drivers, where more readily available government funding leads to improved time performances. Also, the speed of construction associated with OSC encourages its adoption and support from governments worldwide. (sections 6.1.1.6 & 6.1.1.7).

There is a relationship between environmental and (labour, cost, social) drivers. Indeed, the availability of skilled labour can enhance a project's consideration of environment. Also, reductions in waste and energy onsite enable a reduction to accidents onsite. These relationships are clearly explained in sections 6.1.5.1 & 6.1.5.2. With regard to cost and environmental related drivers, lower waste and energy will lead to reduced projects costs. At the same time, sufficient accounting for environmental aspects enables improvements to the environmental performance of a project (section 6.1.3.3). In general, the cost savings when using OSC are an advantage that enhances government support. Alternatively, funding introduced by the government reduces cost (see section 6.1.3.5). Furthermore, the social factor has a moderate significant relationship with policy, suggesting that adopting safety standard rules will improve the health & safety performance. These findings are also reported in sections 6.1.6.2. Furthermore, the government role is important in providing training for labour to improve their skills (see section 6.1.7.1 for relationship details between policy and labour).

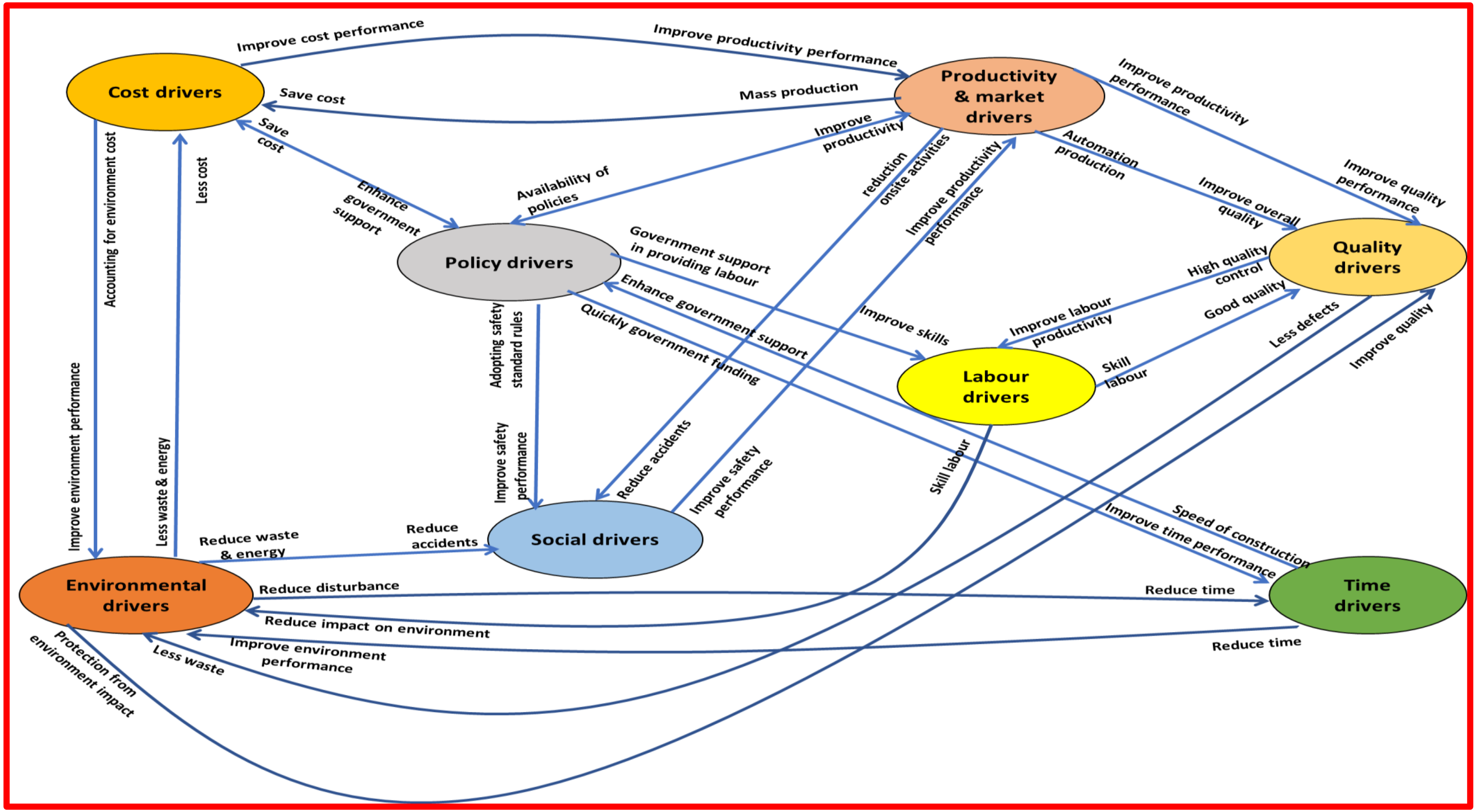


Figure 6-14: Schematic diagram representation of moderate-significant relationships for drivers of the using OSC in Iraq

6.1.10 The classification of the drivers factors affecting the adopting of OSC in Iraq

This section reveals the priorities concerning the significance of the driver's factors to adopting OSC in Iraq and is based on the results illustrated in previous sections obtained from the qualitative and quantitative analysis. It appears that time drivers play an important role in adopting OSC in Iraq. Indeed, the use of OSC is vital in order to provide fast affordable housing to overcome the urgent need for 4-5 million houses in Iraq (Teen & Gramescu, 2018). In fact, the increasing demand for the fast delivery of affordable housing is one of the drivers for using OSC (Fenner et al. (2018); Bendi (2017); Fenner, Zoloedova, et al. (2017). However, the second two important factors found in this research are cost and quality drivers. Indeed, Sutrisna and Goulding (2019) found that the time-cost-quality triangle was one of the main aspects for consideration during the design phase for projects using OSC. The third important factor found is productivity & market drivers. Indeed, Durdyev and Ismail (2019) also believe that the use of OSC leads to improvements in project productivity. This research also found other significant factors for the adoption of OSC in Iraq, which are labour, and social related drivers. Indeed, increasing labour productivity and improved safety are also drivers found by Al-Mutairi (2015) and Fenner, Zoloedova, et al. (2017).

However, environmental drivers seem to be moderate significant in the adoption of OSC in Iraq. Although Abbood et al. (2015) found that the saving energy performance of OSC buildings in Iraq is better to compared to traditional construction, however, there is a lack of knowledge about this method of construction in Iraq. Moreover, the qualitative results emphasised on the drivers related to this factor. Indeed, Mohsin and Ellk (2018) found that there are some barriers to the adoption of environmentally friendly construction materials in Iraq, due to: a lack of awareness gained from dealing with such materials; a lack of adequate data on the potential environmental impacts of the building materials used through their life cycle, and the difficulty to secure the acceptance from society for the use of new instead of traditional materials. Consequently, the moderately significant results for the environmental drivers' factor does not diminish its importance, but it indicates a lack of awareness or lack of interest in environmental aspects by some stakeholders. Therefore, the environmental drivers' factor will not be excluded from this study as the use of OSC can contribute to reducing CO_2 emissions, which in turns reduces global warming and improve energy efficiency. Indeed, leverage environmental aspects is one of the important objectives of the emerge of modern methods of construction

Nevertheless, according to quantitative results the policy related drivers shows a moderate significant relationship with other drivers; however, the qualitative results emphasised the importance of this factor in driving the adoption of OSC in Iraq. This was ascertained by the government's role in enhancing its use, by issuing legislation, providing Iraqi codes and establishing standards and financial support. This is supported by the Iraqi Ministry of Planning (2018) who established a national development plan for 2018-2022 that aims to address the problems that Iraq suffers in different sectors, including housing deficiencies and slums. The focus is on establishing legislation to accelerate the production of housing by using modern methods of construction and providing direct support to private investment companies in the field of private housing.

6.2 Barriers for using OSC in Iraq

This section will discuss the questionnaire and interview results regarding the barriers affecting the use of OSC in Iraq. See figure below

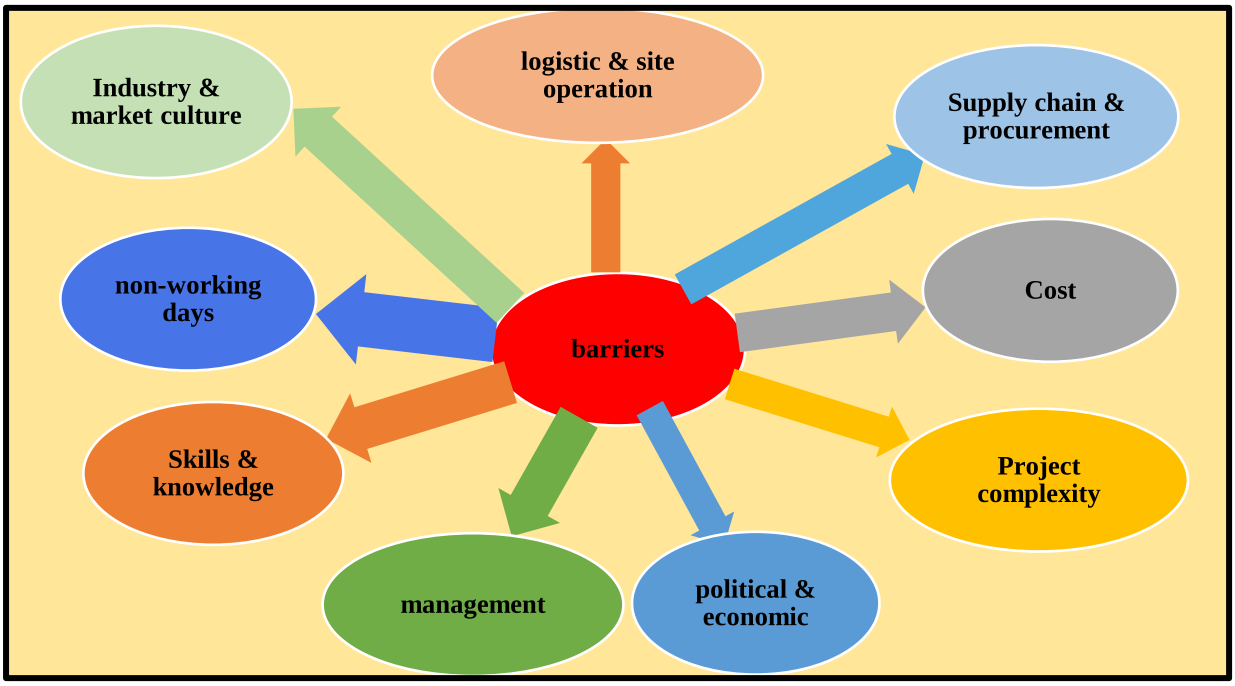


Figure 6-15: Barriers for Using OSC in Iraq

6.2.1 Logistics and site operation barriers

The logistics and site operation factor consist of the following related barriers:

- Restricted site layout, space, size, access, storage and site location,
- Unsafe sites controlled by external parties
- Difficulties in transporting materials and components from factory to the site.

According to the questionnaire, similar results were found between the USECB (52%) and construction companies (CC) (50%) for the following related barriers: restricted site layout, space size, access, storage and site location. However, the results for 'unsafe sites controlled by external parties' were noted as follows: USECB (46%) and CC (44%), whilst, the results for 'transportation issues' were noted as 54% (CC) and 48% (USECB) (sections 4.6.4 and 4.7.4). Moreover, the Kruskal-Wallis test shows that there is no difference between the construction companies and USECB groups regarding logistics & site operations related barriers hindering the use of OSC in Iraq. Interviewees emphasised that unsafe sites controlled by external parties lead to either increased costs or can halt a project. Moreover, Haitham and Shibani (2016) found that war and military operations and terrorist attacks were the most significant risk factors to threaten construction projects in Iraq. Some interviewees revealed that unsafe situations can affect any construction, although, others believed they have a greater impact on OSC (section 5.2.1). Interviewees also illustrated that the site layout can be a barrier when using OSC, such as narrow sites or a lack of space, as this can create difficulties for access. (Hwang et al., 2018; Elnaas, 2014; Rahman, 2013; Shahzad, 2011); Blismas and Wakefield (2007) found that logistics and site operations related barriers hindering the use of OSC.

Interviewees added that transportation issues represent a barrier to OSC in Iraq as they can delay the receipt of materials or products. These can occur due to poor and old road networks, many governments checkpoints, new laws for lorries entering cities, and congestion. Interviewees recommended improving the road network in Iraq and the careful management of transportation logistic issues (section 5.2.1). Moreover, Bendi (2017) reported that a lack of transportation infrastructure is one of the barriers to using OSC in India, whilst Hairstans et al. (2014) recommended the use of 'just in time' methods to overcome the barriers associated with logistics and site operations, including transportation, to guarantee and monitor the agreed delivery time and process. The logistic & site operation factor has a relationship with other factors and will explain in the next sections.

6.2.1.1 Logistics and Site operations - political & economic related barriers relationship

According to results for the chi-square test for independence, logistics and site operations related barriers have a significant relationship with political & economic related barriers for both groups (sections 4.8.2.3 and 4.8.2.4). Moreover, the correlation ranking order revealed a highly significant relationship (rho=0.640) for construction companies, and a significant relationship (rho= 0.403) for the USECB group (section 4.8.3.3&4.8.3.4). The interviewees pinpointed that the high-risk security situation in Iraq substantially impacts OSC; for example, the site will be unsafe when the security is poor and the government is unable to control the militias (section 5.2.1). Mohammed (2018) reported that the instability of a project region and disputes over land ownership are also risk factors that confront construction projects in Iraq; these can arise due to the existing weak security situation following the extinction of the regime in 2003 when Iraq became a base for many terror organizations.

6.2.1.2 Logistics and site operations - industry & market culture related barriers relationship

The chi-square test for independence found another significant relationship between logistic & site operation and industry & market culture related barriers factors (sections 4.8.2.3 and 4.8.2.4). The spearman rho shows a highly significant relationship between these factors for the construction companies (rho= 0.531), while low significant relationship was found for the USECB group (rho= - 0.056) (section 4.8.3.3&4.8.3.4). Furthermore, the interviewees' views were interpreted as a highly significant relationship, as they believed that some contractors have no desire to implement such construction in the unsafe conditions that Iraq cities currently face (section 5.2.1).

Furthermore, in the construction industry in Iraq, Haitham and Shibani (2016) stated that contractors are concerned that their projects might be destroyed. This is particularly significant, as Iraqis' insurance companies do not cover all damage and the compensation claims against the government of Iraq can take a long time to settle, which means further costs for the contractors.

Another point highlighted by the interviewees is the high number security checkpoints, which increases the possibility of the delayed transportation of materials (see section 5.2.1).

6.2.1.3 Logistics and site operation - management related barriers relationship

The chi-square test indicated a significant relationship between the logistic & site operation and management related barriers for both groups (sections 4.8.2.3 and 4.8.2.4). The spearman rho test indicates a low-significant relationship for construction companies (rho= -0.242), while a significant relationship was noted for the USECB (rho = 0.322) (section 4.8.3.3&4.8.3.4). Haitham and Shibani (2016) and Mohammed (2018) emphasised the importance of risk management to evaluate the risks associated with construction sites that are difficult to reach, unsecure and located in unstable project regions. This can help to avoid the effect of such risks on the cost and completion time of the project. Furthermore, literature has also highlighted the importance of risk assessment and management to protect projects and buildings, and reduce injuries and fatalities in the event of terrorism (Hatem & Al-Tmeemy, 2015)

6.2.1.4 Logistic and site operation - cost related barriers relationship

According to the chi-square test, logistics and site operations related barriers have a significant relationship with cost related barriers (sections 4.8.2.3 and 4.8.2.4). Furthermore, the spearman results show a low relationship amongst construction companies (rho= -0.256), while a low significant relationship was found between these factors for the USECB (rho=0.098) (section 4.8.3.3&4.8.3.4). However, the interviewees believed that unsafe sites would mean increasing costs for construction projects. This would be due to the high delivery costs of materials and equipment to the job site influenced by the threats of terrorist attacks (Hatem & Al-Tmeemy, 2015)

6.2.1.5 Logistic and site operation - project complexity related barriers relationship

The chi-square for independence revealed a significant relationship between (logistics & site operations, and project complexity) related barriers (sections 4.8.2.3 and 4.8.2.4). Furthermore, a spearman rho test indicated a significant relationship amongst construction companies (rho=0.437), while a low significant relationship was indicated by the USECB group (rho= 0.168) (section 4.8.3.3&4.8.3.4). Furthermore, interviewees believe that simplifying the design eases the implementation and erection onsite (section 5.2.2 and section 5.3.8).

6.2.1.6 Logistic and site operation - skills & knowledge related barriers relationship

The chi-square test for independence revealed a significant relationship between (logistic & site operation, and skills & knowledge) related barriers (sections 4.8.2.3 and 4.8.2.4). Furthermore, the spearman rho test indicated a significant relationship amongst construction companies (rho=0.374), while a low significant relationship was indicated by the USECB group (at rho= -0.112) (section 4.8.3.3&4.8.3.4). Indeed, OSC requires onsite knowledge and skills for installation components, as a lack could lead to the inaccurate assembly of components, delays and increased project costs (Brennan, Vokes, & Tanner, 2017). Interviewees also agreed that OSC requires skilled labour for the implementation of onsite activities (section 5.2.3 and 5.1.5). Nevertheless, skilled labour may often refuse to work in unsafe sites in Iraq that are liable to terrorist attacks (Hatem & Al-Tmeemy, 2015).

6.2.1.7 Logistic and site operation - supply chain & procurement related barriers relationship

The chi-square test for independence revealed a significant relationship between (logistic & site operation and supply chain & procurement) related barriers for both groups (sections 4.8.2.3 and 4.8.2.4). Furthermore, a spearman rho test indicated a significant relationship for the construction companies' group (rho=0.489), while a low significant relationship was indicated for the USECB group (rho=0.198) (section 4.8.3.3&4.8.3.4). The interviewees emphasised that unsafe sites and site layouts can affect OSC because of the difficulties faced in transportation, especially when importing materials or bringing in expertise from different countries (section 5.2.1). Moreover, interviewees stated that the current, insufficient road network in Iraq leads to transportationn delays for materials and can cause damage to materials. Thus, in posing many limitations, including the size and weight of components, and route selection, transportation logistics play a vital role when using OSC (Shahzad, 2011).

6.2.1.8 Schematic representation of the Logistic and Site operation related barriers relationship with other related barriers.

This section explains the interaction of the (logistic & site operation) related barriers with (political & economic, industry & market culture, management, cost, project complexity, skills & knowledge and supply chain & procurement) related barriers. These relationships are illustrated in Figure 6-16. The relationship between (logistic & site operation and political & economic) related barriers is found to be significant. In fact, a poor security situation and too many checkpoints result in unsafe sites and delayed transportation. Moreover, the figure illustrates a significant relationship between logistics & site operation and industry & market culture related barriers. Indeed, less secured sites result in less desirable work. Meanwhile, the relationship between the (logistics & site operation and management) related barriers was found to be moderate significant. In other words, a poor management system leads to an unsafe site.

Furthermore, the relationship between (logistics & site operation and cost) related barriers are moderate significant. If the project construction is implemented on an unsafe site, this will increase the overall cost of the project, as more money is needed to overcome unforeseen situations, such as the increased number of security check points.

The figure also reflects the moderate relationship between the (logistic & site operation and project complexity) related barriers. Indeed, a complex design enables a hard implementation onsite. The other relationship is found between the related barriers of (logistics & site operation with skills & knowledge); however, this is moderate significant, as shown in Figure 6-16 . Whilst a lack of skills leads to a poor project construction performance, unsafe sites can result in skilled labour refusing to work in such locations.

Ultimately, the figure illustrates the relationship between the (supply chain & procurement and logistic & site operation) related barriers. This relationship is moderate significant. It is important to note that an insufficient road network will delay the transportation of resources. These relationships are reported in detail from sections (6.2.1.1-----6.2.1.7).

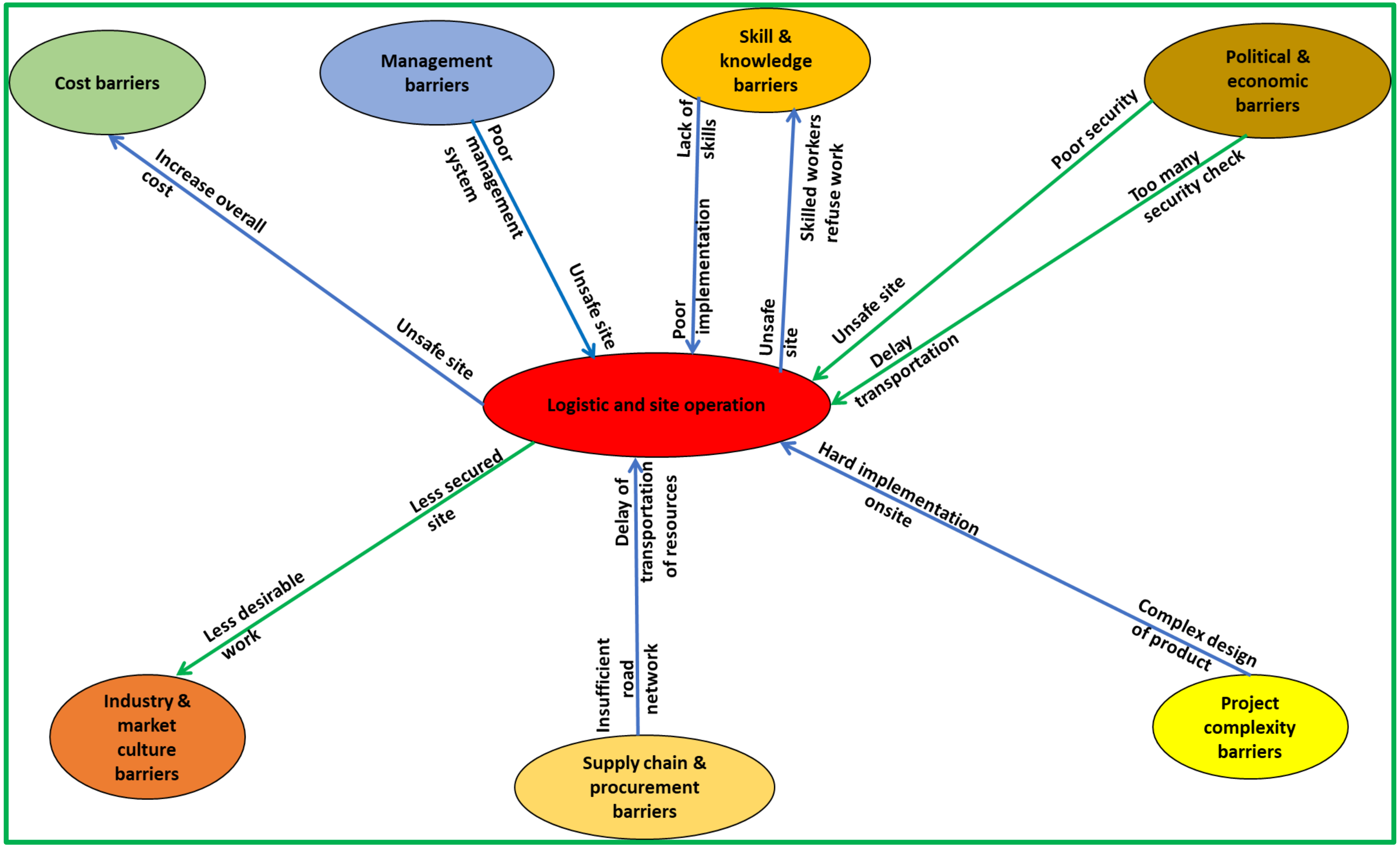


Figure 6-16: Schematic diagram of Logistic & Site operation barrier relationships with other barriers

6.2.2 Cost barriers

The related barriers of the cost are:

- Higher transportation costs where long distances are required.
- OSC is often considered more expensive compared to traditional methods
- Higher initial cost.

The results of the descriptive analysis found that both groups (construction companies and USECB) agreed that higher transportation costs due to long distances represented a barrier, (at 72% and 70% respectively) (sections 4.6.4 and 4.7.4). In addition, fewer participants agreed with the barrier that 'OSC is often considered more expensive compared to traditional methods', at 26% (USECB) and 28% (CC). The third barrier (higher initial costs) was been agreed by 46% (USECB) and 38% (CC) of participants.

Moreover, the Kruskal -Wallis test revealed differences between construction companies and academic consultants regarding cost related barriers factor (section 4.8.4.2). Most interviewees believed that the cost of OSC reduced with mass production, and that a single production is expensive (section 5.2.3). Some interviewees claimed that using OSC can cause cost reduction up to 30% more than for classic construction, while other interviewees stated that such reductions can reach 50%. One of the interviewees justified that: the symmetry of production and moving the moulds from place to place leads to improved productivity and reduced time. The literature aligns with the interviews results; for example, Xue et al. (2018) found that the mass production of building components can effectively reduce construction costs.

This resonates with the findings of Faghirinejadfard et al. (2015) who stated that OSC was not economically feasible for low investment companies; however, investments of more than 100 units are more economical than the classic method of construction.

Similarly, transportation can also increase costs when using OSC. Most interviewees believe that there is an extra cost when materials need to be transported over long distances. However, it is usual to ensure the site is located near to a factory when a big project is involved. Interviewees emphasised the importance of existing factories within a reasonable distance from the site to avoid the extra cost for transportation and to avoid damage (section 5.2.3). Similarly, Xue et al. (2018) found that economic outcomes and reasonableness should be considered when determining the location of OSC factories, as the transport radius (Rt) and transport efficiency (Et) affects the cost of transportation (Ct) of OSC products. Sutrisna et al. (2019) found that the choice of transportation can impact the cost of the project, including the capacity to deliver materials, the regulation of loads on highways, and site access. Thus, sites that are more difficult to access mean more costs are required. As such, the initial or capital cost can be high due to transportation from the factory to the site (Xue, Zhang, Su, & Wu, 2017; Faghirinejadfard et al., 2015; Blismas & Wakefield, 2008).

6.2.2.1 Cost -- skills & knowledge barriers relationship

The chi-square test for independence shows a significant relationship between (cost and skills & knowledge) related barriers (sections 4.8.2.3 and 4.8.2.4). The spearman ranking test revealed a significant relationship between (skills & knowledge and cost) related barriers for the USECB group(rho=0.450), while a low significant relationship was indicated for the construction companies group (rho=0.271) (section 4.8.3.3&4.8.3.4). Interviewees found that OSC requires skilled labour for installation and this can incur an extra cost when training is also required (section 5.2.7). This aligns with the findings of Zhai, Reed, and Mills (2014) and Chiang, Chan, and Lok (2006), who declared that the cost of OSC can be increase as a result of training requirement to ensure the provision of skilled labour both in the factory and onsite for assembly and jointing.

6.2.2.2 Cost ---project complexity barriers relationship

Following the chi-square test, a significant relationship was found between (cost and project complexity) related barriers (sections 4.8.2.3 and 4.8.2.4). Furthermore, the correlation non-parametric test revealed a significant relationship between (cost and project complexity) related barriers for the USECB group, rho=0.456, while a low significant relationship was recorded for the construction companies group, rho=0.20 (section 4.8.3.3 and 4.8.3.4). The interviewees believed that changes to the design impacts on the cost; also, it is, ‘difficult to make changes onsite and if it happens, it will be costly’ pinpointed by E1 (section 5.2.2). Chiang et al. (2006) found that design alterations result in unreasonable time and cost for OSC manufacturers and contractors, whilst Xue et al. (2017) similarly found that design group factors affect cost.

