PhD Thesis

SUPPLY CHAIN MANAGEMENT IN PREFABRICATED HOUSING CONSTRUCTION IN NIGERIA

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STATEMENT OF ORIGINALITY

I hereby certify that the work embodied in the thesis is my own work, conducted under normal supervision. The thesis contains no materials that have been accepted or are being examined for the award of any other degree or diploma in any tertiary institution and, to the best of my knowledge, contains no materials previously published or written by another person, except where due reference has been made. I give consent to the final version of my thesis being made available worldwide when deposited in the University's digital repository, subject to the provisions of the Copyright Act 1968 and any approved embargo.

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List of Publications:

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DEDICATION

This research is dedicated to God Almighty for his continuous guidance, protection, and love over me.

ABSTRACT

Urbanization has drastically increased the number of people living in cities. This has resulted in a shortage of accommodation for many sectors of society, specifically those on low incomes. This deficiency cannot be remedied by conventional construction methods, as these have long been criticized for their low productivity, cost overruns, long construction durations and wastage of resources. A shift from labour-intensive to modern approaches involving prefabricated methods of building construction is seen as a major opportunity to significantly increase the productivity and effectiveness of housing delivery. Prefabricated housing construction is also cost-effective when properly planned. Despite the potential advantages of prefabrication, the use of this approach remains low. Several authors in various countries have identified several barriers to its implementation. These include the initial high cost of establishing prefabrication firms, negative perceptions of local stakeholders, lack of infrastructure, and skill shortages. Previous research has also shown that supply chain management remains a major barrier to the implementation of prefabricated housing construction, and this has not been well-researched to date. While several studies have investigated the barriers, the literature on supply chain management in Nigeria is sparse. A comprehensive supply chain management system is required to exploit and maximize the potential of prefabricated housing construction in that country. This has motivated this study of supply chain management for prefabricated housing construction in Nigeria. The study seeks to answer the overarching research question "**How can supply chain management for prefabricated construction be enhanced in Nigeria"?**

This research question was serviced by the following objectives: (1) To review current supply chain management practices in the Nigerian construction industry and elsewhere. A Systematic Literature Review (SLR) was conducted to collect data, the outcomes of which informed objective (2), to investigate the barriers affecting the supply chain management of prefabricated housing construction in Nigeria. Semi-structured interviews were conducted with relevant stakeholders, and then transcribed and analysed. These were supplemented by the relevant literature, and recommendations for improvements in the supply chain management of prefabricated housing construction in Nigeria were made in response to objective (3). The recommendations include:

- Provision and enforcement of favourable policies
- Bottom-up approach to implementation of policy
- Training and retraining of relevant stakeholders

- Improved cooperation between project participants to enhance information sharing and relationship creation
- Establishment of more prefabrication firms to guarantee the availability of components to the people
- There must be strategic alignment and commitment among prefabricated construction supply chain members from the start of a building project until the end of a typical construction project, among others.

These recommendations, if adopted by the respective stakeholders, should improve supply chain management for prefabricated housing construction in Nigeria.

ACRONYMS

CSCM	-	Construction Supply Chain Management
CSC	-	Construction Supply Chain
CSCM	-	Construction Supply Chain Management
SCM	-	Supply Chain Management
CPFR	-	Collaborative Planning, Forecasting, and Replenishment
ETO	-	Engineer-to-Order
GDP	-	Gross Domestic Product
GSCF	-	Global Supply Chain Forum
I.T.	-	Information Technology
IBS	-	Industrialized Building System
JIT	-	Just-In-Time
MC	-	Main Contractor
MMC	-	Modern Methods of Construction
MO	-	Manufacturing Order
MOP	-	Manufacturing Order Processing
NHF	-	National Housing Fund
OSP	-	Offsite Production
OPP	-	Order Penetration Point
PCSCM	-	Prefabricated Construction Supply Chain Management
PMI	-	Primary Mortgage Institution
PPP	-	Public Private Partnership
PPA	-	Public Procurement Act
SCM	-	Supply Chain Management
SCOR	-	Supply Chain Operations Reference

DEFINITION OF TERMINOLOGIES UNDERLYING THE STUDY

The researcher cannot go into an in-depth study with the assumption that everybody is familiar with the terminologies being discussed. Therefore, these terms are briefly defined in this section. They include:

Flat-pack kit homes	Set of partially prefabricated materials commonly assembled by an owner instead of a builder, with a history of use in New Zealand, Australia, and the USA (Steinhardt et al., 2014)
Industrialization	Term incorporating manufacturing processes but also including general concepts such as scheduling, efficiency, and technology improvements (De Souza & Koskela, 2014)
Industrialized Building Systems (IBS)	Term formally defined in Malaysia in the early 2000s, encompassing the use of prefabricated, offsite, mass production of components (De Souza & Koskela, 2014).
Industrialized housing	Prominently used in Sweden and other European countries since the early 2000s, incorporating offsite manufacturing of materials, supplier coordination and the systematization of build processes. Historically used in the 1970s and 1980s in New Zealand.
Modern Methods of Construction (MMC)	The term was first used in the United Kingdom to describe changes to improve social housing construction methods (The Housing Corporation, 2003), which refers to both offsite work and onsite efficiency improvements.
Manufactured homes/housing	Used in the USA since the 1976 introduction of the alternative Housing and Urban Development (HUD) building

	code to refer to relocatable, typically low-quality homes built in a factory that includes an integral chassis for transporting the structure on wheels. Used in Australia to refer to houses built in a factory, inconsistently covering both temporary structures installed in caravan parks and villages and permanent dwellings installed on standard building sites (Steinhardt et al., 2013a)
Modular construction	Used widely, including in the UK, Australia, and North America to refer to volumetric elements constructed offsite and joined to form a permanent house. Specifically distinguished in the USA from manufactured housing, which has its own building code, while the modular building is controlled by the standard state building codes.
Offsite Manufacturing (OSM)	Used widely, including in the UK and in Australia in construction policy documents, referring to work carried out away from the building site.
Offsite Fabrication (OSF)	Widely used term with varying interpretations, usually referring to offsite manufacturing of buildings, or parts thereof, prior to installation or assembly on site.
Prefabricated housing	Used in the United States to refer to both modular and manufactured housing as a group. These two modes are both manufactured off-site but differ in terms of the building codes that are relevant.
Preassembly	This is a less commonly used term, interchangeable with offsite manufacture and variations.

Relocatable homes	Terms commonly used in Australia and New Zealand to refer to transportable houses, completely prefabricated offsite and delivered to site fully finished.
Standardisation	Standardised and industrialised production in a factory environment can be performed using unified technical criteria (O'Connor et al., 2015; Wuni & Shen, 2020). During production, operators can manage component quality, minimise faults, and ensure overall component quality. By reducing wet procedures on site, numerous services can be installed at the same time. Besides, standard prefabricated components can be recycled, removed, and reassembled, resulting in energy savings and environmental protection (Weber et al., 2011).

Note: **"Construction supply chain"** refers to the different participants/partners involved from the conception of construction projects through to their delivery. The process of integrating the partners to promote overall performance and to enhance project delivery is called **"construction supply chain management".** It reinforces the problems in the construction supply chain and may well hinder supply chain performance if adequate attention is not given to it. Poor management of construction supply chain partners may hinder the successful delivery of supply chain management. Thus, **"construction supply chain"** and **"construction supply chain management"** are both used in the thesis to explain the respective scenarios.

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CHAPTER ONE

GENERAL INTRODUCTION

1.0 Introduction

The problem of housing delivery is of great concern in many countries of the world. This problem is especially prominent in developing countries where people are faced with the problems of inadequate housing. This poses several challenges to the inhabitants of cities, and to low-income earners, and has been magnified because of a myriad of issues, including a high population growth rate, shortage of necessary skills, slow pace of construction, lack of infrastructure and logistics and the poor quality of available housing stock.

The movement of people from rural to urban areas has led to environmental problems characterized by the inadequate supply of housing in major cities. This has resulted in an unbalanced economy. The same problem occurs in developing nations, Nigeria included. Despite several attempts to address housing problems by the Nigerian government, Nigeria is still facing a housing deficit of well over 22 million dwellings (Adegoke & Agbola, 2020). For this to be significantly reduced, about one million housing units need to be built annually (Ibem et al., 2011; Lagos State EIU, 2012). Given this position, researchers and practitioners in the Nigerian built environment sector have advocated for a shift from traditional methods of construction to more advanced and efficient methods (Cao et al., 2015; Liang et al., 2017). Traditional construction methods have long been criticized for their low productivity, poor cost and safety control, long construction duration, significant resource consumption, and considerable waste production (Tavares et al., 2021).

Prefabricated construction methods have been widely recognized as a sustainable alternative to traditional construction methods. This is because of their considerable potential to improve building quality, shorten construction duration, increase efficient resource utilization, reduce construction waste, enhance health and safety performance, and enlarge economies of scale, resulting in the overall reduction of building construction costs. Adopting prefabricated methods of construction should enhance housing affordability(Steinhardt & Manley, 2016). Vanke, the largest residential real estate developer in Mainland China, reported that the construction of the Vanke Xinlicheng project in Shanghai reduced energy usage by 70%, raw materials usage by 50%, construction by 40%, and on-site labour by at least 50%, because of adopting prefabricated construction methods. Prefabricated construction thus provides promise to deliver housing. The average share of prefabrication in the construction industry across the

European Union is 20 - 25%. This share is even higher in the northern European countries, where it is up to 40–50%. However, despite the commonly cited advantages and successes of prefabricated construction around the world, the adoption of prefabricated construction in developing countries, and Nigeria in particular, is still at a low level.

Research has identified the barriers that hinder the development of prefabricated construction. These include cost, process, and knowledge, among others. Previous researchers have indicated that supply chain management is a significant challenge to the development of prefabricated building (Liu et al., 2020; Mostafa & Dumrak, 2014; Steinhardt & Manley, 2016). According to Vernikos et al. (2013), prefabricated technology is strategically important in realizing timely installation and increasing the productivity of the construction industry. This is also supported by (Minunno et al., 2018). However, performance is often hampered when the supply chain for prefabrication components is not properly managed. This is often due to the lack of real-time information about off-site elements, and the construction site (constructor) and prefabrication components manufacturer (supplier) not coordinating effectively and reacting efficiently to optimize the production, delivery, and assembly plan to eliminate impending deficiencies.

1.1 Need for low-cost housing

The population in Nigeria is over 200 million (UN, 2020). According to the estimated population density (UNDP, 2019), Nigeria has roughly 124 individuals per square kilometre, making it the seventh most densely populated country in the world. Nigeria is often referred to as the world's most heavily populated region. The availability of decent and affordable housing is a formidable problem that has made housing an issue of national concern. Housing in developing countries is one of the most important basic needs of low-income communities, as asserted by (Mukhtar et al., 2016). Mukhtar et al. (2016) has shown that Nigeria's lack of housing is a manifestation of poverty, which is the key reason why a large percentage of urban residents live in poor housing and environmental conditions of high density. This has posed major health risks and challenges to their overall productivity. The poverty level of most Nigerians makes it difficult for individuals to own their houses (Daramola et al., 2005) because the costs of building are beyond the reach of the poor. It is important to address the costs of traditional building materials with an emphasis on low-cost alternative local and indigenous building materials.

1.2 Research background

According to a United Nations study, 50% of the world population is currently living in cities. This number is expected to increase to up to 70% by 2050 (United Nations Human Settlements Programme, 2008). Meanwhile productivity in the construction sector has not increased at the same pace. This has had an impact on the housing market, which is characterized by a declining trend. Facing greater obstacles now, and under pressure to create sufficient and affordable living spaces, the construction industry needs to change its ways of thinking, and one way of doing this is to embrace alternate methods of housing construction, including prefabrication. Prefabricated construction methods have been proven to deliver houses in the most effective and efficient manner.

In the 1990s, reports from Great Britain, suggested that the industrial procedures being used in other industries should be implemented in the construction industry to improve its overall efficiency. made similar suggestions regarding the Swedish construction market. Despite these recommendations, little progress has been made in Nigeria, largely because of the project-based nature of the construction industry. Prefabrication is a construction technique that existed in the 1850s, and its use became more prominent after World Wars I and II. This construction method has since been adopted in the housing sectors of many countries, most notably in the UK, USA, Malaysia, Singapore, Sweden, Japan, India, and China (Buntrock, 2017; Rahim et al., 2012; Steinhardt et al., 2020) . However, the construction method still lacks popularity in many other countries of the world.

Prefabrication in building development has gained increased popularity and momentum in many countries of the world because of the clear potential of this approach to address housing shortages. It is increasingly being adopted world-wide to reduce housing shortages and promote improved housing delivery. The increasing recognition of the importance of prefabrication technology in building construction has resulted in studies on the management of prefabricated construction in academic journals.

Despite the potential benefits of prefabricated construction, this approach has only achieved a negligible share of the housing market in Nigeria. This is because of several barriers. These include a skills shortage, the views of the public, trust, and the supply chain. Several investigations have been carried out to address many of the barriers confronting prefabricated construction methods. As noted above, researchers from developed countries have made significant contributions to the development of the prefabrication domain, while those from

developing countries (including Ethiopia, Malaysia, and Iraq, among others) have also shown increasing interest in promoting prefabrication-related research.

1.3 Research problems

Prefabricated methods of building construction have been one of the most widely used modern methods of construction (MMC) in the world. Prefabrication is a method of construction in which the components of buildings are produced in a specific manufacturing facility and then installed on site. However, its adoption by the Nigerian construction industry has been slow. Traditional methods of housing construction have been criticized and there has been a continuous call for alternative construction methods (Baghchesaraei et al., 2015; Kolo et al., 2014a; Rahimian et al., 2017). Researchers and practitioners in the built environment have made concerted efforts to address the challenges facing building prefabrication construction technology. As argued by (Adebayo & Dixon-Ogbechi, 2017; Knaack et al., 2012; Wuni & Shen, 2020). Better coordination and management of prefabricated construction is an important factor that requires full resolution. Robust supply chain management is important for the delivery of a successful prefabrication project; however, previous researchers have focused on other factors (Rahimian et al., 2017; Xuejian & Shusheng, 2019). Despite being aware that supply chain management is one of the major barriers inhibiting prefabricated construction methods, little investigation has been completed on the management of the supply chain, thereby limiting the prospects for the technology in Nigeria (Bakhtiarizadeh et al., 2021; Kolo et al., 2014a). Effective supply chain management should improve prefabrication in building construction (Kolo et al., 2014c; Rotimi et al., 2022).

Arashpour et al. (2017) have argued that the main driver behind the adoption of SCM concept is its success in other industries (automotive manufacturing, aerospace, and service industries, among others). According to Latham's report, "Constructing the Team", which was published in 1994 as a result of the downturn in the construction industry, recommended the adoption of SCM principles to enhance the behaviour and performance of the industry. Therefore, this study will investigate supply chain management in prefabricated housing construction, with the goal of improving the use of prefabricated housing and to increase the national housing delivery effort in Nigeria.

1.4 Supply chain management in building construction

Supply chain management (SCM) is the systematic strategic management and coordination of a network of relationships within a firm and between interdependent organizations and business

units (Kazemi et al., 2019; Mackelprang et al., 2014). It consists of material suppliers, purchasing, production facilities, logistics, marketing, and related systems. SCM facilitates easy flow of materials, services, finances, and information from the producer to the final customer. This also adds value, maximizes profitability through efficiencies, achieves customer satisfaction and improves the long-term performance of the individual companies and the supply chain.

SCM has been successfully used in various industries to enhance efficiency and effectiveness for decades. However, it is still considered an emerging area in building construction (Lennartsson & Björnfot, 2012). SCM is still in its infancy and has been slowly adopted by construction companies. Lennartsson and Björnfot (2012) address the prefabricated housing problem, supply chain management is required to exploit the potential of prefabricated construction. Stakeholders in the business of prefabricated housing construction must be seen working together to make prefabrication construction methods a popular alternative in housing delivery efforts in Nigeria. This is the focus of this study.

1.5 Lagos State Region

Nigeria is a sub-Saharan African country with urban centres that are rapidly growing into a world-renowned mega city, Lagos. Nigeria's infrastructure base has remained fragile, inefficient, and obsolete because of several years of neglect. The supply of power remains grossly insufficient and unpredictable. As road, rail, air, water, and pipeline transport networks are all in a state of disrepair, transport facilities are weak, with a significant adverse effect on inter- and intra-city transport. Like many African countries, the deplorable state of the economy has hampered the government's ability to better find urban infrastructure and services to fit the rapidly rising urban centres. It must be noted that Lagos is Nigeria's former capital and, apart from being the largest city in the sub-region, it is the commercial centre of West Africa. With a population of about 14 million and annual increase of 3.2%, the megacity of Lagos has emerged as one of the world's fastest growing megacities (NPC 2016). The state of public infrastructure and services in the city, including transportation (roads), energy and water, are in a deplorable condition. The security situation in the city is worsening, characterized by a rising crime rate. Considerable man-hours are wasted in the ever-chaotic traffic system due to the poor state of the roads in the metropolis. More than 500,000 people move into the city every year from different parts of the country and the challenge of affordable housing is rated top among other challenges faced by the people. In the management of their construction projects, building contractors in the city face tremendous challenges, particularly in the management of

the material supply chain. The key problems are related to the existence of traffic and security situations in the region.