6.2.2.3 Cost--- political & economic barriers relationship

The chi-square test for independence indicated a significant relationship between (cost, and political and economic) related barriers (sections 4.8.2.3 and 4.8.2.4). According to correlation results, the cost barriers factor has a significant relationship with the political & economic barriers factor for the USECB, rho=0.394 and a low significant relationship for the construction companies group, rho=-0.146 (section 4.8.3.3&4.8.3.4). Moreover, the interviewees explained that stakeholders will not risk adopting OSC in an unstable security and financial situation in case it goes unfunded or they lose money (section 5.2.5). Haitham and Shibani (2016); Hatem and Al-Tmeemy (2015) confirm that the unstable security situation in Iraq resulting from war and terrorism have impacted the cost of construction projects, as contractors may be unable to secure funding or ensure a return on their money in the event of destruction. Due to Iraq's political and security conditions, studies have concluded that projects have been delayed and the actual cost of projects have been far greater than their value (Bekr, 2017).

6.2.2.4 Cost -- supply chain barriers relationship

According to the questionnaire results, the chi-square for independence test demonstrated a significant relationship between the (cost and supply chain) related barriers factors for both groups (USECB and CC) (sections 4.8.2.3 and 4.8.2.4). Moreover, the correlation test indicates a low significant relationship between these factors for construction companies (rho = -0.064), while a low positive relationship is found for the USECB group (rho = 0.287) (section 4.8.3.3&4.8.3.4). The interview emphasised that delays and long transportation distances lead to increased costs (sections 5.2.3 and 5.2.6).

6.2.2.5 Cost-- management barriers relationship

According to the questionnaire results, the chi-square test for independence demonstrated a significant relationship between (cost and management) related barriers for both groups (sections 4.8.2.3 and 4.8.2.4). Moreover, the correlation test indicates a significant relationship for the construction companies (rho= 0.309), while a low significant relationship was found for the USECB group, rho=- 0.165 (sections 4.8.3.3 and 4.8.3.4). The interviewees believed that improper management systems, including delayed decision making and poor communication between stakeholders, leads to deficiencies in dealing with the project and can lead to project failure due to time and cost overruns (section5.2.8). Indeed, Khaleefah and Alzobaee (2016) and Al-Turfi (2017) found that construction projects in Iraq suffer from poor performances due to poor management systems, which impact cost, time and quality.

6.2.2.6 Schematic representation of the Cost barrier relationships

Figure 6-17 illustrates the interactions between the cost related barriers and (skills & knowledge, project complexity, political & economic, management and supply chain & procurement) related barriers. These relationships were determined from the questionnaire and interview results in Chapters 4 and 5. A moderate significant effect is reflected in the relationship between the (cost and skills & knowledge) related barriers. In fact, the need for skilled labour for OSC means an increase in the overall cost of the project, particularly for small-scale works.

Moreover, another moderate significant effect is found between the (cost and project complexity) related barriers. Obviously, the change in design will lead to increased project costs. Furthermore, (the political & economic and cost) related barriers relationship also demonstrates a moderate significant effect. Indeed, an unstable security and financial situation will increase the cost of a project. Ultimately, the moderate significant relationship was found between the (cost and management) related barriers, although a poor management system will cause cost overruns. Finally, the (supply chain & procurement and cost) related barriers have a moderate significant relationship, as long-distance transportation and delays of materials mean an increase in cost. The results of the relationships are reported in sections (6.2.2.1---6.2.2.5).

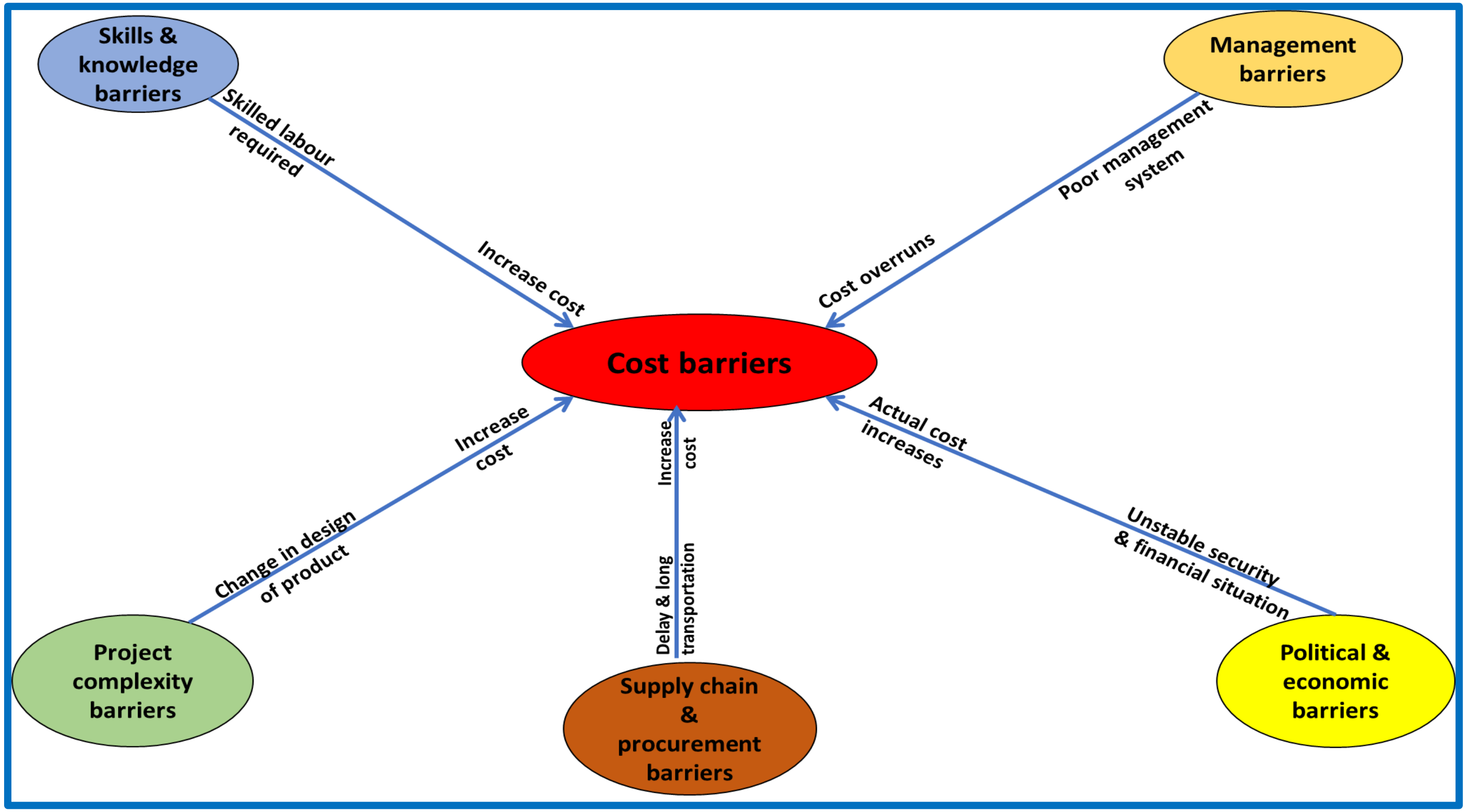


Figure 6-17: Schematic diagram of Cost barriers relationships with other barriers

6.2.3 Project complexity barriers

This factor contains three related barriers examined in this study, namely:

- Complex and limited design options,
- An inability to make changes in the field by using OSC
- Building regulation/legal framework requirements.

The descriptive analysis showed that lower agreement on the building regulation barrier was found for (USECB)at 28% than 54% (CC). Meanwhile, the inability to make changes was agreed by more USECB participants (66) than CC participants (50). However, complex and limited design received similar agreement between both groups, at 34% (USECB) and 30% (CC) (section 4.6.3& 4.7.4). Moreover, the Kruskal-Wallis test revealed differences between construction companies and USECB groups concerning the impact of the project complexity related barriers hindering the use of OSC (section 4.8.4.2).

Most of the interviewees agreed that the design process is not complicated when using OSC. Some agreed that design options might be limited but standardised and typical, and recognised that it is difficult to make changes in the field (section 5.2.2). Indeed, researchers have found that inflexibility to late design changes is the most important barrier to the adoption OSC (Zhang et al., 2018; Rahman, 2013) whilst this study found that there are limited design options when using OSC, as well as the inability to make changes in the field by using OSC (Al-Mutairi, 2015).

Interviewees illustrated the need for revisions to building regulations as a key consideration. One of the interviewees identified commitment as an important obstacle in construction projects, and emphasised on the role of legal considerations in the case of any breaks in contract commitment; this aligns with the recommendations of Khaleefah and Alzobaee (2016). Indeed, the successful implementation of OSC requires an earlier commitment to the supply chain (Fraser, Race, Kelly, & Winstanley, 2015).

Finally, the lack of regulation and guidelines are also indicated in the literature review as a barrier to the uptake of OSC (Jiang et al., 2018; Bendi, 2017; Arif et al., 2012).

6.2.3.1 Project complexity -- supply chain barriers relationship

The chi-square test for independence indicated a significant relationship between (the project complexity and supply chain & procurement) related barriers for both groups (sections 4.8.2.3 and 4.8.2.4). Furthermore, the ranking order test showed a highly significant relationship between the project process and supply chain & procurement for both construction companies and the USECB, at rho=0.509 (CC) and rho= 0.608 (USECB) (sections 4.8.3.3 and 4.8.3.4). The interviewees indicated that Iraq is unable to provide variety in its OSC products; therefore, in some cases contractors import from another country. This means that interference can occur in the regulations and specifications between the import and export countries, which can mean long lead times (section 5.2.6). For example, Mirus et al. (2018a) demonstrated that the location of New Zealand and its heavy reliance on material exports has resulted in extensive lead times. On the other hand, the improper policies lead to cause poor manufacturing capability (Gan, Chang, Zuo, et al., 2018). According to interviewees there is a lack of policies that enhance the use of OSC which lead to poor manufacturing capacity (section 5.2.6).

6.2.3.2 Project complexity-- political & economic barriers relationship

There is a significant relationship between (project complexity and political & economic) related barriers according to the chi-square test for independence for both groups (sections 4.8.2.3 and 4.8.2.4). Also, the spearman test revealed a significant relationship (rho=0.386) for the USECB group and a significant relationship (rho= 0.455) for construction companies (section 4.8.3.3&4.8.3.4). In fact, Bekr (2017) pinpointed that contractors in Iraq are associated with different parties and politicians, and receive different amounts of money as bribery; meanwhile, the project may become inactive or poor implementation specifications may be used in order to increase the potential profit. This was also confirmed by the interviewees, who stated that financial mismanagement in Iraq leads to poor project performances (section 5.2.2).

6.2.3.3 Project complexity--- skills & knowledge barriers relationship

The chi-square test results confirm a significant relationship between (project complexity and skills & knowledge) related barriers factors for both groups (sections 4.8.2.3 and 4.8.2.4). Also, the spearman test revealed a highly significant relationship between these mentioned factors for the USECB group (rho=0.677), while a low significant relationship was recorded for the CC (rho= 0.244) (section 4.8.3.3&4.8.3.4).

Moreover, Gan, Chang, Zuo, et al. (2018) noted that issuing policies to address the barrier associated with a lack of knowledge and expertise could resolve poor manufacturing capabilities, and ineffective logistics. The interviewees also supported these findings by confirming that OSC needs skilled and expert engineers to ensure appropriate design and implementation both in the manufacturing phase and onsite (section 5.2.7).

6.2.3.4 Project complexity --- industry& market culture barriers relationship

A chi-square for independence indicated a significant relationship between these barriers' factors for both groups (sections 4.8.2.3 and 4.8.2.4). A low significant relationship was found for the USECB group concerning (project complexity and industry & market culture) related barriers, rho= 0.227, while a significant relationship was found amongst construction companies, rho= 0.351 (section 4.8.3.3&4.8.3.4). The lack of knowledge and suitable regulations to support the use of OSC can lead to cultural resistance amongst clients and contractors. Also, the interviewees illustrated that the difficulties in obtaining formal approval for the use of OSC leads to long lead times for construction projects (section 5.2.4).

6.2.3.5 Schematic representation of the Project complexity barriers relationships with other barriers

The relationships between project complexity barriers and (skills & knowledge, supply chain & procurement, industry & market culture and political & economic issues) barriers are discussed in this section, and figure 6-18 illustrates these relationships. The relationship between (project complexity and skills & knowledge) related barriers was found to be significant. Indeed, a lack of knowledge and skills leads to a poor project performance. The relationship between (project complexity and supply chain & procurement) related barriers is highly significant, as the inability to provide varieties of OSC products result in a long lead-time. Alternatively, a lack of policies that enhance the use of OSC which lead to poor manufacturing capacity. However, the relationship between (project complexity and industry & market culture) related barriers was moderate significant. This relationship is explained by the lack of regulation, which can cause cultural resistance amongst clients and contractors. On the other hand, difficulties in obtaining formal approval for this type of construction will lead to long lead-times. Ultimately, the relationship between the (project complexity and political & economic) related barriers indicates a significant effect. Indeed, political and economic mismanagement can result in a poor project performance. These relationships can be found in sections (6.2.3.1---6.2.3.4).

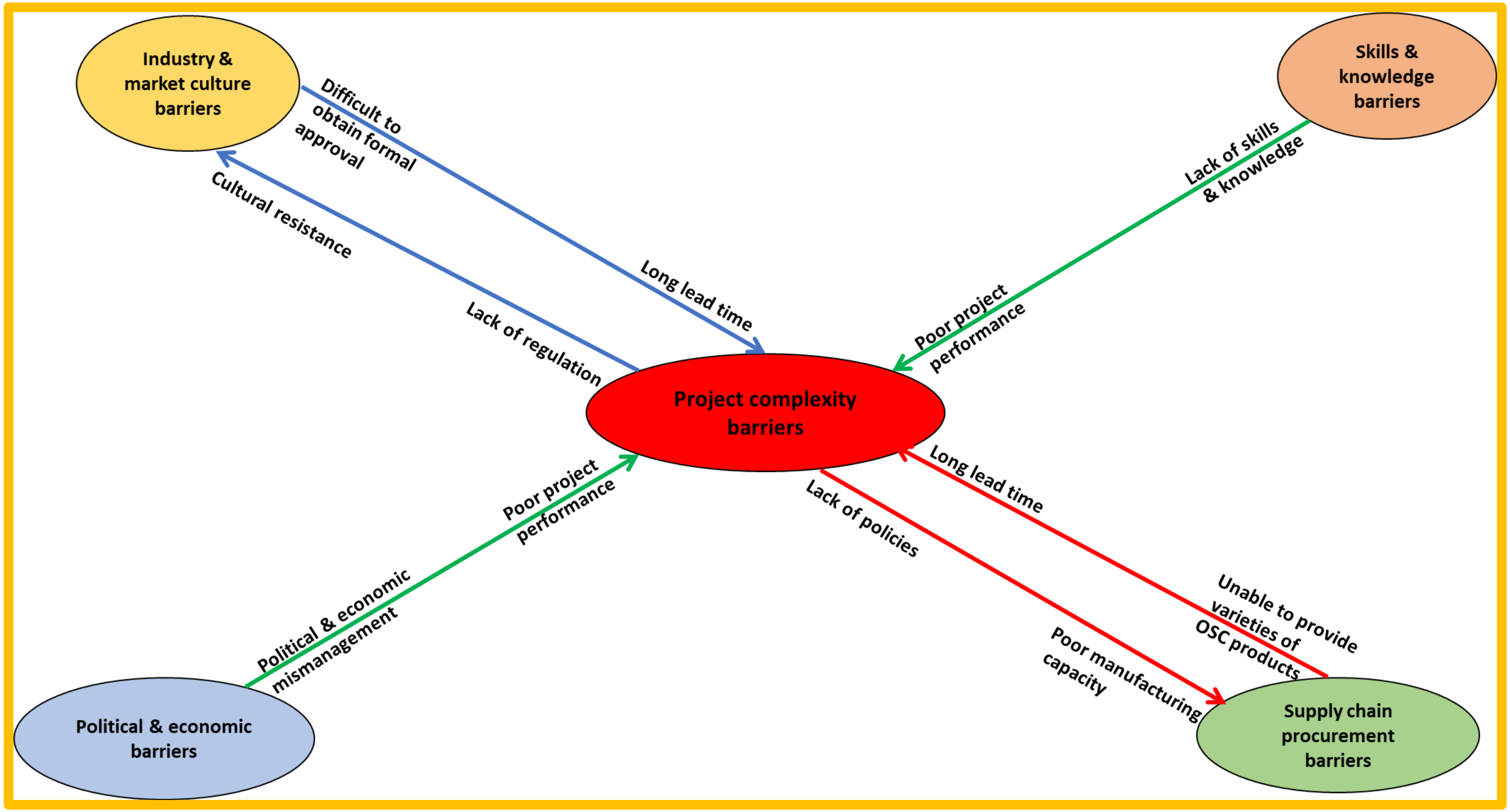


Figure 6-18: Schematic diagram of Project complexity barrier with other barriers

6.2.4 Political and Economic barriers

According to the descriptive questionnaire results, the related barriers of this factor are

- An unstable security situation,
- Fluctuations in financial status
- Unstable current market conditions

These barriers were agreed by more than 50% of both groups (USECB &CC) (sections 4.6.4 and 4.7.4). However, the Kruskal-Wallis test shows differences between these groups concerning these related barriers for political & economic factor (section 4.8.4.2). Construction projects in Iraq suffer from the unstable political and economic circumstances that arose following the war in 2003; these situations are ongoing, affecting the performances of construction projects (Bekr, 2017; Hatem & Al-Tmeemy, 2015). Indeed, the interviewees agreed that these related barriers factor has a great effect on the use of OSC in Iraq, while some believed that it could affect any type of construction. Also, some interviewees illustrated that the existence of financial and administrative mismanagement in Iraq affects construction projects through the referral of projects to unreliable companies (section 5.2.5). Similarly, Al-Turfi (2017); Bekr (2017) found that political changes and financial and administrative corruption negatively affect construction projects in Iraq. Moreover, the most significant political and economic issues affecting the performance of construction projects, that include cost, time, quality and safety, have also been pinpointed by a number of researchers (Hasan & Mohammed, 2018; Mohammed, 2018).

6.2.4.1 Political & economic -- skills & knowledge barriers relationship

According to chi-square test results, there is a significant relationship between (political & economic, and skills & knowledge) related barriers for both the USECB and CC (sections 4.8.2.3 and 4.8.2.4). Moreover, the spearman test revealed a low significant relationship between these factors for the USECB, rho= 0.255, while a highly significant relationship was found amongst construction companies, rho= 0.547 (sections 4.8.3.3 and 4.8.3.4). One of the interviewees illustrated an important point that most Iraqi skilled labour died during the wars and those who survived with the relevant labour skills have now retired. Moreover, a shortage of projects emerged as a result of the embargo after 1991 that stopped the transferral of knowledge to a new generation, and further explains the shortage of skilled construction labour (section 5.2.7). This aligns with the findings of Alkinani (2013) who stated that skilled labour in Iraq has been badly affected by the wars and embargo. Another interviewee stated that, if sufficient skilled labour was available, the use of OSC would increase, and this in turn would become an economic factor, as OSC would be more competitive with classic construction. Moreover, Mohamad Kamar (2011) identified the importance of skills, training and knowledge to ensure the successful implementation of OSC.

6.2.4.2 Political & economic-- industry & market culture barriers relationship

According to the chi-square for independence test, there is a relationship between the (political & economic and the industry & market culture) related barriers for both the USECB and CC (sections 4.8.2.3 and 4.8.2.4). The spearman test also shows a low significant relationship for the USECB group, rho=0.076, while a highly significant relationship was found for the construction companies, rho=0.559 (section 4.8.3.3 and 4.8.3.4). The phenomenon of financial and administrative corruption in Iraq increases the negative image of OSC because such projects are frequently contracted to unreliable construction companies that produce poor quality work. This reflects the findings of Bekr (2017); Khaleefah and Alzobaee (2016) who similarly noted the corruption within contracting in Iraq that leads to unreliable construction companies taking on active projects, or deficiencies in implementation.

6.2.4.3 Political & economic -- supply chain & procurement relationship

The result from the chi-square test for independence shows that there is a relationship between the political & economic factor, and supply chain & procurement for both the USECB and CC (section 4.8.2.3 and 4.8.2.4). The ranking order test also shows a highly significant relationship between these factors for the USECB group, rho= 0.601, while a significant relationship is determined for the CC group, rho=0.477 (section 4.8.3.3 and 4.8.3.4). Interviewees illustrated that there is no capacity in the Iraqi industry to produce different types of OSC products; therefore, the companies sometimes import from different countries and hence, materials are involved in a number of long security inspection checks. The interviewees also noted that contractors will not take the adventure of building a factory of OSC when there is unstable situation in Iraq when there is no demand as the cost of the factory is expensive or may import from outside the country as well when there is no demand. Furthermore, Mohammed (2018) reported that, the monopoly of materials is resulted because of the unexpected political factors and the late delivery of material mysteriously are risk factors face the construction industry in Iraq.

6.2.4.4 Political & economic-- management barriers

The result from the chi-square test for independence shows that there is a relationship between the political & economic factor, and management for both the USECB and CC (section 4.8.2.3 and 4.8.2.4). Although, the correlation test shows low significant relationships between these barriers for both groups in which (rho= -0.298) (CC) against rho= 0.164 (USECB). However, the interviewees emphasised that the mismanagement in political and economic aspects in Iraq reflects negatively on construction projects because it may lead to choose inefficient or bad leadership to manage the project who in turns effect badly on project performance. This is also in line with Al-Turfi (2017) findings.

6.2.4.5 Schematic representation of the Political & Economic barriers relationships

This section illustrates the interaction of the political & economic barrier with skills & knowledge, supply chain & procurement, and industry & market culture. These relationships are illustrated in Figure 6-19 and considered significant. Indeed, the wars and embargo have led to a skills shortage in Iraq, whilst political and economic mismanagement will lead to a poorer image of OSC in Iraq. Moreover, the relationship between the political & economic and supply chain & procurement barriers was found to be significant. An unstable policy due to political and economic issues will result in a disturbance to the supply chain and procurement. These relationships are discussed in sections 6.2.4.1---6.2.4.3. The other relationship is found between political & economic factor and management factor which considerate as a moderate significant. This relationship is justified as mismanagement of both political & economic lead to choose bad leadership to manage the project which cause negative results on project performance (section 6.2.4.4)

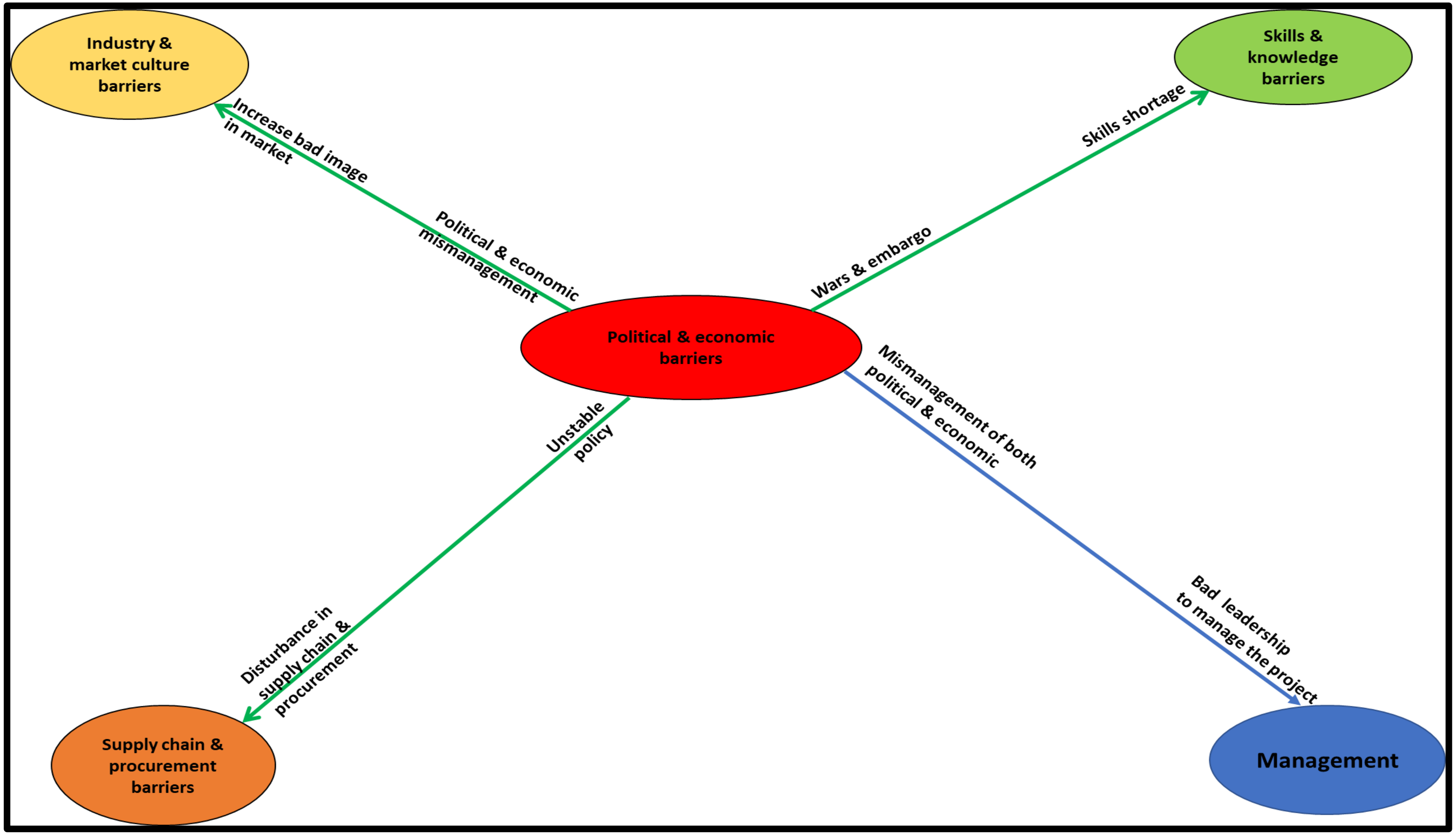


Figure 6-19: Schematic diagram of Political & Economic barriers with other barriers

6.2.5 Industry & Market culture barriers

Industry and market culture related barriers were found to be a significant in hindering the use of OSC in Iraq. The related barriers within this factor are:

- Clients desire traditional and custom-made construction,
- The negative image from past attempts to apply OSC may limit acceptance, and
- Difficulty in obtaining formal approval.

Both groups (CC and USCEB) strongly agreed within the descriptive analysis (sections 4.6.4 and 4.7.4), and the results of the Kruskal-Wallis test indicated no differences between the construction companies and USECB groups regarding this factor (sections 4.8.4.1).

Indeed, stakeholders still hold many negative perceptions of the applicability of OSC despite the range of advantages offered by this construction method (Izatul, Ismail, & Aziz, 2018). The interviewees indicated that clients and contractors do not like to use OSC as this type of construction needs specialist people and accurate work, which may explain the contractor's reluctance to change (section 5.2.4). Moreover, negative attitudes and a conservative construction culture are widely illustrated in the literature (Fenner et al., 2018; Gan, Chang, Zuo, et al., 2018; Izatul et al., 2018; Bendi, 2017; Fenner, Zoloedova, et al., 2017). The interviewees similarly explained a number of reasons for people's resistance, including: the expense; assumptions that it is not durable; an inability to change the future of housing, and delays to (or an inability to obtain) formal financial approval. This also aligns with findings from the literature including Krishnanunny and Anoop (2018); Zhang et al. (2018).