1.6 Research questions

Based on the background and synopsis of the problems facing the housing sector in Lagos, it is apparent that prefabrication is greatly under-utilized. This research thus seeks to answer the principal and over-arching research question:

How can supply chain management for prefabricated construction be enhanced in Nigeria?

1.7 Research aim and objectives

1.7.1 Aim

The primary aim of this study is to explore barriers and solutions to supply chain management for prefabricated construction in Nigeria.

1.7.2 Objectives

The following objectives will help to achieve the aim of the study:

i. Review current supply chain management practices in the Nigerian construction industry and elsewhere
ii. Investigate the barriers affecting the supply chain management of prefabricated construction in Nigeria
iii. Propose solutions to improve the SCM of prefabricated housing construction in Nigeria.

Constructivism was chosen as the philosophical paradigm guiding the research, because it allows for the use of multiple methodologies in analysing a fact or situation that is observe to exist or happen, especially one whose cause or explanation is in question (Richards & Morse, 2012). Systematic literature review was therefore employed to collect relevant information on the topic. Several barriers was identified from the literature. Primary data were also collected using the qualitative methods in the form of interviews to address a research objective 1. Raw interview data were later transcribed and thematically analysed using Nvivo 11 Qualitative data Analysis software. Relationships between research sub-questions, objectives and methods were also defined to help answer the overarching research question and achieve the objective of the study. These are presented in the later chapters of this study.

1.9 Research scope and limitations

1.9.1 Scope

The study investigates supply chain management for prefabricated housing construction in Nigeria, focusing on enhancing the adoption of PC through SCM enhancement to improve housing delivery. The scope of the study excludes other building types and forms and is limited to residential housing provision. Thus, issues of providing affordable housing are outside of the scope of this PhD study. The study particularly investigates the supply chain management of prefabrication technology in building construction to address the housing shortage that the country is facing. The study explores the management of the supply of raw materials to prefabrication firms, the stages through the prefabrication process and the movement of prefabricated building components from factories to construction sites for final installation. The study was conducted in Lagos, Nigeria. Lagos is the commercial and economic centre of Nigeria, with high volumes of construction activities. As a result of this, most of the prefabrication construction companies in Nigeria have their head offices, or at least a branch/operation office, located in the city. Lagos also houses a rich collection of construction industry practitioners and experts. The housing shortage in Lagos State is enormous, and the deficit is quantitative and qualitative in magnitude.

Figure 1.1: Map of Lagos, showing the 20 Local Government Areas

1.9.2 Limitations

The two major limiting factors during the study are as listed below.

- Due to the lack of a comprehensive database for Nigerian construction experts and other relevant stakeholders, the sample composition of stakeholders proved challenging. While Nigeria's construction industry lacks a comprehensive database of professionals, this limitation was circumvented by examining the websites of relevant professional bodies to create data for the study.
- It was challenging to get suitable stakeholders and making them to cooperate. Many prospective stakeholders turned down the interview request.

1.10 Justification and significance of the study

Several studies have established the concept of prefabrication in building construction and its potential advantages in housing delivery. The associated barriers have also been identified. Despite the great advantage of this construction method, the barriers have always been a great drawback. Past studies have focused on these barriers (Hope, 2012). However, there appears to be a scarcity of research on building supply chain management in Nigeria, with just a few studies having been completed (Oisamoje & Areloegbe, 2014; Ojo et al., 2013; Saka & Mudi, 2007). This research has therefore decided to focus on this important but neglected areas of building prefabrication technology.

The research is expected to contribute to knowledge about the housing deficit in Nigeria. The research aims to:

- Contribute to existing literature on supply chain management for the prefabricated building construction domain
- Propose recommendations for improvements in supply chain management in prefabricated housing construction
- Investigate the barriers to adopting prefabricated building technology and possible solutions to supply chain management for prefabricated building construction.

1.11 The research Design

The research design entails the logical integration of research methods to ensure that the research question and the objectives of the study are met. The nature of the research problem was also a factor that determines the design used in any study. The research challenges in this case are related to Nigeria's housing shortage and how to handle the problem, as well as public

support for prefabricated building construction technology supply chain management. It is critical to improve the acceptance and coordination of prefabricated construction. Being exploratory research, a Constructivist research paradigm is considered appropriate. Deductive research approach was also used to extract direct information from interview participants. The interview records were late transcribed and analysed to answer the research question of the study. The research design for this study is summarized in Figure 3.2.

1.12 The research framework

A research framework provides an underlying structure for the collective research effort. Being an amalgamated set of activities, the framework is the summarized read-out of the research journey. This thesis employs a systematic literature review, face-to-face interviews, and a thematic approach to address the research objective and to answer the overarching research question of the research. The thesis is then divided into eight chapters.

Chapter One has provided the general introduction and background to the problem statement of the research. The conceptual framework underpinning the study has been identified, based on the theoretical precepts about housing deficit, prefabrication as a promising alternative and the absence of supply chain management for effective prefabricated housing delivery. The research question, research aim, and the objectives have been outlined. The scope of the study was also defined. The methodological approach and significance of the research have also been clearly stated.

Chapter Two presents the general literature review on housing issues in Nigeria. These include housing provision, housing deficit and the possibility of leveraging the option of prefabrication technology to improve the housing stock in Nigeria, with Lagos State as a case study. The theoretical foundations of the study are also discussed. Considerable research effort through virtual analysis eventually reveals that the lack of proper supply chain management has been one of the major challenges in prefabricated housing construction practice. This has been responsible for the low pace of adoption of prefabrication technology.

Chapter Three outlines the research philosophies, methodologies and methods guiding the study. Based on a qualitative method, the study takes an epistemological stance and applies a constructivist paradigm that reflects on lived experiences.

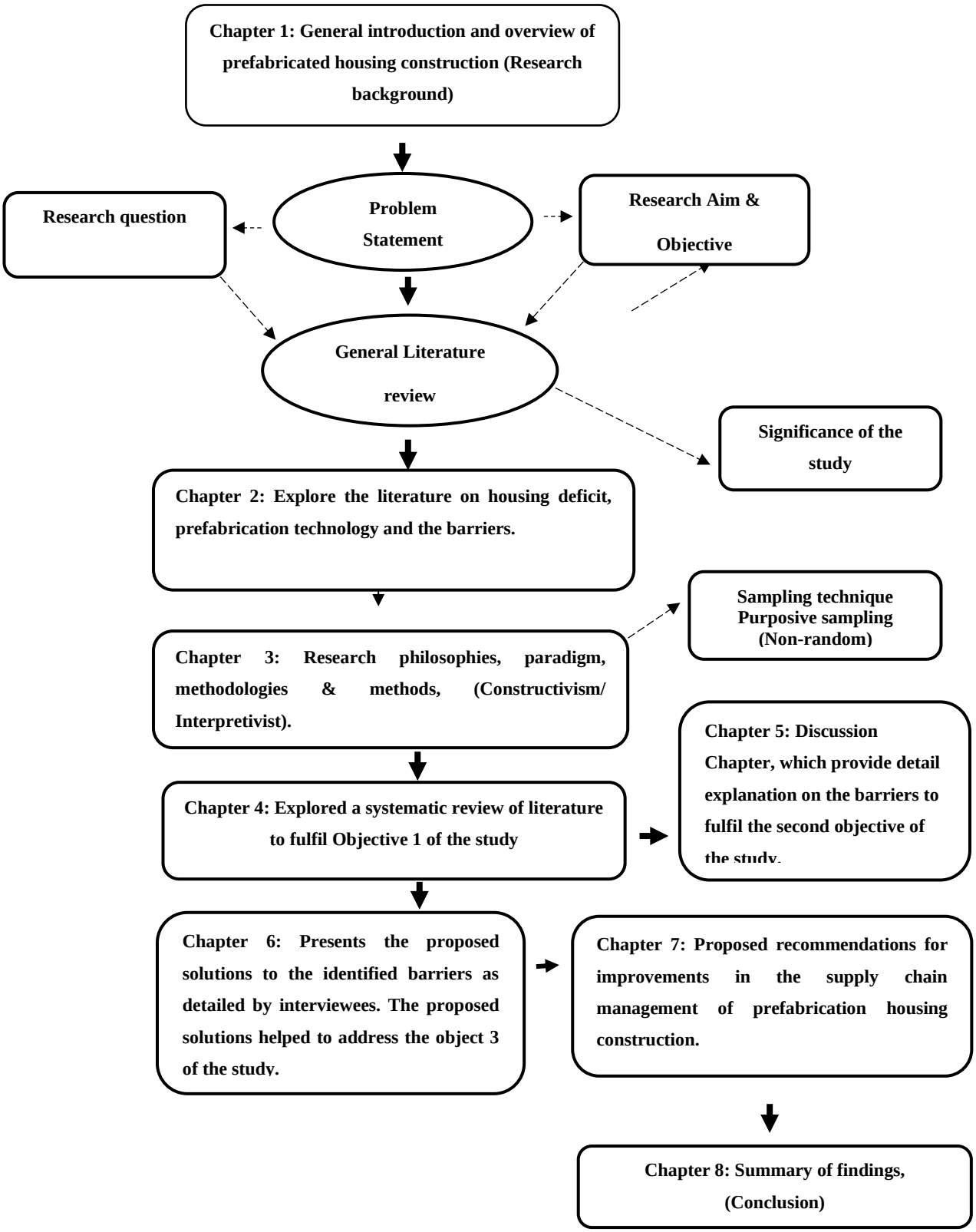


Figure 1.2: The research structure

Research strategies, characteristics of the case study area, data gathering and sampling techniques, data analysis and ethical approaches are discussed. In this study, semi-structured interviews were conducted to elicit practical information from relevant stakeholders. The results from stakeholder interviews were thematically analysed and developed to answer the over-arching research question of the study.

Having identified supply chain management as a major factor that has received less attention in prefabricated housing construction, Chapter four employs a systematic review of literature to fulfil Objective 1 of the study," to review current supply chain management practices in the Nigerian construction industry and elsewhere". This was chosen to assess what other researchers have done in this direction. A systematic literature review (SLR) identifies, selects, and critically appraises existing research to answer clearly formulated research question – "How can supply chain management for prefabricated construction be enhanced in Nigeria?" The systematic review followed a clearly defined protocol in which the inclusion and exclusion criteria were clearly stated to guide the review process.

Chapter Five is the discussion chapter of the thesis. It provides explanations based on the findings from Chapter Four. This chapter presents a qualitative analysis of the interview data collected from 28 participants among four groups of stakeholders in Lagos, Nigeria. Details of interview participants are presented in Table 5.1. The interview sessions were recorded by the researcher.

The interviews considered the views of participants about supply chain management for prefabricated construction components in Nigeria. The interviews were transcribed and coded. Data were later interpreted based on the participants' comments and experiences of prefabricated housing development, and the challenges they had faced. Subsequently the chapter presents the barriers the interviewees identified as impeding the adoption and growth of prefabricated building construction. This, therefore, necessitated an improved supply chain management to actualize the potential growth of prefabricated technology in the building industry. Each barrier is discussed in detail.

Having explored the barriers militating against the general acceptance of prefabrication technology in Chapter Five, Chapter Six presents proposed solutions to the identified barriers as identified by interviewees.

Chapter Seven addresses the third objective, having explored the barriers identified by the participants and the proposed solutions. The chapter therefore proposed recommendations for improvements in the supply chain management of prefabricated housing construction.

Chapter Eight is the final chapter of the thesis. It contains a summary of the findings, (Conclusion), implications for theory and practice as well as recommendations for future research.

CHAPTER TWO

LITERATURE REVIEW (TRADITIONAL)

2.0 Introduction

This chapter reviews the literature about affordable housing provision. It examines the relationship between housing demand and supply worldwide and in Nigeria in particular. It summarizes arguments, assertions, opinions, declarations, and acknowledgments of researchers to understand the fact. It explores issues related to affordable housing delivery, government intervention in housing issues and the National Housing Policy in Nigeria. Affordable housing refers to housing that is deemed affordable to persons with a household income at or below the median by a recognised housing affordability index (Babalola et al., 2019; Patel et al., 2018) . It is a housing type that is appropriate for the needs of a wide variety of extremely low to moderate income households and priced so that these households can meet other essential living costs like food, clothing, transportation, medical care, and education (Ahmed & Sipan, 2019). Housing is considered affordable if it cost less than 30% of a household's gross income (Malik et al., 2020; Morris et al., 2020; Oyalowo et al., 2021). The demand for housing in Nigeria far exceeds supply, and this continues to put pressure on rents and house prices, leading to a decline in the number of available affordable houses. People on low incomes living in rental housing are some of the most vulnerable people in the community and are at high risk whenever there is any tightening of supply or price increases in the private rental market.

The present housing crisis in Nigeria can be likened to the post-world war I and II era.(Egan, 1998b; Ogunde et al., 2016) Prefabricated housing became popular in the United Kingdom (UK) shortly after World II, as it gave an expedient solution to the peoples' housing demands. As a result, housing specialists in Nigeria have often argued that the UK's experiences might serve as a valuable example of what can be accomplished in Nigeria, using the strategy. This means that employing prefabricated homes to solve the deficit is a viable option This method would result in quicker construction times, lower prices, and higher quality buildings (Albus & Meuser, 2018; Karmod Nigeria, 2016; Ogunde et al., 2016).

The design adopted by any study is determined by the research problem. In this case, the research problems are concerned with the housing deficit in Nigeria and how to address the challenge through the option of housing prefabrication. Robust supply chain management will improve the delivery of prefabricated buildings in Nigeria (Chileshe et al., 2015). The positivist

paradigm is adopted to answer the overarching research question - “How can supply chain management for prefabricated construction be enhanced in Nigeria?”

A deductive research approach was also embraced as interview questions were prepared and relevant groups contacted to answer semi-structured questions. Responses from the interviewees coded with NVivo software and analysed. The research design for this study therefore is as summarized in Figure 3.2.

The chapter provides an overview of the construction industry in Nigeria, the concept of conventional building construction, and the concept of prefabricated building construction.

2.1 Issues with affordable housing delivery

There is a growing need for the development of new buildings and infrastructure to meet the rapidly increasing world population. The building industry contributes 13% of the global economy and employs more than 110 million workers globally. A United Nations report has estimated that the global population will grow to 2.4 billion by 2050 and 3.9 billion by 2100. Most of this increase will occur in developing countries. For example, between 2015 and 2018 the population of Nigeria increased by 14 million and resulted in increased demand for housing infrastructure. The construction sector in Nigeria is thus projected to grow in alignment with the population of the country.

Nigeria is not alone in grappling with these challenges. Housing delivery problems are of great concern in many countries of the world. They are especially prominent in developing countries where housing is often inadequate because of population increases. This poses many challenges for inhabitants of these cities. Nigeria, Africa’s most populous country, is a striking example of a developing country with a high urban growth rate. This has been magnified because of a myriad of issues, including a high population growth rate, shortage of necessary skills and disintegrated supply chain.

It is observed that urbanization has brought about a massive movement of people from rural to urban areas in Nigeria. This has led to environmental problems characterized by an inadequate supply of housing, resulting in an unbalanced economy. Nigeria has a current housing deficit of 22 million units. For this deficit to be significantly reduced, about 1 million housing units need to be built annually, with an average unit cost of 3.5m. This cost is far above the reach of common people. Therefore, professionals within the Nigerian built environment professions have advocated for a change from the use of conventional construction methods to more advanced and more cost-effective construction methods. The present housing shortage in

Nigeria can be compared to the shortage experienced in the United Kingdom (UK) during the post-First and Second World War era. Prefabricated housing became popular in the UK immediately after the war, as this provided an immediate solution to the housing needs of the people. Housing experts in Nigeria have, therefore, continually suggested that the experiences in the UK might serve as a useful example of what can be achieved in Nigeria with this approach. This implies that the deficit problems can be managed with the use of prefabricated housing. This approach would deliver shorter construction periods, reduced costs, and result in improved quality buildings.

Azman et al. (2012) have observed that the Nigerian construction industry is reluctant to accept new technologies because of some barriers. These include the dearth of prefabrication firms, Personal safety, High and multiple levels of taxation, Lack of policy support for the adoption and promotion of prefabrication technology in building construction, Lack of compliance with standards for prefabricated components, Stakeholder resistance to the prefabricated building technology, Prototype buildings decrease the value placed on the building, among others.

This is like the initial experience in the UK, with the call for the shift from conventional systems of construction to more adaptable prefabricated approaches (Feng et al., 2017; Ogunde et al., 2016). This has impacted positively on the housing sector in the UK. It is therefore important for the Nigerian housing sector to prepare for off-site manufacturing to be incorporated into its construction industries.

One of the continuing challenges posed by unprecedented urbanization in developing countries is the provision of adequate housing. The same challenges are being faced in African cities, and Nigeria is no exception. Despite several attempts to mitigate the problem by past administrations, Nigeria is still facing a housing deficit of well over 22 million dwellings (Adegoke & Agbola, 2020; Ayedun & Oluwatobi, 2011). The economic recession of the 1980s and attempts to restructure economies under International Monetary Fund (IMF) stabilization programs did not help. The structural adjustment policies that were formulated to address broad economic problems were drawn up with little regard for the adverse effects on the housing sector. Nigeria's housing problem is derived from a historical lack of focus on housing development. Over the years, the country has not been able to develop a viable and sustained housing finance system, either because of lack of expertise and up-to-date and knowledgeable industry leaders, especially in policy making, or lack of funding for relevant institutional agencies and political corruption.