Interviewees offered another important point concerning the negative perceptions of OSC; they stated that this comes from negative past experiences of OSC application by unreliable companies in Iraq, which has led to poor quality work and meant that people have lost trust in this type of construction. This aligns with the findings of Al-Turfi (2017); Khaleefah and Alzobaee (2016) who confirmed the award of contracts on the basis of the lowest cost tender; this is in turns leads to contracts with inefficient companies and negatively affects the performance of the project. However, some interviewees have indicated that people's perspectives in Iraq have started to change positively towards OSC, especially for vertical buildings, as there are now some successful as well as negative applications.

6.2.5.1 Industry & market culture --skills & knowledge barriers relationship

According to the chi-square test for independence, there is a significant relationship between the (industry market culture and skills & knowledge) related barriers factors for both the construction companies and USECB (sections 4.8.2.3 and 4.8.2.4). Moreover, the spearman test revealed a highly significant relationship between these factors for both groups, rho= 0.644(USECB) and rho=0.532 (CC) (sections 4.8.3.3 and 4.8.3.4). The interviewees indicated that people (clients or contractors) generally do not want to use this type of construction and the delays in obtaining formal and financial approval are the result of a lack of knowledge and experience in OSC (section 5.2.4). This accords with the findings of Gan, Chang, Zuo, et al. (2018) who stated that the lack of conducive social climate and wider acceptance is largely determined by limited knowledge and expertise. Moreover, Izatul et al. (2018) recommended the importance of awareness programmes, promotion and education to change people's thinking about OSC and to increase demand.

6.2.5.2 Industry & market culture -- supply chain & procurement barriers relationship

There is a significant relationship between (industry & market culture and supply chain & procurement) related barriers according to the results from the chi-square for independence test for both groups (sections 4.8.2.3 and 4.8.2.4). Moreover, the correlation test revealed a highly significant relationship between these factors for the USECB group, rho=0.511, while a low significant relationship was found amongst construction companies, rho= 0.193 (sections 4.8.3.3 and 4.8.3.4). The interviewees believed that some contractors do not want to use this type of construction as there is not the capacity to provide different types of OSC in Iraq, which means importing materials from outside and this involves many problems, including increased cost and time (section 5.2.6).

This finding reflects those of Gan, Chang, Zuo, et al. (2018) who identified that the lack of knowledge and experience has a direct impact on poor manufacturing capacity, and this affects the lack of conducive social climate and acceptance. Zhang et al. (2018) justified that the lack of experienced suppliers, contractors and designers in the market may cause increasing costs and lower quality prefabricated buildings. Fenner et al. (2018) stated that transporting building modules is a critical and difficult task that influences the demand for OSC.

6.2.5.3 Industry & market culture -- management barriers relationships

The chi-square for independence test revealed a significant relationship between (industry & market culture and management) related barriers (sections 4.8.2.3 and 4.8.2.4). Furthermore, the spearman rho test indicated a highly significant relationship between these factors for construction companies (rho= - 0.514), while a low significant relationship was noted for the USECB group, rho= 0.228 (sections 4.8.3.3 and 4.8.3.4). Moreover, Bekr (2017); Khaleefah and Alzobaee (2016) found corruption in contracting in Iraq that leads to the commissioning of unreliable construction companies, which in turn leads to deficiencies in implementation. The interviewees believed that an improper management system, delays to decision making, poor communication between stakeholders, and deficiencies in dealing with the project by contracting unsuitable companies, which leads to project failures (including time and cost overruns), and increases the negative image of OSC (sections 5.2.4 and 5.2.8).

6.2.5.4 Schematic representation of the Industry & Market culture barriers relationships with other barriers

The results represented in Figure 6-20 indicate the relationships between industry & market culture related barriers with the (skills & knowledge, supply chain & procurement, and management) related barriers. The relationship between the (industry & market culture and skills & knowledge) related barriers is highly significant. In fact, a refusal by contractors and clients to adopt such construction resulted from a lack of knowledge and experience.

However, a significant relationship was found between (industry & market culture and supply chain & procurement) related barriers. The contractors refuse to adopt this type of construction because of the inability to provide different types of OSC products. Another significant relationship was found between the industry & market culture and management related barriers, as management deficiencies result in an increasingly negative image of OSC. These relationships are discussed in sections (6.2.5.1---6.2.5.3).

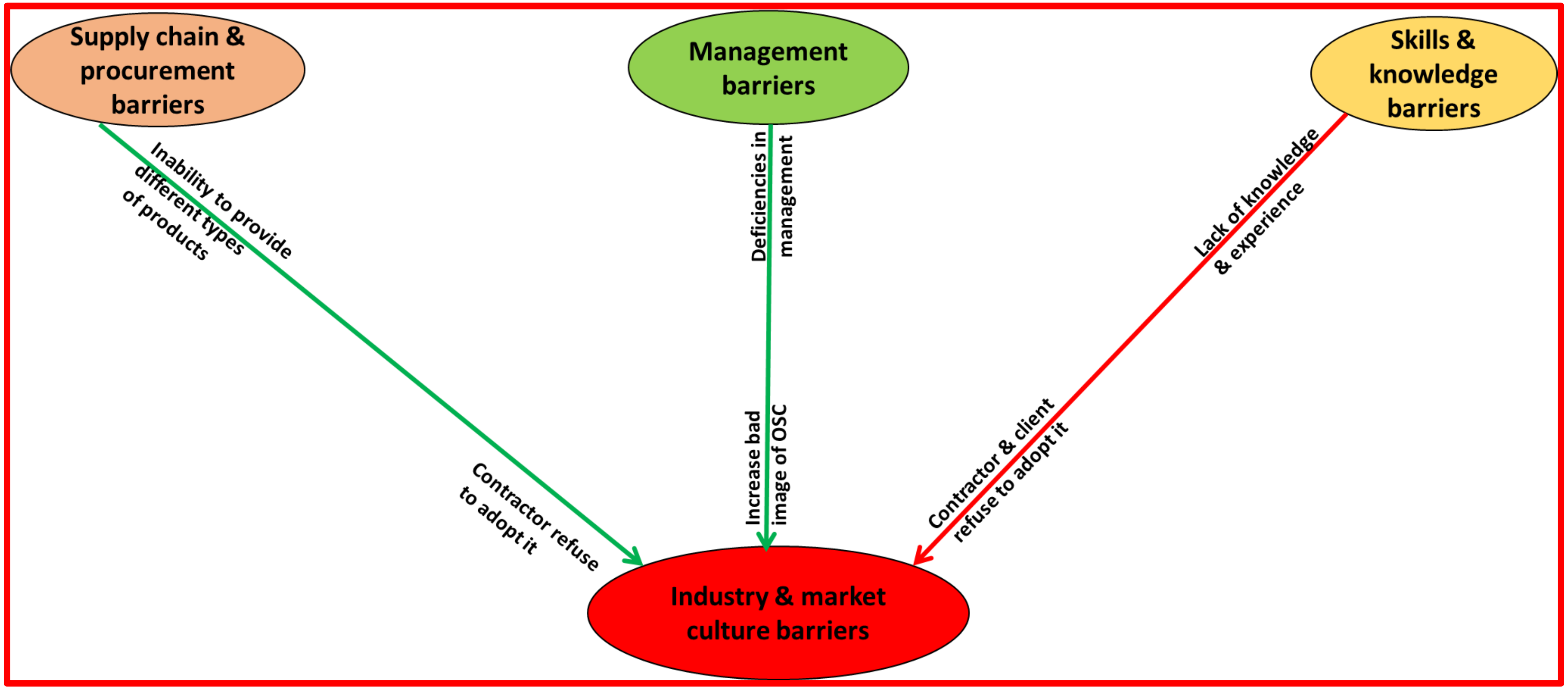


Figure 6-20: Schematic diagram of Industry & Market culture barrier relationship with other barriers

6.2.6 Supply chain & Procurement barriers

The immaturity of the OSC market development conditions was revealed by two key aspects; firstly, the dependence on the government, and secondly, less developed supply chains (Jiang et al., 2018). The descriptive analysis of the questionnaire (sections 4.6.4 and 4.7.4) found that the related barriers are as follows:

- The industry capacity to supply diverse varieties of OSC is limited due to the lack of infrastructure support and limited resources. Although both groups strongly agreed with this barrier, the USECB has the strongest agreement (78%) compared with the CC (56%)
- The use of OSC requires a firm control of the supply chain, which can involve greater risks. Most of the USECB participants agreed with the barrier (78%) whilst only 34% of CC participants agreed.
- More complex payment terms, cash flow processes and financial administration are required when mixed offsite and onsite components. The USECB group indicated 58% agreement with this barrier compared with 44% agreement amongst construction companies.

Moreover, the Kruskal-Wallis test demonstrated a significant difference between both groups regarding the supply chain and procurement related barriers factor (section 4.8.4.2).

With regard to the interview results, Iraq is unable to supply a variety of OSC products and this can represent a barrier to its adoption. It could also lead to imports from other countries and hence the possibility of legislation conflict, increased costs, transportation problems, the need to pay taxes, and delays (section 5.2.6). Fenner et al. (2018); Zhai et al. (2014) found that transportation is also a critical and difficult task that impacts the supply chain and the demand for OSC.

The incapacity of manufacturing to produce OSC is also indicated in the literature, as Rahimian et al. (2017) found that few factories are involved in the manufacture of OSC products, which represents a barrier to the uptake of OSM in Nigeria. There are also shortfalls within the New Zealand supply chain that lead to increased material costs (Mirus et al., 2018b). Moreover, some interviewees indicated that the OSC supply chain steps require firm control through close integration and communication as any mistake can halt or delay the process of a project. This reflects the findings of Zhai et al. (2014) who identified that the concept of integration must apply at all stages of OSC, and within and between organisations involved in the offsite process.

6.2.6.1 Supply chain & procurement -- management barriers relationship

Results from the chi-square test for independence found a significant relationship between the (supply chain and management) related barriers factors for both construction companies and the USECB (sections 4.8.2.3 and 4.8.2.4). Moreover, the spearman rho indicates a significant relationship amongst the USECB group, rho=0.322 and a low significant relationship for the construction companies, rho=0.090 (sections 4.8.3.3 and 4.8.3.4). The interviewees ascertained the importance of effectively managing the supply chain when using OSC to prevent delays or increased cost (sections 5.2.6 and 5.2.8), whilst Zhai et al. (2014) found that, with the increasingly complex levels of construction projects, it is essential to improve the level of supply chain integration from a managerial perspective. Thus, effective communication across the supply chain needs to be recognised to coordinate the process and manage the duration of the project from the beginning to completion (Pan et al., 2008; Blismas & Wakefield, 2007). Moreover, Mohamad Kamar (2011); (Pan et al., 2008) noted that the integration of the supply chain is vital to ensure the successful implementation of OSC by providing partnerships and close relationships with suppliers and sub-contractors from the early stages of the project process.

6.2.6.2 Supply chain & procurement -- skills & knowledge barriers relationship

According to the questionnaire results, the chi-square test for independence revealed a significant relationship between the (skills & knowledge and supply chain & procurement) related barriers factors for both groups (sections 4.8.2.3 and 4.8.2.4). The spearman rho test also indicated a highly significant relationship amongst the USECB group, rho=0.655, while a significant relationship was found for the construction companies, rho=0.320 (sections 4.8.3.3 and 4.8.3.4). Gan, Chang, Zuo, et al. (2018) found that the lack of knowledge and experience has a direct impact on the poor manufacturing capacity. Moreover, Mohamad Kamar (2011) indicated that poor human capital development in OSC affects both contractors and the whole supply chain. The interviewees supported these findings (section 5.2.7).

6.2.6.3 Schematic representation of the Supply chain & Procurement barriers relationships with other barriers.

Figure 6-21 demonstrates a significant relationship between the (supply chain & procurement and skills & knowledge) related barriers. Indeed, the lack of knowledge and experience results in a poor supply chain. On the other hand, improper management system will lead to disturbances in procurement and the supply chain; nevertheless, this relationship is found to be moderate significant. The relationships in this section are explained in detail in sections 6.2.6.1 & 6.2.6.2.

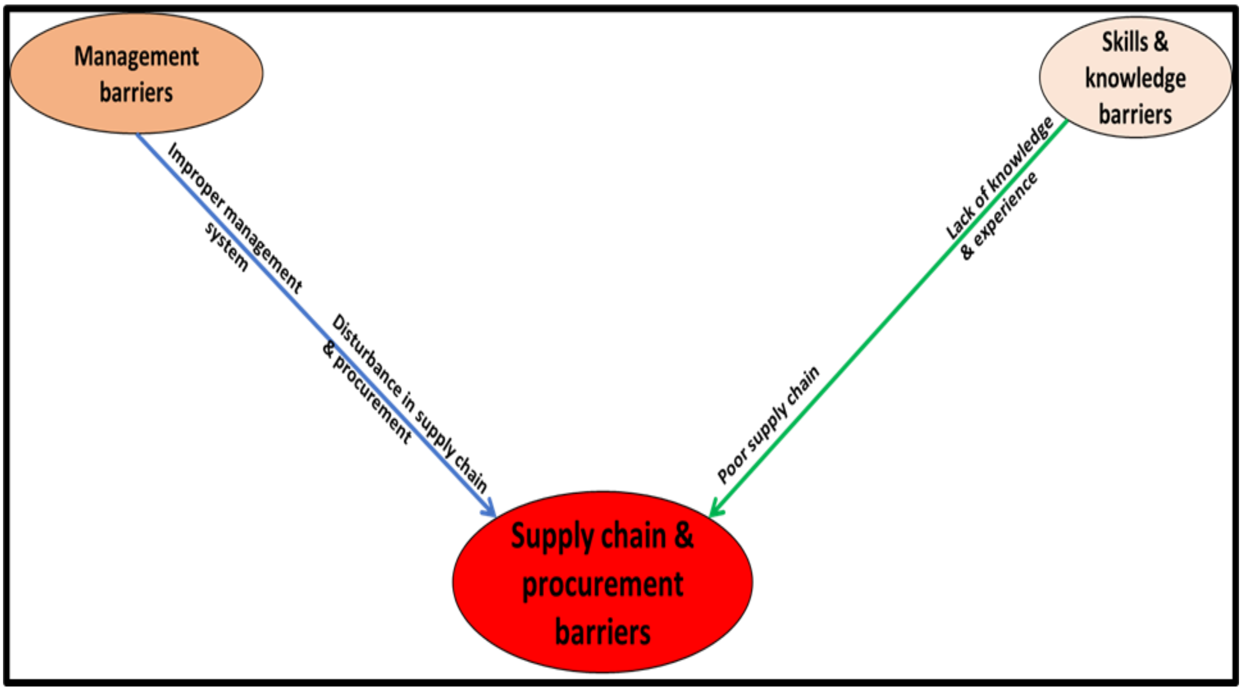


Figure 6-21: Schematic diagram of supply chain & procurement barrier relationship with other barriers

6.2.7 Skills & Knowledge barriers

According to the descriptive questionnaire results, there is an agreement from both groups about the skills & knowledge related barrier for adoption of OSC in Iraq (sections 4.6.4 and 4.7.4). These sub-barriers are: -

- Lack of knowledge and awareness,
- Lack of R&D in OSC and
- Lack of previous experience and skilled workforce.

Also, the Kruskal-Wallis test results indicated no significant differences between the two groups regarding the skills and knowledge related barriers factor (section 4.8.4.2). Interviewees explained that there is a lack of knowledge and awareness of this type of construction in Iraq (section 5.2.7). Also, there is limited research and development on OSC in Iraq in general. The literature similarly illustrated this barrier finding that there are knowledge deficiencies amongst people in Iraq concerning OSC (Abbood et al. (2015); Abod et al. (2011); Mohee (2011).

Indeed, skills are required at all OSC operational levels, from finance to assembly, design to manufacture and operation to decommission (Hairstans et al., 2014; Sashitharan et al., 2014). This was also confirmed by the interviewees (section 5.2.7) who highlighted that Iraq suffers from a lack of skilled labour and expertise in the construction field in general and in OSC specifically. One of the interviewees attributed this to the wars and the embargo that Iraq faced, as well as the demise of many expert people, which halted such construction projects, and arrested the transferral of skills to a new generation. This reflects the findings of Mirus et al. (2018b) who found that the wars lead to the loss of trained, skilled labour. The interviewees suggested overcoming this barrier by training Iraqi workers, while some believed that this barrier would not be difficult to resolve due to the repetitive process of OSC. Moreover, the researchers demonstrated that the shortage of skills and experience represented a barrier to the use of OSC; therefore, education and training were recommended to overcome this barrier (Mirus et al., 2018b; Bendi, 2017; Al-Mutairi, 2015; Elnaas, 2014; Sashitharan et al., 2014). However, some interviewees expressed another opinion, that the use of OSC overcomes the shortage of skilled labour in Iraq as it requires a smaller number of skilled labours onsite. This view also reflects findings within the literature (Alazzaz & Whyte, 2014) (Pan et al., 2007).

6.2.8 Management barriers

According to the descriptive results of the questionnaire, the related barriers of the management factor are (sections 4.6.4 and 4.7.4):

- Delays to decision making by the leadership (to which more than 50% agreed amongst both groups)
- The absence of effective communication between project team members (to which 40% of CC participants and 48% of USECB participants agreed).
- Deficiencies and corruption in managing project barriers shows a similar agreement between the groups, as half of the CC respondents agreed (50%), whilst 48% agreed amongst the USECB group.

The interviewees identified the importance of management and leadership as any deficiencies in projects management can cause problems, such as delayed decision making that mean delays and increased costs (section 5.2.8). Therefore, interviewees emphasised the importance of clear and continued communication among the project team, and attributed delayed decisions to:

- The existence of inefficient individuals in key decision-making positions.
- Mismanagement issues, such as corruption, that can either go against or with OSC projects.
- Withdrawn decisions from the resident site engineer, and
- A lack of knowledge when dealing with OSC projects

Moreover, they stated that, if the legal requirements stipulate to avoid delay then no problem should arise when implementing and completing an OSC project. Thus, the interviewees ascertained the importance of clear and continuous communication between the project team and supplier.

Furthermore, Khaleefah and Alzobaee (2016) emphasised that financial and administrative corruption are key failure factors for construction projects in Iraq. Therefore, they recommended developing the abilities and characteristics of project managers and engineers with a focus on leadership through proper and continuous training programs (Khaleefah & Alzobaee, 2016). Moreover, Mohammed (2018); (Haitham & Shibani, 2016) identified some management risk factors that need to be allocated and carefully managed. Indeed, Fenner et al. (2018) stated that an unfamiliar contractual process and the lack of best contractual practices within the industry may cause deep contractual and financial issues, especially for small companies. Therefore, Khaleefah and Alzobaee (2016) recommend the establishment of legislation that places legal and financial responsibilities on key individual/s (project manager, contractor, designer, director, consultant or others) who commits to reduce the frequency of administrative error.

6.2.8.1 Management -- skills & knowledge barriers relationships

The chi-square independence test revealed a significant relationship between (management, and skills and knowledge) related barriers. However, the correlation test indicated a low significant relationship (rho=0.019) for the USECB and (rho= - 0.283) for the construction companies' group. The interviewees indicated that a lack of knowledge and experience lead to delayed decision making by the management team and leadership (Section 5.2.8). Al-Turfi (2017) found that unqualified leadership in managing a project in Iraq due to a lack of knowledge and experience leads to delays and poor project performances. See Figure 6-22: Schematic diagram of the relationship between Skills & knowledge and Management.

Figure 6-22: Schematic diagram of the relationship between Skills & knowledge and Management

6.2.9 A schematic representation of the relationships between the barriers factors for using OSC in Iraq

Figure 6-23 shows the schematic diagram of comprehensive details of the barriers interacting relationships, which affect the adoption of OSC in Iraq. A full discussion of these relationships was provided in the previous sections. The red arrows indicate high- significant relationship, while green arrows indicate significant relationship. However, the moderate significant relationship is demonstrated by blue arrows.

The highly significant relationships are found between (project complexity and supply chain & procurement) related barriers, as the inability to provide varieties of OSC products result in a long lead-time. Alternatively, a lack of policies that enhance the use of OSC which lead to poor manufacturing capacity (section 6.2.3.1).

Moreover, the relationship between the (industry & market culture and skills & knowledge) related barriers is highly significant. In fact, a refusal by contractors and clients to adopt such construction resulted from a lack of knowledge and experience (section 6.2.5.1).

On the other hand, logistic & site operation related barriers has three significant relationships with (political & economic, industry & market culture and management) related barriers. In fact, a poor security situation and too many checkpoints result in unsafe sites and delayed transportation (section 6.2.1.1). Another significant relationship is between logistics & site operation and industry & market culture related barriers. Indeed, less secured sites result in less desirable of work (section 6.2.1.2). Meanwhile, the relationship between the (logistics & site operation and management) related barriers justified as poor management system leads to an unsafe site (section 6.2.1.3).

The other significant relationships are between the political & economic barriers with (skills & knowledge, supply chain & procurement, and industry & market culture) related barriers. Indeed, the wars and embargo have led to a skills shortage in Iraq (section 6.2.4.1), whilst political and economic mismanagement will lead to a poorer image of OSC in Iraq (section 6.2.4.2). Moreover, the relationship between the political & economic and supply chain & procurement barriers was found to be significant. An unstable policy due to political and economic issues will result in a disturbance to the supply chain and procurement (section 6.2.4.3).

Ultimately, the relationship between the (project complexity and political & economic) related barriers indicates a significant effect. Indeed, political and economic mismanagement can result in a poor project performance. These relationships can be found in section (6.2.3.2).

Moreover, a significant relationship was found between (industry & market culture and supply chain & procurement) related barriers. The contractors refuse to adopt this type of construction because of the inability to provide different types of OSC products. Another significant relationship was found between the industry & market culture and management related barriers, as management deficiencies result in an increasingly negative image of OSC. These relationships are discussed in sections 6.2.5.2 and 6.2.5.3.

Another significant relationship exists between the supply chain & procurement and skills & knowledge-related barriers. Indeed, the lack of knowledge and experience results in a poor supply chain (see section 6.2.6.2). Also, the relationship between (project complexity and skills & knowledge) related barriers was found to be significant. Indeed, a lack of knowledge and skills leads to a poor project performance (see section 6.2.3.3). Lastly, the significant relationships between (skills & knowledge and management) related barriers justified as a lack of knowledge and experience leads to delays of decision making by teamwork & leadership (see section 6.2.8.1).

However, a moderate significant effect is reflected in the relationship between the (cost and skills & knowledge) related barriers. In fact, the need for skilled labour for OSC means an increase in the overall cost of the project, particularly for small-scale works (section 6.2.2.1).

Moreover, another moderate significant effect is found between the (cost and project complexity) related barriers. Obviously, the change in design will lead to increased project costs (section 6.2.2.2). Furthermore, (the political & economic and cost) related barriers relationship also demonstrates a moderate significant effect. Indeed, an unstable security and financial situation will increase the cost of a project (section 6.2.2.3). Ultimately, the moderate significant relationship was found between the (cost and management) related barriers justified, as a poor management system will cause cost overruns (section 6.2.2.5).

Furthermore, the (supply chain & procurement and cost) related barriers have a moderate significant relationship, as long-distance transportation and delays of delivery mean an increase in cost. The result of the relationship is reported in sections (6.2.2.4). Furthermore, the relationship between (logistics & site operation and cost) related barriers are also moderate significant. If the project construction is implemented on an unsafe site, this will increase the overall cost of the project, as more money is needed to overcome unforeseen situations, such as the increased number of security check points (section 6.2.1.4).

A moderate relationship is found between political & economic factor and management factor. This relationship is justified as mismanagement of both political & economic lead to choose bad leadership to manage the project which cause negative results on project performance (section 6.2.4.4).

This figure also reflects the moderate relationship between the (logistic & site operation and project complexity) related barriers. Indeed, a complex design enables a hard implementation onsite (section 6.2.1.5). The other moderate relationship is found between the related barriers of (logistics & site operation with skills & knowledge), whilst a lack of skills leads to a poor project construction implementation, unsafe sites can result in skilled labour refusing to work in such locations (section 6.2.1.6).

Ultimately, the figure illustrates the relationship between the (supply chain & procurement and logistic & site operation) related barriers. This relationship is moderate significant. It is important to note that an insufficient road network will delay the transportation of resources. These relationships are reported in detail in (section 6.2.1.7).

Furthermore, the relationship between (project complexity and industry & market culture) related barriers was moderate significant. It justified as the lack of regulation, can cause cultural resistance amongst clients and contractors. On the other hand, difficulties in obtaining formal approval for this type of construction will lead to long lead-times (section 6.2.3.4).

Additionally, improper management system will lead to disturbances in procurement and the supply chain; nevertheless, this relationship is found to be moderate significant. The relationship is explained in detail in sections 6.2.6.2

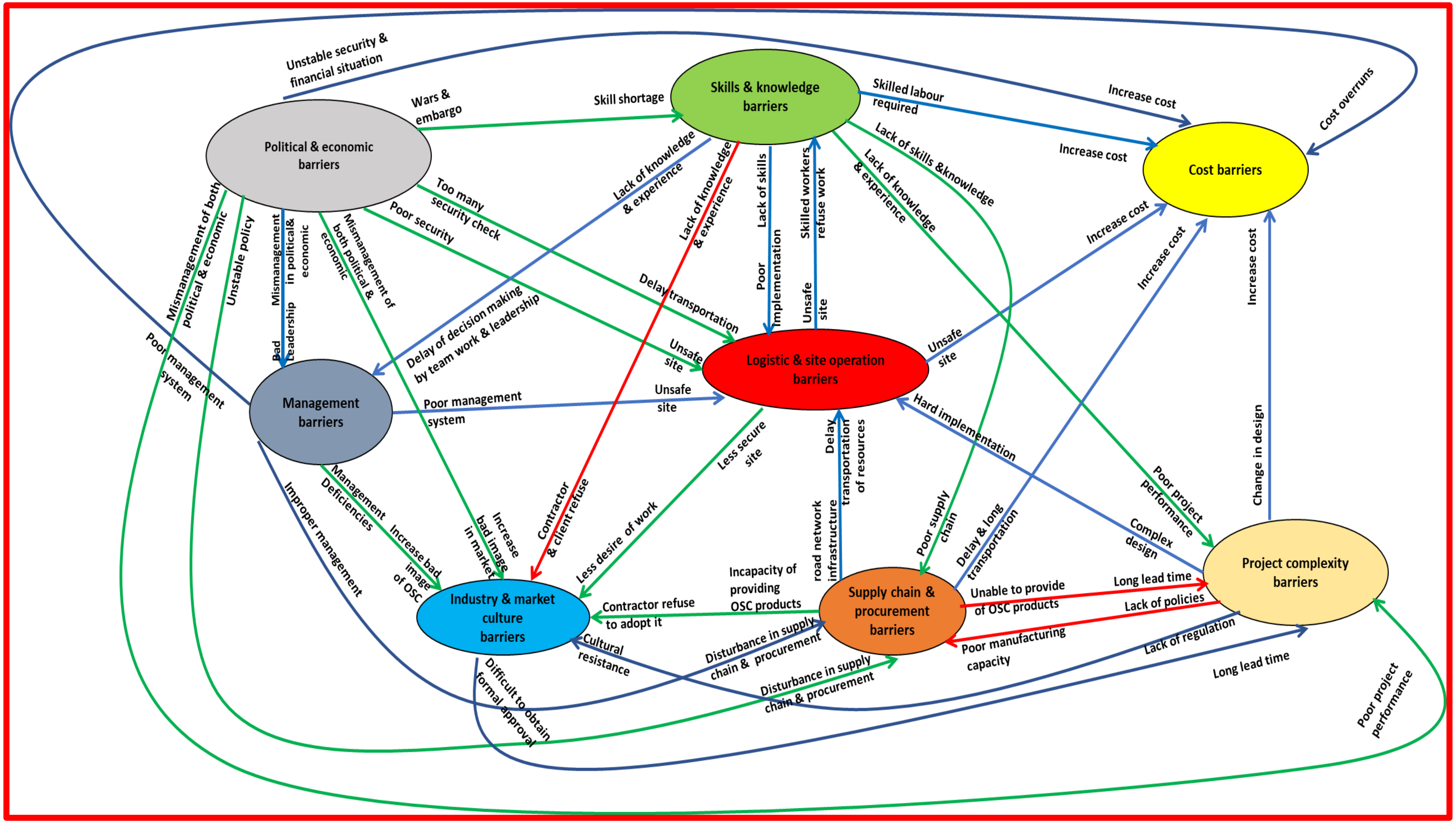


Figure 6-23: A schematic representation of the interaction of the relationships between barriers for using OSC in Iraq

6.2.10 Non-working days barriers

Another barrier has been explored from the interviews result is (non-working days). In Iraq, there are a lot of formal and informal non-working days, including religious non-working days, which cause road closures. Two of the interviewees identified this factor as an important obstacle to the uptake of OSC projects, which requires a continuous supply. Thus, such events lead to delay in transportation, disturbance to the continuity of project activities and supply chain, increased mismanagement which delays in the completion of projects and increased cost and affect negatively the quality performance of the final building which in turns can increase the bad image about OSC application in Iraq. One of the interviewees added that such problems could be avoided if the factory and site of the project are located in the same area, but this is not the case when there are differently located projects**.** However, both interviewees emphasised the importance of taking effective measures to overcome this barrier.