The housing problem basically relates to quantitative and qualitative insufficiencies. On the supply side, various government strategies have, in the past, been formulated to overcome the enormous shortage through several housing reform programmes. Despite these efforts, housing continues to be a mirage to ordinary Nigerians. Presently, there are various ongoing mass housing schemes that utilize public-private partnership efforts and numerous private finance initiative models. These have not been able to adequately address the problem, as they only provide about 3% of the required national housing stock. This suggests the need for a holistic solution to the problem.

The right to adequate housing that is safe, secure, healthy, available, and inexpensive is enshrined in the Habitat Agenda. Irrespective of the policies, organizations, and regulations which the Nigerian government has put in place since independence in 1960, there is still a shortage of housing, especially for the low-income sector. The Federal Mortgage Bank of Nigeria (FMBN), which provides mortgages to low-income earners through the National Housing Trust Fund (NHTF), has operational and financial capability restraints. These limit its efficiency because these mortgages are limited to workers in the civil or public services. The few low-income earners who own their own houses usually obtain land and build incrementally, while high-income house owners use money, or mortgage finance, and usually pay this back over a maximum period of 10 years.

A major shortcoming concerns ownership rights under the Land Use Act 1978, which confers ownership of all land to the Governors of each state. This is a substantial deterrent to housing and housing investment in Nigeria. The right of occupancy is endorsed with a Certificate of Occupancy issued to the recipient. This often delays and adds significant costs to the registration process. An additional task in delivering affordable housing to low- and middle-income households is the affordability gap. Though some households have additional informal income, this is not included in loan approvals. Additional major issues affecting housing provision in Nigeria include slow administrative procedures and the high cost of land registration and titling. Housing provision in Nigeria needs the intervention of relevant stakeholders (government intervention in the form of housing loans and other incentives for individual and corporate entities such as real estate developers for improving housing delivery in Nigeria) in all aspects to ensure that the deficit gap is bridged. One way to achieve this is through the introduction of innovative products like housing microfinance, which have been effectively adopted in other countries with similar macroeconomic indices.

have stated that due to population growth and the subsequent shortage of housing, many have resorted to living in squatter settlements and others in slums. The Nigerian federal

government's housing policy has been directed towards delivery of low-cost housing on a large scale, with the numerous states having similar policies, and providing core housing and walk-up flats. The government also established satellite towns and high-rise apartments for government employees. The execution of these projects initially contributed greatly to the housing sector of the economy. It later emerged that this housing approach is not sustainable over time due to changed government priorities.

Therefore, with the fast growth of the Nigerian population and slow housing development, there is the need for intervention measures to address these longstanding problems (Adetayo, 2013). Concerted efforts are required by all to develop strategies that will facilitate the supply of good quality and affordable housing for the teeming Nigerian population.

2.2 Government intervention in housing issues in Nigeria

Various Nigerian governments have attempted to intervene in the housing crises in Nigeria. The breakdown of some of these interventions since independence is presented below.

2.2.1 The First National Development Plan (1960-1968)

In the 1960-1968 Development Plan, the government tried to provide housing, mainly in Lagos. However, out of the 61,000 units that were to be built during the period, only 500 units (1.22%) were built by the federal government.

2.2.2 The Second National Development Plan (1970-1974)

In this plan, the government sought to improve housing by establishing the National Council of Housing in 1971. It also intended to construct about 59,000 housing units nationwide, with 15,000 in Lagos and 4,000 in each of the then 11 other state capitals. However, a review of this plan shows only marginal improvements. Only 7,080 dwellings were built at the end of the regime. This represents 12% of the target.

2.2.3 Third National Development Plan (1975-1980)

Under this plan the government accepted housing as its social responsibility. It undertook comprehensive and active interventions in the housing sector and involved itself directly in the provision of housing. During this plan, the government renamed the Nigerian Building Society the Federal Mortgage Bank of Nigeria. Though there was a slight improvement in housing provision, only 30,000 housing units out of the planned 202,000 were achieved. The plan was thus not successful.

2.2.4 The Fourth National Development Plan (1981-1985)

This plan witnessed a housing provision drive based on affordability and citizenship participation. During this period, the government embarked on an ambitious programme and in the first phase planned the construction of a total of 180,000 housing units nationwide between 1979 and 1983. It proposed the construction of 2000 houses for each of the then 19 states and for Abuja annually, out of which 80% was earmarked for low-income earners. It was not successful, and by 1983 only 47,234 housing units out of the proposed 180,000 were built, representing 23.6% of the target.

2.2.5 National Housing Program 1986-1999

The Military Government between 1986–1999 launched the National Housing Program, with the goal of granting all Nigerians access to decent housing by the year 2000. This was a response to the United Nations slogan of the time, "Housing for All by the year 2000". Out of the 121,000-housing units proposed for the first stage, only 5500 units were built (see Table 2.1).

2.2.6 New National Housing and Urban Development Policy (NHUDP) 2002

The Civilian Government led by Chief Olusegun Obasanjo in 1999 launched the New National Housing and Urban Development Policy (NHUDP) in 2002. Its goal was to ensure that all Nigerians owned or had access to decent housing through private sector-led initiatives. It was planned to construct about 10,271 housing units through Public-Private Partnership (PPP) arrangements in different schemes across the country. Two thousand serviced plots were completed in Ikorodu, Lagos. Approximately 4400 housing units were completed in Abuja, Port Harcourt, Akure and Abeokuta. The National Housing and Urban Development Program (NHUDP) presidential mandate housing scheme did not take off in many states.

Table 2.1: Nigerian Government Housing targets and achievement (1960 - present)

Source: Adapted from (Marshal & Onyekachi, 2014) and (Mukhtar et al., 2016)

Period	Targeted Housing Units	Achieved Housing Units
1962-1968	61,000 housing units	500 houses, 0.4 percent of the planned units constructed

1971-1974	59,000 low-cost houses	7080 units, which is 12% of planned housing units
1975-1980	Proposal for 202,000 low-cost housing units	30,000 houses, 14.9% units completed
1986-1999	Phase 1: 160,000 houses, for low-income persons proposed	Phase 1: 47,234 houses, 29.5% completed
1986-1999	121,000 housing units of site-and-services	5500 houses, 4.5% of the housing units completed
1999-2010	1. 10,271 houses via public-private partnership (PPP) 2500 houses in Presidential mandate housing scheme across the 36 state and Federal Capital Territory, Abuja.	1. 2000 serviced lots via PP site & services in Lagos 2. 4440 houses completed in FCT, Akure, Abeokuta, & Port-Harcourt (63%) 3. Took place in Ogun State only with only 100 units, which is 20%
2007-2015	500 Mass housing for Lagos state	Work is 90% completed
2012-2015	40,000 houses for FCT workers in Abuja	Work is 90% completed
2018-Date	8000 pilot housing schemes for selected states, by the World Bank	Work in progress. Work is 75% completed

2.7 The Presidential Mandate Housing Scheme (NHUDP)

The Government also planned the construction of 500 housing units in the presidential mandate housing scheme (NHUDP) in all 36 state capitals and the Federal Capital Territory, Abuja. A pilot project involving 40,000 units per annum nationwide was initiated. Records of the achievement levels are not available. The (NHUDP) presidential mandate housing scheme did not take off in many states. More details are presented in Table 2.1.

2.3 The National Housing Policy of Nigeria

A ten-man committee was set up by the military government of Ibrahim Babangida in 1985 to formulate a new National Housing Policy for Nigeria. This ambitious policy was launched by

the government in 1991 with a slogan "Housing for All by the Year 2000A.D. The goal was for all Nigerians to have access to decent housing at an affordable cost before the end of 2000. The housing needs in the country at the launch of the policy stood at about 8 million units. The inability and failure of the policy to adequately resolve the housing backlog caused the civilian government of President Obasanjo to review the 1991 National Housing Policy in 2006. A new policy was aimed at removing the impediments to the realization of the housing goals. The goal of the policy was to ensure that Nigerians owned or had access to decent, safe, and healthy housing at an affordable cost. Having considered all the failed attempts, the new policy proposed transitional strategies in which the government made significant efforts in partially disengaging from housing provision and encouraged privately developed housing. Under the policy, adjustments such as the amortization period (which was 25 years under the previous policy) was increased to 30 years, interest on NHF loans to Primary Mortgage Institutions (PMI) was scaled down from 5% to 4% while the lending rate to contributors was reduced to 6% from 9%. The following are some of the revised housing policy objectives:

- Provision of incentives and an enabling environment for greater private sector (formal and informal) participation in the provision of housing.
- Active participation of government in national housing delivery.
- Creation of a necessary and appropriate institutional framework for housing delivery.
- Strengthening of the institutional framework to facilitate effective housing delivery.
- Development and promotion of measures to mobilize long-term sustainability and cost effective for the housing sector.
- Government patronage, development, and promotion of the use of certified locally produced building materials as a means of reducing construction costs.
- Appointment of relevant and fully registered Nigerian professionals to provide appropriate designs and management for housing delivery.
- Development and promotion of the use of appropriate technology in housing construction and materials production.
- Convenient and affordable provision of land for housing developments.
- Improvement of the quality of rural housing, rural infrastructure, and environment.
- Provision of fiscal incentives to small and medium-scale local manufacturers of building materials.

To achieve these housing policy objectives, some strategies were designed to be implemented as identified in the policy document, including strengthening, and sustaining the federal ministry of Housing and Urban Development to harmonize and monitor housing delivery in Nigeria. Unfortunately, most of the objectives could not be achieved because of lack of interest and other leadership crises.

2.4 Overview of the Nigerian construction industry

Nigeria is the most populated country in Africa, with a current approximate population of 202 million and an annual population increase of 2.5%. Nigeria is one of the largest growing economies in Africa, with a GDP average of $568.5 billion. This has been achieved through the contribution of major industries, such as telecommunications, solid minerals, real estate, building construction, hotels, and restaurants. The construction industry is the third-largest contributor to the economy. It remains vibrant, occupies an important position and stimulates the economic growth of the country.

Figure 2.1 shows the contributions of major industries to the economy of Nigeria. The construction industry in Nigeria is divided into formal and informal sectors. The latter includes the construction of private residential buildings, such as simple residential buildings by private owners, where artisans and labourers are hired by owners who also supervise construction (NBS, 2015). The government does not recognize this sector, as their activities are not regulated by legislation and no taxes are remitted. The formal sector involves all registered construction companies whose activities are organized and operate under construction acts, labour law and who remit taxes to the government. The formal construction sector began in the early 1940s with a few foreign companies. The "oil boom" era between 1970 and 1983 had a tremendous impact on construction activities. There has been a remarkable and steady growth in this sector owing to increased demand for housing and infrastructure, resulting from increasing population. Results are, however, still far from expectations as delivering housing for the entire population remains a challenge. Against the complete reliance on conventional construction methods, the potential of prefabrication in housing construction shows promise in alleviating the shortage. Though efforts have been made, the potential of prefabricated housing construction has not been thoroughly explored in the Nigerian construction industry.

The construction industry in Nigeria grew by 14.81% in nominal terms in the first quarter of 2019. It represented 4.1% of the total GDP while the real growth rate stood at 11.65 billion (Figure 2.1) and 4.34%, (Figure 2.2) contribution to total real GDP in the first quarter of 2019.

Since it is mostly project-driven, complex, and conservative, the construction industry is resistant to change, and it is characterized by fragmented markets and processes.

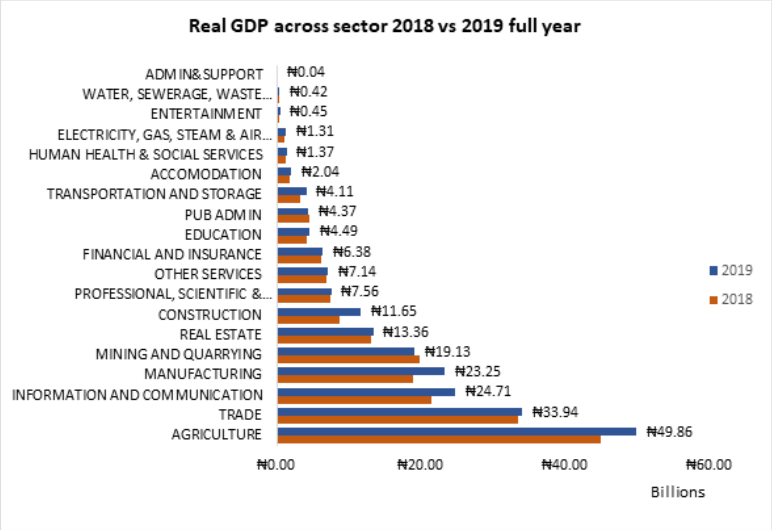


Figure 1.1: Contributions of major industries to the Nigerian economy 2019

Source: National Bureau of Statistics (2019)

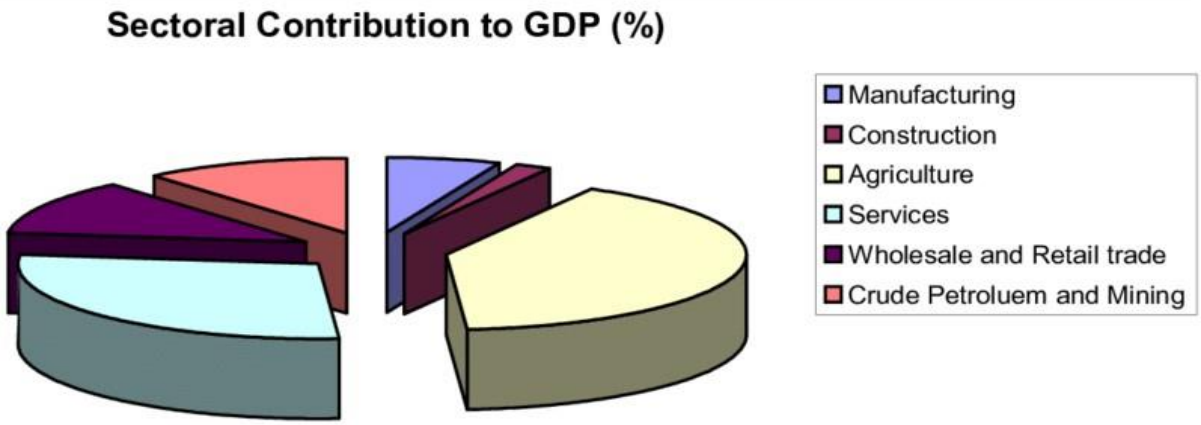


Figure 2.2: Contribution of construction industry to real GDP growth in Nigeria

Source: National Bureau of Statistics (2019)

2.4.1 Challenges facing the Nigerian Construction Industry

The construction industry has one of the highest expansion rates among all sectors of the Nigerian economy. However, despite the planned strategies, it has faced several challenges which have limited it. These are presented in Table 2.2.

Table 2.2: Challenges facing the Nigerian Construction Industry

Source: Adapted from (Ebekozien, 2020) and (Anny et al., 2015)

Challenges	Author(s)
Lack of synergy: There is no coordination between associations such as trade unions and professional bodies that are involved in the industry.	(Kasimu & Isah, 2012; Odediran et al., 2012; Omotayo et al., 2018)
Cashflow: Some construction companies are not able to finance construction projects even when given a reasonable sum of the total contract sum upfront. Some clients, especially the government, do not pay for completed work on time.	(Akarowhe; Chidambaram et al., 2012; Ofori & Toor, 2012)
Materials shortages: Some materials are foreign imported, whilst the majority are locally sourced. These imported materials sometimes are unavailable due to logistics and procurement problems.	(Dantata, 2007; Ofori, 2012b; Oke & Aghimien, 2018)
High and unstable price of materials: Importing materials is expensive. Due to the unstable nature of the rate regarding foreign exchange, the prices of these materials are not stable.	(Akarowhe; Dantata, 2007; Mansfield et al., 1994)
Intermittent power supply: Electricity supply in Nigeria is not stable. Most construction firms must provide alternatives, such as generators.	(Afolabi et al., 2018; Dantata, 2007)
Technical-know-how:	

Lack of local workers with the technical knowledge required for specialized construction processes necessitates the employment of expatriates.	(Ahady et al., 2017; Ofori, 2012a)
Poor management: The industry suffers from poor project and contract management resulting from inexperience, lack of training and absence of specialization.	(Ahady et al., 2017; Aibinu & Odeyinka, 2006; Ofori, 2012a)
Changes in site conditions: This is a technical problem which emanates from inadequate technical know-how of how to conduct site feasibility studies.	(Aibinu & Odeyinka, 2006; Iyagba & Mafimidiwo, 2016)
Unethical practices: Corruption is one the main problems of the industry. This happens at different stages of projects, from the preparation the bill of quantities through the bidding stage to the award of contract, execution and up to the delivery stage. All of these have negative effects on the quality of project delivery	(Alutu, 2007; Ameh & Odusami, 2009; Okoye et al., 2015).
Lack of skilled manpower: The industry lacks skilled manpower due to ineffectiveness of the nation's technical education institutions.	(Babalola & Idehen, 2011; Isa et al., 2013; Ubaku et al., 2015)
Project delays: These could be caused by clients, contractors, consultants, and/or extraneous factors.	(Aibinu & Odeyinka, 2006; Okoye et al., 2015)
Poor implementation of policies and programmes: Several policies and programmes aimed at improving the industry are poorly implemented.	(Isa et al., 2013; Ogunde et al., 2017)
Incompetency (Corruption): Some incompetent companies are corruptly awarded building project contracts. In most cases, they end up abandoning such projects because of lack of capacity to handle them.	(Dantata, 2007; Tanko et al., 2017)

Racial discrimination: There is racial discrimination in the industry. Preference is given to foreign companies because of the belief that foreigners have the technical ability to deliver a good job.	(Tanko et al., 2018)
Undeveloped ancillary industries: Ancillary industries to support the construction industry are not developed.	(Ubaku et al., 2015)
Lack of modern building methods and equipment: The Nigerian construction industry lacks modern equipment for building construction. There is also a lack of up-to-date approaches due to several factors. These include lack of finance to purchase equipment, lackadaisical attitudes, technical-know-how, and a lack of interest in continuous professional development by construction professionals among others	(Ogunde et al., 2017; Ubaku et al., 2015).
Political and social unrest: The restiveness in several parts of the country is a major challenge to the industry. Construction activities have been severely affected in some parts of Nigeria where there is violence or terrorism.	(Dantata, 2007; Tanko et al., 2017).
Project abandonment: All the above challenges could lead to project abandonment.	(Ogunde et al., 2017; Olusegun et al., 2011)

It is therefore clear that a range of challenges face the construction industry in Nigeria. The next section describes the conventional/traditional methods of construction prevalent in Nigeria.

2.5 Concept of conventional/traditional building construction in Nigeria

Conventional housing procurement is a way of acquiring new housing units in which an architect is commissioned by the client to design a building, while other consultants are often chosen to collaborate with the architect for general project design and execution. A building

contractor is also chosen to carry out the construction work on site. A contractual agreement is entered into with the client after the tendering process has been completed, as defined by (Tavares et al., 2021). Traditional procurement has long been in use in Nigeria and has been used for most of the country's projects. This approach allows clients to easily understand the operation as well as their financial commitments towards their projects long before designs are documented for execution.

At the outset of such projects, the target of any client is to receive a quality structure, delivered on schedule and within budget. Research has shown, however, that this goal is not reached in most cases (Babatunde et al., 2010). The traditional building construction methods of mud and thatched roof are believed to be out of date. They therefore enjoy less patronage. The conventional method of cement block and sand is the commonest method of construction and is popular with the people. Considering several challenges with this method of construction and the clear advantages of prefabricated buildings in delivering housing solutions, prefabricated methods of construction are gradually gaining popularity in the developed nations of the world.

Conventional construction techniques can be both expensive and inefficient. The construction industry in Nigeria is struggling to deliver on schedule, within budget and to specification requirements with large projects. In a survey, 98% of these projects experienced cost overruns of more than 30%, and 77% were at least 40% late (Rehm & Ade, 2013). Big projects were found to require at least 20% more time to complete and up to 80% longer than was budgeted. The unrealized need for the industry to adapt to new technologies has meant gradually diminishing financial returns for clients and contractors.

While construction is generally a long-term activity, the industry appears not to take a long-term view (Wuni & Shen, 2020). This attitude contributes to poor productivity and cost outcomes, which are part of the problems with conventional methods of construction. Labour productivity cannot keep up with overall economic growth. There are strong indications that prefabricated construction has the capacity to deliver housing units at a faster rate and with higher quality compared to traditional methods of construction (Arif et al., 2009; Han et al., 2022; Kolo et al., 2014a; Kolo et al., 2014b; Wuni & Shen, 2020). Some important conventional construction problems are as follows:

2.5.1 Limited skill capabilities

A cultural problem with conventional construction is that contractors tend to work with the people and teams of workers they have previously worked with. They fail to connect with more capable firms and manpower that might be better suited for projects.

2.5.2 Weak management

Midstream changes, inadequate communication, and lack of accountability lead to unresolved issues, which have negative effects on building projects most of the time.

2.5.3 Inadequate risk management

Construction managers and contractors usually investigate the long-term risks of planning, design, construction, operations, and maintenance of buildings. Risks that are encountered on the job are usually overlooked. These minor construction issues may snowball into lengthy delays in decision making and eventually result in major schedule overruns.

2.5.4 Organizational structure

Construction project management practice's decision making, and procurement processes do not have the capacity for the current speed and scale needed to meet the growing housing deficit.

2.5.5 Deficiencies in communication

Construction companies generally lack central data systems, and this results in delayed and inconsistent sharing of information and reports. This leads to subcontractors, contractors and owners not having a common understanding of a project's state at any given time.

2.5.6 Precautionary measures and safety

Work injuries can set project schedules back by weeks or more and may cause budgets to be exceeded as a result. Improving on "basic" project management skills is the most potent remedy for reducing housing construction problems and improving construction performance.

Embracing transparency and real-time collaboration creates a continuous workflow. A transparent environment makes it easier to resolve issues faster. Efficient and effective tracking aligned with preparedness for unforeseen events enable construction teams to anticipate micro-changes and allow them to adapt and adjust accordingly. With transparency, real-time data, and tracking a change-order process can be created. This minimizes time delays in disputes during construction. The result would be reduced idle time and a most promising solution to

improving construction site productivity. The integration of technology in industrial practice plays a huge role in improving construction productivity. Using this will strategically improve their overall project management performance and effective project delivery. Improvement in performance and productivity usually leads to improvement in financial returns, but there is a bigger picture here. Creating a trend towards a healthy and productive construction industry will result into great benefit to all.

2.6 The concept of prefabricated building construction

Prefabricated methods of building construction have been widely used and considered as potential ways of improving housing delivery in many nations. This involves a set of construction technologies and processes through which building components are manufactured in a controlled environment, transported, and assembled on the job site to minimize on-site works. A variety of interchangeable terms are associated with housing that uses prefabrication technology. They include off-site construction, modular housing, industrialized building, modern methods of construction, and prefabricated housing, among others.

2.6.1 Adoption of prefabricated building construction

The use of prefabrication as a building construction technique date back to the 1850s. Its use became more prominent after World War I and II. This method of building came into prominence in different countries for several reasons. These include housing deficits, skills shortages, new innovations in construction, and cost advantages (Aye et al., 2012; Jaillon & Poon, 2009; Steinhardt et al., 2013b). Prefabricated building technology has been embraced and is growing prominently in many countries. These include USA, Australia, Malaysia, New Zealand, Sweden, Japan, India, and China, to mention a few (Jaillon et al., 2009; Li et al., 2017b; Persson & Engevall, 2008).

The influential reports by Latham and Egan advocated that the UK construction industry should embrace manufacturing components for building construction. This resulted in greater demand for prefabricated buildings. The UK government, however, played a major role in the development of prefabrication by sponsoring reports and putting policies in place to support and set up an organization - Build offsite with the responsibility for promoting the uptake of prefabrication within the construction industry. Depending on the country and sometimes instances of usage, prefabrication construction technology has other synonymous terms. Because of this, ‘prefabrication’ is called different things by different categories of people and

by different countries. They are referring to the same thing. Some of these terms are as presented in Table 2.3.

Table 2.3: Definition of terms used in this study

Source: adapted from (Persson & Engevall, 2008) and (Baghchesaraei et al., 2015)

TERM	EXPLANATION
Industrialization	Term incorporating manufacturing processes but also including general concepts such as scheduling, efficiency, and technology improvements.
Modular building	Used widely, including in the UK and in Australia and North America, to refer to volumetric elements constructed offsite and joined to form a permanent house. Specifically distinguished in the USA from manufactured housing, which has its own building code, while modular building, is under standard State building codes.
Offsite fabrication	Widely used term with varying interpretations usually referring to offsite manufacturing of buildings, or parts thereof, prior to installation or assembly onsite.
Relocatable homes	Terms commonly used in Australia and New Zealand to refer to transportable houses completely prefabricated offsite and delivered to site fully finished.
Flat-pack kit homes	Sets of partially prefabricated materials commonly assembled by an owner instead of a builder, with a history of use in New Zealand, Australia, and the USA (Ågren & Wing, 2014; Thame, 2017).

Manufactured homes/housing	Used in the USA since the 1976 introduction of the alternative Housing and Urban Development (HUD) building code to refer to relocatable, typically low-quality, homes built in a factory and including an integral chassis for transporting the structure on wheels. Used in Australia to refer to houses built in a factory, inconsistently covering both temporary structures installed in caravan parks and villages and permanent dwellings installed on standard building sites (Durst & Sullivan, 2019; Sutley et al., 2020).
Industrialized Building Systems (IBS)	Term formally defined in Malaysia in the early 2000s encompassing the use of prefabricated, offsite, mass produced and standardized components(Mohd Amin et al., 2017).
Modern Methods of Construction (MMC)	Term first used in the UK to describe changes to improve social housing construction methods (The Housing Corporation, 2003), which refers to both offsite work and onsite efficiency improvements (Pan et al., 2007; Rushton, 2022).
Industrialized housing	Prominently used in Sweden and other European countries since the early 2000s incorporating offsite manufacturing of materials, supplier coordination, and the systematization of build processes. Historically used in the 1970s and 80s in New Zealand (Musa et al., 2016; Yusof et al., 2016).
Offsite Manufacturing	Used widely, including in the UK and in Australia, as construction policy documents, referring to work carried out

	away from the building site (Kolo et al., 2014a; Mostafa et al., 2014b).
Prefabricated housing	Used in the USA to refer to both modular and manufactured housing as a group. These two modes are both manufactured off-site but differ in terms of the building codes that are relevant to them (Wang et al., 2017a).
Preassembly	This is a less commonly used term, interchangeable with offsite manufacture and variations (Wood, 2012). .
	The application of rules for the manufacturing of consistent interchangeable components, particularly in mass production, is referred to as this (Weber et al., 2011). It refers to the adoption and creation of worldwide marketing rules. This aids in the cost-effective simplicity of procurement and production (Akinradewo et al., 2021; Kozhevnikov, 2017; O'Connor et al., 2015).

2.7 Summary

Problems of overcrowding, homelessness, slums, squatter developments and other related issues have characterized the delivery of housing in Nigeria. This has the resultant effect of Nigeria's growing housing shortfall, among others, particularly in metropolitan areas. Despite several housing policies and programs aimed at addressing the housing shortage, the desired outcomes have not been met, prompting the introduction of structured private sector housing delivery in 2002. Being an alternative to conventional building construction, prefabricated building technology is seen to be embraced and is becoming more popular around the world because of several benefits.

This chapter has identified several barriers that deter people from using modern construction methods. Most of these barriers, however, have been investigated by other researchers. The supply chain management of prefabricated housing delivery was found not to have been

researched in depth. This is a major gap. The chapter has identified the supply chain management of prefabricated housing technology as a major gap to investigate in detail. This is further articulated in the next chapters.

CHAPTER THREE
RESEARCH METHODS AND METHODOLOGY

3.0 Introduction

This chapter introduces the design of the methodology for the research by outlining the appropriate philosophies, methodology and method used to collect, present, and analyse data and produce findings that will provide answers to the over-arching research question. This section therefore presents a detailed description of the research process (research design, methods, strategy, and techniques).

Every research investigation should follow a suitable design and well-defined procedures. These aim to provide answers to the study's research question, research aim and objectives. This chapter discusses the strategies, data collection techniques, methods of data analysis, ethical considerations and research plan adopted in addressing the research question "How can supply chain management for prefabricated construction in Nigeria be enhanced?"

Establishing the ontological, epistemological, and methodological position of the research dictates the direction of the research and helps to determine the methodology and methods to be used. Thus, this chapter outlines the step-by-step procedures used to achieve the objectives of the study. The methodology is divided into four parts. The first part covers the philosophical assumptions that underpin the study based on the research question, as stated above. The research aim is to explore barriers and solutions to enhance the supply chain management for prefabricated housing construction in Nigeria. The pragmatic (or positivist) paradigm, which aligns with deductive research, was considered most appropriate to achieve the research aim.

The second part of the methodology describes the qualitative methods adopted for the study. The aim of the qualitative methods is to broaden the perspective from a subject to object orientation, common in the natural sciences, to include the dimensions of social relationships, organizational structures, and to put the study into a wholistic context. Here, the researcher tried to see the fact from the inside, which is often achieved in close conjunction with the person directly involved in the fact being studied. This involved field works. Relevant stakeholders were purposely selected, and semi-structured, in-depth, and face-to-face interviews were conducted in which the stakeholders were asked questions about their personal lived experiences. This was done to elicit information relevant and to have their perceptions about the study. Opportunities was also provided to probe further and obtain detailed information on

the issues raised to have the full perception of the interviewees. Results from the interviews were analysed thematically using NVivo 12 software.

The third part involved selecting the relevant stakeholders from which information was elicited. Four groups of people who were considered relevant to supply chain management in prefabricated building construction were selected. These included: raw material suppliers, logistics firms, prefabrication firms and construction firms. This study has not investigated commercial, institution and other forms of housing development. It is mainly for residential housing needs of the people. Therefore, an interview guide was prepared for questioning individuals from each group. The guide was also scrutinized to ensure that the questions asked were relevant and would help to answer the research question of the study. It was initially proposed that ten participants from each of the four groups (prefabrication firms, construction firms, logistics firms and the materials suppliers) would participate in the interview exercise, giving a total sample size of 40 interviewees. This is considered practical and realistic when conducting qualitative research. However, only 28 interviews were conducted in total before the point of saturation was reached. A small sample size is acceptable for a qualitative study, especially when saturation has been reached (Basias & Pollalis, 2018). The second part of the guide provided the main interview questions. Different semi-structured questions were prepared for the different groups, as mentioned above.

The fourth part provides an analysis of the interview data. The 28 face-to-face interviews conducted were audio-recorded, transcribed, and analysed using thematic analysis, where emerging themes were categorized, coded, and sorted into further categories based on their characteristics. Thematic analysis is a technique for identifying and uncovering patterns in qualitative data. It enables researchers to describe some of the research's occurrences and causes. The methodical and flexible techniques of thematic analysis was used to thoroughly understand the fact. This was then used to describe and reveal a group's behavioural patterns and perceptions. It also primarily analyses information gathered through a semi-structured interview or documented text. The data from the interview analysis coupled with relevant material from the literature informed the recommendations for improvements in supply chain management for prefabricated building construction in Nigeria.

3.1 Research paradigm

The research design and approaches in this study are based on ontological, epistemological, and methodological positions. defined research philosophy as the development of the research background, knowledge, and nature. Every research paradigm is based on the ontological and

epistemological assumptions of the researcher. Since all assumptions are speculations, the philosophical underpinnings of each paradigm can never be empirically proven or disproven. Different paradigms inherently contain differing ontological and epistemological views; therefore, they make different assumptions about reality and knowledge which underpin their research approach.

Ontological assumptions are concerned with what constitutes reality. In other words, what knowledge is. Epistemological philosophical assumptions concern the nature and forms of knowledge. Here, assumptions are concerned with how knowledge can be created, acquired, and communicated. In other words, how we know it corresponds to 'ontology', what values go into it corresponds to 'axiology', how we write about it corresponds to 'rhetoric' and the processes used in studying it correspond to 'methodology'. explain that epistemology asks: 'what is the nature of the relationship between the would-be-knower and what can be known?'

3.1.1 Research paradigm and adopted methodology

The purpose of methodology in any research project is to reveal how the inquiry will be conducted by the inquirer. It also identifies the tools needed for the inquiry. According to , methodology is the approach taken in any research project to obtain answers to research questions. It outlines why, what, when and how data are collected and analysed Ontology *(what is out there to know)* and epistemology *(what and how can we know about it)* combine to dictate the methodology *(how can we go about acquiring that knowledge)* of the study. The methodological philosophy question developed by is: "*How can the inquirer (would-be knower) go about finding out whatever he or she believes can be known"?* The answer to this question is based on the researcher's ontological and epistemological positions. It informs the methodology to be adopted for a study. Methodology is how the research (search for knowledge) is conducted. Research methodology is quite different from research methods. It is logically linked, but not the same. Methods are techniques employed in data collection and analysis to provide evidence for the knowledge being researched. A simple interrelationship is shown in Figure 3.1.

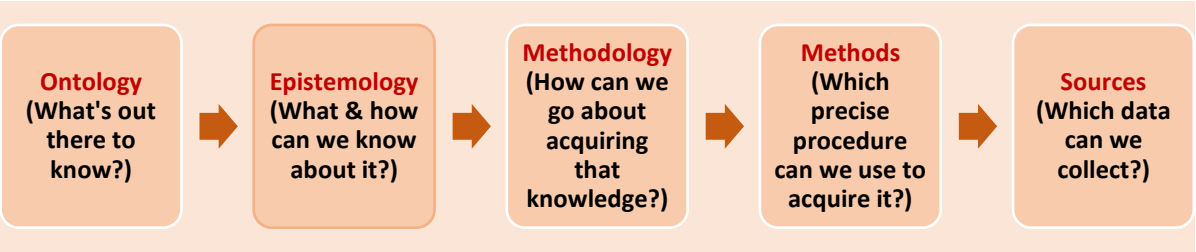


Figure 3.1: Interrelationship between research components

Source: adapted from Hay, 2012

Deciding on appropriate research methodologies and methods to achieve the aim of the study is dependent on research paradigms and assumptions. Therefore, it is important to explore research paradigms to find a suitable match for this study. According to the Merriam Webster Dictionary, a paradigm is defined as:

"*A philosophical and theoretical framework of a scientific school or discipline within which theories, laws, and generalizations and the experiments performed in support of them are formulated*".