Jaber (2015) stated that unofficial holidays represent an important risk factor affecting construction projects. Indeed, official and non-official non-working days were recognised as a barrier by Bekr (2017); Bekr (2015). Moreover, the law established by the Iraqi parliament in 2013 confirmed that some cities with religious affiliations are allowed to determine their own holidays (Bekr, 2017). The large number of official and unofficial (national and religious) holidays can halt projects, which have negative impacts on labour productivity, threaten the timely completion of projects and can increase the costs; this can also lower the performances of projects (Al-Turfi, 2017; Bekr, 2017; Dakhil et al., 2017). Indeed, the large number of holidays have a negative impact on Iraqi economic and overall activities (Bekr, 2017). Therefore, the researchers recommended to implement actions to prevent or eliminate the risks of such barrier such as risk management and government responsibilities in managing such phenomenon in Iraq.

6.2.10.1 Schematic of Non-working days barrier relationship

The holiday barrier seems to be an important barrier to the uptake of OSC in Iraq. Indeed, the impact of national and religious holidays can be summarised as: -

- Causing negative impact on labour productivity
- Increasing overall costs
- Disturbing project activities

- Increase mismanagement in the project
- Delaying and causing difficulties in the transportation of resources.
- Disturbing the supply chain.
- Negatively impacting the economics of the country.
- Lower the project performance, which in turns lead to increase bad image about OSC application. This relationship is indicated by dot line in figure 6-24 as it is not direct effect.

These impacts are represented in Figure 6-24. Moreover, it is worth noting that the researcher agreed with the interviewees on the importance of this barrier in affecting the adoption of OSC in Iraq.

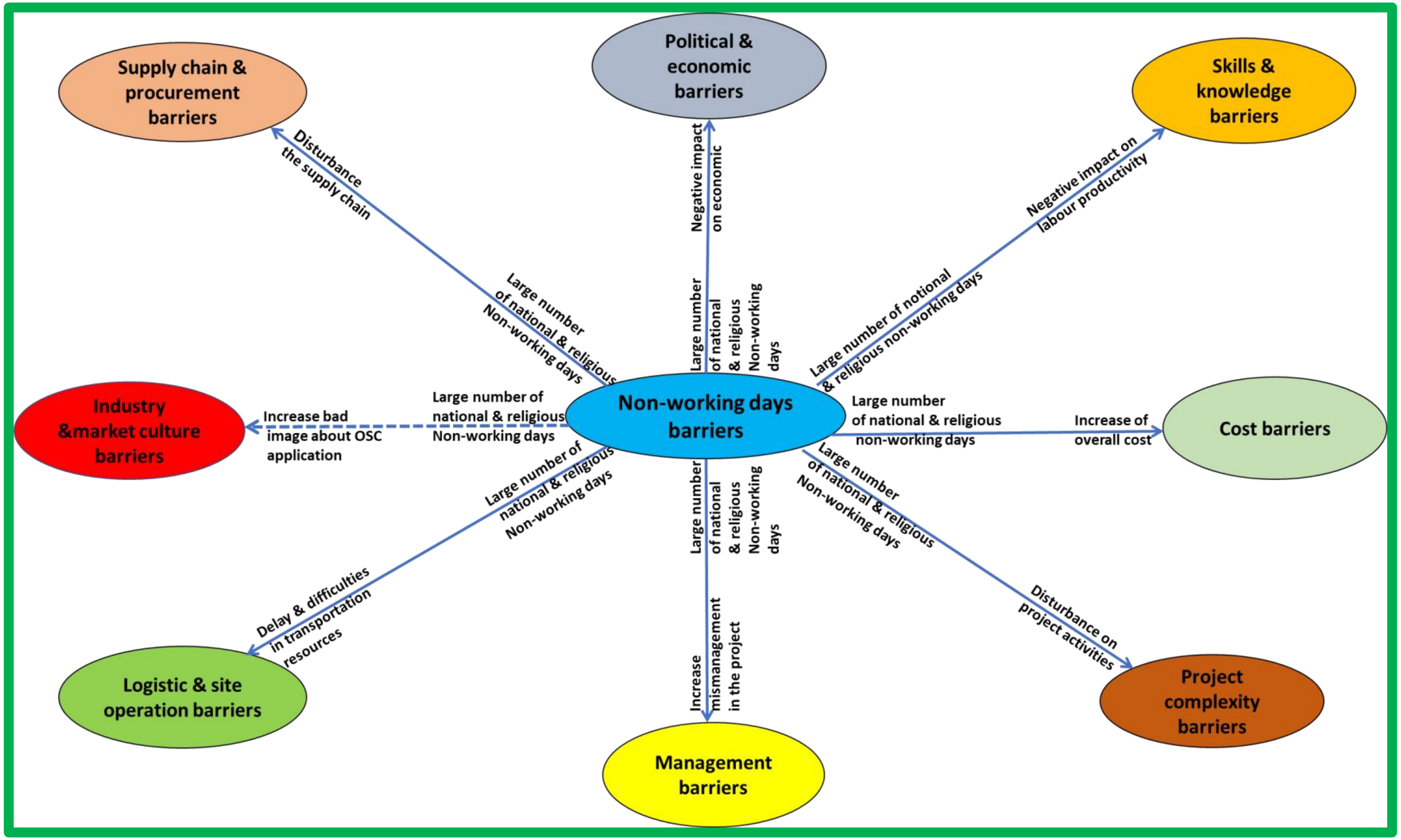


Figure 6-24: Schematic diagram of Non-working days barriers relationship with other barriers

6.2.11 The most significant barriers factors affecting the adoption of using OSC in Iraq

Based on results obtained from the preceding sections, this section discusses the most significant barriers affecting the use of OSC in Iraq. According to the quantitative results, it appears that construction companies found that industry & market culture was the most significant factor hindering the use of OSC in Iraq. This is due to its highly significant relationship with political & economic, skills & knowledge, logistic & site operation, and management barriers factors. The second significant factor hindering the use of OSC for construction companies' group is a political & economic, as it has three highly significant relationships, with logistic & site operation, industry & market culture & skills & knowledge barriers. It is worth noting that the political issues negatively affect the implementation of construction projects were also indicated by (Al-Turfi, 2017; Jaber, 2015). In addition, the third important barriers include skills & knowledge and logistic & site operation as they represent two highly significant interacting relationships. Indeed, the industry & market culture (including people's negative perception and client resistance) barrier and skills shortage are similarly barriers found by Rahimian et al. (2017) and Bendi (2017). Figure 6-25: High significant relationship barriers (construction companies) shows high significant relationship barriers (construction companies) and table 6-4 illustrates the interactions between these factors according to correlation results.

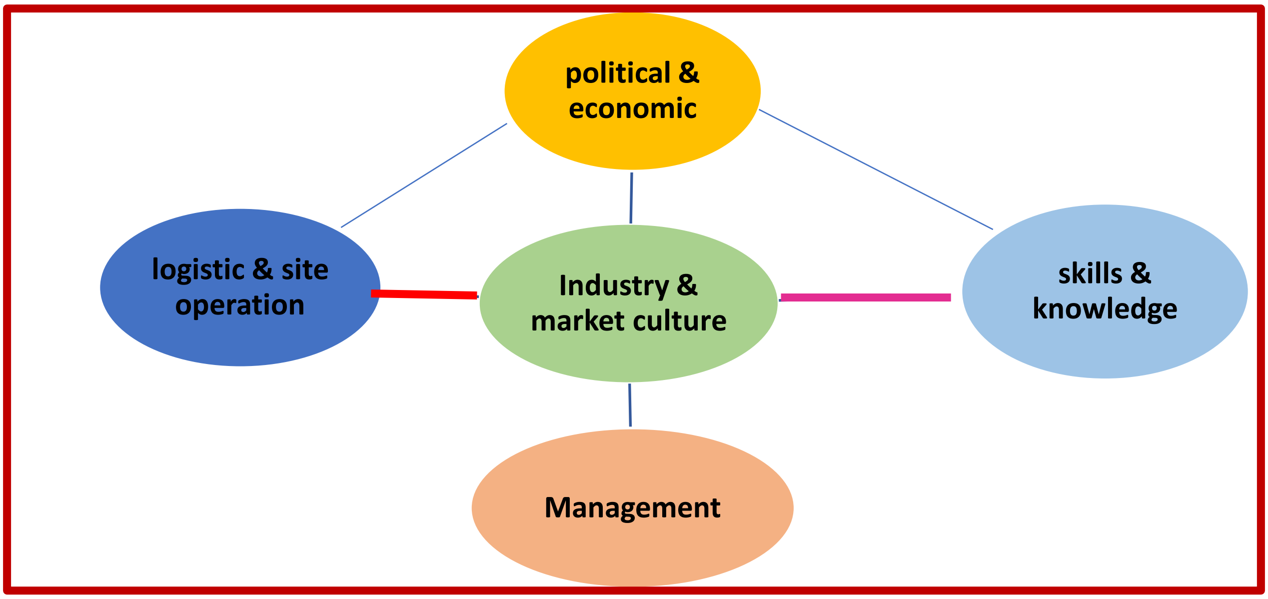


Figure 6-25: High significant relationship barriers (construction companies)

Table 6-4: High-significant barriers correlation for construction companies' sample

BARRIER1	BARRIER2	RHO VALUE
Logistic	Political	0.64
Industry	Political	0.559
Political	Skills	0.547
Industry	Skills	0.532
Industry	Logistic	0.531
Supply	Project complexity	0.509

However, the USECB groups found that supply chain & procurement is the most significant factor hindering the use of OSC in Iraq. This is due to its highly significant relationship with (industry & market culture, skills & knowledge, political & economic and project complexity) barriers. The supply chain factor is widely indicated in the literature as a barrier as there is a lack of manufacturing capacity to provide different types of OSC product (Gan, Chang, Zuo, et al., 2018; Bendi, 2017; Al-Mutairi, 2015). The second most significant factor from the perspective of this group is skills & knowledge, which has three highly significant relationships, with (supply chain, industry & market culture, and project complexity) barriers. Meanwhile, the third influential barrier factor is found to be project complexity as it has two highly significant interacting relationships with (skills and supply) barriers. Moreover, the construction companies also demonstrated the highly significant interacting relationship between (supply chain and project complexity) barriers. The project complexity related barriers is indicated in the literature (Gan, Chang, Zuo, et al. (2018); Amlus (2014) which confirms that inadequate policies include poor guidelines, unclear standards and information, and unclear regulation hinders the use of OSC

Consequently, this influences the policies of construction companies and their uptake of the OSC construction method. On the other hand, Bendi (2017) found that long lead times a barrier in using OSC in India. Figure 6-26 and

Table 6-5 reveal the interaction between these factors.

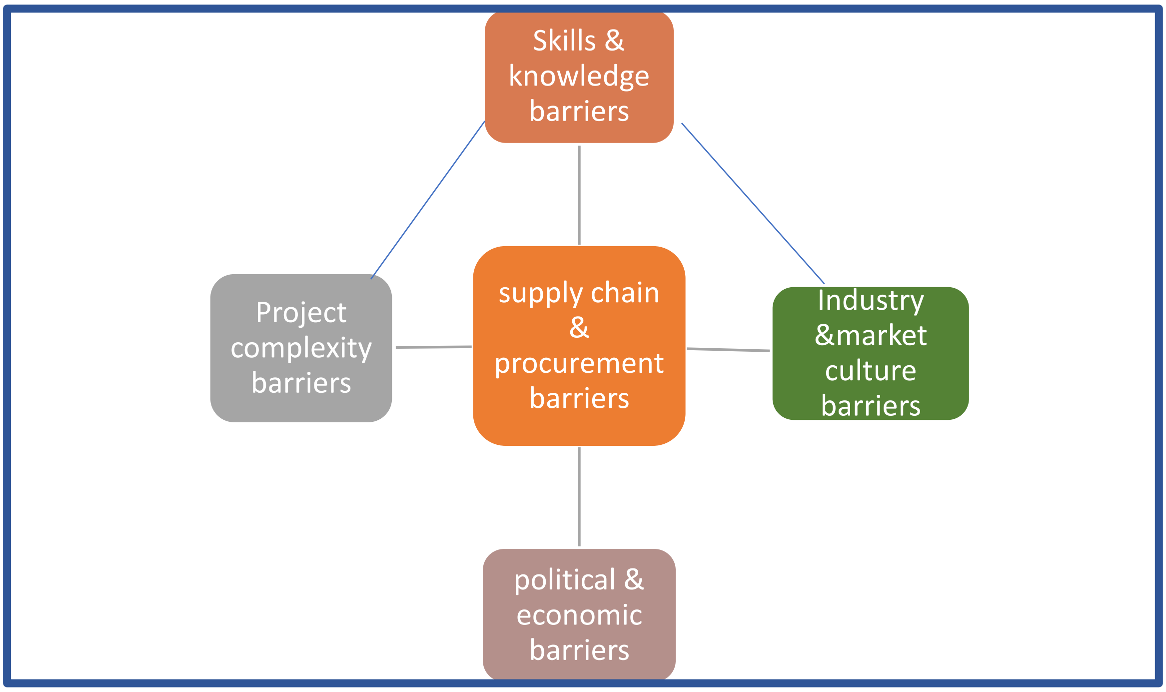


Figure 6-26: High Significant Barriers (USECB)

Table 6-5: High significant barriers correlation according to USECB group

BARRIER1	BARRIER2	RHO VALUE
Supply chain	Skills & knowledge	0.655
Supply chain	Industry & market culture	0.511
Supply chain	Political & economic	0.601
Supply chain	Project complexity	0.608
Skills & knowledge	Industry & market culture	0.644
Skills & knowledge	Project complexity	0.677

Furthermore, the results obtained from the Kruskal-Wallis test shows agreement from both groups on the barriers of (logistic & site operation, skills & knowledge, and industry & market culture). It can be concluded from the above findings that the results obtained by companies regarding the barriers and their interactions reflect a close picture of the reality of OSC construction in Iraq, as these individuals are most concerned with its operational aspects. Meanwhile, the universities' results illustrate an interest in supply chain, skills and design issues, which reflect the more theoretical, academic than practical concerns.

Therefore, barriers of political & economic issues, industry & market culture, skills & knowledge, supply chain & procurement, logistic & site operation and project complexity play an important role as obstacles to the adoption of OSC in Iraq. Moreover, these barriers have a substantial influence on the cost of the project, although controlling those factors can positively affect the overall cost. This is in line with findings by Gan, Chang, Zuo, et al. (2018) who indicate that barriers such as, poor manufacturing capacity, lack of skills, ineffective logistics, inadequate policies and regulation, dominated of traditional construction and low standardisation lead to increased costs in OSC. All the afore-mentioned factors that hinder the use of OSC in Iraq are supported by the interviewees.

According to the results obtained from the quantitative methods for both groups, the management factor was found to be moderately important compared with other barriers. However, the qualitative (interviews) emphasised the significance of the management barrier and its impact on the use of OSC in Iraq. Therefore, it is worth to mentioning that cost and management can be considered barriers to the use of OSC in Iraq and need more attention through further investigation. Many researchers indicated poor management systems in Iraq when dealing with construction projects, which can lead to poor performances (Al-Turfi, 2017; Bekr, 2017; Khaleefah & Alzobaee, 2016). Indeed, Fenner et al. (2018) ascertained the importance of proper management techniques and an awareness of the barriers to uptake of OSC in mitigating negative impacts.

Finally, according to interview results, the non-working days explored another barrier to the use of OSC in Iraq, which can affect negatively on other factors. Therefore, this factor will be considered as a barrier to the use of OSC in Iraq in this study.

6.3 Chapter summary

This chapter discussed the findings from the literature review, questionnaire survey, and semi-structured interviews. The questionnaire analysis explored the views of Iraqi industry participants towards the factors affecting the use of OSC in Iraq. The interview findings resonated with the results obtained from the questionnaire. Furthermore, the results also presented eight main drivers' factors and nine main barriers factors affecting the uptake of OSC in Iraq. This chapter also discussed and clarified the interaction between both the drivers' factors and barriers factors in adopting OSC in Iraq. A set of schematic representations of the relationships between the drivers and barriers was also presented.

Chapter 7 **Strategic guideline**

7.1 Introduction

The final objective of this thesis is to develop a strategic guideline for the development of best practice for using OSC in Iraq. The purpose of this strategic guideline is to provide a proposal to decision-makers in the Iraqi government and construction companies in order to address managerial and organisational weaknesses, including issues around project leaders, project managers, project team and contractors. The guideline detailed within this chapter allows researchers, practitioners, or developers to synthesise key themes, leading to a better understanding of best practice when using OSC for all types of buildings.

This strategic guideline has been developed by fully utilising existing theory and knowledge based on the literature review and findings of this research, which act as the foundation for a structural strategy to help to adopt OSC in Iraq. The strategic guideline began with the first section and involved the classification of factors that drive the use of OSC in Iraq, also identifying the challenges that can inhabit these drivers. Moreover, indicative actions to overcome these challenges will be provided, which are based on the interview's recommendations and literature review. The second section will explore barriers to the use of OSC in Iraq. Indicative actions will be developed to face these barriers based on the interviewee's recommendations and literature review. The red texts in both documents explored from validation stage conducted in chapter 8.

7.2 Indicative actions for the drivers of using OSC in Iraq

This section will explain the challenges affecting the drivers of using OSC in Iraq. However, indicative actions will be developed to overcome these barriers. The red texts included in this section explored from validation stage in Chapter 8.

7.2.1 Challenges inhibiting Time and Cost drivers

The challenges affecting time and cost drivers are somewhat the same, therefore the table below illustrated these challenges. Nevertheless, indicative actions to face these challenges will be discussed. Moreover, the details of these indicative actions will be provided under each table.

Table 7-1: Indicative actions to overcome challenges inhibiting Time & Cost drivers of using OSC in Iraq

challenges inhibiting time & cost drivers	**Sub-challenges**	**Cross links**	**Indicative actions to face challenges (See section 7.2.1.1 for details)**	**Cross links**
Materials	• Delay in delivering materials. This results from supplier delays or/and transportation issues and in case of importing outside Iraq, they may delay due to permissions from Iraqi Custom & Border Protection. • Fluctuation on the prices of materials. • A lack of communication between different locations from the same supplier can lead to the delivery of the wrong materials to the wrong site. • Monopoly of market from some suppliers	Section 2.8.2 Sections 5.2.1,5.2.3,5.2.5, 5.2.6 and 5.2.7 Chapter 6 Section 6.2.1 Section 6.2.1.4 Section 6.2.4.3	• Adopt efficient delivering system. • Facilitate the passage of building materials • Use local resources and materials. • Ensure effective supply chains • Establish negotiation strategy	Chapter 6, Section 5.2.3, Section 5.2.7 Section 5.3.1 Section 5.3.11 Section 2.8.8

Management	• Lack of efficient cost planning/monitoring during the pre and post contract stage • Un-reliable subcontractors and specialist firms causes poor performance • Poor communication and coordination between parties. • Delay in the decision-making process. • Poor site management and supervision.	Section 5.2.8 Section 6.2.2.5 Section 2.8.2	• Cost performance management. • Awarding a contract to efficient contractors • Risk management • Clear communication and cooperation • Effective site management and supervision. • Avoid delay of decision making • Strong policy for effective legislation.	Sections 5.2.8, 5.3.2, 5.3.11 Section 2.8.2 Section 2.8.9
Labour & equipment	• Lack of skilled workforce • Lack of experience. • Equipment unavailability or failure. • Accidents • Insufficient equipment	Section 2.8.2 Section 6.2.8.1 Section 5.2.7 Section 6.2.2.1	• A certification and training program • Incentives to attract students to learn such construction • The application of health & safety procedures • The use of local factories to support the local economy • The use of proper and modern construction equipment	Section 5.3.4 Section 5.3.9 Section 6.1.1.3 Section 6.1.3.4 Section 5.3.10

Financial issues	• The insufficient estimation of the financial capability of the owner leads to their inability to fund the complete project. • Delayed funds. • Delayed owner payments to contractors or from contractors to workers.	Section 2.8.2 Section 5.2.2 Section 5.1.7	• A proper check of the owner's financial ability. • The establishment of a fine system • Accelerating government funding.	Section 5.3.6 Section 2.8.2 Section 6.1.1.7 Section 2.7
Design	• Changes to the design • Errors and mistakes in the design • Inappropriate design • A lack of codes and standards for OSC components.	Section 2.8.2 Section 5.1.7 Section 6.2.2.2	• The standardisation of design information. • The use of BIM technology. • Complete, accurate and suitable designs provided at the right time. • Establishing Iraqi codes and standards.	Section 5.3.7 Section 5.3.9 Section 5.2.2 Section 5.3.8 Section 2.8.9
Schedule control	• A lack of commitment lead to change the schedule agreed • Ineffective planning and scheduling • Non-working days	Section 2.8.2 Section 5.2.2 Section 5.2.9	• The establishment of a fine system • The provision of effective, clear and up to date planning and scheduling. • The government has to address the increasing of non-working days problem in Iraq seriously by establishing laws	Section 2.8.2 Section 5.2.1 Section 5.3.6 Section 5.2.2 Section 6.2.10

			controlling the effect of this problem.	
External factors	• Weather conditions • The effects of changing government laws, cultural and security influences and impacts. • Lack of close infrastructure or difficulties in accessing them.	Section 2.8.2 Section 6.2.4 Section 6.2.4.3	• Choosing an appropriate time for implementation. • Risk management. • Insurance project • Ensure that the infrastructure is close to the site and easily accessible	Section 5.1.4 Section 2.8.10 Section 5.3.11
Contractual issues	• Aggressive competition at the tender stage • Lowest bid prices • Conflicts between the contract documents • Issues with the contractor selection • Underestimation of time for completion of the projects	Section 2.8.2 Section 2.8.9 Section 5.1.7 Section 5.2.8	• Decision-makers must focus on a value-bid instead of a lower bid • Fair support in competing at the tender stage • The ministries have to cooperate to provide contract documents relating to the OSC method, including all stages of the project. • Allocating the perfect time of completion project.	Section 5.1.7 Section 5.2.4 Section 5.3.1 Section 5.3.2

7.2.1.1 Indicative actions for challenges to Time and Cost drivers

- **Materials**
  - **Adopt an efficient transportation system:**
    - Decision-makers must encourage and develop other transportation instead of relying on road transport; instead, railways and shipping can also be used, and the role of Ministries in Iraq should be updated on such ways. Ministry of transport in Iraq is responsible for rehabilitate the road network
    - Key components and modules may have programme lead times, which are irreconcilable with the design for wider offsite multi service modules; however, early advice and decisions on the supply chain would alleviate this issue. The component supply should form part of both early assessment and preconstruction programming. Leadership ensures the supply of materials from the early stages of a project.
  - **Effective supply chains:** Cooperation throughout the project is not only important for the supplier and the site construction teams but also between all different sites construction when they have the same supplier to prevent any conflicts in supplying. including a general understanding of production lead times.
  - **Use local resources and materials**: Iraq is a country rich in oil, sand, and stone. Therefore, it is not difficult to provide such materials when producing OSC products; however, the reduction and fix of raw material prices and subsidising the price of raw materials is essential in order to encourage the stakeholders to establish local OSC factories. The Ministry of Industry determines the prices of materials and the Ministry of Trade must legislate laws and issue instructions to fix prices.
  - **Facilitate the passage of building materials:** Authorities should introduce customs facilities to ensure access to materials that are imported from outside Iraq. This will help construction companies to undertake a project within the planned time and cost. The Ministry of Finance, in accordance with Ministry of Construction and Housing, can facilitate rules for the passage of materials; moreover, they can reduce taxes and pass instructions to the Iraqi Custom & Border Protection.
  - **Establish negotiation strategy**. This can be achieved through; for instance, develop a strategic partnership with the monopoly supplier that benefits both parties.

- **Management**

  - **Cost performance management**: Effective cost measurement throughout the project and ensuring controls in the process, mean that the project manager can strengthen the calculation and control of the project cost in all construction phases. Thus, they can also realise the goal of saving and dropping construction costs. Also, it is necessary to consider the cost of various changes and risks, which can happen during construction, and to report on such information (especially cash flow onsite) daily.

  - **Effective site management and supervision**: It is recommended that the abilities and characteristics of project managers and engineers are developed through proper and continuous training programs concerning effective project management. These should focus on the area of leadership. The roles and responsibilities of teams have to be clarified to prevent the application of different decisions by different parties. This potentially means designing employees' jobs around core business processes, enhancing horizontal authority and empowering employees to manage their business processes.
  - **Clear communication and cooperation**: The project team must negotiate and consult with departmental managers on various issues and have frequent progress meetings. This may mean adopting an information communication technology-driven system (ICT) as a substitute for existing paper-based methods. It may also entail the establishment of an electronic database to facilitate the maintenance of the data produced throughout execution the business processes, and to sharing them amongst the company's projects and units
  - **Risk management**: Contractors should learn how to share and shift risks by hiring specialised staff or specialised subcontractors. It is suggested that the contractor is forced to employ a specialised project management company for large projects. Contractors should make unremitting efforts to avoid financial failure by following strict cash flow management procedures. They should also understand how to take advantage of transferring and sharing risks by employing a professional team or professional subcontractors.
  - **Contracts awarded to sufficient contractors:** To avoid future failure of the project, authorities have the responsibility of awarding a contract according to a contractor's experience and reputation, and not for lower bid. Committees in Ministry of Housing

and Construction are responsible for arranging these instructions and rules when advertising for a bid.