The term is also referred to as a worldview. The object being studied, and the nature of a research problem are the major factors used to determine the paradigm or worldview to adopt in a particular investigation.

The composition of paradigms in research varies and is based on an author's claims. For instance, identified four worldviews, these being 'positivist/post-positivist', 'constructivist, 'advocacy/participatory' and 'pragmatist'. Similarly, identified 'positivism', 'post-positivism', 'critical' and 'constructivist' as inquiry paradigms.

Constructivism is the belief that social phenomena are in a constant state of change because they are totally reliant on social interactions as they take place. This will be suitable for addressing the objective as well as addressing the research question that this study seeks to answer. Constructivist researchers mostly address the processes of interaction among individuals and focus on the specific context in which people live and work to understand the historical and cultural background of the participants.

To answer the research question "How can supply chain management for prefabricated construction in Nigeria be enhanced?" and to achieve the aim and objectives of this study, the constructivist paradigm has been found appropriate. Constructivists claim that it is through subjective interpretation that reality can be understood. They concur that interpretations of reality exist but maintain that these interpretations are part of the knowledge being pursued.

support this claim and posit that constructivists rely on the participants' views of the situation under study and that they recognize the impact of their background and experiences on the study. Ontological positions hinge on relativism - the belief that multiple realities exist as subjective constructions of the mind. These differ from one person to another. In relativism, reality is assumed to be constructed by how individuals perceive, understand, and interpret the world socially and experimentally.

3.1.2 Selected research paradigm

The Constructivist paradigm involves investigating human interactions, as well as the historical and cultural context inhabited by humans (Khan, 2010). Participants have prior knowledge of the phenomena, and such studies rely on the participants' views as much as possible. This approach ensures in-depth interactions between researchers and research participants to construct a meaningful reality. Therefore, it uses qualitative methods such as narratives, interviews, observations, ethnography, case studies, pen-ended questionnaires and role playing to obtain data. However, interviews provide in-depth understanding of social context superior to other quantitative methods such as questionnaires.

Interviews, as described by (Rahman, 2015) is an appropriate method when detailed insights about situations are required. Understanding and perception (of materials availability, prefabrication factories, transportation, and other logistics in moving prefabricated components to a construction site, technical-know-how for installation, among others) are required from individuals in this study. Since this study seeks to understand forms of information about the management of prefabricated building construction, it is argued that questionnaires would be inadequate. Interviews will enable in-depth investigation into Objective 2, "Investigate the barriers affecting the supply chain management of prefabricated construction in Nigeria". Objective 3, "Propose solutions to improve the SCM of prefabricated housing construction in Nigeria". Interviews seek to find answers to research questions that ask 'who', 'what', 'where', 'how much' and 'how many'. According to, they are aimed at generalizing from a sample of a population by using structured interviews to collect data. Similarly, interviews have been described as appropriate when the researcher intends to generalize findings from a sample to a larger population (Rowley, 2012; Woods, 2011). They are also known to be a fast and economical way of obtaining information on behavioural topics. This strategy was found appropriate to achieve Objective 2, since it offered opportunities to explore the issues envisaged. It also enabled the researcher to obtain relevant information about the practice, situations, and views of participants on the subject being studied as well as the research

question that this study is designed to answer. Interview data were collated and analysed. Emerging themes from the interview analysis guided the development of the proposed solutions.

A considerable number of similar studies have adopted a single method, mixed methods, and multiple methods of enquiry. This study, however, employed the single qualitative method of semi-structured interviews. Several open-ended questions were prepared to elicit information from relevant stakeholders through semi-structured interviews. Emerging themes from the data collected were identified, coded, and analysed using thematic analysis with NVivo 12 qualitative data analysis to gain more understanding on issues relating to prefabrication supply chain management as part of the effort to address the problem of housing shortages in Nigeria.

3.2 Research design

The research design entails the logical integration of research methods to ensure that the research question and the objectives of the study are met. The nature of the research problem was also a factor that determines the design used in any study. The research challenges in this case are related to Nigeria's housing shortage and how to handle the problem, as well as public support for prefabricated building construction technology supply chain management. It is critical to improving the acceptance and coordination of prefabricated construction.

Being exploratory research, a constructivist research paradigm is considered appropriate. Deductive research approach was also used. Since the study investigates the supply chain management for prefabricated housing in Nigeria, field research in the form of semi-structured interviews was considered appropriate to extract direct information from identified participants. The interview records were late transcribed and thematically analysed with the aid on NVIvo 12 software to answer the research question of the study. The research design for this study is summarized in Figure 3.2.

Figure 3.2: Summary of Research Design

3.3 Research purpose

It is important to identify the research purpose to determine an appropriate research strategy to apply to a study. The research purpose may be exploratory, descriptive, or explanatory. Therefore, understanding the tenets of each will inform an appropriate choice.

3.3.1 Descriptive research:

This seeks to describe, ascertain, and provide information about types of research variables in a a fact or situation that is observed to exist or happen, especially one whose cause or explanation is in question. In this process, consideration of successive variables is common without association or comparison.

3.3.2 Explanatory research

This uses hypotheses to identify and explain the nature of certain relationships between variables in each situation. Some authors have described it as an experimental study because it seeks to find out the possible causes of a fact or situation that is observed to exist or happen, especially one whose cause or explanation is in question and assesses causal relationships between or among variables.

3.3.3 Exploratory research

Exploratory research is a process of enquiry used when there is little or no prior information or knowledge about a situation of interest. Researchers explore a setting, a fact or situation that is observed to exist or happen, especially one whose cause or explanation is in question, or an event to identify and clarify a problem as well as describe and interpret the issues involved. If prefabricated construction methods of housing have been proved with many advantages over the conventional construction, and that despite the inherent advantages, many countries are reluctant to embrace this construction methods, Nigeria inclusive. Then, exploratory research would be helpful to unravel what is the major issues for the reluctance. Exploratory research has therefore been found appropriate. It is conducted when there are few or no earlier studies to which reference can be made for information. The concept of supply chain management for prefabricated construction has been studied in some developed countries (Boateng, 2019; Zhang & Yu, 2021). This study therefore draws on previous studies to inform the study of these practices in Nigeria. There are limited studies about integrating supply chain management into the construction industry. Yet, supply chain management has been reported as necessary to improve prefabricated building construction (Jiang et al., 2020; Kirschke & Sietko, 2021).

3.4 Research approach

Deductive research approaches have been identified by several authors as the major characteristics of a research approach. Deductive approach was used in this study to address the objectives and answer the overarching research question of the study.

3.4.1 Deductive reasoning

This starts with observation and ends with a concept, being the result of data analysis. It is a process where researchers collect data, analyse the data, and then formulate a concept. According to (Azungah, 2018) , deductive reasoning starts with a problem, “a germ of an idea”, through a discovery journey where local terrains are mapped, data are gathered, participants are listened to and observed, steps are reviewed and directions changed, all with the aim of generating new ideas. The discovery journey has been likened to searching for patterns.

Therefore, for the purpose of this study, a deductive approach will be used to achieve the research aim, “To explore barriers and solutions to enhance the supply chain management for prefabricated housing construction in Nigeria”. The objectives of the study will also be addressed.

Deductive approaches are appropriate in an investigation which involves a small sample of participants as well as the personal involvement of the researcher (Azungah, 2018; The Critical Methodologies Collective et al., 2021) . This allows for revision of data collected and flexible interactions with stakeholders. This approach is commonly associated with qualitative research. The product of deductive reasoning is to develop a theory that explains these patterns.

3.5 Research methods and justification for each objective

The research objectives and the justification for the methods used to achieve each of the objectives are explained below.

3.5.1 Objective 1

Review current supply chain management practices in the Nigerian construction industry and elsewhere.

3.5.1.1 Research Methodology

A systematic literature review was employed for the first objective of the study. This involves the use of an online search of a database that indexes over three million articles (journals and conferences), and technical reports from engineering and environmental technology for titles and abstracts with relevant keywords. These also included publications related to architecture, building construction and project management, the built environment and housing development, supply chain management practice, housing supply and developing countries. Articles containing these terms in the title/abstract/keywords were considered. Inclusion and exclusion criteria were also set as a guide to define the systematic literature review. The scope of the review took account of publications within the last fifteen years (January 2005 to December 2020). The details of these are presented in the next chapter of the thesis.

3.5.2 Objective 2

Investigate the barriers affecting the supply chain management of prefabricated building construction in Nigeria. This objective was achieved with the help of face-to-face interviews with relevant stakeholders.

3.5.2.1 Research Methodology - Semi-Structured Interview

Semi-structured interviews can be conducted face-to-face (Personal Interview), via telephone or by video call. For this study, face-to-face (Personal interviews) were adopted as they provide opportunities to probe for rich data and to capture verbal and non-verbal input, including emotions and behaviours (Woods, 2011). With this, problems commonly associated with

telephone and video call interviews were mitigated (Rahman, 2015; Woods, 2011). Photographs were also adopted in this study as they provide visual evidence to support the investigation. This study has not investigated commercial, institution and other forms of housing development. It is mainly for residential housing needs of the people. Thus, Asides the common demographic/background information that is common to all participants from the four-stakeholder group, participants from the different stakeholders were made to respond to different semi-structured technical questions that provide relevant information.

A total of twenty-eight participants were interviewed across the four groups of prefabricated supply chain to get to their perceptions about the study. Four groups of people who were stakeholders in prefabrication construction projects were interviewed to obtain relevant information about their awareness, attitudes, perceptions, and other relevant factors affecting them. The first group are: the suppliers of raw materials to prefabrication factories. The second group are key officers at the established prefabrication factories, producing prefabricated building components in Lagos, Nigeria. The third group are in logistics (transportation firms) whose main function is to move prefabricated components from the factories to construction sites for installation. The fourth group are the designers and other construction professionals with a minimum of five-years' experience involved in managing the installation process of prefabricated components. Relevant professionals involved in the supply chain management procedure was also interviewed. The interviewer and interviewees were familiar with the language used and this facilitated easy communication during the interviews.

Certain factors were considered in the formation of the semi-structured interview questions. These include ensuring that questions are asked, such that one can get descriptive answers from interviewees as much as possible (Marshall et al., 2013; Yin, 2015). Simple language was also used throughout to ensure that it was easily understandable to participants. There are two sets of question to all participants. The Demographic/Background questions and the Business questions. The demographic questions were common to all participants. As much as possible, questions were also made to be short, important, and direct. Asides the background questions, all other questions on the interview guide were derived from the literature and consisted of the themes investigated in the study (Zhai et al., 2019; Zhai et al., 2015b; Zhai et al., 2018; Zhai et al., 2017b). Responses to the interview question were later manually transcribed. Emerging themes and their relationships were later identified, categorized, coded, and analysed using thematic analysis with NVivo 12 qualitative data analysis software.

Here, relevant stakeholders in the business of building prefabrication technology, who could potentially share practical and relevant experiences about the technology, were identified.

There was a lack of knowledge about how those involved in the delivery of prefabricated housing were carrying out their activities. Hence, this study conducted interviews to explore the factors preventing the general acceptance of prefabrication in building construction. A total of 40 prospective participants were identified using a convenience sampling method.

Researchers have made different suggestions about the number of interviews required in qualitative studies (Dodgson, 2017; Fetters et al., 2013). Theoretically, the point of saturation can be achieved after conducting between ten (10) and (30) interviews (Creswell, 2013a; Marshall et al., 2013). This study eventually conducted a total of 28 interviews until it reached the point of saturation, where the interviewees provided no new information.

An information statement and consent form were sent to prospective interviewees through their identified email addresses, with the intention of securing appointments with them (see information statement (Appendix i), interview questions (Appendix ii) and consent form (Appendix iii)) prior to the interviews. The interview sessions were conducted face-to-face between the researcher and interviewees, with the interview guide providing the framework for the interviews. The interviewees were asked questions as outlined in the guide, while the researcher recorded their responses to each question.

A list of different sets of semi-structured interview questions (according to the four groups of participants) was prepared in advance. These questions were posed to participants in the form of semi-structured interviews. Collected qualitative data was thematically analysed to identify the themes that highlight the barriers inhibiting the growth in the numbers of people interested in adopting the building prefabrication technology. Stakeholders from Lagos State, Nigeria, were selected, using a convenience sampling method (Etikan et al., 2016). They participated in the interviews to share their knowledge about the problems in question.

They were interviewed to investigate the factors preventing the growth of prefabricated building construction, as it is generally observed, and despite the clear advantages of the technology. Participant names were de-identified within the text, in agreement with the ethics approval for the study. The main ideas expressed by participants were represented with codes. Themes were later generated through the combination of many of the identified codes. These themes were reviewed to confirm the relevance of each code to its corresponding theme. Each theme was named in accordance with its content. Lastly, a report was written to elaborate and elucidate the findings. This final step provides coherent arguments that include analytical narratives.

The steps given above were followed to analyse the interviews and generate themes. To do so, the audio recordings of the interviews were transcribed and carefully reviewed. This helped the researcher to understand the content of the interviews and the importance of what was said. During this step, some notes were produced to identify significant information and comments. Next, several codes were generated based on the interview contents.

After 28 interviews, it was found that interviewees were providing similar data, and this was moved between the themes according to their content. As mentioned by (Yin, 2015) the relationships between the themes were evaluated, helping to arrange the themes and sub-themes. These themes were checked to ensure they were relevant to their codes. After refining themes and sub-themes, some of them were combined. Next, the themes were named and defined to distinguish them from one another and to clarify their structure.

As it would be difficult and time-consuming to analyse a large amount of qualitative data, the sample size of qualitative studies is recommended to be reasonably small (Wilmot, 2005). However, adequate information must be collected from the selected sample. Adequate information means reaching the point of saturation in the collected data. This point is when gathering new information provides no new and undiscovered views and information (Braun & Clarke, 2006; Etikan et al., 2016).

3.5.2.2 Justification

Interviews provide an in-depth understanding of social phenomena superior to most quantitative methods, such as questionnaires. Interviews are considered an appropriate method when detailed insights about a fact are required from individuals. Since this study seeks to gain a deep understand of a specific situation, rather than a surface description of a large sample of the population, it also aimed to understand how the participants derive meaning from their surroundings and how their meaning influences their behaviours. Interviews will allow in-depth investigation of Objectives 2 and 3, and this approach is used in contemporary events where control of variables is not required. This justifies the choice of interviews. With this method, it could be difficult to realize insights relating to the causes of phenomena. It has also been known to be a fast and economical way of obtaining information on behavioural topics. This strategy is appropriate for achieving Objective 2 since it offers opportunities to explore the issues envisaged and enables the researcher to obtain data about the practices, situations, and views of participants on the phenomena being studied.

3.5.3 Objective 3

Propose solutions to improve the SCM of prefabricated housing construction in Nigeria.

3.5.3.1 Justification

Both quantitative and qualitative methods are valuable for conducting research in the field of construction management. While quantitative research is measurable. It also involves the objective extraction of facts, and the findings can be generalizable, with its validity being independent of the specific social context from which data is derived. However, the aim of this research is 'to explore barriers and solutions to enhance the supply chain management for prefabricated housing construction in Nigeria"

This study applied the literature review and qualitative methods of research to achieve the objectives of the study. After extensive exploration of available and relevant literature (SLR) about the research topic, Semi-structured interviews were conducted. This involves collecting data from the lived experiences of participants and interpretation based on the meaning held by the people. In addition, the social dimensions of prefabricated housing construction and managing the supply chain for effective delivery of prefabricated housing construction involves the intersection between society and nature. It is also considered a product of the social structure and those concerned in the society. This study is open to individual historical understanding and conviction in the advantages and disadvantage of the technology. It thus requires qualitative methods to be better studied.

Qualitative studies are also useful for understanding the participants' perspectives, the context within which they act and the influence the context has on their actions. They involve broadly stated questions about the experiences and realities studied through sustained interaction with respondents in their natural habitat. Therefore, to explore barriers and solutions to enhance supply chain management for prefabricated housing construction in Nigeria, which is the aim of the research, a qualitative approach will be appropriate. Interviews will be able to produce descriptive data that helps to practically understand the experience of the people.

Qualitative research strategies comprise narratives, ethnographies, and case studies from which multiple meanings can be derived to better understand the issues being studied.

Qualitative studies are also useful in considering the viewpoint of the participants, the context in which they behave and the impact of the context on their acts. Qualitative research often includes broadly articulated questions about the attitudes and perceptions that were analysed through ongoing contact with respondents in their natural environment, providing rich

descriptive data that allows us to understand attitudes. In view of the above, this analysis uses a qualitative approach to fulfil the criteria of congruence and purposeful methodology.

3.6 Thematic analysis

Thematic analysis was used to find the main themes in the collected data. The following paragraphs explain this method and its significance.

Thame (2017) have emphasized the flexibility and accessibility of thematic analysis. Flexibility permits researchers to use different approaches to perform thematic analysis. For example, themes can be identified directly from information and comments. Codes are generated based on the contents of the interviews. The codes in this study were revisited and altered multiple times to improve their accuracy. This step helped to reduce the data into a few manageable codes. Some of the main codes that were generated include cost, logistics, construction barriers, supply chain and construction materials, among others. The identified codes were organized to provide a clear view of the findings.

As practiced by , similarly related codes were combined. This step helped to locate codes that were relevant to Objective 2 of this study. These codes were later reviewed and categorized to produce themes. Several initial themes and sub-themes were produced and discarded to obtain an appropriate arrangement. During these steps, codes were replaced and moved between the themes according to their content. The relationships between the codes were also considered to perform thematic analysis. For example, themes can be identified directly by analysing the data, or some concepts and ideas can be used to determine and interpret the themes.

Thematic analysis is used to determine and reveal patterns embedded within the fabric of qualitative data. It permits researchers to explain some of the events and factors observed in the research. Events and phenomena can be interpreted appropriately using the systematic yet flexible procedures of thematic analysis. It can be used to describe and unveil the behavioural patterns and the ways of thinking in a specific group. Additionally, it mainly analyses data collected through a semi-structured interview or documented text.

3.7 Research methodology

Constructivism was chosen as the philosophical paradigm guiding the research, because it allows for the use of multiple methodologies in analysing a fact or situation that is observe to exist or happen, especially one whose cause or explanation is in question (Richards & Morse, 2012). Systematic literature review was therefore employed to collect relevant information on

the topic. This revealed several identified barriers from the literature. Primary data were also collected using the qualitative methods in the form of interviews to address a research objective 1. Raw interview data were later transcribed and thematically analysed using Nvivo 11 Qualitative data Analysis software. Relationships between research sub-questions, objectives and methods were also defined to help answer the overarching research question and achieve the objectives of the study. These are presented in the later chapters of this study.

Face-to-face interviews were held with four groups of selected and relevant stakeholders. The interviews gathered details about the operations and relevant details about the different stakeholders in the business of prefabricated housing delivery. They include suppliers of raw materials, prefabrication firms, logistics/haulage firms and construction firms.

To address the aim, objectives, and research question of this study, a qualitative research method with deductive approach has been adopted. This approach is considered fit for data collection for this study because it involves the gathering of lived experiences of individuals on the subject in question. It is suitable for research problems that are unstructured, and for which there is little or no research evidence in the literature. Individual opinions need to be obtained from suitably qualified participants to obtain relevant information. Interviews are generally used in qualitative research where the researcher is interested in collecting "facts", or gaining an understanding of opinions, attitudes, experiences, processes, behaviours, or predictions on those concerned.

Interviews draw information about the views, experiences, beliefs, and motivations of individuals about specific matters. They could also be viewed as communication in which there is a message and feedback. Interviewers send messages while interviewees give feedback. This ensures that both interviewer and interviewee understand the central theme of the study. John describes this as an interaction in which the interviewer provides stimuli to generate a reaction. That reaction from the interviewee is also a stimulus to which the interviewer responds. and identified three fundamental types of research interviews. These are: structured, semi-structured, and unstructured. The degree to which participants have control over the process and content of an interview is the main difference between the approaches. For this study, semi-structured interviews were used. This is a qualitative method of inquiry that combines a semi-structured set of open questions with the opportunity for the interviewee to respond further. Different sets of interview questions were prepared for the four categories of stakeholders identified for the study.

There are five sets of interview questions (a-e), with one set of questions for each stakeholder. The demographic questions (a) are common to all. The questions are used to ascertain the background and other preliminary information about each respondent and the business questions (b-e) are for the relevant four groups of respondents or the four stakeholders in prefabricated building supply chain management. While demographic questions are common to all the four groups, technical questions are separated for each group of respondents based on the different phases of building prefabrication supply chain management. See the interview guides (Appendix ii).

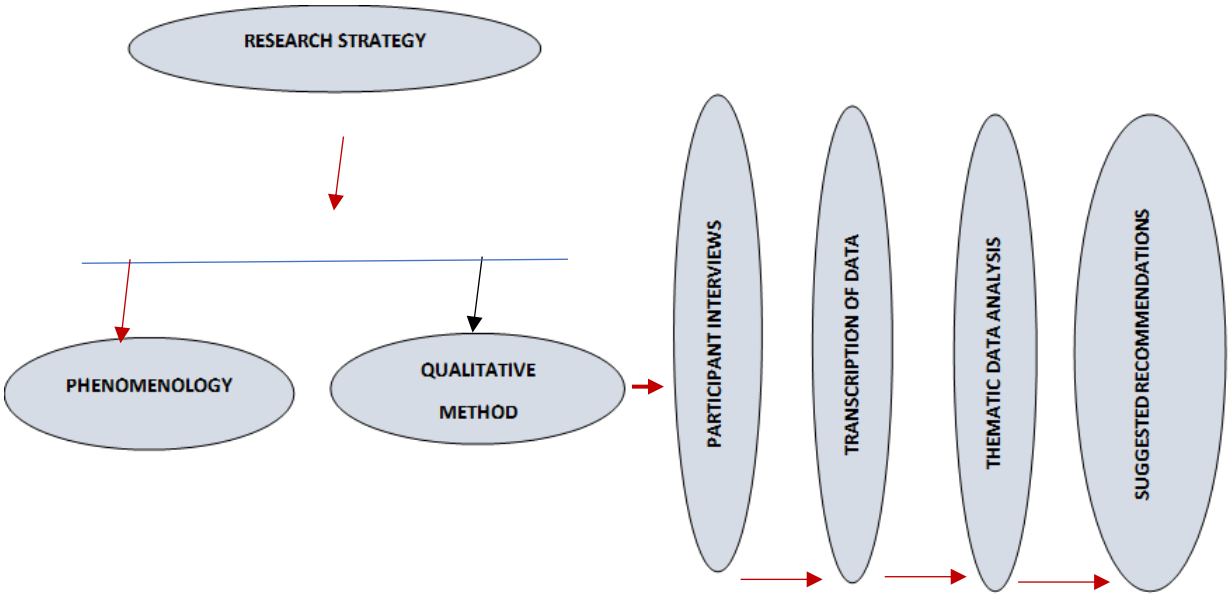


Figure 3.3: The Research Strategy

Source: Researcher's construct, 2020

The interview participants were identified. Their respective email addresses were also collected as a means of contacting them. A Participant Information Statement was later sent out to the participants (through their respective email addresses) to introduce the project and to inform them of the researcher's interest in conducting an interview with their organization. However, only insignificant numbers of stakeholders responded to these emails. A follow up visit was made, in some cases several times, before the researcher was able to have the full attention of participants. During the interviews, extra questions were put to participants to gain a more detailed understanding of their explanations. Following recommended practice, further probing also occurred, depending upon how the participants responded to the first questions asked. These follow-up questions helped to expand the researcher's understanding of the issues in

question in more detail. The Participant Information Statement and interview questions for the four group of stakeholders are presented in Appendices i and ii.

Interviews can be conducted either with one person – individual interviews – or with a group of people in a focus group. Semi-structured interviews allowed for more detailed questions. They also have the potential to achieve high response rates and detailed information about feelings, perceptions, and opinions. The limitations of this approach include subjectiveness, retrospectivity, and opacity. However, they provided an in-depth understanding of the social phenomena that this study seeks to understand. Further elaboration could also be obtained during the interview. A face-to-face semi-structured interview was preferred because of the opportunities it provided to probe for rich data and to capture verbal and non-verbal input.

A semi-structured interview is one in which the interviewer already prepared pre-determined set of questions to extract relevant information from the interviewees (Kallio et al., 2016; Yin, 2015). In most cases, the interview approach encourages two-way conversation between the interviewer and interviewee. It is a common practise for semi-structured interview-based researchers to ask questions that cannot be answered straight with a simple 'Yes' or "No" (Yin, 2015). Based on the answers, the interviewer will ask follow-up questions to draw out more specific evidence that may be required.

Although considered expensive and time consuming compared to other approaches, face-to-face interviews have been proven to be effective by qualitative researchers. Language was not a barrier for face-to-face interviews since English is the official language in Lagos, Nigeria, where the study was conducted. Each interview session lasted between thirty (30) and forty-five (45) minutes. With the approval of the interviewees, interview sessions were audio recorded. The information gathered was later analysed using thematic analysis. Thematic analysis is a form of analysis where emerging themes are categorized. For this study, data obtained from interviews were coded and sorted into categories based on their characteristics.

The interview questions were composed in accordance with the recommendations of. Careful consideration was given to the contents, wording, format, structure, and layout of the interview guide. This is an important and effective tool for structuring an interview. It is a list of pre-prepared questions to be asked during an interview session. This ensured that the questions were easily understood, not biased and applicable to the interviewees. The pilot interview, (a trial of how the interviews would be conducted in the field) as recommended by was conducted with two assumed respondents, believed to meet the selection criteria for some of the selected interview participants. This was considered necessary as it prepared the researcher for some of

the possible challenges likely to be met in the field. It also helped the researcher to prepare ahead for possible challenges. Collected data were analysed, as described by, as follows:

i. Transcribing*:* What was said during the interviews was transcribed verbatim by typing in a word processor. The resulting documents were saved as computer files.

ii. Initial reading*:* Transcripts were read through to gain an impression of the raw data. At this stage, a rudimentary coding was done using NVivo 12, a qualitative data analysis computer software application.

iii. In-depth reading*:* This stage is distinct from the previous stage. The transcripts were systematically coded, using NVivo 12 for coding, organizing, linking, and exploring notes.

iv. Codes assigned and arranged by theme: Codes that share the same characteristics were assigned together.

v. New codes assigned for further probing: This is the stage where additional questions were asked and new data collected, resulting into the creation of new codes to give a clearer understanding.

3.7.1 Target participants

Semi-structured in-depth interviews was conducted to address Objective 2. Four stakeholder groups were interviewed. The interviews were conducted face-to-face, and audio recorded with the permission of the interviewees. A total of twenty-eight (28) interview scripts were recorded. The recordings were later transcribed and analysed with NVivo 12 analysis software. The transcripts of the interviews were coded and thematically analysed. Results from the literature were married with the outcomes of the interviews.

3.7.2 Sampling techniques

Sampling, as described by , is ‘observing a part to glean information about the whole [and] is an almost instinctive act’. It is a process where a unit of the population is selected, analysed, and generalizations made to represent the entire population based on the sample. The process adopted in selecting participants to be interviewed is called judgemental/purposive sampling. It is a non-probabilistic sampling technique in which researchers rely on their judgement when choosing the population to participate in their study. It is adopted for this study due to the non-availability of detailed and comprehensive lists of the firms involved in the manufacturing and use of prefabricated elements in building construction. Since prefabricated components for building construction are not in common use, a purposive sampling technique was used to

identify the few that are known to use the technology, and to extract relevant information for the study. The technique helped to locate respondents to interview to get relevant information considered helpful in achieving the set objectives of the study.

3.7.3 Sample size

Determining the sample size for interview participants can be difficult. It is not the sole decision of the researcher but depends on factors such as population and the sampling frame of the study. This implies that there is no definite way of determining the sample size in an interview exercise. However, a population average of between 9 and 10 persons is considered an appropriate sample for a study and is the key to a successful investigation. If the sample size is too small, the research questions may not be answered adequately, and if it is too large, it is time consuming and costly.

This research seeks to invoke a deep understanding of the research problem, hence, the need to collect qualitative data where selected. Participants will be interviewed to collect relevant information that will be used for the study. Since the researcher will be collecting the qualitative data, a small number of participants is expected and accepted for such studies (Jenkins et al., 2010; Silverman, 2017). The study initially proposed conducting 40 interviews across the four groups of stakeholders, with 10 participants from each of the respective stakeholder groups. However, only 28 interviews were conducted in all before the point of saturation was reached. There were no new ideas being recorded and what the participants were saying had become repetitive (Low, 2019; Morse, 2015). Since a small sample of participants is acceptable for interview-based research (Saunders, 2012; Yin, 2011), a total of 28 participants were considered enough to carry out the research. Creswell (2013b) and Bradley et al. (2007) have suggested that a sample of between 10 to 30 participants is suitable in a qualitative study. Therefore, a total of 28 interview scripts across the four groups of stakeholders were transcribed and analysed for the study. These form the instrument used in conducting the research (Woods, 2011).

Several industrial websites in Nigeria were used to locate firms that fall within the four categories of stakeholders (material suppliers, prefabrication, logistics, and construction), as earlier identified from the literature. Among the factors considered in selecting the four categories are the total assets, number of employees, capital employed, volume of output and the net worth of the firms. The four major stakeholder groups (prefabrication firms, logistics firms, construction firms and materials suppliers) in the supply chain for prefabricated housing were targeted. Based on the set inclusion and exclusion criteria (participants had to be in one

of the above groups, with a minimum experience of five years), relevant and key representatives were purposively selected for semi-structured interviews. The participants included project managers, operations and technical managers, resident architects, civil engineers, sales managers, and transport officers, among others. The choice to include professional and non-professional participants was made to solicit general perceptions about prefabricated housing provision.

Table 3.1: Distribution of interview participants in the stakeholder groups

Stakeholders	Targeted respondents	No of Participants
Materials Suppliers 'M'	This category of firms are registered contractors and the suppliers of relevant building materials to prefabrication firms, and sometimes, where possible, to the contractors on construction sites. A purposive sampling method was also employed to select participants (with considerable years of experience). Only three interviews were conducted in this category before the point of saturation was reached. A General Manager and two Sales Managers were interviewed in each firm respectively. They include: Daltrade Nigeria Limited, Skein Nigeria Limited and SKENNING. Daltrade Nigeria Limited is the first Polish/Nigerian Joint Venture in Nigeria, established in 1962 to manufacture and supply building materials manufactured in accordance with European Union and Nigerian high-quality standards. The materials they supply include security doors, metal and poly doors, wooden and insulated steel doors, paving stones, glass blocks, POP suspended ceilings, PVC deco panels, door handles and wooden floor panels. Skein is a leading provider and supplier of reliable building products and power solutions for the Nigerian and West African market. Skein has been the exclusive distributor of Armstrong suspended ceiling systems in Nigeria for close to 30 years. Skein provides a large variety of products in stock and excellent service. Skein have built a strong reputation with stakeholders in the building industry who seek high quality building products with excellent	3

	acoustics, resistance against sag (or high relative humidity), fire retardance, energy conservation amongst others (www.skeinnigeria.com).	
Prefabrication firms 'P'	Eight identified established building prefabrication firms that are specialized in offering the services associated with producing prefabricated components for building construction were purposively selected for interview. They include Karmod Nigeria Prefabricated Technologies, HFP Engineering (Karmod Nigeria) Limited, Tempo housing Nigeria, Nigerite, Vitapur prefabricated construction, Ecosteel Prefab Homes, TLI Design Limited and Liquid Engineering Services. The heads of the technical departments of each firm were interviewed and relevant information extracted.	8
Logistics Firms 'L'	The logistics firms usually have their expertise in the supply of raw materials to components prefabrication firms and movement of finished prefabricated components from production firms to the construction site. They also haul prefabricated components to retail shops, where customers can buy them in units. Eight (8) firms were also contacted for interview to elicit the necessary information for use in the study. They include Fafem Haulage Nigeria Ltd, Wadoye Express –Supply Chain & Logistics, Nosak Haulage Limited (Nosak Group), and Fastrade Logistics Limited.	8
Construction site 'C'	Construction site personnels, including the Architects, Builders, Civil Engineers, Project Manager and other different relevant professionals and tradesmen who are stakeholders in the housing prefabrication construction projects, were interviewed. Among the construction companies visited were HFP Engineering, Elalan Construction Company, Cappa &	9

	D'Alberto Plc, among others. Purposively, nine personnel were selected for the interviews in these categories.	
Total	A total of 28 interviews were recorded, transcribed, coded, and analysed.	28

3.7.4 Data Collection Instruments

Research data are in the form of primary data and secondary data (Bryman, 2015; Rowley, 2012). The methods used for data collection are known as methodology (Pan & Tan, 2011). The methodology adopted for this study was qualitative and the methods used were literature reviews and semi-structured in-depth interviews. Collated findings from interviews were married with facts from the literature to form the list of recommendations proposed for improvements in the supply chain management of prefabricated housing construction in Nigeria, based on the findings from the literature and the results from the interviews.

3.8 Definition of the analytical method

A description of the process for analysing data is presented in Figure 3.1. Qualitative data are coded with data analysis computer software package NVivo 12. Interpretations are based on the familiarity of the participants with respect to the supply chain management of prefabricated building construction methods.

Primary data in the form of interview discussions were collected from four relevant stakeholder groups as identified earlier in the chapter. Each of the four stakeholder groups differ in their functions and ability to keep prefabricated building technology recognized and popular. They include prefabrication firms (P), construction firms (C), logistics firms (L) and materials suppliers (M), as seen in Table 3.1. Codes were assigned to de-identify participants. A total of 42 codes were generated from the interviews. After refinement of the initial codes, a total of 18 codes were later identified with a higher level of abstraction, which resulted in the formulation of the themes.