- **Avoid delay of decision-making**. The importance of having the decision-making by specialised people and avoid longer decision by authorities that unfamiliar with this type of construction. The government bodies can help in minimising the long process of approval by authorities.
- **Strong policy for establishing effective legislation** in the contract which obligates the project manager, contractor, designer, director, consultant or others in all the legal and financial responsibilities and reduces the recurrence rate of administrative error.

- **Labour and Equipment**
  - **Certification and training program**: Construction companies have to continuously develop their labour skills. Establishing an offsite association is important in providing training for workers. The other role is related to academic universities and colleges in providing courses for OSC in order to expand knowledge. Otherwise, this could involve hiring expert labour or international managers, especially for large projects.
  - **Incentives for attracting people to learn about OSC:** This is the duty of Ministry of Construction and Housing and Ministry of Planning in promoting incentives amongst younger people to learn such skills.
  - **Local factories:** Establish local factories that will support the use of OSC in Iraq by easing the supply of materials and facilitating access to new materials instead of those that have been damaged. The Ministry of Industry can help manufacturers by providing raw materials and reducing the energy taxes of factories. The Ministry of Trade controls raw materials in the market and both ministries facilitate the import of materials.
  - **Use proper and modern construction equipment**: This is the backbone of large construction projects, as it contributes to the project economics, quality, safety, speed and certainty regarding the completion time. Construction companies have to use appropriate equipment when applying OSC, as the benefits will overwhelm the price. Establishing Iraqi OSC association can help this by offering equipment to contractors, or the contractors themselves can help each other by hiring equipment to reduce the cost under the umbrella of OSC association.
  - **Apply health & safety procedures**: The contractors have to ensure the safety of their workers and thus, legislation has to be applied in the contract. The government role in

monitoring is essential and can be achieved by allocating government authorities to control and apply health and safety onsite. Workers should be aware of the importance of personal protective equipment. The project manager is responsible for securing the construction site, providing PPE, dealing with injuries, and providing emergency equipment and medical assistance.

- **Financial issues**
  - **Proper checks of the owner's financial ability:** It is essential to understand the owner's budget before implementing a construction project to prevent future cash flow problems. Formal meetings between the contractors, sub-contractors, owners, etc at the early stages of the project can achieve this.
  - **Fine system**: There is a widespread problem concerning the lack of commitment amongst the construction industry, especially when contractors have many projects at one time, or the owner has difficulties in paying. Therefore, establishing a system of fines will force the stakeholders to commit. The contract has to include laws to force stakeholders to commit to the project schedule and cost.
  - **Accelerating government funding:** this is fundamental in order to ensure time completion and improve financial performance. The Ministry of Planning and Finance, in cooperation with the Ministry of Housing and Construction prepares a strategic plan to provide financial support for companies related to the Ministry of Housing or the private sector. Banks' committees could participate in the strategic plan to offer loans for investors.
- **Design issues**
  - **Standardisation of design information:** This helps to avert the omissions, errors and continuous changes that can affect the development of the projects. This recommends being done by designers.
  - **Having a complete, accurate and suitable design at the right time**: This can be achieved if cooperation is established from the early stages of a project. The client has to be involved in meeting other stakeholders to clarify their needs and expectation. The designer should explain the consequences of changing a design to the clients. The consultants have to ensure the suitability, accuracy, clarity and validity of the design drawings and specifications

- **Establish Iraqi codes and standards**: This can reduce design conflicts between the stakeholders from different regions in Iraq and bad quality products. The role of government departments is essential in helping to integrate OSC design experiences gained in different regions to develop a set of design standards and codes applicable across all regions. Committees from different ministries, such as the Development and Quality Control Committees in the Ministry of Housing in cooperation with committees from the Engineers Association and the Ministry of Planning, develop the required Iraqi codes and standards and present them in the form of laws and guidelines for Iraqi contracting.
- **Use BIM technology**: This can help with design and construction process efficiencies, Collaborative working stakeholder engagement, means providing manufacturing information and meeting client information requirements. The project manager ensures the application of BIM from the early stage of the project to enable stakeholders to understand the process and facilitate effective communication.

- **Schedule control**
  - **Provide effective and clear planning and scheduling**: Expert consultants and contractors have to ensure the project planning and scheduling runs effectively.
  - **Fine system**. The problem associated with a lack of commitment is widespread across the construction industry, and particularly occurs when contractors have many projects running at one time, or when the owner has difficulties in paying. Therefore, establishing a fine system will force the different stakeholders to commit. The contract has to include laws to force stakeholders to commit to the project schedule and cost.
- **External factors**
  - **Choosing an appropriate time for implementation:** Stakeholders need to understand the best time of the year to implement their project in order to avoid bad weather conditions and to avoid joints problems.
  - **Risk management must be established from the early stage**: The contractors and consultants have to ensure the holding of risk management in a project at the early stages, to mitigate risks and prepare alternative solutions when risks occur. The Construction Leadership Council is responsible for issuing this legislation in cooperation with the Ministry of Housing and Planning; for example, medical

emergencies to treat injuries, storage for materials, alternative suppliers, and security for construction sites.

- **Insurance project**. It is vital for construction companies to insurance their project in such unstable political and security situation.
- **Ensure that the infrastructure is close to the site and easily accessible**: The project teamwork must consider the accessibility of facilities like sewages in the feasibility study of the project. Leadership is responsible for studying the construction site and providing infrastructure when required, such as electricity, water and gas pipes.

- **Contract issues**
  - **Focus on value-bids instead of lowest cost:** Authorities and decision makers must focus on value-bids instead of lowest cost.
  - **Improving contract conditions related to the OSC**: Ministries (Ministry of planning and Ministry of Housing) have to cooperate to provide contract documents related to the OSC method. These needs to clearly include all stages of the project to reduce conflict and identify enough time to prepare the contract documents.
  - **Fair support in competition at the tender stage:** Decision-makers have to give the project to a reliable contractor and the government must authorise trustful people to prevent the possibility of mismanagement.
    - **Allocating the perfect time of the completed project.** The cooperation is important between the stakeholders of the project in the planning stage in order to allocate and ensure the best time for completion including extra time to address any risk factor, such as security issues, delayed materials, non-working days and weather issues. Consultants need to specify the project requirements at the pre-construction stage.

7.2.2 Challenges inhibiting Quality drivers

This part discusses the challenges affecting the quality of the final products including (Management, skills & knowledge, design issues, production factors, construction related factors. However, the indicative actions to overcome these challenges will be identified and illustrated in the table below. Moreover, the details of these indicative actions will be provided below the table. The red texts explored from validation stage conducted in chapter 8.

Table 7-2: Indicative actions to overcome challenges inhabiting Quality drivers of using OSC in Iraq

Challenges affecting quality drivers	Sub-challenges affecting quality	Cross links	Indicative actions to overcome these challenges (details in section 7.2.2.1)	Cross links
Management	▪ Poor communication and coordination between parties. ▪ Poor site management and supervision ▪ Fraudulent practices and kickbacks	Section 5.1.2 Section 2.4.2	• Clear communication and cooperation • Proper structured site management and supervision • Prevent the possibility of mismanagement of accepting bad quality	Section 5.1.2 Section 5.2.8 Section 2.4.2
Skills & knowledge	• Lack of knowledge ▪ Lack of skilled workforce ▪ Lack of experience, including amongst designers & contractors, of the OSC method	Section 5.1.2 Section 2.4.2	• Cooperation between industry and academia. • Establishing associated specialists in OSC • Certification and training program	• Section 5.3.5 • Section 5.3.6 • Section 5.3.4

Design issues	▪ Unsuitable design ▪ Design changes ▪ Lack of codes and standards for OSC components. ▪ No building information modelling (BIM) application.	▪ Section 2.4.2 ▪ Section 5.1.2 ▪ Section 6.1.2.6	▪ Complete and suitable design available at the right time. ▪ Decreasing the numbers of design change. ▪ Using a BIM application. ▪ Developing a set of design standards and codes applicable at all regions.	▪ Section 5.3.9 ▪ Section 5.3.7 ▪ Section 2.4.2
Production factors	• Poor quality raw materials • A lack of production quality management system in the factory production process. • A lack of quality assurance measures for the storage and transportation of OSC components	Section 2.4.2.	• Ensuring proper material procurement • Allocating an observer engineer in the factory. • Emphasising the importance of quality assurance measures for the storage and transportation of OSC products.	Section 2.4.2 Section 5.1.2
Construction related factors	• Inadequate construction of the connecting points between the core components • Poor-quality components due to the lack of on-site checking measures and poor equipment testing. • Limited construction time imposed by project clients. • A lack of technical guidelines for the construction of OSC projects. • lack of construction quality criteria for OSC components.	▪ Section 2.4.2 ▪ Section 5.1.2 ▪ Section 6.1.1.1	▪ Construction has to be implemented by a skilled team. ▪ Allocating a suitable timeframe and good quality materials for joints. ▪ Monitoring and following up the process is vital by consultant engineers. ▪ The importance of cooperation between stakeholders from the initial stages to determine the perfect time for project completion. ▪ Design for manufacturing and assembly ▪ Apply global quality criteria within construction companies.	▪ Section 6.1.1.1 ▪ Section 5.3.9 ▪ Section 6.1.2.3 ▪ Section 2.4.2 ▪ Section 5.3.6

Financial issues	• Low cost allocated in the contract for the product design and construction stages. • Failure in funding the whole project.	• Section 2.4.2 • Section 6.1.2.2 • Section 2.8.8	• Allocating a reasonable and well-planned cost of product design and construction cost in the contract. • A proper check of the owner’s financial ability	• Section 6.1.2.2 • Section 5.3.6 • Section 2.8.8

7.2.2.1 Indicative actions for the Quality drivers

- **Skills & knowledge**

    - **Cooperation between industry and academia.** The cooperation between industry and academia is essential to share knowledge. Universities and colleges have to teach students about OSC in order to create a new generation of engineers and technicians familiar with this type of construction.
    - **Establishing associations of OSC.** Like the Build-Offsite Association in the UK that gathers and supports companies by providing information, training, and the sharing other successful experience, both nationally and internationally.
    - **Hiring experts internationally.** To address the shortage of construction companies or skilled labour, it is advisable to hire experts internationally to enhance the skills of contractors, managers and labour nationally. This action can be adopted by Ministry of housing and build OSC association.
    - **Certification and training program**: Construction companies have to continuously develop their labour skills. Establishing an offsite association is important in providing training for workers. The other role is related to academic universities and colleges in providing courses for OSC in order to expand knowledge. Otherwise, this could involve hiring expert labour or international managers, especially for large projects.

- **Productivity factors**

    - **Ensure proper material procurement**. The contractor has to ensure the procurement of materials from a reliable supplier who can provide materials on time and of a good quality. An effective procurement plan has to be implemented by the teamwork in the initial stage. It is advisable to expect suppliers to have ISO 9001 accreditation, which should cover design along with manufacturing.
    - **Allocation of an-observer engineer in the factory**. The construction companies must be reliable, expert and able to allocate an-observer engineer in the factory supply to ensure perfect quality control is adopted and they are able to refuse bad quality products before transportation into the site. The client could deal with the designer and manufacturer to determine which tests can be conducted at the factory prior to delivery.

- **Emphasising the importance of quality assurance measures for the storage and transportation of OSC products**. Transportation is one of the fundamental issues that need to be evaluated and monitored effectively. Design a logistic tool to ensure the safe and efficient delivery to, and movements within, the site. Usually, suppliers - in accordance with contractors - ensure optimal transportation in order to protect the product. Temporary storage and material handling requirements may be needed if the adjacent yard is not large enough to contain the materials. The project may need to budget separately for this depending on how the supply chain is organised. Measures need to be considered by the project manager in order to provide storage with a good space layout and good atmosphere to prevent humidity and thus protect the quality of materials.

- **Construction related factors**
  - **Construction has to be implemented by a skilled team**. To avoid mistakes and improve quality performance, the OSC method has to be undertaken by skilled labour and an expert contractor, according to a quality standard like ISO 2015.
  - **Allocate a suitable timeframe and good quality materials for joints**. The consultant's engineers must ensure the best time of year to implement this type of construction and ensure the best results of joints between the components with considering the best materials for connections.
  - **Monitoring and following up process**. The project must be monitored and followed up by consultant engineers in order to specify problems at each stage to ensure a good quality end product and save time. The management team should also present the quality performance metrics and consider the variation figures.
  - **Design for manufacturing and assembly.** The design approach should focus on the ease of manufacture and efficiency of assembly. By simplifying the design of a product, it is more likely to be effectively manufactured and assembled in the shortest time and at a lower cost. It is essential that what is produced is easy to handle once it gets to the site to decrease mistakes.
  - **The importance of cooperation between the stakeholders**. Cooperation between the owner, consultants, contractors, sub-contractors, suppliers is important from the initial stages to sort out the perfect time for project completion. A restricted completion time can affect the quality of the final product as it may mean that corrective actions

for bad quality products are ignored. Therefore, it is essential to identify a reasonable time for completion in the initial plan of the project.

- Apply global quality criteria within construction companies. The decision makers in construction companies have to ensure the use and applying global quality criteria and standards for instance, ISO 9001 to ensure best end quality product.

- **Financial issues**

  - **Cost planned-well in contract**. The stakeholders must allocate reasonable and well-planned product design and construction costs in the contract. The effective calculation of the initial capital cost and the subsequent operation and maintenance costs should be ensured. It is important for design professionals and construction managers to realize these costs and not to focus only on construction cost as a component related to capital cost. It is important for the owners to estimate the related operation and maintenance cost of each alternative for a proposed facility in order to analyse the lifecycle costs. This is important as the owner is usually interested in achieving lower cost projects that align with their investment objectives.

  - **Proper checks of the owner's financial ability:** It is essential to understand the owner's budget before implementing a construction project to prevent future cash flow problems. Formal meetings between the contractors, sub-contractors, owners, etc at the early stages of the project can achieve this

- **Design issues**
  - Have a complete and suitable design ready at the right time. Contractors and the management team ensure that completed documents offer clarity consistency. Therefore, it is vital to consultant professional engineers in order to create design related documents.

  - Decrease the number of design changes. From the early stages of a project, clients need to be aware of the consequences of changes as OSC needs an early design freeze to produce components. Thus, any change leads to cost and time increases and may cause deficiencies to the end product. Therefore, it is essential to integrate and understand the client's requirements at the early stage.

  - **Use BIM to help with the design and construction process**. This is for efficiency, collaborative working, stakeholder engagement, the provision of manufacturing information, and to meet client information requirements. BIM needs to be used from the early stage of the project.

- The government departments have a role in helping to integrate OSC design experiences gained in different regions to develop a set of design standards and codes applicable across all regions. The Ministries of Housing and Planning are responsible for issuing the codes and standards for the Iraqi construction industry.

- **Management**
  - **Effective site management and supervision**. It is recommended that the abilities and characteristics of project managers and engineers are developed through proper and continuous training programs on effective project management with a focus on leadership. The role and responsibilities of teams have to be clarified to prevent the division of decisions amongst different parties. This entails redesigning employees' jobs around the core business processes, enhancing horizontal authority, and empowering employees to manage their business processes in a way that creates self-esteem.

- **Clear communication and cooperation**. The project team must negotiate and consult with departmental managers on various issues and having frequent progress meeting. Establishing an electronic database to facilitate the maintenance of the data produced throughout execution the business processes, and sharing them with the company's projects and units
- Prevent the possibility of mismanagement by accepting bad quality. Government bodies have to be aware of the possibility of mismanagement and to allocate appropriate actions, such as award contracts to reliable contractors. Also, distributing roles among the team and giving the decision-making power to each process manager at each stage can reduce the phenomenon of mismanagement.

7.2.3 Challenges Inhibiting Productivity & Market drivers

This part demonstrates challenges inhibiting productivity & Market drivers of using OSC in Iraq. These challenges are design, policy information, regulation, management, and construction site. However, Indicative actions to overcome these challenges will be developed. The red texts explored from validation stage conducted in chapter 8.

Table 7-3: Indicative actions to overcome challenges inhibiting Productivity & Market drivers of using OSC in Iraq

Challenges inhibiting productivity & market drivers	Sub-challenges	Cross links	Indicative actions to overcome challenges Details (section 7.2.3.1)	Cross links
Design	• Delays in the planning process • Recurrent changes to the design • Incomplete and imprecision in the design • Lack of experienced planners and designers	Section 2.4.4 Section 5.2.7	➢ Effective planning and scheduling. ➢ Standardization of the design information. ➢ Providing proper design. ➢ Allocate efficient designers	➢ Section 5.3.8 ➢ Section 5.3.7 ➢ Section 6.1.1.4
Policy formation	• Lack of certainty and continued project construction • No career prospects for new graduates	Section 2.4.4 Section 5.2.4	➢ Flexibility policies regarding construction industry. ➢ Offers job opportunity for new graduates.	➢ Section 6.1.4.4 ➢ Section 5.3.1

Regulation	• Poor contract requirements • Lack of regulation to support the use of OSC in Iraq	Section 2.4.4 Section 5.1.7	➢ Adopt new engineering contract ➢ Revise regulations to support the use of OSC in Iraq	➢ Section 6.1.4.4 ➢ Section 5.3.1 ➢ Section 5.1.7
Management	• Coordination problems between the project team • Lack of a standard method for productivity measurement. • Too many supervisors at one site	Section 2.4.4 Section 5.2.8	➢ Proper communication between project team ➢ Enhancing the standardisation of productivity measurement tools ➢ Affective site management and supervision	➢ Section 2.4.4 ➢ Section 5.3.6
Construction site	• Poor health and safety system • Unavailability of skilled labour • Rework	Section 2.4.4 Section 6.1.4.3	➢ Integrate H& safety program in company strategy and policy ➢ The construction has to be implemented by skilled team and expert contractor ➢ Initiatives on labour training	➢ Section 6.1.4.1 ➢ Section 6.1.4.3 ➢ Section 5.1.6 ➢ Section 5.3.4 ➢ Section 2.8.5

7.2.3.1 Indicative actions for the Productivity & Market drivers

- **Design**

➢ **Effective planning and scheduling:** Through a precise analysis of the requirements and needs from the beginning and emphasising the cooperation of the client to avoid delays. A guideline should be organised for document control, response, and reporting procedures. Moreover, the role of the project leadership is to ensure effective planning and scheduling in coordination with consultants' engineers.

➢ **Provide a proper design for the implementation** of the on-site assembly and installation and ensure the assembly sequence is easy to follow. Moreover, coordination of the different specialties through a logical sequence of information transfer and avoiding incorrect assumptions.

➢ **Standardise the design information** to avert the omissions, errors and continuous changes that affect the development of projects.

➢ **Allocate efficient designers:** Decision makers need to ensure the plan is developed and to design the project using experienced national or international designers.

- **Policy formation**

➢ **Adopt transparent and flexibility policies regarding the construction industry.** Strategies have to be developed to support the use of OSC, such as offering lands to implement such construction with continued projects. The role of the Ministries of Planning and Housing should include the approval of lands for construction after following the submission of a report by the Construction Leadership Council that details each city's requirements and the suitability of lands for construction. Hence, this could encourage investors to apply OSC projects by assuring the continuation of a project.

➢ **Offers job opportunity for new graduates.** Decision-makers must exploit the potential of graduate people by opening job opportunities for them, especially in the field of OSC in order to acquire skills and fill the gap of skills shortage for this type of construction. The Ministry of Work and Social Affairs is vital in providing jobs and offering training programmes. This can encourage investors to implement OSC projects when skilled labour is available; moreover, it can help to enhance the economy of the country by reducing unemployment in Iraq.

- **Regulation**
  - **Adopt new engineering contracts for OSC work** in the private and public sector, which focus on the qualifications and experience of contractors. All parties work together to achieve the client's objectives, sharing the risks between parties. The contract document should be clear, simple and easy to understand. The Ministry of Housing is responsible for presenting such documents in collaboration with the Ministry of Planning.
  - **Revise regulations to support the use of OSC in Iraq including codes and standards.** The council prepares a report to display details for each city; this includes the examination of the city's budget plan, its climatic resilience and agricultural areas, and whether there are railway oil pipelines. Then, it submits its recommendations to the Ministry of Planning to determine whether these areas are suitable for OSC. Consequently, the Ministry of Planning establishes the regulations and sends them to the Iraqi Parliament for approval.
- **Management**
  - **Proper communication between the project team**: proper management communication and control tools to facilitate the transferral of information, including the use of advanced technology tools, such as BIM.
  - **Enhance the standardisation of productivity measurement tools**. Choose a standard productivity measurement method to evaluate and monitor the performance of business operations according to company requirement and abilities.
  - **Affective site management and supervision**. Develop the abilities and characteristics of project managers and engineers through proper and continuous training programs on effective project management with a focus on leadership. The role and responsibilities for teams have to be clarified to prevent the division of decision-making amongst different parties. Redesign employees' jobs around the core business processes. Enhance horizontal authority and empower employees to manage their business processes in a way that creates self. Prepare a guideline for a document control, response and reporting procedure.

- **Construction Site**
  - **Integrate health and safety within company strategy and policy.** This can add to business excellence and success, allowing businesses to contribute to sustainable growth. Business owners and company directors are legally responsible for H&S management. This means they need to ensure that workers - and anyone else visiting their sites - are protected from anything that may cause harm, and to control any risks that can cause injury in the workplace**.** Moreover, it recommends employing an officer on the construction site to monitor and check safety procedures during implementation.
  - **Construction has to be implemented by skilled teams and expert contractors**. To avoid mistakes and improve quality performance, OSC has to be undertaken by skilled labour and expert contractors according to a quality standard, such as ISO 2015. Owners need to ensure they employ expert contractors and skilled labour.
  - **Certification and training program**. Construction companies have to develop their labour skills continuously. Establishing offsite association is important in providing training for workers. The other role is related to academic universities and colleges in providing courses for OSC to expand knowledge. Alternatively, hire expert international labour or managers, especially for large projects.

7.2.4 Challenges inhibiting Social drivers

Challenges affect social drivers will be identified in table 7.4. However, indicative actions for overcoming the challenges to Social drivers will be explored. Moreover, the details of these indicative actions will be provided under the table.

Table 7-4: Indicative actions for overcoming the challenges to Social drivers of using OSC in Iraq

Challenges affect Social drivers	Sub-challenges affect Social drivers	Cross links	Indicative actions Details in section 7.2.4.1	Cross links
Management	• Inadequate safety planning after the contract has been awarded	Section 2.8.5 Section 6.1.3.4	• Proper safety planning • Effective H&S legislation in the workplace.	Section 2.8.5 Section 6.1.6.2 Section 6.1.3.4

	• Indifference to changing unsafe practice • Insufficient finance allocated to health and safety		• Strong commitment to change unsafe practices • Preparation of an appropriate budget to cover H&S requirement	
Knowledge & attitude	▪ Lack of knowledge and awareness. ▪ Contractor apathy about health & safety.	Section 2.8.5 Section 5.1.4	▪ Leverage awareness among companies and workers. ▪ Employ efficient contractors.	Section 2.8.5 Section 6.1.6.1 Section 5.1.4
Construction site	▪ Difficult manual handling and lifting. • Time pressure and overtime project. • Accidents	Section 2.8.5 Section 6.1.1.3	• Enhance the ease and safety of construction site procedures. • Efficient use of personal protective equipment. • Risk management.	Section 2.8.5 Section 5.3.11 Section 2.8.10

7.2.4.1 Indicative Actions for the Social drivers

- **Management**

➢ **Proper safety planning.** A proper safety strategy should be developed and implemented as part of the company's economic policy. This plan could involve instructions on how to avoid danger and the best way to react when a person in danger. For example, according to The Iraqi Legislation Base of the Supreme Judicial Council, for projects with more than 100 and up to 500 workers, responsibility is assigned to a committee within the project called the Occupational Safety and Health Committee, which is formed according to the following membership:

- The business owner or his representative - Chairman
- The Technical Director and Heads of Technical Departments - members
- Project doctor or nurse - member
- A representative of the trade union committee - member

  - One of the workers, responsible for occupational safety and health - full-time member
  - A rapporteur of the committee, who should have passed a basic course at the National Centre for Occupational Health and Safety.
- The inspection section in the Department of work and Vocational Training is responsible for:
  - Supervising the implementation of occupational safety and health in accordance with the provisions of the work Law No. 71 of 1987 and the instructions issued pursuant thereto.
  - Coordinating with the National Centre for Occupational Health and Safety on the implementation of work and safety precautions, and health and safety
  - Following-up and completing transactions related to occupational health and safety.
  - Committees who are responsible for assigning tenders to ensure the suitability of contractors when performing H&S procedures in the workplace.
  - Contractors who are responsible for providing PPE. Training workshops could be held by the project manager to leverage the knowledge among the workforce on how to be safe. These requirements should be agreed in the contract between the project team.
- **Effective H&S legislation in the workplace**. The proper implementation of health and safety legislation can increase the possibility of cost effectiveness, giving way to higher profitability. Therefore, the decision-makers have to validate such legislation and be involved in the contract. The inspection section in the Department of work and Vocational Training is responsible for:

  - Supervising the implementation of occupational safety and health in accordance with the provisions of the work Law No. 71 of 1987 and the instructions issued pursuant thereto.
  - Coordinating with the National Centre for Occupational Health and Safety on the implementation of work and safety precautions, and health and safety
  - Following-up and completing transactions related to occupational health and safety.

- Committees who are responsible for assigning tenders to ensure the suitability of contractors when performing H&S procedures in the workplace.

➢ **A strong commitment to change unsafe practices.** Management commitment plays a major role in health and safety performance, as the manager can conduct the majority of training in health and safety legislation. A good manager has a strong impact on changing unsafe practices by leverage H&S procedures and encouraging their team to train and follow these procedures.

- **Knowledge & attitude**

➢ **Leverage awareness among companies and workers.** The roles of the Iraqi OSC association and decisionmakers are essential to provide meetings and workshops for construction companies that address induction training, safety committees, subcontractor safety, safety records and documents, safety manager actions, and safety considerations.

➢ **Conducting efficient contractors.** The optimal choice of contractor with a good image in and commitment to maintaining health and safety performance. Committees who are responsible for assigning tenders to ensure the suitability of contractors when performing H&S procedures in the workplace,

➢ **Preparation of appropriate budgets to cover H&S requirements.** This can include training and providing Personal Protective Equipment for workers. Contractors who are responsible for providing PPE. Training workshops could be held by the project manager to leverage the knowledge among the workforce on how to be safe. These requirements should be agreed in the contract between the project team.

- **Construction site**

➢ **Enhance ease and safety of construction site**. Design teams need to take the health and safety implications into account when considering different options in their designs to avoid accidents. Weight and centre of gravity and safe lifting points should be clearly identified on each element to facilitate mechanical and manual handling where appropriate. In addition, it is important to check that transport and delivery method minimise manual handling.

➢ **Efficient use of personal protective equipment.** The leadership can ensure this point and motivate their workers by enforcing their policy, creating a culture of safety for instance, encourage feedback on how to create a safety environment, perform hazard analysis, carry out regular training, choose the right PPE.