3.9 Summary

The methodology for the study was described in this chapter. The appropriate philosophies, methodologies, and methods to gather, present and analyse data that would help answer the over-arching research question have been identified and explored. This study aligns with the relativity ontology paradigm that knowledge warrants attention. As a result of this, the study employed a qualitative method based on participants' experiences in the form of interviews to have a better understanding of the fact. A deductive approach was used to obtain knowledge based on the experiences of participants in the supply chain management for prefabricated housing construction in Nigeria. Table 1.1 shows the distribution of participants and the parameters for sample selection. Semi-structured, face-to-face interviews were conducted with relevant stakeholders. An analysis of data collected is presented in Chapter Five of this study.

CHAPTER FOUR

SYSTEMATIC LITERATURE REVIEW TO FULFIL OBJECTIVE 1

4.0 Introduction

This chapter explores supply chain management (SCM) for prefabricated construction components in Nigeria. It addresses research Objective 1: "Review current supply chain management practices in the Nigerian construction industry and elsewhere". A sub question: What is the current supply chain management practices in the Nigerian construction industry as well as elsewhere? was raised. This was also addressed through the systematic literature review (SLR). SLR was. The SLR was conducted to identify, select, and critically appraise the relevant literature. This followed a Prisma systematic review protocol that clearly defined the criteria before the review was conducted (Moher et al., 2015; Okoli & Schabram, 2010).

SLR allow researchers to view the 'lie of the land' in a particular area (Kothari, 2004; Okoli & Schabram, 2010). This sets out the background against which this study of supply chain management took place. An SLR is necessary to justify and demonstrate an understanding of phenomena (Kothari, 2004). Journal articles and reports were reviewed to establish current SCM practices in the Nigerian construction industry and elsewhere.

4.1 The systematic literature review

A SLR was employed to address Objective 1. The review specifically targeted relevant literature on supply chain management for prefabricated housing construction. It involved the use of online searches of six databases - Web of Science (WOS), Emerald Insight (EMR), Scopus (SCP), ProQuest (PRQ), EBSCO (EBS), and ASCE (ASC) – using the keywords presented in Table 4.1. Google Scholar was also used to locate additional records. Each database was scanned to filter and retrieve the most relevant papers for review and to help in identifying evidence of the existing scholarly works (Farias et al., 2019). To address the specific target of Objective 1, 6400 relevant articles were initially downloaded from journals, conferences, technical reports, and other related publications in architecture, building construction, project management, the built environment, housing development, housing, supply chain management practice, and developing countries. Downloaded citations and articles were managed and processed using Endnote X9. An overview of the 6400 records identified through the database searches is shown in Table 4.1. The PRISMA flowchart (Figure 4.1) illustrates the processes involved in the systematic review to screen and select eligible

articles. Furthermore, Figure 4.1 shows how the documents were filtered to arrive at the final selections. Selected peer-reviewed journals were analysed for the study. The SLR was used to specifically target articles about supply chain management for prefabricated housing construction, and the views of different relevant authors were extracted, compared, and contrasted. This over-rode the bias of the researcher (Marshall & Rossman, 2014; Yin, 2015).

Initially, articles containing relevant terms in their title, abstract, and/or keywords were considered. A protocol was defined with the help of a PRISMA checklist. Inclusion and exclusion criteria were also set to reduce the risk of bias, increase transparency, and ensure uniformity amongst the research terms. Research into the supply chain management for prefabricated building construction is not new. A considerable number of studies have been carried out by other researchers around the world on related topics. The term "supply chain" was coined in 1982 by Keith Oliver. It has also been used in the automobile industry and other manufacturing sectors over the years (Mathivathanan et al., 2018). However, the term only began to gain popularity about 15 years ago with respect to building construction (Irizarry et al., 2013; Thangaraj & Chan, 2012).

The scope of this review took account of relevant academic peer-reviewed journals publications from January 2005 to February 2022. These comprise the mainstream journals with a reputation for publishing influential papers on managerial issues in the construction industry. The journals were ranked by SCImago Journal & Country Rank, Australia Research Council, or other journals, and have been acknowledged as first-tier journals by peer reviewers who specialize in the topic and technical studies, including publications related to architecture, building the built environment, housing prefabrication, standardisation among others.

Table 4.1: Compendia database, industry, and other non-academic publications

Searched terms	**No. of Articles from Database**					
	WOS	EMR	SCP	PRQ	EBS	ASC
Supply Chain Management in Nigeria	94	52	76	50	67	32
Prefab Housing Construction in Nigeria*	68	64	41	36	83	21

Supply Chain Management for Prefab Hous**	34	115	69	39	96	47
Housing Construct in Lagos State, Nigeria*	99	49	50	86	74	18
Prefabricat Housing Construct**	56	38	77	71	41	23
Container(ised) (hous)*	112	47	59	89	112	31
factory assembled "	74	8	69	92	74	27
factory built "	86	92	84	112	86	78
Industrialised "	141	88	16	69	141	52
Modern methods of building construction	39	62	67	24	39	35
Offsite	78	62	41	55	78	71
Prefabricated "	61	24	18	34	61	11
*Preassemb**	46	75	76	32	46	33
Prefabrication "	70	57	64	61	70	13
Prefab "	66	52	68	27	66	64
Panelled "	92	86	37	46	12	23
Relocatable "	41	91	52	35	41	52
Transportable "	17	35	70	40	17	35
Standardization		20	18	34	28	12	15
Sub-total/ Database	1,294	1,115	1,068	1026	1,216	681
Overall Number of Articles from database	**6,400**					

The keywords used in the SLR are presented in Table 4.1. The asterisk (*) refers to a wildcard character, allowing expansion of terms such as hous* to house, houses, housing, and other similar terms to systematically summarize the existing published evidence regarding the

potential barriers and drivers of prefabricated housing uptake, with an emphasis on SCM of prefabricated housing construction.

As the search terms were broad, all abstracts or reference details from relevant journal articles were reviewed for relevance. Full-text copies of articles deemed to be relevant were sourced where possible. Further relevant references were identified through a review of the full articles and their reference lists. These were considered in the selection of target academic peer-reviewed journals from six databases. Supplementary searches using the above terms on standard Google web-searches and Google Scholar were undertaken to identify further relevant papers or reports that were within the scope of the compendia database, industry, and other non-academic publications. Each database was scanned to filter and retrieve the most relevant papers for review. This is presented in Table 4.1.

The Prisma diagram was used as the protocol to narrow down selected articles to those most relevant for the study. The search criteria were carefully selected and fed into the databases. Inclusion and exclusion criteria were also set to select relevant articles. The screening of articles started with a review of the abstracts of downloaded articles to identify and remove duplicated articles from the different databases. Out of a total of six thousand four hundred (6400) articles, nine hundred and three (903) articles were successfully removed at this stage. Supply chain management is not confined to the construction industry. Therefore, articles not directly relevant to the thesis were also removed. One hundred and nine (109) articles were removed at this stage. After a further review of the remaining articles, another five hundred and eighty-four articles (584) were deleted because they were not relevant to the research question while a few were not written in the English language. This left a total of one hundred and eighty-three (183) eligible articles for the study. However, only forty-nine (49) of these articles were later found to be peer-reviewed articles and meet the other selection criteria. The final selection of publications was then subjected to qualitative analysis. Finally, a total of forty-nine (49) relevant publications, comprising mostly peer reviewed journal articles, conference papers and reports, were selected and reviewed for this study. These are further presented in the Prisma flow diagram as seen in Figure 4.1.

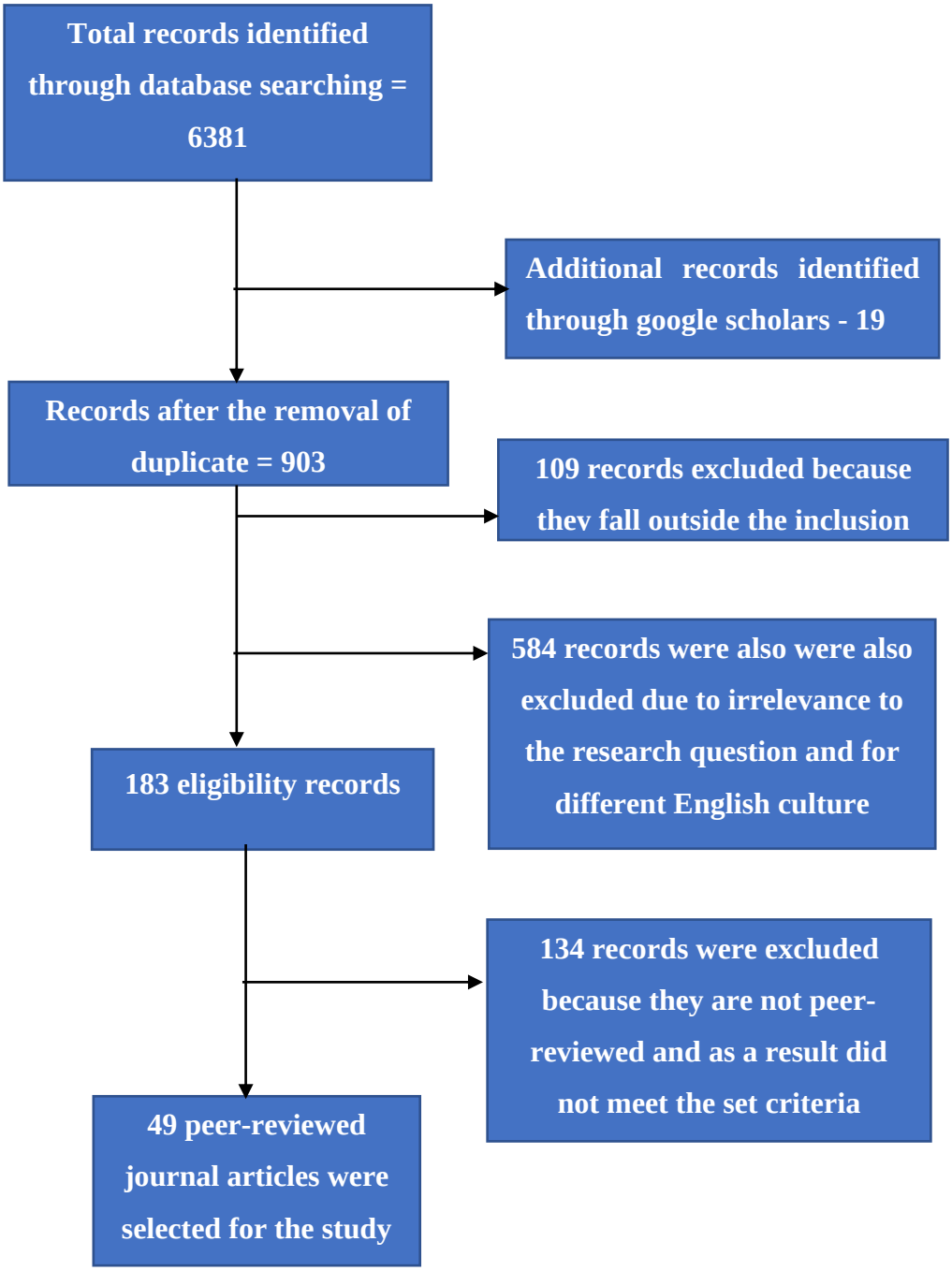


Figure 4.1: Prisma Flow Diagram

The review was conducted to inform the remainder of the study. Relevant topics were identified and then collated. These are presented below.

A systematic literature review is a summary of past research (secondary data) in a field of study (Mostafa et al., 2016). It usually sets out the background, including the inclusion and exclusion criteria, against which a study takes place. This is necessary to justify and demonstrate the understanding and establishment of the theoretical framework of the study. It will also help in developing a methodology that will support the new findings. A systematic literature review

identifies, selects and critically appraises research in order to answer a clearly formulated question, problem or research gap (Dewey & Drahota, 2016). Review of the protocol and process further reduces the bias potentially introduced by the researcher. SLRs help to answer the overarching research question "How can supply chain management for prefabricated construction in Nigeria be enhanced".

4.2 The concept of supply chain management

The term supply chain management, according to (Mensah & Merkuryev, 2014) and (Li et al., 2014a), is relatively new. It was first reported in logistics literature in 1982 as an inventory management approach with an emphasis on the supply of raw materials. It was argued in the 60s (Mensah & Merkuryev, 2014; Zhang et al., 2015) that a SCM doctrine was needed because a single activity could not ensure the effectiveness of a system that was dependent on chains of activities. It was further reported that a supply chain involved a network of firms, their key business processes, and facilities for the delivery of products, services or information to a given category of end users or customers (Olaniyan et al., 2015a)(Olaniyan et al., 2015). The concept of SCM arose from the idea of goods and services merging with other processes that transform raw materials into final products (Mensah et al., 2014). It involves the active streamlining of the supply-side activities of businesses to maximize customer value and gain a competitive advantage in the marketplace (Estampe et al., 2013; Moneke & Echeme, 2016).

This chapter investigates how supply chain practices are being managed for prefabricated housing construction. Global trends in prefabrication in building construction were studied. Here the operation and performance of this approach in different countries is explored to identify best management practices and the measures of SCM efficiency. The chapter ends by summarising the constraints affecting the adoption of SCM for prefabricated construction in the Nigerian construction industry.

SCM was described by Mensah et al. (2014) as a collection of activities carried out by an organization to facilitate the effective management of its supply chain. In their research work, Al-Werikat (2017) and Moneke and Echeme (2016) described supply chain management as a network of various organizations linked upstream and downstream in a chain through integrated processes and activities aimed at products for end customers. It can be concluded from the concept that components of SCM practices include issues of supply and inventory control, events, exchange of knowledge and customer service. According to (Mensah et al., 2014), organizations seek to maximize the degree of integration of the entire supply chain for relevant industries. It is noteworthy that there is no universally accepted definition of SCM,

but there is a clear connection and agreement between the different definitions that point in a similar direction, especially in the construction industry.

A supply chain consists of all parties that directly or indirectly try to fulfil a customer demand (Mostafa & Dumrak, 2014; Zhai et al., 2018). SCM is the systematic strategic management and coordination of a network of relationships within a firm and between interdependent organizations and business units (Ojo et al., 2014b). It consists of material suppliers, purchasing departments, production facilities, logistics, marketing, and related systems that facilitate the forward and reverse flow of materials, services, finances, and information from producers to final customers. This has the benefit of adding value, maximizing profitability, and improving efficiency to achieve customer satisfaction and improve the long-term performance of individual companies and the supply chain as a whole (Stock & Boyer, 2009).

The SCM concept originated from the manufacturing industry, where it has been successfully used to regulate the supply of goods. It has also been widely applied to many other industries, like mining, transportation, storage, property and business services to improve productivity, efficiency and save costs (Moneke & Echeme, 2016). Several research advances have been carried out by other researchers aimed at performance assessment and best practice for SCM in regard to the regular use of information by organizations (Christopher, 2017). These often have a tacit dimension, embedded partly in individual skills and partly in collective social arrangements.

However, SCM is still considered an emerging area of practice and has been slow to be adopted by construction companies (Forsman et al., 2012a; Liu et al., 2014). SCM in construction seeks to adopt the same practices that originated from the manufacturing industry.

The concept of SCM can be applied to the construction industry, which is highly fragmented and subject to changes. The objectives of SCM include service orientation, system orientation, competitiveness, and efficiency, minimizing time and improving visibility, demand and quality (Arashpour et al., 2017; Chopra et al., 2013).

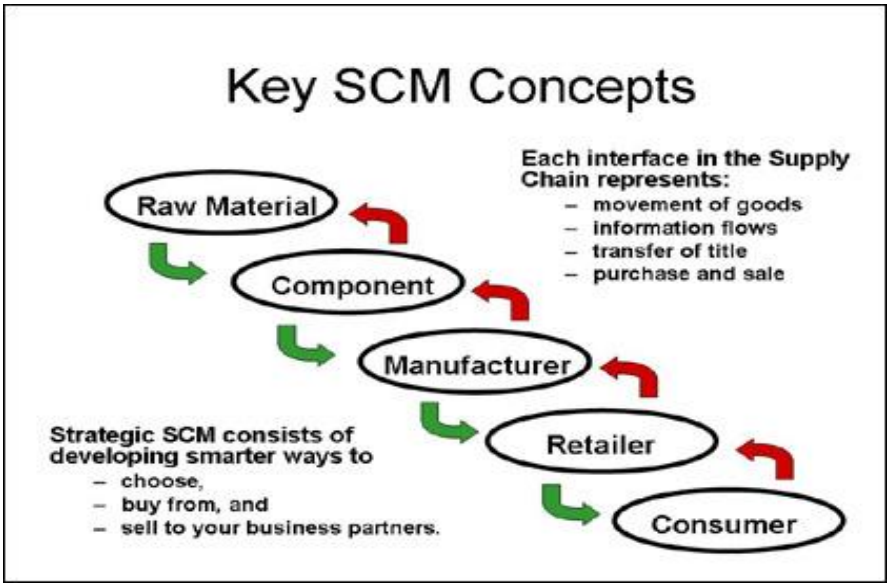


Figure 4.2: Typical supply chain management concept.