- A project manager or supervisor needs to talk to their employees about the dangers of the equipment or location they are working in.
- The supervisor or manager needs to explain to their workers what could happen if they are not using their PPE, and how could it protect them when they use them. Once workers can foresee the results of an accident, they are more likely to realise the importance of using their PPE protection.
- Workers need to be involved by creating their own "Why I Work Safe" boards; where they can post pictures of loved ones or even a favourite hobby they could not do if they were hurt.
- Pay Attention to your workers' preferences on model and brand of PPE. If a certain type is comfier for them, try to adapt their preferences.
- Each incoming worker has to be shown and trained on how to wear and use the PPE required for his or her job.
- The manager and supervisor need to lead a good example for their workers by using their PPE when are out in the field even for a few minutes.

➢ **Risk management.** The project manager has to consider the possibility of risks in a project, especially time overruns and adopting pre-prepared emergency alternative plans to avoid a negative impact on the safety performance.

7.2.5 Challenges inhibiting Environmental drivers

Challenges inhabiting the effectiveness of environmental drivers will be demonstrated in this part. Moreover, indicative actions will be explored. Details of such actions will be provided under the table. The red texts explored from validation stage conducted in chapter 8.

Table 7-5: Indicative actions to overcome challenges inhibiting Environmental drivers of using OSC in Iraq

Challenges inhabiting the effectiveness of environmental drivers	Sub-challenges	Cross links	Indicative actions details in section (7.2.5.1)	Cross links
Construction	• Improper handling of waste materials • Lack of efficient thermal insulation • joints problems, for instance, the use of improper materials for joints or choosing the inappropriate time of the year to fill the joints.	Section 2.8.6 Section 5.2.2	• Promote recycled materials and resources • Plan efficiently • Use efficient thermal insulation materials. • Use efficient joints materials in optimal time of the year.	Section 5.3.9 Section 2.8.6 Section Section 5.1.2
Knowledge & attitude	• Lack of knowledge and skills for sustainable building • Lack of public awareness and interest	Section 2.8.3	• Leverage awareness and education • Enhance company's reputation and brand image • Availability of skilled labour	Section 5.3.4 Section 5.3.2 Section 6.1.5.1
Regulation	• Lack of finance support • Lack of firm regulation to support sustainable construction	• Section 2.8.3	• Financial incentives • Establishment of legislation.	• Section 6.1.3.3 Section 2.8.3

7.2.5.1 Indicative Actions for Environmental drivers

- **Regulation**
  - **Establish legislation.** To ensure that the stakeholders follow best practice and implement sustainable construction. Government agencies need to ensure that sustainable designs and construction practices are combined in new buildings. The Iraqi Environment Ministry in cooperation with the Ministry of Housing is responsible for issuing rules to protect the environment when implementing projects and using renewable resources.
  - **Financial incentives**. More tax rebates and subsidies for OSC projects to encourage investors and enhance sustainability.
- **Knowledge & attitude**
  - **Company's reputation and brand image.** Decision-makers need to ensure the optimal choice of contractor company with a moral obligation to protect the environment
  - **Leverage awareness and education**. The role of the Environmental Protect Ministry is essential to raise awareness through workshops, media, etc. Cooperation between academic consultants and construction companies is also important to leverage awareness and enhance people's attitudes. Also, the benefits of sustainable construction should be readily available to the public.
- **Construction site**
  - **Promote recycled materials and resources**. Reused materials and products, such as used reinforcements or any refused products. Designers are responsible for evaluating the lifecycle of materials (e.g. renewable or non-renewable, long or short)
  - **Use efficient thermal insulation materials**. Use materials with a low impact on the environment (e.g. low pollution, low energy use). Professional designers are responsible for creating efficient thermal insulation. Contractors should ensure the purchase of efficient insulation and not simply focus on cheap prices.
  - **Plan efficiently**. Design with the whole lifecycle in mind to minimise waste and follow the specifications provided to reduce wastage and monitor labour usage. Use alternative and durable materials that have little impact on the environment.
  - **Use efficient joints materials in optimal time of the year**. The most important problem in OSC is the joints with respect to the thickness of the joint and the type of material used to fill the joints and the time of dictation, which is preferable to be in

winter and when temperatures are the lowest possible to determine the depth of dictation in proportion to the width of the joint and according to recommendations of the manufacturer of joint material to avoid tearing.

7.2.6 Challenges inhibiting Policy drivers

This part will show how policy drivers can be affected by some inhabiting challenges. However, in order to face these inhabiting challenges, indicative actions will be illustrated in table 7-6. Moreover, the details of these indicative actions will be provided. The red texts explored from validation stage conducted in chapter 8.

Table 7-6: Indicative actions to overcome challenges inhabiting Policy drivers of using OSC in Iraq

Challenges to policy drivers	Sub-challenges	Cross links	Indicative actions Details in section 7.2.6.1	Cross links
Management	• Lack of commitment • Fragmentation of authorities • Unreliable leadership	• Section 5.2.8 • Section 5.2.2	• Authorities require more power to ensure the industry players are following the rules and regulations • Consensus among authorities in decision making • The optimal choice of efficient leadership in making decision.	• Section 5.3.6
Regulatory procedures	• Lack of government support • Lack of codes and standard • Lack of regulation support using of OSC	• Section 5.1.7 • Section 6.1.8	• Financial incentives • Establishment of Iraqi codes and standards • Strengthen legal machinery to support OSC.	• Section 5.3.1 • Section 5.3.7 • Section 6.1.8 • Section 2.8.9

7.2.6.1 Indicative actions for the Policy drivers

- **Management**
  - **Authorities require more power to ensure that industry players** follow the rules and regulations provided, such as heavier fines or more stringent laws in the case of no commitment. The Construction leadership council in cooperation with Ministry of Planning and housing could issue these regulations
  - **Consensus among authorities in decision-making**. The establishment of stronger enabling institutions (e.g. a specific agency coordinating governments and authorities) is recommended in order to unify decisions and integrate the legal documents.
  - **The optimal choice of efficient leadership in making decision.** To avoid the mismanagement and the neglection of the regulations, it is highly recommended to allocate efficient, expert, committed leadership to drive the project affectively and prevent the bad implementation.
- **Regulatory procedures**
  - **Financial incentives**. More tax rebates and subsidies for OSC to attract investors and to provide incentives that promote a good image of OSC implementation. The Ministry of Finance has a vital role on providing financial support in cooperation with the Ministry of Housing.
  - **Establish codes and standards.** It is important to provide an Iraqi code to facilitate OSC work and implementation, so that construction companies and manufacturers can follow these codes and standards. Committees from different ministries, such as Development and Quality Control in the Ministry of Housing, in cooperation with committees from the Engineers Association and the Ministry of Planning, develop the required Iraqi codes and standards and present them in the form of laws and guidelines for Iraqi contracting.
  - **Strengthen the legal machinery to support the uptake of OSC.** The government needs to implement a policy for sustainable construction and effective legislation. The Iraqi contract needs to be reviewed to support the use of OSC in Iraq by decision-makers.

7.2.7 Challenges inhibiting Labour drivers

Challenges inhabiting the labour drivers of using OSC in Iraq will be illustrated in the table below with their indicative actions. Details of these actions are also provided with their details.

Table 7-7: indicative actions to overcome challenges inhabiting the Labour drivers of using OSC in Iraq

Challenges to labour drivers	Sub-challenges	Cross links	Indicative actions Details in section 7.2.7.1	Cross links
Skills & knowledge	• Lack of knowledge & skills	• Section 5.2.7	• Certification and training programs • Hiring experts	• Section 5.3.4 • Section 5.3.1
Work environment	• Poor health & safety system • Work in difficult weather	• Section 2.8.5 • Section 2.8.4	• Strong commitment to change unsafe practices • Ensure the best time of the year for implementation	• Section 2.8.5 • Section 2.8.4
Management	• No incentive • Poor salary	• Section 2.8.4	• Ensure a fair salary and reliable incentives for workers	• Section 2.8.4 • Section 5.3.2

7.2.7.1 Indicative Actions for Labour drivers

- **Certification and training programs**. Construction companies have to continuously develop their labour skills. Establishing an offsite association is important to provide training for workers. The other role relates to the provision of courses for OSC to expand knowledge by academic universities and colleges. Furthermore, it is necessary to hire expert international labour or managers especially for large projects.
- **Strong commitment to change unsafe practices.** Management commitment plays a major role in health and safety performances, as the manager can conduct the majority of training on health and safety legislation. A good manager has a strong impact on changing unsafe practices by leverage H&S procedures and encouraging their team to train and follow these procedures.

- **Choosing an appropriate time for implementation:** Stakeholders need to understand the best time of the year to implement their project in order to avoid bad weather conditions.
- **Ensure a fair salary and reliable incentives for workers**. The project manager role in ensuring this action is vital in order to ensure good labour productivity.
- **Hiring expert people**. To prevent poor design and rework design, an expert designer must be involved in the design process nationally or an expert designer should be hired, especially for large projects. The Ministry of Housing can facilitate the hiring of expert professionals in cooperation with the Ministry of Foreign Affairs.

7.3 Indicative actions for barriers in using OSC in Iraq

This section will demonstrate the barriers affecting the use of OSC in Iraq. Indicative actions will be developed in order to overcome these barriers. The red texts explored from the validation stage conducted in chapter 8.

Table 7-8: Indicative actions to overcome the barriers affecting the use of OSC in Iraq

Barriers factors	Related barriers	Cross links	Indicative actions to overcome barriers details in section 7.3.1	Cross links
Skills & knowledge	• Lack of knowledge and experience • Lack of skills • Lack of Research & Development • Lack of information or strategic planning to enhance the use of OSC • Non-working days lead to negative impact on labour productivity.	• Section 6.2.7 • Section 5.2.7 • Section 5.3.10 • Section 6.2.10	• Integration between academic and industry participants • Certification and training programs • Incentives to attract people to learn such construction • Proper strategic planning established • Reduce non-working days • Hiring experts • Ready model	• Section 5.3.10 • Section 5.3.4 • Section 5.3.6 • Section 5.3.3

Logistic & site operation barriers	• Unsafe sites restricted by external parties • Restricted site layout, space size, access, storage and site location. • Difficulties and delays in transporting of materials and components from factory to site • Hard implementation onsite. • Poor implementation.	• Section 5.2.1 • Section 6.2.1 • Section 6.2.1.5 • Section 6.2.1.6 • 6.2.10	• Secure construction site by authorities and effective rules established to protect construction projects. • Improved site tidiness. • Provision of suitable equipment, cranes and special transport vehicles for lifting and transporting products. • Provision of clear information on the working conditions and risk assessment. • Trustworthy companies. • Local factories • Reducing non-working days	• Section 5.3.2 • Section 5.2.3 • Section 5.3.1 • Section 5.3.11 • Section 5.3.6 • Section 2.5.6 • Section 5.2.1

Supply chain & Procurement barriers	• Unable to provide varieties of OSC products • Delays and the long-distance transportation of material. • Insufficient road network • Disturbances to the supply chain • Poor supply chain • More complex payment terms & cash flows process and financial administrations where mixed offsite and onsite components are required.	• Section 5.2.6 • Section 6.2.6 • Section 5.2.1 • 6.2.6.2 • 6.2.10	• Develop efficient road networks. • Efficient supply chain management is required • Register different OSC providers. • Adoption of an advance plan for the inventory and storage of materials needed by the project. • Local factories • Reducing the numbers of non-working days	• 5.3.1 • 5.3.12 • 5.2.6 • 5.2.1 • Section 2.5.5 • Section 2.8.8

Project complexity barriers	• Long lead time • Poor project performance • Lack of regulation • Complex and limited design • lack of requirement for the specification of OSC in Iraq • Unable to make change in field • Lack of commitment	• section 5.2.2 • section 6.2.3 • section 6.2.3.1 • section 6.2.3.2	• Early advice and decisions on the supply chain. • Reliable companies • Established Iraqi codes and standards • An engineering role to simplify the design is essential. • *Specifying the details of requirements in the bids* • Regulations • Fine system • Good management system	• Section 2.5.5 • Section 2.5.4 • Section 2.8.9 • SECTION 5.3.2 • SECTION 5.3.7 • Section 5.3.8 • Section 5.2.2

Management barriers	• Delayed decision-making. • Absence of effective communication between project team members • Deficiencies and corruption in dealing with project management. • Poor management system	• Section 5.2.8 • Section 6.2.8 • Section 6.2.1.3 • Section 2.8.8 • Section 2.5.7	• Proper project management system. • Improved communication between project teamwork. • Avoidance of delays in decision making • Risk management • Involve financial manager for monitoring and controlling the project process. • A comprehensive review should be conducted into current laws in the General Conditions of Contract for Works of Civil Engineering. • The adoption of a scientific basis is advisable for the correct, accurate and fair classification of contractors and their potential financial knowledge, experience and reputation. • The appointment of oversight committees and inspectors.	• Section 5.2.8 • Section 5.3.11 • Section 2.5.7 • Section 2.8.9

Industry & market culture barriers	• Clients desire traditional construction and custom made • Negative image from past attempts of the application of OSC can limit acceptance • Difficult to obtain formal approval (financial insurance for this type of construction).	• Section 5.2.4 • Section 6.2.5	• Models: Establish ready models of OSC to leverage awareness and knowledge. • Use reliable companies • Conduct awareness workshops • Integrate between academic and industry participants • Flexibility in dealing with planning approval for such construction by local authorities. • Service after selling • Reducing the length of the implementation chain • Enhance public-private partnership	• Section 5.3.3 • Section 5.3.2 • Section 5.3.1 • Section 5.3.5 • Section 5.3.6 • Section 5.3.12 • Section 2.5.2

Cost barriers	• Higher transportation cost where long distances are involved • OSC is often considered more expensive compared to traditional methods • Higher initial cost	• Section 5.2.3 • Section 6.2.2	• Mass production. • Establishing factories inside Iraq • Government support. • Adopt cost-benefit analysis • Identify economical insulation to reduce costs • The length of the implementation chain should be reduced as this increases the cost of the housing unit • Attractions should be offered to local people to encourage participation in the OSC industry • Ensure early occupation for cost effectiveness	• Section 5.3.1 • Section 5.2.3 • Section 2.5.1 • Section 5.3.9

Political & economic barriers	• Unstable security situation
	• Financial status fluctuation
	• Unstable Current market condition.
		• Section 5.2.5
		• Section 6.2.4
		• Section 2.5.8
		• Section 2.8.6
			• Adopt effective policy to protect construction projects
			• Issuing special laws to deal with sabotaged projects
			• Allocate a special budget for rehabilitate the destroyed projects
			• Adopting special Insurance policy to protect projects
			• Supporting and stabilizing the prices of raw materials included in the construction vocabulary of building units.
			• Designers and contractors have to improve safety in design and structure that can endure or resist terrorist attacks
			• Risk assessment
			  ◦ Allocate a special budget to protect the projects that will be established
			  ◦ Training specialized cadres to guard projects
			  ◦ Providing advanced security surveillance cameras linked to specialized security agencies to face the security chaos that may be exposed to the project
				• Section 2.5.8
				• Section 5.3.11
				• Section 5.3.1
				• Section 5.2.1
				• Section 2.8.6
				• Section 5.1.2

Non-working days	• Large numbers of religious and national non-working	• Section 6.2.10	• The government has to address this problem seriously by establishing laws controlling the effect of this issue • Risk assessment and provision of alternative practical solutions • Development of an efficient implementation plan to address the non-working days. • Leverage awareness • Provide small temporary specialized factories close to the site to provide materials needed by the project, such as doors, doors handle, pipes, and lights. • Establish mobile local factories, like concrete batching plants	• Section 6.2.10 • Section 5.2.9

7.3.1 Details of indicative actions for barriers affecting the use of OSC in Iraq

This section gives details of the indicative actions for the barriers of using OSC in Iraq. The red texts actions explored from the validation stage conducted for this research in chapter 8.

7.3.1.1 Indicative actions for Skills & Knowledge barriers

- **Integration between academics and industry participants**. The integration and sharing of knowledge between academic consultants and industry construction participants is essential to improve the adoption of OSC in Iraq. Clients, the industry and government should build an alliance aimed at fundamentally changing the entire market to encourage the adoption of innovation in construction. A business model workstream could be created to promote and lead this change. This could be applied by the Ministries of Planning and Housing or by the Construction Leadership Council.
- **Certification and training program**. Construction companies have to continuously develop their labour skills. Establishing an offsite association is important to provide training for workers. The other role relates to the provision of courses to expand knowledge on OSC by academic universities and colleges. Furthermore, hiring expert international labour or managers especially for large projects. The Construction Industry Training Board (CITB) could offer training support. Information about the skills requirements for OSC, which could also be available from the Engineering Construction Industry Training Board (ECITB).
- **Incentives to attract people to learn such construction.** This is the duty of the Ministry of Construction and Housing and Ministry Of Planning who allocate such incentives for younger people to learn new skills.
- **Establish proper strategic planning**. There must be clear and appropriate planning based on scientific foundations. Moreover, there should be support and government incentives for this type of construction. *Continuous effort by the Construction Industry Development Board (CIDB) to establish a better training scheme is vital, along with the Continuous Professional Development (CPD) and Continuous Contractor Development (CCD) programmes. The Ministry of Finance in cooperation with banks, the Ministry of Planning and Housing collaborate to develop a strategic plan that*

involves actions to help investors work with OSC projects. This could include finance support, land, training workshops, the provision of raw materials and tax breaks.

- **Hiring expert people**. To prevent poor design and rework design, an expert designer must be involved in the design process nationally or an expert designer should be hired, especially for large projects.
- **Models.** Establish ready models to leverage awareness and knowledge about OSC in Iraq. The models could be undertaken by the Ministry of Housing to leverage awareness among clients. It has to be open for clients and engineering consultants in order to benefit from feedback. In addition, companies could build a model in order to advertise their products and receive feedback; indeed, national and international events offer good opportunities to show models.

7.3.1.2 Indicative actions for Supply chain & Procurement barriers

- **Establish local factories**. It is vital to establish offsite manufacturing factories to produce different types of products in Iraq. Moreover, providing the raw materials and tools for assembly in the Iraqi market enables an efficient supply chain. Thus, establishing local factories will significantly support the use of OSC in Iraq as it will ease the supply of materials and reduce transportation problems.
- **Develop an efficient road network.** Authorities have to efficiently develop the quality and capacity of the road network. In general, the Ministry of Transport and Communications, with its organizational structure and current powers, is the closest to adopting a strategic direction in its planning for the national transport sector and the active participation of all other parties involved in the sector's operations. This entails:
- Rehabilitating damaged roads and bridges, and establishing various new types of road including rapid, arterial, secondary and rural.
- Developing rail to reduce the road transportation of goods.
- Legislating a new law or amending current legislation to impose fees at specific rates for the use of main and arterial roads and the use of bridges. This could secure adequate funding for the regular and sustainable maintenance of roads and bridges.
- Introducing modern and advanced technologies with economic returns to rehabilitate and maintain road works and provide the means for their success.
- Enhancing the role of the private sector in providing services.

- **Efficient supply chain management is required.** Top management must demonstrate their leadership and commitment to procurement so that officials understand that procurement is a key job. Some actions related to supply chain management are as follows:

  - ❖ Effective communication among project participants is required to increase efficiency between supply chain participants.
  - ❖ Effective management system is required for managing cash flow during mixed onsite and OSC.
  - ❖ OSC requires a procurement strategy that can clearly recognize the supplier, manufacturer and sub-contractor with not only minimal costs but with the right capability, competence and capacity.
  - ❖ Ensuring that the contract documents are simple, clear, and easy to understand.
  - ❖ Following the design specification.
  - ❖ Providing transparency in procurement decisions.
  - ❖ Accounting for the purchase of environmentally friendly materials; it is preferable to adopt these contracts.
  - ❖ Ensuring that a supplier is able to offer maintenance and a schedule of maintenance.

- **Registered different OSC suppliers**. The companies need to have redundant suppliers to face disturbance and poor supply chain and avoid monopoly. Contractors have to coordinate with different manufacturers to ensure a smooth supply chain. It is recommended that projects understand the capability of manufacturers and whether they are able to supply off-the-shelf or just-in-time products.

- Adoption of an advance plan for the inventory and storage of materials needed by the project. The contractor and project manager are able to facilitate this action affectively to avoid any disturbance in the project

7.3.1.3 Indicative actions for Project complexity barriers

- **Early advice and decisions on the supply chain to reduce long lead times**.

  - ❖ Component supplies should form part of an early assessment and be part of preconstruction programming.
  - ❖ A long-lead time has to be considered by the manufacturers and designers/consultants.

- ❖ Reduced transportation should be enabled to avoid long lead times; thus, it is advisable to locate an OSC factory near construction sites, especially for big projects. Otherwise, it is advisable to use local suppliers.
- ❖ Incentive schemes could be used, for example a bonus in terms of financial reward if completing earlier.

➢ **The role of engineering to simplify design is essential.** The architect could undertake the following: -

- Simplifying the design by producing uncomplicated products, and identical and repeated components.
- Improving the aesthetic value and providing variation to the external outlook.
- Providing creativity for interior design.
- Providing a building design or components that are sufficiently flexible to adapt to future requirements (like functional changes, increased numbers of users).
- Increasing accessibility that is appropriate to all users.

➢ **Establish Iraqi codes and standards**. To reduce design conflicts between the stakeholders in different regions in Iraq, results on bad quality products. The government bodies are essential in helping to integrate the OSC design experiences gained in different regions to develop a set of design standards and codes applicable at all regions. Committees from different ministries, such as Development and Quality Control in the Ministry of Housing in cooperation with committees from the Engineers Association and the Ministry of Planning, should develop the required Iraqi codes and standards and present them in the form of laws and guidelines for Iraqi contracting.

➢ **Good management system**. As the survival of companies depend on their leadership and decision-making regarding systems, procurement and human capital. Leadership experience and effectiveness will allow a company to develop its human capacity, adopt IT and improve their processes and performance.

- **Reliable companies.** It is important to award contracts to reliable, experienced companies with well-known reputation in the market that are able to provide good quality products with a high durability. The existence of such companies is vital to the successful use of OSC in Iraq and in meeting client information requirements.

- **Fine system**: There is a widespread problem concerning the lack of commitment amongst the construction industry, especially when contractors have many projects at one time, or the owner has difficulties in paying. Therefore, establishing a system of fines will force the stakeholders to commit.

➢ **Regulation to support the use of OSC in Iraq**

❖ Government bodies are responsible for implementing such regulations. The council prepares a report to display details for each city in which the city's budget plan is examined, alongside its climatic resilience and agricultural areas, and whether there are railway oil pipelines. Then, it submits its recommendations to the Ministry of Planning as to whether these areas are suitable for OSC. Consequently, the Ministry of Planning establishes the regulations and sends them to the Iraqi Parliament for approval.

❖ A consensus is required among authorities – federal, state, and local.

❖ The integration of legal documents is essential.

- **Specifying the details of requirements in the bids. Government bodies are responsible to specify the details of the project requirement such as table of quantities and standardisation to avoid wrong estimation by the contractors.**

7.3.1.4 Indicative actions for Logistic & Site operation barriers

➢ **Easy access and effective layout**.

❖ Ensuring space and access to execute the production and installation of works. *The site layout should be planned properly. Contractors are responsible for preparing the site layout plan. Waste and rubbish should be cleaned immediately. Thus, a clean site and healthy work environment will decrease site accidents.*

❖ **Improved site tidiness.** For improved site tidiness, the project manager is responsible for effectively managing sites.

- ❖ **Plans deliveries ahead of time,** Planning deliveries ahead of time to ensure efficiency, timeliness, and thus manage costs.
- ❖ The use of BIM can help describe the construction site in 3D and through different phases.

- **Secure construction site** is ensured by authorities and effective rules are established to protect construction projects. The Ministry of Housing is responsible for this in cooperation with Ministry for the Interior.

➢ **Provision of clear information on working conditions and risk assessments**.

- ❖ The working conditions are all the existing circumstances affecting labour in OSC production or installation, including job hours, physical aspects, legal rights and responsibilities and safety procedures.
- ❖ Contractors or sub-contractors should ensure the provision of suitable equipment, special transport vehicles and cranes to lift and transport products. Precast concrete elements can be delivered just in time for erection, thus reducing unnecessary handling and equipment use.

➢ **Local factories**. To avoid transportation problems, it is vital to establish offsite manufacturing factories to produce different types of products in Iraq. Moreover, providing the raw materials and tools for assembly in the Iraqi market enables an efficient supply chain. Establishing local factories will significantly support the use of OSC in Iraq as it eases the supply of materials and facilitates access to new materials instead of materials that have been damaged.

7.3.1.5 Indicative actions for Cost barriers

➢ **Mass production.** It is recommended to use mass production when applying OSC to reduce the overall cost of the project.

➢ **Identify economical insulation to reduce costs.** Architects have the ability to innovate different types of insulation in order to reduce cost. Iraq has the raw materials to make insulation; therefore, the Ministry of Industry could involve their engineers to innovate such insulation.

➢ **Establishing factories inside Iraq.** It is vital to establish offsite manufacturing factories for producing different types of products in Iraq. Moreover, providing the raw materials and tools for assembly in Iraqi market for efficient supply chain.

Establish local factories will support the using of OSC in Iraq dramatically as it eases the supply of materials and facilitate access to new materials instead of materials that have been damaged

- **Government support.** Government enhancement by providing more incentives and tax exemptions and quick funding response and by encouraging the private sector.
- Adopt cost-benefit analysis: it means a process business use to analyse decisions. It applies to examine if the benefits of taken such decision or investment is outweigh its cost by comparing several decisions benefits and costs. It is recommended to be done in pre-construction stage by professional engineers.
- Attractions should be offered to local people to encourage participation in the OSC industry. Manufacturers and contractors need to search for and train local workers to save expenses and sustain work.
- Ensure early occupation for cost effectiveness; contractors and owners should cooperate for mutual benefit (e.g. employ skilled labour and consultants to ensure the best implementation and reduce defects). An early risk assessment should be conducted to avoid any activity or incidents that could disturb the time performance.
- The length of the implementation chain should be reduced as this increases the cost of the housing unit; in Iraq, the tender refers to several parties and each party wants to achieve a profit, which leads to an increase in the final cost of the product.

7.3.1.6 Indicative actions for Industry & Market culture barriers

- **Models.** Establish ready models to leverage awareness and knowledge about OSC in Iraq. The models could be undertaken by the Ministry of Housing to leverage awareness among clients. It has to be open for clients and engineering consultants in order to benefit from feedback. In addition, companies could build a model in order to advertise their products and receive feedback. National and international events are good opportunities to show models.
- **Reliable companies.** Use those providing good quality products with a high durability and with experience and a well-known reputation in the market. The existence of such companies is vital to successful use of OSC in Iraq
- **Awareness workshops.** A general awareness of OSC is crucial to its successful adoption. There is an urgent need to provide workshops and training aimed to improve awareness of OSC among manufacturers, architects, engineers, designers and local

planning and building personnel. Increased awareness is essential, because only through that can OSC become more accepted in Iraq with less resistance. An Iraqi OSC association has an important role to provide such workshops and training**.**

- **Integration.** The integration and sharing of knowledge between academic consultants and industry construction participants is essential to improve the adoption of OSC in Iraq. Clients, industry and the government should strive to build an alliance aimed at encouraging the entire market to adopt innovation in construction. A business model workstream could be created in order to promote and lead this change. The Ministries of Planning and Housing or the Construction Leadership Council could apply this.
- **Flexibility in dealing with planning approval for such construction by local authorities**. The role of associations is important to support the use of OSC in Iraq and to ease the approval by contractors
- **Service after selling.** Companies have to provide service after sales and provide a customer service options in order to build trust between the end user and companies which in turn can lead to reduce negative image about this type of construction.
- Enhance public private partnership. This involves cooperation between a government bodies and a **private**-sector company for finance, build, and implement projects. The following should influence the construction process: current government-funded demand-side motivation for house building; measures to ease the planning system; public land supply initiatives; tax breaks for investors, and tax-free raw materials.
- Reducing the length of the implementation chain is recommended because this increases the cost of the housing unit; in Iraq, the tender refers to several parties and each party wants to achieve a profit, which leads to an increase in the final cost of the product and this consequently leads to reluctance of people to buy.

7.3.1.7 Indicative actions for Management barriers

- **Proper project management system**.
  - This is recommended to develop the abilities and characteristics of project managers and engineers through proper and continuous training programs on effective project management with a focus on leadership. CITB is responsible for training courses. The Ministry of Labour and Social Affairs can provide training programmes in accordance with other ministries in order to provide skilled labour and leadership and offer jobs.

- A focus on research and development to study management with a focus on leveraging leadership capabilities. Through education courses, colleges and universities could make their curricula more approachable to leadership and consider management's need for modern engineers.
- The role and responsibilities for teams have to be clarified to prevent the division of decisions amongst different parties. Redesigning employees' jobs around the core business processes is necessary, as well as enhancing horizontal authority and empowering employees to manage their business processes in a way that creates self.
- Prepare a guideline for document control, response and reporting procedure

- **Improve communication between project teamwork**.
  - The project team must negotiate and consult with departmental managers on various issues and hold frequent progress meeting. Establish an electronic database to facilitate the maintenance of the data produced throughout the execution of business processes, and to share them with the company's projects and units. Managers and supervisors within organizations should address communication needs
  - Employ technologies use through the project implementation such as BIM.

- **Avoid delayed decision-making**. The importance of consulting specialised individuals in decision-making can avoid longer decision processes by authorities who are unfamiliar with this type of construction. Government bodies can help to minimise the long process of approval by authorities.
- **Risk management**. Contractors should learn how to share and shift risks by hiring specialised staff or specialised subcontractors. It is suggested that the contractor enforces the employment of a specialised project management company for large projects. Contractors should make unremitting efforts to avoid financial failure by following strict cash flow management procedures. They also have to understand how to take advantage of transferring and sharing risks by employing a professional team or professional subcontractors.
- Involve financial manager for monitoring and controlling the project process. The role of such manager is essential to monitor the cash flow and to manage expenses and may be able to find alternative ways for enhancing profits.

- **A comprehensive review should be conducted into current laws** in the General Conditions of Contract for Works of Civil Engineering; these suffer from a clear imbalance which can lead to a negative outcome for projects at all stages
- **The adoption of a scientific basis is advisable for the correct, accurate and fair classification of contractors** and their potential financial knowledge, experience and reputation. Committees in Ministry of Housing are currently responsible for these.
- **The appointment of oversight committees and inspectors** affiliated with the Ministry of Housing could monitor the progress of work and reduce the possibility of corruption when implementing construction projects.

7.3.1.8 Indicative actions for Political & Economic barriers

- **Adopt an effective policy to protect construction projects**. Government involvement is crucial to provide a security protection policy. Specialized committees involving the Ministries of Planning, and Housing and Construction developed this plan with the purpose of protecting projects. The implementer of this plan is the Ministry of the Interior. The plan also establishes laws for the construction of buildings and housing in the governorates with need. The plan also defines housing requirements and the Ministry of Construction and Housing. It implements required projects in the governorates, especially afflicted ones, through its subsidiary companies or these are presented to the private sector for implementation.
- **Special laws should be issued to deal with sabotaged projects**. The Ministry of Construction & Housing could issue these laws in accordance with the Ministry of Industry and Ministry of Trade. For example, the Ministry of Trade imports materials to replace the damaged ones and accelerates the rehabilitation process of destroyed projects. This means issuing laws to accelerate action and providing bulldozers to remove damaged materials and rubbish; the council of regions that face destruction could provide such equipment.
- **Allocate a special budget for sabotaged projects**. Allocating a special budget for sabotaged projects that could be allocated by the Ministry of Finance for the Ministry of Housing and could finance projects that have been destroyed in order to help the owner and contractor.

- **Adopt a special insurance policy to protect projects.** Adopting a special insurance policy to protect projects, as the owner or contractor needs to deal with insurance companies to protect projects in the case of explosions, accidents, militia attacks and floods. These companies have to be specialised and with a quick rescue plan and decisive actions.
- **Support and stabilise the prices of raw materials included in the construction of vocabulary of building units**. Support and stabilise the prices of raw materials including the construction of a vocabulary of building units. The Ministry of Industry determines the prices of materials and the Ministry of Trade can legislate laws and instructions to fix prices and set up control committees to monitor the price of local and imported materials in local markets. The Ministry of Housing recommends buying raw materials from factories affiliated with the Ministry of Industry to avoid high prices and monopolies.
- **Risk management:** potential terrorist threats should be examined and evaluated, and it is crucial to provide practical alternatives for any destroyed project, rather than build a new one. For example, storage could be allocated in different regions to supply materials in case of terrorist attacks or theft; alternative routes could be determined for the transportation of materials if the usual road is unsafe; helicopters could be launched to protect and control materials that are transported by road from neighbouring countries; security checkpoints could be established by the Ministry of the Interior along roads to protect the transportation of materials.
- **A special budget could be allocated to protect the projects that will be established**. Designers, owners, contractors, and leaders should be aware of the following: -
  - The allocation of money to guard the project.
  - The allocation of money for training cadres to protect construction sites.
  - The assignation of money to establish security surveillance cameras linked to specialized security agencies to protect construction sites and storage spaces.
  - The provision of emergency plans and actions to treat injuries.
- Training specialized cadres to guard projects. The Ministry of Labour and Social Affairs, in cooperation with the Ministry of Interior, is responsible for providing training for cadres to protect projects
- Providing advanced security surveillance cameras linked to specialized security agencies could address the security chaos that the project may be exposed to. Surveillance towers can

be set up by the Ministry of the Interior in cooperation with insurance companies to protect large projects. Surveillance cameras can be placed every 10 km from a project to monitor any suspicious movement of armed groups.

- Designers and contractors have to improve safety in design and structure that can endure or resist terrorist attacks. The structure of the building needs to be able to resist explosion. Designers need to ensure the quality and strength of the materials that will be used for constructing the buildings. Contractors need to use materials with such specifications particularly for conflict zones.

7.3.1.9 Indicative actions for Non-working days barriers

- The government has to address this problem seriously by establishing laws controlling the effect of this issue. The government has to address this problem by establishing laws that control the impact of this issue. Iraq has the highest number of non-working days worldwide and this causes high economic loss. A decision by the Iraqi parliament is needed to address this issue by reducing the number of non-working days resulting from formal and informal events as these dramatically affect construction projects.
- Conduct risk assessments and provide alternative practical solutions, for example:
    - Contractors can employ two shifts of work in a day;
    - The number of workers on working days could increase and could be offered initiatives to ensure the project is finished with the scheduled time;
    - Local workers could be employed for onsite activities so that disruption is minimised from the road closures resulting from religious events and the cancelation of work limited;
    - A cost model should be considered at the design stage by considering these days and monitoring the cost during all stages of work;
    - Alternative ways can be found to save costs when the project is affected by such non-working days;
    - Develop an efficient implementation plan to address the non-working days. This includes a time frame for all activities involved in the project with consideration of the nonworking days. The leadership of the project has an important role in managing the implementation plan.
- Leverage awareness towards the negative outcomes on a project and the economics of the country of these non-working days as a result of the significant number of religious

and national non-working days. Conferences could be held in universities, engineering associations and committees related to Ministry of Construction and Housing to leverage awareness.

- Provide small temporary specialized factories close to the site to provide materials needed by the project, such as doors, doors handle, pipes, and lights.
- Establish mobile local factories, like concrete batching plants.

7.4 Chapter summary

This chapter presented the strategic guidelines for the development of best practice for using OSC in Iraq derived from the findings of the mix method approach. The first section demonstrated the drivers of using OSC in Iraq. Challenges that can inhabit these drivers are also included, while indicative action to eliminate these challenges were developed. However, section 2 shows the barriers of using OSC in Iraq. Indicative actions are developed to eliminate these barriers. Some of the remarkable indicative actions found in these guidelines are:

- The importance of government support
- Establishing Iraqi codes and standards
- Cooperation
- Integration between academic and construction companies
- Training programs
- Risk management
- Reliable companies
- Public-private partnership
- Commitment
- Strong leadership

Hence, the proposed strategic guideline is expected to benefit governments, policymakers and academics by enabling them to identify the area of concerns and determine best practice in order to take full advantage of the benefits offered by OSC. In the next chapter validation of the guideline will be presented.

Chapter 8 Validation

8.1 Introduction

Throughout Chapter 8, the applicability of the proposed guideline regarding OSC in Iraq was tested, and the guideline subsequently resynthesized to meet the requirements to improve the use of OSC in Iraq. Moreover, semi-structured interviews were conducted with participants from construction industry and academic consultants for testing the applicability of the strategic guideline, and to acquire a broader confirmation concerning the guideline's validity, credibility, and applicability. Consequently, this chapter presents the procedure adopted in conducting this round of interviews, the results obtained from this exercise, and the details of the final recommended strategic guideline to improve the use of OSC in Iraq.

8.2 Validation Process

The strategic guideline produced in Chapter 7 can be seen as one of the important contributions of this study. This guideline is based on the literature review and research findings from the questionnaire survey and interviewees. This helped to obtain further confirmation and a broader view regarding:

1) Its use and potential for utilisation in practice to enhance the use of OSC in Iraq
2) The completeness and validity of this guideline
3) Whether it is understandable, logical and suitably sequential as a guideline

A validation exercise was undertaken with four leading and highly qualified experts in the field of construction management. Participants involved in the validation process were selected based on their experience in OSC. The first participant was a senior manager and selected for his position as a consultant in the Iraqi Ministry of Construction and Housing, which is considered the official owner of most Iraqi government construction companies (IGCC). The second interviewee was an executive director of one of the IGCCs and selected for his experience in the practices employed by their company in delivering construction projects. The other two interviewees were from higher education institutions, holding PhD degrees in construction management, and already engaged in OSC projects In Iraq. Table 8.1 demonstrates the key information of the interviewees who participated in the validation exercise.

Table 8-1: Information of the interviewees involved in the guideline validation interviews

Participant Name	Position / Role	Experience (years)	Organisation
RV1	Senior Manager/ Consultant	30	The Iraqi Ministry of Construction and Housing
RV2	Executive Director	25	An IGCC
RV3	Lecturer	17	An Iraqi Higher Education Institution
RV4	Associate Dean	27	An Iraqi Higher Education Institution

The interviews were held using skype and phone, at different times, as designated by the participants. Employing a similar process to that used in the second round of data collection, participants were initially provided with a brief explanation of the research aims and objectives. Thereafter, interviewees were invited to examine the guideline strategy in detail, and asked to add, adjust, or remove any element or feature of the strategic guideline as required. Moreover, by the end of each interview, the participants were asked several questions to validate the guideline's strategy for enhancing the use of OSC in Iraq and determine whether they can accept the guideline. All interview sessions were held in Arabic. The conversations with most respondents were recorded using an electronic recording device, and the recorded data were then transcribed and analysed manually.

8.3 Participants' responses to the strategic guideline

The validation interviews asked participants to express their perspectives regarding the strategic guideline's usefulness and capacity to improve the use of OSC in Iraq, including the ease of understanding and use, its main advantages and disadvantages, and the completeness of the strategic guideline. The interviewee feedback is illustrated in table 8.2.

Generally, the feedback gained from the interviewees was positive; all participants found the strategic guideline useful and believed that it would enhance the use of OSC in Iraq. They also mentioned several advantages that could be gained from implementing the strategic guideline, without stating any disadvantages within the strategic guideline itself. From their perspective, it is clear and easy to understand. However, VE4 believes that some indicative actions mentioned in the strategic guideline may take a long time to be implemented. Moreover, VE2 recommended the production of an Arabic version of the strategic guideline to make it more understandable for Arabic speakers.

Moreover, most interviewees were motivated to deploy the strategic guideline. Nevertheless, they did not hide their anxiety about the challenges that could be faced in the implementation process. While VE1 recommended implementing the strategic guideline immediately, VE4 believed that some indicative actions could not implemented in short time. Moreover, VE3 predicted that there would be many challenges for its implementation due to the need to change the organisational culture. Nevertheless, VE2 emphasised that there are a number of critical success factors that should be carefully considered in order to ensure a successful implementation. Meanwhile, VE3 recommended that, in order to reduce the implementation challenges, it would be better to implement the strategic guideline first on a limited scope, such as within one of the governmental companies. This would firstly facilitate the identification and management of problematic points and difficulties, and secondly, give a good opportunity to understand the advantages and disadvantages of the strategic guideline in practice. Indeed, all these views are valuable; however, the implementation of the strategic guideline is out the scope of this study.

Nonetheless, the interviewees agreed on the completeness of the strategic guideline, and VE1 declared that the strategic guideline covers all the aspects required to improve the use of OSC in Iraq. Similarly, both RV3 and RV4 considered it a holistic improvement strategic guideline designed to optimise the practices of OSC, whereas VE4 commented that the strategic guideline may be improved during the implementation. In fact, an important feature of the strategic guideline is that it is designed to be flexible rather than mandatory so that it can be continually improved based on the feedback and further recommendations obtained. Consequently, it can be concluded that the interviewees agreed overall that the strategic guideline is useful and can enhance the use of OSC in Iraq. However, further studies are required to cover all aspects of its implementation.

Table 8-2: Participants' responses to the strategic guideline

Questions	VE1	VE2	VE3	VE4
Do you find the strategic guideline useful and could it enhance the use of OSC in Iraq?	Yes, it helps in spotting the obstacles and understanding the solutions. It also assists in allocating the roles and responsibilities to manage and develop the use of this construction	Absolutely, I believe it is very useful and rich in information that would improve our company's performance for this type of construction if this strategic guideline is properly followed. Indeed, it can be useful to be use for any type of construction project.	Yes, since it simplifies and expands knowledge about this type of construction	Yes, nobody can doubt its usefulness
What are the advantages and disadvantage of the strategic guideline?	There are many advantages in the strategic guideline, like the logic of the interactive actions to overcome barriers, playing an educative role in informing decision making and companies; the suggestion of establishing an OSC association is the most important feature of the strategic guideline. In terms of disadvantages, I cannot see any disadvantages; it is all ok.	Ensuring a systematic way of executing and controlling projects, providing clear roles and responsibilities for the key stakeholders. Nevertheless, some critical success factors need to be evaluated in order to achieve the best implementation. These include, for example, ensuring top management awareness and absorbing the need for this strategic guideline, highlighting contradictions within the Iraqi regulations and a	This strategic guideline is a standard framework for guiding companies on how they should manage their project in order to undertake them successfully. It provides efficient actions for controlling the obstacles. Thus, it can ensure continuous improvement in the adoption of OSC. But in terms of disadvantage I can't note any.	The strategic guideline has the potential to introduce a step change to improve the use of OSC in Iraq. However, due to the current local culture and the current political situation, it is expected that there will be many challenges in its implementation. I mean, some actions need a long term for adoption like establishing Iraqi codes and standards.

		willingness to change amongst the stakeholders.		
Do you find the strategic guideline is easy to understand?	Yes, it is quite understandable and achievable	Yes, it is easy to understand. However, an Arabic version of it will be helpful for Arabic speaking people.	Yes. However, people who are more familiar with this type of construction can understand it more easily	Yes, it is very clear
How do you assess the completeness of the strategic guideline?	It is an inclusive strategic guideline that covers all the key aspects required to optimise the use of OSC in Iraq.	It is quite a comprehensive strategic guideline, and I'm very glad about its detail and elements. I really hope that such a strategic guideline will be adopted in our companies**.**	Yes, it is a holistic approach contains logic suggestions and recommendations for improving the use of OSC; from my point of view, it can be considered complete.	It is complete. Yet, this guideline can be improved, or even amended, after the implementation starts when all the strategic guideline assumptions will be tested
Do you find the strategic guideline is easy to use?	Yes, I would recommend working on applying it immediately.	Yes, if it is ensured that the decision makers have undertaken an awareness programme regarding the need for such a strategic guideline.	Applying this strategic guideline would mean needing to change the organisational culture, implementing an electronic system, and ensuring competent and well-trained employees, etc. Therefore, I recommend implementing it first on large government companies to test its applicability.	It can be implemented immediately. However, some actions can be achieved in a short time, while others may need a long time to achieve. Indeed, the implementation of the strategic guideline will require further studies.

8.3.1 Validation of the challenges and their Indicative Actions related to the drivers for using OSC in Iraq within the strategic guideline

The interviewees were asked to examine and validate the strategic guideline produced in Chapter Seven. All participants agreed with strategic guideline elements, whilst some recommendations were added to enhance its clarity and efficiency. The following shows the recommendations indicated by the participants:-

8.3.1.1 Time and cost drivers

The challenges and indicative actions identified for these two drivers (cost and time) are strongly agreed by all participants. However, the interviewees noted some extra challenges and indicative actions. Interviewee VE1 pinpointed the "monopoly of the market by some suppliers" as an important barrier that should be added to the materials group, as it can cause time and cost overruns; for instance, refusing the selling of products for the company. Moreover, this barrier was agreed by interviewees VE3 and VE4; VE4 further added that, to overcome this challenge, "a negotiation strategy has to be established" such as developing a strategic partnership with a monopoly supplier. Another point indicated by VE2 for the management barrier is a "strong policy for effective legislation" in order to effectively control the project performance. Interview VE3 appreciated this action and offered the following amendment, "Good note, I would recommend adding it too".

In regard to the external factors' challenge, VE1 demonstrated another important challenge, which is a "Lack of close infrastructure or difficulties in accessing them". He justified that this problem can negatively affect time and cost or perhaps halt the project; therefore, ensuring such facilities are close to the site is vital to any construction project. EV1 further indicated the importance of an "insurance project" to reduce the impact of an unstable political and security situation. All interviewees agreed on this point.

All interviewees agreed on this point. Nevertheless, they also agreed on the contractual challenge with indicative actions. However, EV2 explored another challenge relating to the contractual issues' category; namely that can cause time and cost overruns which represent an "Underestimation of time for [the] completion of … projects". This can be avoided by agreeing an appropriate project completion time amongst the team at the planning stage.

8.3.1.2 Quality drivers

Three of the experts accepted the description of the challenges that can inhabiting the quality drivers and its indicative actions without any further comment. However, VE3 added an important challenge to the category of construction related factors, which is, *"the lack of quality criteria for OSC components, either in [the] production stage or construction stage which lead[s] to quality failure."*

This an important point that was agreed by interviewee EV4 who also emphasised "*the importance of having such criteria not only within the implementation stage but also in the production process in order to leverage the quality of the final products".* In this context, EV4 strongly agreed with the idea of having allocated an observer engineer in the factory to monitor the quality control; this was explored as an indicative action within the production factor category. Moreover, EV3 further added that *"... construction companies have to apply global quality criteria and standards for instance, ISO 9001 to ensure best end quality product."*

8.3.1.3 Productivity & market drivers

In regard to productivity & market drivers, interviewees VE1, VE2 and VE3 confirmed the challenges and their indicative actions. However, Interviewee VE4 believed that some indicative action relating to regulations supporting the use of OSC may not achieved in a short time.

On the other hand, VE1 explored an important challenge, which is "*No career prospects for new graduates and this one of the issues for the recent October 2019 revolution".* VE1, VE2 and VE3 strongly agreed with this challenge. Therefore, all interviewees emphasised the importance of job opportunities for graduates in order to support this type of construction, as *"this construction* will be *the future of face housing shortage worldwide*" (EV1).

8.3.1.4 Social drivers

All experts agreed with the points mentioned in the strategic guideline without further comments. However, EV3 suggested that it would be useful if the researcher explained more about how to motivate workers to wear their PPE. The researcher takes this point into consideration and added more detail on this in the indicative actions.

8.3.1.5 Environmental drivers

The participants agreed with the challenges and indicative actions demonstrated for the environmental drivers. In general, they emphasised the phenomenon of improperly dealing with waste materials in construction projects in Iraq. Interviewee VE3 noted that, *"Indeed, Iraq is suffering from increasing waste as a result of construction activities, However, with using OSC, the waste of materials is dramatically decreased but still there is a possibility of waste especially when there is mixed of onsite and OSC".* VE1 explored an important challenge regarding construction category, namely, *"…joints problems, for instance, the use of improper materials for joints or choosing the inappropriate time of the year to fill the joints."* He further added that this point has to be taken in consideration in the design and construction stage, whilst this point was also agreed by interviewees VE2, VE3 and VE4. While, interviewee VE3 emphasised the importance of "*Using efficient joints materials in an optimal time of the year, which I recommend being in winter to avoid tearing*". Therefore, interviewee VE4 believes that this type of construction has to be implemented by reliable and expert construction companies.

8.3.1.6 Labour drivers

All interviewees agreed on the challenges and indicative actions affecting the labour drivers without further recommendation, although interviewee VE4 also stated,

> *The lack of skilled workers for this type of construction slows down its development because the need for trained skilled workers is not limited to the work onsite, but also in the factories, to deal with machines and even for loading, handling and transporting … materials, so I recommend and highly agree with your indicative action regarding training and the need to study this type of construction in colleges and universities to get a generation aware of this kind of construction.*

8.3.1.7 Policy drivers

Although the experts agreed with the challenges and indicative actions illustrated in the strategic guideline regarding policy drivers, Interviewee VE4 believes that,

> *Although I agree with you, the need for the existence of Iraqi codes and laws to support this type of construction, but the process of implementation of these laws and codes cannot happen in a short time given the current instability of political*

> *and economic issues in Iraq, but the recommendations explained in this* strategic *guideline, which I highly agreed, can be implemented immediately while some need a long time to be implemented.*

In the same context, Interviewee VE2 stated that *"I recommend using global codes like British codes, for this type of construction until establishing Iraqi codes and standards which need time to be validated."*

Nevertheless, EV2 recommended adding unreliable leadership factor under the management challenge in which can inhibiting the policy drivers,

> *I believe that the existence of efficient reliable leadership is important to leverage this type of construction; thus, ... unreliable leadership in the decision-making process may lead to wrong decisions that are not in favour of this type of construction or may lead to accepting the offers of some inefficient companies to complete projects of this type of construction, which ultimately results in poor performances.*

Interviewees EV3 and EV4 agreed with this challenge, whilst the researcher also agreed with this point and tried to explore recommendations for this barrier that need to be adopted by the government.

8.3.2 Validation of barriers and their indicative actions for the use of OSC in Iraq within the strategic guideline

With regard to the first barrier, skills & shortage, all the participants were highly satisfied with the sub-barriers which cause skills and knowledge shortages, and their indicative actions. However, interviewee EV2 indicated that "*I believe that it is important to add the need for hiring expert people; for instance, consultants' engineers and [a] skilled workforce in order to transfer experience and skills to Iraqi workers and engineers until this construction is widespread in Iraq."* The researcher has already indicated this action within the labour driver's category, although believes it is useful to add this action under the skills and shortage barrier.

On the other hand, interviewees EV1 and EV4 ascertained the importance of proper strategic planning to develop knowledge and skills for this type of construction. EV1 and EV2 believed this is the role of the Ministry of Planning, who should develop a roadmap to the reduce skills shortage in Iraq; for instance, companies offering more work placements to students in this field and sending their executive and design cadres to international companies in order to realize global experiences, transfer expertise and expand knowledge.

According to the political and economic issues. All interviewees agreed on the sub-barriers and their indicative actions that were developed by the researcher. However, interviewee VE1 added an extra indicative action for inclusion, namely:

- Allocate a special budget to protect the projects that will be established
- Train specialised cadres to guard projects
- Provide advanced security surveillance cameras linked to specialised security agencies to address the potential security issues that the project may be exposed to.

Later, all interviewees agreed with EV1's actions, whilst which EV3 believes *"I [am] highly satisfied with [the] indicative action that the researcher made, and other extra recommendations made by EV1".* Meanwhile, interviewee EV4 also agreed with these points and further commented that *"Indeed, these indicative actions will not only be specific for OSC project, but also I think we can adopt them for all types of construction*."

Furthermore, while all experts agreed that the supply chain and procurement are barriers to the use of OSC in Iraq, EV1 explored an important indicative action for consideration by the researcher, which is *"I would recommend [the] adoption of an advanced plan for the inventory and storage of materials needed by the project, as this is really important action, which I personally adopted to overcome any disturbance in the supply chain like delayed materials, which saved me time and cost*". This point was also agreed by interviewee VE2 who stated, *"good point, I highly support this action".*

For non-working days, which were explored as a barrier to use of OSC in Iraq, EV4 stated, *"Indeed, I agree with [the] all actions you explored, but I emphasised the importance of the ... development of an efficient implementation plan to address the non-working days".* However, EV1 added the following two valid and valuable points, *"I recommend to provide small, temporary specialized factories close to the site, to provide materials needed by the project such as doors, doors handle, pipes, and lights and establishing mobile local factories, like a concrete batching plant, these are more practical solution to avoid delay as the OSC requires continues supply chain".*

Interviewees agreed on its sub-barriers and indicative actions for to the industry & market culture barrier; furthermore, all interviewees noted the importance of engaging the private sector in this type of construction. EV2 believes that, *"public-private partnership is a key to success for the spread of this type of construction".* Nevertheless, EV3 commented that, *"PPP is so important for leveraging this type of construction; however, the private sector is unconfident about government support, for instance finance, continued projects and lands for investment due to unstable economic and political issues."*

Moreover, in regard to the project complexity barrier, the interviewees satisfied about the barriers and indicative actions. Moreover, interviewees EV1 and EV4 emphasised on the barrier indicated in the strategic guideline that would disturb the project, namely *"[a] lack of requirement for the specification of OSC in Iraq".* Therefore, EV1 suggests, *"I highly recommend specifying the details of requirements in the bids, for instance, details of quantities survey as this will ease the work process and reduce mistakes."* Furthermore, the cost factor sub-barriers were accepted by all expert participants emphasised the adoption of mass production to reduce cost. Meanwhile, EV4 recommended the use of cost-benefit analysis as a systematic approach to indicate the positives and negatives of the project process, including activities and process requirements.

Indeed, the logistic and site operation sub-barriers and their indicative actions were strongly agreed by all interviewees without further comments. In addition, the management sub-barriers and their indicative actions were also agreed by all interviewees. In fact, all expert participants ascertained n the importance of having a proper management system within the company as this can effectively specify the roles and activities in order to enhance the project performance. EV1 stated, *"… the role of effective leadership is vital to drive the project successfully."* Moreover, interviewee VE4 recommended the addition of another indicative action, *"I recommend engaging the Finance Manager in the monitoring and controlling project process by means of a reflection of his role in monitoring the budget of projects."*

8.4 Refinement of the Strategic Guideline

Based on the amendments given to the researcher during the conduct of the research, the opinions from the validation stage will be taken into consideration before presenting the final strategic guideline. Table 8.3 illustrates the main corrections that should be applied to the strategic guideline and its position regarding drivers and their barriers and indicative actions, while, Table 8.4 demonstrated the main corrections that should be applied to the strategic guideline and its position regarding barriers and their indicative actions.

Table 8-3: Refinement of a strategic guideline for drivers of using OSC in Iraq.

Drivers	**Challenges inhabiting the effectiveness of drivers**	**Indicative actions**
TIME & COST	**Materials**/Monopoly of market from some suppliers	Establish a negotiation strategy
	Management/No added barrier	Strong policy for effective legislation
	External factors/Lack of close infrastructure or difficulties in accessing them	Insurance project Ensure that the infrastructure is close to the site and easily accessible
	Contractual issues/ Underestimation of time for completion of the projects	Allocating the perfect time of completion project.
QUALITY	**Construction related factors**/Lack of construction quality criteria for OSC components.	Apply global quality criteria within construction companies.
PRODUCTIVITY & MARKET	**Policy formation**/No career prospects for new graduates	Offer job opportunities for new graduates.
ENVIRONMENTAL	**Construction**/joints problems; for instance, the use of improper materials for joints or choosing	Use efficient joints materials at an optimal time of the year.

	the inappropriate time of the year to fill the joints	
POLICY	**Management**/Unreliable leadership	The optimal choice of efficient leadership in making decision.

Table 8-4: Refinement of a strategic guideline for Barriers to using OSC In Iraq

BARRIERS	SUB-BARRIERS	INDIACTIVE ACTIONS
SKILLS & KNOWLEDGE	X	Hiring experts
SUPPLY CHAIN & PROCUREMENT	X	Adoption of an advanced plan for the inventory, and storage of materials needed by the project.
PROJECT COMPLEXITY	X	Specifying the details of requirements in the bids
MANAGEMENT	X	Involve the financial manager in monitoring and controlling the project process
INDUSTRY & MARKET CULTURE	X	Enhance public-private partnerships
COST	X	Adopt cost-benefit analysis

POLITICAL & ECONOMIC	X	• Train specialized cadres to guard projects • Provide advanced security surveillance cameras linked to specialized security agencies to address the security chaos that the project may be exposed to. • Allocate a special budget to protect the projects that will be established.
NON-WORKING DAYS	X	• Provide small temporary specialized factories close to the site to provide materials needed by the project, such as doors, doors handle, pipes, and lights. • Establish mobile local factories, like concrete batching plants • Development of an efficient implementation plan to address the non-working days.

8.5 Chapter Summary

This chapter revealed the process and procedures involved in validating the strategic guideline to ensure the validity, credibility, usefulness and possibility of adoption when enhancing the use of OSC in Iraq. The examination showed that there is a strong consensus amongst the interviewees on the validity and completeness of the strategic guideline. However, they recommended a few amendments to the strategic guideline to increase its clarity and validity. Moreover, the validation exercise also revealed that the guideline is useful and can enhance the use of OSC in Iraq. According to the interviewees, it is very clear and easy to understand. Additionally, most of the interviewees were optimistic about its adoptability by construction companies and decision-makers. However, they also indicated that the process of implementing the strategic guideline could face several challenges. All refinements suggested by the experts were presented in this chapter and marked in the original sections of the strategic guideline. The next chapter presents the conclusion of the current research with recommendations.

Chapter 9 Conclusion

9.1 Introduction

This chapter provides a summary and conclusion to this research project by summarising and consolidating the content of the previous chapters. It starts by revisiting the research objectives and identified how each was attained. They are followed by comments on the limitations of the research. Thereafter, this chapter concludes with a statement of the potential contribution of the research to knowledge and practice with suggestions for a number of future research directions.

9.2 Achievement of the Research Objectives

The key research findings are presented based on the objectives summarised below.

9.2.1 Objective 1

The first objective was to review and explore the current knowledge about OSC concepts, barriers and drivers of using this construction in both developed and developing countries. To address this, an extensive literature review was conducted to establish the state of the art in knowledge and practices identified in previous studies on OSC, including its systems, drivers and barriers, within the construction industry. After thoroughly examining the literature review for OSC in developed and developing countries, the researcher explored the current status of the Iraqi construction industry, including problems within the industry in Iraq and the current situation for OSC construction. The problems can be summarised as, housing shortages, delayed projects, problems with materials, contractual issues, a lack of awareness of sustainability, labour productivity issues, problems with energy use, a weak understanding of health & safety, and a poor project management system. Moreover, this review identified a lack of knowledge, and the slow adoption and use of OSC as further barrier in Iraq. The motivation to investigate the current construction industry in Iraq, which mainly uses traditional construction, stems from the researcher's desire to understand the challenges and gaps in this industry. After reviewing the literature, a solid foundation and understanding was formed, which presented cohesive grounds to specify a number of factors that could be influential in the use OSC in the Iraqi context. These factors were then incorporated into the quantitative and qualitative methods to gather the data for this research. The factors divided into two categorises mainly drivers and barriers of using OSC which illustrated in table 9-1.

Table 9-1: Factors affecting the use of OSC

Drivers for using OSC	Barriers to using OSC
• Time drivers • Quality drivers • Cost drivers • Productivity & Market drivers • Social drivers • Environmental drivers • Policy drivers • Labour drivers	• Logistic & Site Operation barriers • Cost barriers • Project Complexity barriers • Management barriers • Political & Economic Issues barriers • Skills & Knowledge barriers • Supply Chain & Procurement barriers • Industry & Market Culture barriers

9.2.2 Objective 2

The second objective was to investigate (professional and practitioner) perceptions towards barriers, drivers and good practice when utilising OSC in Iraq. The objective was achieved by gathering data via a comprehensive literature review and quantitative and qualitative empirical research activities. The findings for this objective were documented in Chapters 4, 5 and 6. It can be concluded the following: -

- The research identified that time plays an important role in adopting OSC in Iraq, as less time is required onsite, the speed of construction increases, whilst the overall project schedule reduces.
- Indeed, the use of OSC is vital to provide fast affordable housing that addresses the urgent need for accommodation in Iraq.
- The other two highly significant drivers were found to be cost and quality. This is due to the highly predictable quality of the end product, and the reduction in overall cost especially due to mass production.

- The other important driver was found to be productivity and the market, as OSC enables the development of mass production units in less time with improved overall productivity.
- This research also found other significant drivers for the adoption of OSC in Iraq, which are labour, and Social. In fact, OSC is not only needs a smaller number of labourers compared to traditional construction, but also enables improved safety performances.
- Environmental driver seems to be moderate significant in the adoption of OSC in Iraq. Nonetheless, participants acknowledged the advantages associated with this factor including less material wastage and decreased energy. However, the prevailing culture in the construction industry in Iraq seems to be more focused on achieving financial profits than addressing environmental aspects. Consequently, the moderate of significant results, for environmental drivers' factor does not diminish its importance, but it indicates a lack of awareness or lack of interest in environmental aspects by some stakeholders. Therefore, the environmental drivers' factor will consider as an effective driver in this study with moderate effect as the use of OSC can contribute to reducing CO_2 emissions which in turns reduces global warming and improve energy efficiency. Indeed, leverage environmental aspects is one of the important objectives of the emerge of modern methods of construction.
- Nevertheless, the policy driver shows a moderate significant for the using of OSC in Iraq. The construction companies' participants show more agreement for this driver than USECB participants, this is because they are directly affected by this factor. The participants ascertained the government's role in enhancing the use of OSC in Iraq, by issuing legislation, providing Iraqi codes and establishing standards and financial support.

This research found that the following barriers play an important role as obstacles to the adoption of OSC in Iraq:

- Political & economic issues, industry & market culture, skills & knowledge, supply chain & procurement, logistic & site operation and project complexity. Moreover, these barriers have a substantial influence on the cost of the project, although controlling those factors can also positively affect the overall cost.
- In spite of the results obtained from the quantitative methods for both groups, the management factor was found to be less important than the other barriers. However, the

qualitative (interviews) emphasised the significance of the management barrier and its impact on the use of OSC in Iraq. Therefore, it is worth noting that cost and management can be considered barriers to the use of OSC in Iraq and need more attention through further investigation.

❖ Another important factor that emerged from the qualitative analysis was a large amount of non-working days which leads to increased time and cost; disturbances to the supply chain & procurement, negative impact on the economic and labour productivity, disturbance on project activities, mismanagement on all project activities, and delay & difficulties of transportation resources.

Also, when considering the findings from this study with those from the literature review, it was found that other developing and developed countries also identified most of these drivers and barriers. Moreover, when considering good practice in utilising OSC in Iraq, the interviewees (in Chapter 5) explored a number of recommendations to enhance the use of such construction. Thereafter, these recommendations were incorporated into indicative actions in the strategic guideline that presented in Chapter 7.

9.2.3 Objective 3

The third objective sought to establish the relationships and interdependencies between factors that impact on the implementation of OSC in Iraq. The findings of this objective are discussed in Chapter 6. It was found that the factors of time, cost and quality were overriding drivers with the most significant inter-relationships. This accords with other researchers' findings regarding the importance of these factors. In addition, this significance is consistent with the iron triangle concepts in which time, cost and quality are presented as interrelated factors, and are closely considered by stakeholders within the construction industry. However, other factorial relationships were found to be significant including: -

- Time with (Productivity & Market, Labour and Social)
- Labour with (Productivity & Market, Cost and Social).
- Productivity & Market with Environmental.
- Social with (Cost and Quality).
- Quality with policy.

The remaining relationships are less significant relationships which are: -

- Productivity & Market with (Quality, Cost, Social and policy).
- Labour with (Quality, policy and Environmental)
- Time with (Environmental and policy)
- Cost with (Environmental and policy)
- Quality with (Environmental)
- Social with (Environmental and policy).

Furthermore, the findings of this research regarding the barriers' relationships summarised below: -

- It appears that construction companies found that industry & market culture was the most significant factor in preventing the use of OSC in Iraq. This was attributed to its highly significant relationship with political & economic, skills & knowledge, logistic & site operation, and management. The second most important factor for the construction companies' group was political & economic, as this has three highly significant relationships, namely with logistic & site operation, industry & market culture & skills & knowledge.
- In comparison, the USECB groups found that supply chain & procurement was the most significant barrier to affect the use of OSC in Iraq. This was attributed to its highly significant relationship with industry & market culture, skills & knowledge, political & economic and project complexity. The second most significant factor according to the USECB group was skills & knowledge, which had three highly significant relationships, with the supply chain, industry & market culture, and project complexity. Meanwhile, the third influential barrier was found to be project complexity as it had highly significant interacting relationships with skills and supply. Moreover, the construction companies also demonstrated a highly significant interacting relationship between the supply chain and project complexity.

Nevertheless, the researcher found significant agreement on some drivers, barriers and their interrelationships between the academic group and construction companies. This suggested the gap between the two groups was not too large. However, it seems that the results obtained from the companies may be more reflective of the reality of construction in Iraq than those of the academics because companies reflect the practical facet of projects while academics reflect the theoretical. However, both opinions must be considered in order to develop an appropriate and effective strategic guideline to support the adoption of OSC in Iraq.

9.2.4 Objective 4

Objective 4 was addressed in Chapter 7 and considered the formulation of strategic guideline that support the use of OSC in Iraq for all types of buildings. It was conducted to offer solutions and guidance on how to combat the negative factors that can inhibit the optimal outcomes following the application of OSC in Iraq. It also offers effective tools to facilitate the shift in focus of these construction companies towards the best management of OSC projects.

The objective was achieved by organising the key findings of the study in a structured format that was easily usable by decision-making institutes and construction companies. The content of the strategic guideline is based on well-researched outcomes that have been validated through reference to experts in the field. A strategic guideline was developed based on the main established and validated themes and factors that emerged from the research findings. The final version of the guideline was designed and developed based on two groups and represented under the main themes. Therefore, section 1 consisted of the challenges and their indicative actions relating to the drivers for using OSC in Iraq, while section 2 demonstrated the indicative actions concerning the barriers to using OSC in Iraq.

Some of the highlighted indicative actions for section 1 are: -

- Affective site management and supervision
- Adopt efficient delivering system.
- Risk management
- Clear communication and cooperation
- The standardisation of design information.
- Establishing Iraqi codes and standards.
- The establishment of a fine system
- The ministries have to cooperate to provide contract documents relating to the OSC method, including all stages of the project.
- A certification and training program
- Cooperation between industry and academia.
- Construction has to be implemented by a skilled team.
- Allocating a reasonable and well-planned cost of product design and construction cost in the contract.
- Flexibility policies regarding construction industry.

- ❖ Revise regulations to support the use of OSC in Iraq
- ❖ Proper safety planning
- ❖ Use efficient thermal insulation materials.
- ❖ Strengthen legal machinery to support OSC

Some of the highlighted indicative actions for section 2 are: -

- Integration between academic and industry participants
- Secure construction site by authorities and effective rules established to protect construction projects.
- Efficient supply chain management is required
- Establish local factories
- Reliable companies
- Established Iraqi codes and standards
- Proper project management system.
- Risk management
- Establish ready models of OSC to leverage awareness and knowledge.
- Use reliable companies
- Mass production.
- Government support.
- Adopt effective policy to protect construction projects
- Adopting special Insurance policy to protect projects
- Leverage awareness.

9.2.5 Objective 5

Objective 5 aimed to refine and finalise the strategic guideline through validation from industry experts. This final strategic guideline was refined and developed through the incorporation of feedback from experts in the construction field. The aim of this phase was to test the applicability of the proposed strategic guideline to address the challenges inherent in the use OSC in Iraq. The interviewees' responses were analysed, and amendments were made to the strategic guideline.

The indicative actions from the interviewees include:

- ❖ Hiring experts

- ❖ Adoption of an advanced plan for the inventory, and storage of materials needed by the project
- ❖ Specifying the details of requirements in the bids
- ❖ Involve the financial manager in monitoring and controlling the project process
- ❖ Enhance public-private partnerships
- ❖ Adopt cost-benefit analysis model
- ❖ Train specialized cadres to guard projects
- ❖ Provide advanced security surveillance cameras linked to specialized security agencies to address the security chaos that the project may be exposed to.
- ❖ Allocate a special budget to protect the projects that will be established.
- ❖ Provide small temporary specialized factories close to the site to provide materials needed by the project, such as doors, doors handle, pipes, and lights.
- ❖ Establish mobile local factories, like concrete batching plants

Hence, the examination showed that there is a strong consensus amongst the interviewees on the validity and completeness of the strategic guideline. Moreover, the validation exercise also revealed that the strategic guideline is useful and can enhance the use of OSC in Iraq. Therefore, as objective 5 has been achieved, it can be considered that the aim of this research has been fulfilled.

9.3 Limitations of the Study

Although the aim and objectives of this research were achieved, it is noted that the current research faced several limitations during the conduct of the research process. The limitations encountered during this research are detailed below:

1. The research problem was confined to Iraq, with data only collected within the country, although the findings from the literature review concerned a range of different countries and regions, and therefore included drivers and barriers in common with this study.
2. Although the final strategic guideline of the study has been validated by a series of expert interviews, its applicability and practicality remain untested as this is beyond the scope of the study.
3. There is a lack of literature in terms of information and statistical data related to OSC in Iraq.

4. The researcher faced an unstable security situation during the primary data collection period in Iraq, as it was at war with ISIS, which meant the researcher was at risk from terrorist attacks when visiting. Therefore, the researcher could not organize more than one interview on any given day, besides the interviews were sometimes disrupted, so it was either completed on the same day or completed another day; this is all due to the uncertain situation.

9.4 Contribution to Knowledge and Practice

This research contributes to knowledge by the following's points: -

- Although there is a wealth of knowledge on OSC in developed and some developing countries and in a variety of industries, there is limited literature on the Iraqi construction industry. Therefore, the contribution of this study is significant, as it is considered the first of its kind conducted in Iraq. It provides a clear perspective on this type of construction, whilst also identifying and prioritising key drivers for its use and addressing the barriers it may face. By using questionnaires and interviews, this study has reached a conclusion regarding the main factors associated with the implementation of OSC in Iraq. Accordingly, this research closing the gap identified from the literature concerning OSC in Iraq. Consulting construction companies and an academic group in order to gather rich information about the concept of OSC and the factors that influence its adoption has tested these constraints and drivers.
- The research also enriched knowledge by exploring the current most significant problems within the construction industry in Iraq. This, in turn, will provide a foundation for the refinement of research in the construction industry in Iraq in general and for OSC method in particular.
- This research has led to a better understanding of OSC, and clarified the main factors that the government, companies, educators and policy makers should take into consideration when improving the adoption of OSC in Iraq. Equally, this research has provided a solid platform for future research that aims to expand knowledge in this field. Moreover, this research explored the significance of the relationship between the factors affecting the use of OSC in Iraq, which not only benefit the construction industry

in Iraq, but also contribute to an increased understanding of these relationships in other construction industries in different countries.

- Moreover, as there is no formal approach to enhance the uptake of OSC in the Iraqi construction industry, this research has developed a strategic guideline to fill this gap. In doing so, it offers an important and creative contribution to knowledge and practice. This strategic guideline will assist and guide construction industry practitioners to understand the challenges and potential solutions in order to make informed decisions. This can enable the efficient implementation of OSC in a way that meet the needs of different types of construction projects in Iraq, particularly for house building and infrastructure. It will also support government initiatives to develop the field of construction. Indeed, the strategic guideline provides rich information that has been validated by experts in the field of construction.
- Furthermore, the factors relationship schematic diagrams and strategic guideline used in this research can be used for appropriate education and training processes. The schematics diagrams of influential factors could be integrated into higher education programmes within construction-management-related disciplines, while the strategic guideline developed in this study could be used as industry training programmes. This would contribute to improved decision-making in construction management and help to increase the uptake of OSC in Iraq.
- Consequently, to promote the appropriate use of OSC, the influential factors identified in this research should be carefully considered to achieve successful OSC implementation. In addition, the proposed strategic guideline will ensure that organisations are aware of the needs, skills and tools required to enhance the OSC implementation process. Moreover, this could help to minimise and combat the failures that currently occur in the application of OSC in Iraq through use of a validated strategic guideline that is recognised by several experienced experts in the construction industry in Iraq. Thus, this offers the possibility of adopting or adapting these research findings during the creation, implementation, management and evaluative stages of OSC projects in Iraq. It is also possible to use the strategic guideline in different contexts, such as similarly developing countries that aim to conduct OSC projects that may require guidance and appropriate steps to follow in the initial stages of implementation and creation.

9.5 Future research

The following offers some recommendations for future research in this field of study

- Future research could explore and capture the successful elements from organisations which have successfully moved from traditional to OSC, potentially through the use of case studies. The research should identify the success factors that have proved significant in this transformation process and aim to develop a more realistic and robust roadmap for the Iraqi market and its industries.
- As expressed by a number of respondents, the implementation of the suggested strategic guideline could be a challenge due to current local culture. Therefore, further in-depth studies are recommended to identify the key implementation of critical success factors of the proposed strategic guideline.
- The research considers all types of projects; however, it could be useful to study a project's success based on its type (namely, housing, civil engineering, infrastructure, industrial building). This can be achieved by collecting more data on individual project types.
- Since the data was obtained in Iraq, it is suggested that the outcomes from this research should also be tested and verified in different developing countries, such as Egypt, Yemen, Jordan, Libya and Syria, to ensure its applicability to other developing countries. Some modification of the strategic guideline developed within this study may be necessary to accommodate local differences.
- It could be useful to test end users' perceptions of OSC in order to understand their expectations and needs when considering this type of construction.
- A study could be conducted into how Small Medium Enterprises (SMEs) can benefit from the transformation of large contractors in Iraq to OSC.
- An increasing global awareness of sustainability has put the construction industry under immense pressure to improve its project efficiency and deliverables. OSC has the potential to promote sustainable development and green construction, which could be achieved through a controlled production environment, the minimisation of construction waste, an extensive use of energy-efficient building materials, a safer and more stable work environment, and better investment for a long-term project economy. A study is therefore suggested to link and merge OSC and sustainability within an Iraqi context.

- To prioritise the research areas, importance must be given to research that can solve issues concerning cost, such as investigating the whole lifecycle cost of an OSC building. This could also consider the provision of flexibility in design and cheap thermal insulation.
- Further studies could investigate the institution of an appropriate safety net to motivate contractors to become more innovative in OSC and more involved in technological approaches, such as robotics and modular building.
- Future research could conceptualise a readiness framework to assess the maturity level and preparation of construction organisations for adopting OSC practices in Iraq.
- Future study to investigate in details how national and religious non-working days factor has an impact on construction projects and how to reduce the negative impact of this factor and examine the possibility of establishing laws to reduce them.

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Appendices

Appendix 1/ The interview questions

Semi-structured Interview Guideline

Introduction

The main aim of this interview is to understand the interviewee's perspective about factors related to the adoption of OSC in Iraq. The data collected from the interviews will help the researcher understand the current drivers and barriers of OSC as they currently exist in this context. Accordingly, there are not right or wrong answers for the upcoming questions, rather it is a matter of reflecting the interviewee's experience with the phenomena as they were conceived.

Your rights

You may decide to stop being a part of the research study at any time without explanation. You have the right to ask that any data you have supplied to that point be withdrawn or destroyed. You have the right to omit or refuse to answer or respond to any question that is asked of you. You have the right to have your questions about the procedures answered (unless answering these questions would interfere with the study's outcome). If you have any questions as a result of reading this information sheet, you may query the researcher at any time.

Section 1: Participants' information

1 You have been working in construction since……?
2 Which organisation do you belong to?
3 What is your qualification?
4 What is your position?

Section 2: Drivers of using OSC in Iraq

1 How can time factor be a driver for using OSC in Iraq?
2 How do you see the quality of the products when using OSC, what about the quality of the final products?
3 How can you describe the cost of OSC as a driver like reducing construction cost and minimising the overall life cycle-cost of a building?
4 How can you explain the legislation including revision of regulation and availability of codes and standards as a driver to enhance the use of OSC?
5 How would you describe the environmental factor as a driver for using OSC?

6 Do you agree that the Using of OSC increase the workers productivity and minimise the number of workers required in onsite construction?
7 Do you believe that the use of OSC contribute into improve the health and safety issues?
8 How can OSC meet the market needs in Iraq such as housing units?
9 Do you think that OSC can improve overall productivity? How?

Section 3/ Barriers of using OSC in Iraq

1. Can the cost factor be a barrier to use OSC, how?
2. How can you evaluate the political and economic factors in Iraq as a barrier?
3. How can you describe the skills and knowledge as a barrier for using OSC?
4. Can transporting factor be a barrier to use OSC like long distance transportation, how?
5. How can you evaluate these barriers of deficiencies in dealing with managing projects, delay decision from leadership, corruption, lack of communication?
6. How can supply chain & procurement be a barrier in using OSC in Iraq?
7. How can the industry and market culture be inhabiting the use of OSC in Iraq?
8. How can Logistic & site operation be inhabiting the OSC project such as unsafe site location, narrow site and difficulties in transportation?
9. How can you explain that unable to change on site by using OSC and there are limited design options and legal framework requirement can obstacle the use of OSC in Iraq?

Section 4/ Recommendations for using OSC in Iraq

1 How can you evaluate the government role in enhancing the use of OSC construction?
2 Is there any recommendation for future strategy to develop the use of OSC?
3 How do you foresee the integration between the stakeholders of OSC projects?

Appendix 2/ Questionnaire list

Part 1/ the following part show the respondent background

1. What is your position in your company?

1. Civil engineer [ ] 4) Consultant [ ]
2. Manager [ ] 5) Others [ ]
3. Architect [ ]

2. Your experience of OSC:(in years)

2.1 [ ] < 5
2.2 [ ] 5-10
2.3 [ ] 11-15
2.4 [ ] 16-20
2.5 [ ] > 20

3. What are the main sub-sectors that your organisation deals/has dealt with?

- Residential [ ]
- Commercial [ ]
- Industrial [ ]
- Educational institution [ ]
- Government institution [ ]
- Hospitals [ ]

4. Do you support the use of OSC?
   [ ]Yes No[ ]
5. Do you expect that using of off-site construction will increase in the upcoming years?
   [ ]Yes No[ ]
6. Would you consider offsite methods if you have the opportunity?
   Yes, definitely [ ] yes, may be [ ] no, I prefer onsite methods [ ]
7. What are the systems that you used/use in your OSC projects?

   7.1 Volumetric preassembly [ ]

   7.2 Non- volumetric preassembly [ ]

   7.3 Hybrid system [ ]

   7.4 Modular building [ ]

Part 2/ The following table showing the factors driving the use of offsite construction in Iraq. Please tick the most appropriate box on the scale regarding the importance of the factors.

Factors	Drivers	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Time	Reduce the overall project time					
	High speed of construction					
	Ensuring time certainty					
Quality	Achieving high quality					
	Quality control review during manufacturing process and site assembly					
	OSC products are less defects than traditional construction products					
Cost	Minimizing maintenance and replacement cost					
	Reducing construction cost					
	Minimizing overall life-cycle cost					
Social	Reducing accidents onsite					
	Offers employment opportunities for local communities with greater long-term security for the individual worker					
	Improves working conditions for workforce and industry					
Policy	Revision to building regulation to support OSC					
	Government promotion and support					
	Availability of legal, standards and codes framework to cover all stages of the project					
Productivity & Market	Improve overall project productivity					
	Addressing the problem of housing shortage in Iraq					

	High volume production of mass units in short time					
	Providing affordable housing					
Environmental	Decrease the energy use during construction and building usage					
	Reduce materials waste					
	Reducing environmental impact during construction					
Labour	Reduces labour required for onsite construction					
	Improve labour productivity performance					
	Improves management and coordination among workers at the site					
Others, specify……….						

Part 3/ The following table represents the factors constraining the use of OSC in Iraq. Based on your experience, please tick the most appropriate box on the scale regarding the importance of the factors.

Barriers	Sub-themes barriers	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Logistic & site operation	Unsafe sites restricted by external parties					
	Restricted site layout, space size, access, storage and site location					
	Transport of materials and components from factory to site					
	Complex and limited design options					

Project complexity	Inability to make changes in the field by using OSC**.**					
	Building regulation/legal framework requirement					
Cost	Higher transportation cost where long distance is required					
	OSC is often considered more expensive compared to traditional methods					
	Higher initial cost					
Political & economic	Unstable security situation					
	Financial status fluctuation					
	Unstable Current market condition					
Industry and market culture	Clients desire traditional construction and custom made					
	Negative image from past attempts of the application of OSC may limit acceptance					
	Difficult to obtain formal approval (financial- insurance for this type of construction.					
Skills & Knowledge	Lack of knowledge and awareness					
	Lack of R&D in OSC					
	Lack of previous experience and skilled workforce					
Supply chain & procurement	Industry capacity to supply diverse varieties of OSC is limited due to lack of infrastructure support and resources					

	The use of OSC requires firm control of supply chain which can involves high risks.					
	More complex payment terms & cash flows process and financial administrations where mixed offsite and onsite components are required					
Management	Delay of decision making from the leadership.					
	Absence of effective communication between project team members					
	Deficiencies and corruption in dealing with managing project					
Others, specify…….						

Appendix 3/ Ethical approval letter

University of Salford MANCHESTER

Research, Innovation and Academic Engagement Ethical Approval Panel

Research Centres Support Team
G0.3 Joule House
University of Salford
M5 4WT

T +44(0)161 295 5278

www.salford.ac.uk/

14 February 2017

Nehel Saffar Lafta

Dear Nehel,

RE: ETHICS APPLICATION STR1617-26– Developing a roadmap for implementing offsite construction in Iraq

Based on the information you provided, I am pleased to inform you that your application STR1617-26 has been approved.

If there are any changes to the project and/ or its methodology, please inform the Panel as soon as possible by contacting S&T-ResearchEthics@salford.ac.uk

Yours sincerely,

Prof Mohammed Arif
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