Source: (Wieland & Wallenburg, 2011)

Supply Chain Management techniques have been successfully used in various industries, including automotive, aerospace and food, for decades (Dolgui & Proth, 2010). It is suggested that construction companies can learn best practice through leveraging their supply chains and that this would contribute significantly to improving business performance. Such findings align well with many of the recommendations put forward in the reports by Egan and Latham (Egan, 1998b; Latham, 1994a). These reports recommended ways to improve quality and efficiency in the UK construction industry. This study explores the effectiveness of SCM in the uptake of prefabricated building construction in Nigeria. It investigates different tiers in the supply chain associated with projects that use prefabricated construction components. This is motivated by the acute housing deficit and the need for the provision of more affordable housing in Nigeria. The prefabricated option for housing production has been practically proven to deliver housing much faster and cheaper (Brissi et al., 2021; Navaratnam et al., 2019b).

There is a need for a SCM framework to improve the delivery of prefabricated housing to the people. Table 4.2 presents a summary of literature about the major areas related to prefabricated building construction SCM.

Table 4.2: Classification of articles according to areas of concentration

Areas	Reviewed articles based on the main area of concentration
Housing deficit and low-cost housing	(Akinmoladun & Oluwoye, 2007), (Sandberg & Bildsten, 2011), (Olanrewaju et al., 2016), (Ayedun & Oluwatobi, 2011), (Ashkin, 2013), (Ademiluyi & Raji, 2008), (Ogunsanya et al., 2016), (Ibem et al., 2011), (Ajanlekoko, 2011), (Adenuga, 2013), (Emiedafe, 2015), (Emiedafe, 2015), (Aluko, 2010), (Kabir & Bustani, 2009), (Aule & Moh'd Jusan, 2019; Marshal & Onyekachi, 2014), (Lagos State EIU, 2012), (Ebekozien et al., 2019), (Ebekozien et al., 2019), (Taiwo, 2015).
Prefabricated housing construction	(Blismas et al., 2010b), (Mostafa et al., 2014a), (Nadim & Goulding, 2011), (Pour Rahimian et al., 2017), (Xue et al., 2017), (Jaillon & Poon, 2009), (Wong Peter et al., 2017), (Li et al., 2014b), (Musa et al., 2016), (Tam et al., 2007), (Ogunde et al., 2016), (Tam et al., 2015), (Liu et al., 2017), (Bhattacharjee et al., 2016), (Larsson & Simonsson, 2012), (Kolo et al., 2014a)
Prefabricated construction supply chain management (PCSCM)	(Zhai et al., 2017a), (Stroebele & Kiessling, 2017), (Wang & Hu, 2017a), (De Melo & Da Alves, 2010), (Zhai et al., 2015a), (Hsu et al., 2017b), (Han et al., 2017), (Zhai et al., 2018), (Abedi et al., 2016b), (Mostafa & Dumrak, 2014), , (Doran & Giannakis, 2011), (Kim et al., 2016), (Demiralp et al., 2012), (Abedi et al., 2016a), (Wandahl et al., 2007), (Montali et al., 2018), (Du et al., 2019), (Yang et al., 2018b), (Schoenwitz et al., 2017).

4.3 Overview of SCM in prefabricated housing construction

The construction industry is generally considered to be some way behind those sectors where effective supply chain management is regularly practised (Briscoe & Dainty, 2005). Venselaar et al. (2015) noted that the construction supply chain is characterized by converging supply chains, one-off project-based configurations, and made-to-order supply chain relationships with little or no repetition. Scholars have widely recognized the importance of implementing SCM in the construction industry (Okafor et al., 2021). SCM improves the performance of construction activities. It usually saves construction projects from cost and time overruns,

conflicts and disputes by coordinating independent entities (Khalfan et al., 2010; Moon et al., 2015; Wang et al., 2021).

The production of prefabricated building components shows the closest analogy to the manufacturing industry. The house building supply chain can be visualized as shown in Figure 4.3. Here, prefabricated components are generally produced by manufacturers. Some special components are ordered in a timely manner while the common components are produced in large numbers, bought by retailers, and made available to the public. These are then moved directly from the manufacturers to the construction site where they are installed.

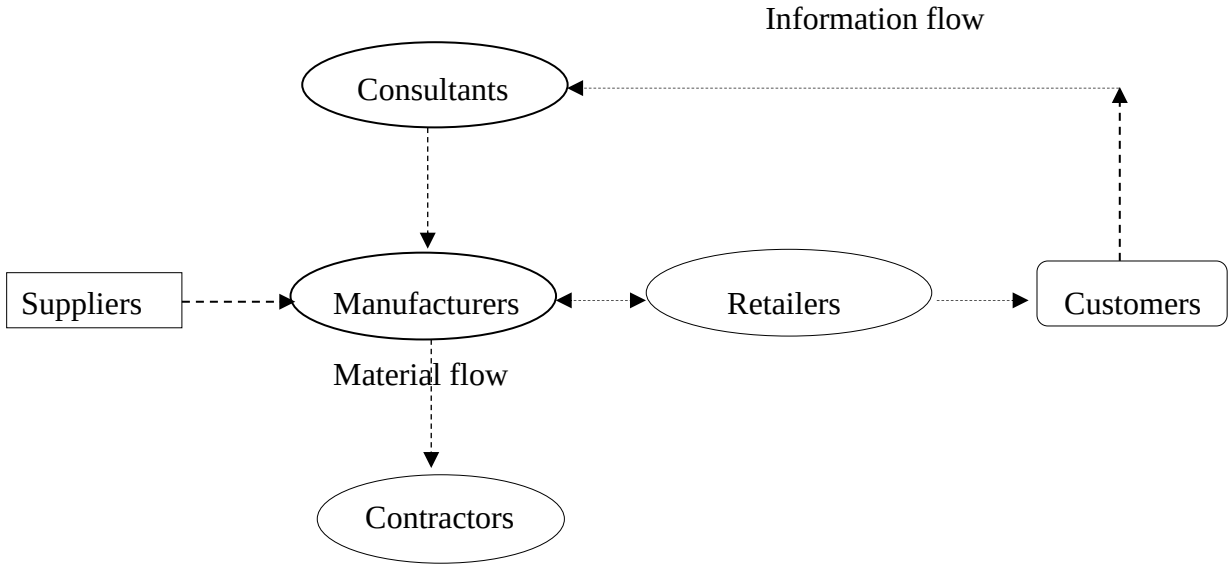


Figure 4.3: Prefabricated housing supply chain representation.

Source: Adapted from (Mostafa et al., 2014b)

SCM in prefabricated housing construction may be considered in three main phases, based on the literature (Stroebele & Kiessling, 2017; Zhai et al., 2015b). These include prefabrication firms, logistics and construction sites. Prefabrication firms generally produce prefabricated components in highly standardized production lines, similar to the automotive industry (Larsson & Simonsson, 2012; Zhai et al., 2015b). The logistics firm is responsible for the movement of completed components to construction sites. These services are sometimes outsourced to third-party companies that provide shipping and warehousing services for the main logistics firm (Lindén & Josephson, 2013). This is usually based on the on-site schedule of the building contractor. Operatives on the construction site then assemble the prefabricated components. There are uncertainties at each of these phases. There is limited literature on the supply of raw materials to prefabrication firms. This is an essential step necessary to complete the supply chain circle for prefabricated building components. A detailed representation of the

various stages of the supply chain for prefabricated housing is provided in Figure 4.4. This shows the major stages in SCM for prefabricated building components. However, the important aspect of 'raw materials purchasing' is not addressed by the authors of Figure 4.4, (Zhai et al., 2016; Zhai et al., 2015b) and (Li, 2020; Stroebele et al., 2017). This important aspect needs to be included in SCM and is therefore presented in the conceptual framework shown in Figure 4.4 and 4.5.

There are four stages in developing a supply chain framework (Stroebele et al., 2017; Zhai et al., 2018). These include:

i. The study of strategic supply chain inventory and the extent of product customization.
ii. Addressing the following five activities: Defining the uncertainties, creating uncertainty profiles for each project, categorizing uncertainties according to the source and originator of supply chain uncertainty, modelling interactions between the uncertainties and plotting them according to probability and implication.
iii. The documentation of methods used in a collaborative environment with all supply chain parties (such as input-output diagrams, flow charts).
iv. The arrangement of suppliers according to predefined categories and the distribution of mapped flexibility uncertainties. This is the final stage.

4.4 Major issues in the various phases of the supply chain for prefabricated construction

The supply chain management issues in prefabricated housing construction occur in three main phases (Stroebele & Kiessling, 2017; Zhai et al., 2015b). These include prefabrication firms, logistics processes and the construction site (see Table 4.3).

Table 4.3: Major Issues in the different phases of the prefabricated construction supply chain

S/N	Phases	Major issues
1.	Prefabrication firms	Raw materials reliability: shortage of raw materials from suppliers (de Melo & da CL Alves, 2010; Hsu et al., 2017a; Zhai et al., 2015a). Production reliability: machine breakdown, materials damage during assembly process and preventive maintenance of plant and equipment (Abedi et al., 2016a; de Melo & da CL Alves, 2010; Zhai & Huang, 2017). Skilled labour shortage: Lack of skilled labour (Stroebele & Kiessling, 2017; Wang & Hu, 2017b; Yang et al., 2018b).
2.	Logistics	Transportation facility reliability: Lack of special trailers, trailer breakdown (Abedi et al., 2016a; Doran & Giannakis, 2011; Zhai et al., 2015a). Transportation uncertainties, traffic jams, bad weather conditions, low efficiency of custom clearance, accidents, re-routing, disruption (Hsu et al., 2017a; Mostafa & Dumrak, 2014; Stroebele & Kiessling, 2017).
3.	Construction sites	On-site storage: Space for storage may be constrained. On-site buffer storage of components may not be possible (Mostafa & Dumrak, 2014; Zhai & Huang, 2017). Late delivery of components: Delays in the delivery of prefabricated components is another important issue with the construction site (Mostafa et al., 2014b; Zhai et al., 2015b). When this happens, contractors are made to fully pay the labourer and site workers, even when they are not able to meet their daily targets.

		On-site assembly process: Damage, accidents, wrong operations, crane breakdowns (Doran & Giannakis, 2011; Hsu et al., 2017a; Stroebele & Kiessling, 2017). Lack of skilled labour: Shortage of skilled labour is another major issue facing the construction industry (Stroebele & Kiessling, 2017; Wang & Hu, 2017b; Zhai et al., 2015a).

All the uncertainties noted in Table 4.3 contribute to time and cost overruns in a construction project (Zhai et al., 2015a). To prevent the time and money savings associated with prefabrication from being depleted, a growing number of researchers have focused attention on ways to mitigate the uncertainties that cause delivery failure (Jaillon & Poon, 2008; Pheng et al., 2016; Tam et al., 2007). Some of the approaches advocated to mitigate supply chain uncertainties include improvement of supply chain visibility, dual sourcing and holding safety stock (Stroebele & Kiessling, 2017; Zhai et al., 2015a).

Due to the characteristics of the prefabricated construction supply chain, some additional actions are required. For example, prefabricated components need to be produced to meet relevant specifications. This means that construction drawings and designs need to be detailed to resolve possible issues at the construction stage of a proposed project. It also means that components need to be produced using factory production scheduling methods (Weiss & Maher, 2009).

It can be argued that SCM goes further to incorporate elements not usually included in a logistics concept, such as information systems, as well as planning and control activities, integration and coordination (Christopher, 2011). Christopher (2011) described a supply chain as upstream and downstream partnership management with manufacturers and consumers to provide superior customer service to the supply chain at a reduced cost.

Construction supply chains are problematical to handle (Saka & Mudi, 2007). There are many parties involved that work on a project basis. While these encounters are temporary from the project's point of view, they linger over time when it comes to business perspectives. In the case of building, much attention in the literature has focused on the management of project supply chains rather than an enterprise's supply chain. The planning horizon is the primary distinction between these approaches, since the first focuses on short-term and temporary decisions and the second focuses on long-term thinking.

4.4.1 The practise of prefabrication in construction and supply chain management (PCSCM)

Researchers contend that in-depth analysis of cost and time plays a pivotal role in identifying potential improvements and developing prefabrication supply chains (Abdelkafi & Pero, 2018). Aloini et al. (2012b) and Li et al. (2014b) have indicated a need for future research on the interrelationship of independent entities in the prefabrication supply chain from an entire system perspective. They regard this as the key element for satisfying a client's needs within budget constraints.

Xu and Zhao (2010) have pointed out that high fragmentation is rooted in the construction industry, so one of the major challenges for prefabrication in construction and supply chain management (PCSCM) is to coordinate members to overcome the barriers that impede logistics to maximize the benefits of adopting prefabrication technology. Research about how to coordinate members to hedge against logistics uncertainty in PCSCM is limited (Amade, 2016a; Stroebele & Kiessling, 2017; Zhai et al., 2018). To obtain the benefits of prefabrication, a well-organized supply chain is important. This involves the coordination of all participants in the overall project to achieve timely delivery, low costs and high-quality standards (Lessing, 2006). Therefore, SCM is needed in the building construction processes from the planning to the delivery stage (Bygballe et al., 2010).

To soften the impact caused by supply chain uncertainty, early delivery of materials is encouraged. However, prefabricated components are heavy and bulky, particularly when assembled into volumetric modules. Furthermore, it may not be possible to accommodate many prefabricated components on-site. This is because construction sites are often confronted with space constraints, especially in dense urban areas. In such instances, the efficiency of site operations will be greatly impacted if the site is congested (Meng, 2010; Spillane & Oyedele, 2013). Transportation companies that move prefabricated components need large spaces for offloading and manoeuvring components. In practice, this is not always possible within normal working hours. The option of just-in-time delivery is embraced at such instances to ensure on-time delivery and to guard against late delivery of components (Mitropoulos & Memarian, 2012).

Regular production and smooth delivery of prefabricated components is necessary for the uptake of the technology. Hence, the unhindered availability of raw materials for prefabrication firms is an important phase for enhancing the supply chain network. Therefore, this study focuses on investigating the different phases of prefabrication in Nigeria compared to other

countries. The introduction of a supplier phase to cater for the supply of raw materials into prefabrication firms in the PCSCM process is shown in Figure 4.5. This will contribute to improving the delivery of prefabricated housing in Nigeria.

The influential reports by Latham and Egan both advocated for the UK construction industry to embrace components manufacturing for building construction (Wolstenholme et al., 2009a). This resulted in greater demand for prefabrication technology in building construction. The UK government, however, played a major role in the development of prefabrication for construction by sponsoring reports and putting policies in place to support and set up an organization (Build offsite), with the responsibility to promote the uptake of building prefabrication within the construction industry (Gibb & Pendlebury, 2006; Hsu et al., 2017a).

Nigeria has been experiencing continuous problems of acute housing shortages. Currently, a deficit of over 22 million housing units is recorded (Adegoke & Agbola, 2020; Ademiluyi, 2010; Kabir & Bustani, 2009). Nigeria is also currently experiencing a skills shortage in the construction industry (Ayedun & Oluwatobi, 2011). To significantly reduce this deficit, one million housing units need to be built annually (Adetayo, 2013). Given this position, stakeholders within the Nigerian built environment have advocated for a change from the conventional mode of construction to a more advanced mode so that the need for housing can be met (Ashkin, 2013). Since Nigeria has a similar problem to that experienced in the UK during the post-war era, it is argued that the problem of a housing deficit can be managed with prefabrication technology (Ashkin, 2013; Schwartz, 2014). This is because of the benefits of speed, better quality, and low cost associated with this construction method.

4.5 The Conceptual Framework of the Study

A conceptual framework categorizes and defines concepts important to a research task, as well as sketching out the links between the various constructs. To carry out this study, a conceptual framework was developed to show the relationship between the dependent and independent variables and identify the phenomena to investigate. The dependent variable in this study is successful prefabricated construction project delivery, while independent variables are establishing trust and long-term relationships among supply chain partners, supply chain finance, supply chain and continuous performance measurement, quality management, information, technology, supply base management, and supply chain and continuous performance measurement, senior management involvement and supply chain orientation. Figures 4.4 and 4.5 depict the constructs and connections between the research variables.

4.5.1 Stages in prefabricated construction supply chain

The logistics firm is responsible for the movement of completed components to construction sites. These services are sometimes outsourced to third-party companies that provide shipping and warehousing services for the main logistics firm. This is usually based on the on-site schedule of the building contractor (Zhai et al., 2019; Zhai et al., 2017b). Operatives on the construction site then assembles the prefabricated components for installation. There are uncertainties at each of the installation phases, with components lapping one another (Zhai et al., 2019). There is limited literature on the supply of raw materials to prefabrication firms. This is an essential step, necessary to complete the supply chain circle for prefabricated building construction. A detailed representation of the various stages of the supply chain for prefabricated housing is provided in Figure 4.4. This shows the major stages in the SCM for building prefabricated components. However, the important aspect of 'raw materials purchasing' is not properly addressed (Stroebele et al., 2017; Zhai et al., 2017b). This important aspect needs to be included in SCM and is therefore presented in the conceptual framework, as shown in Figure 4.4 and 4.5.

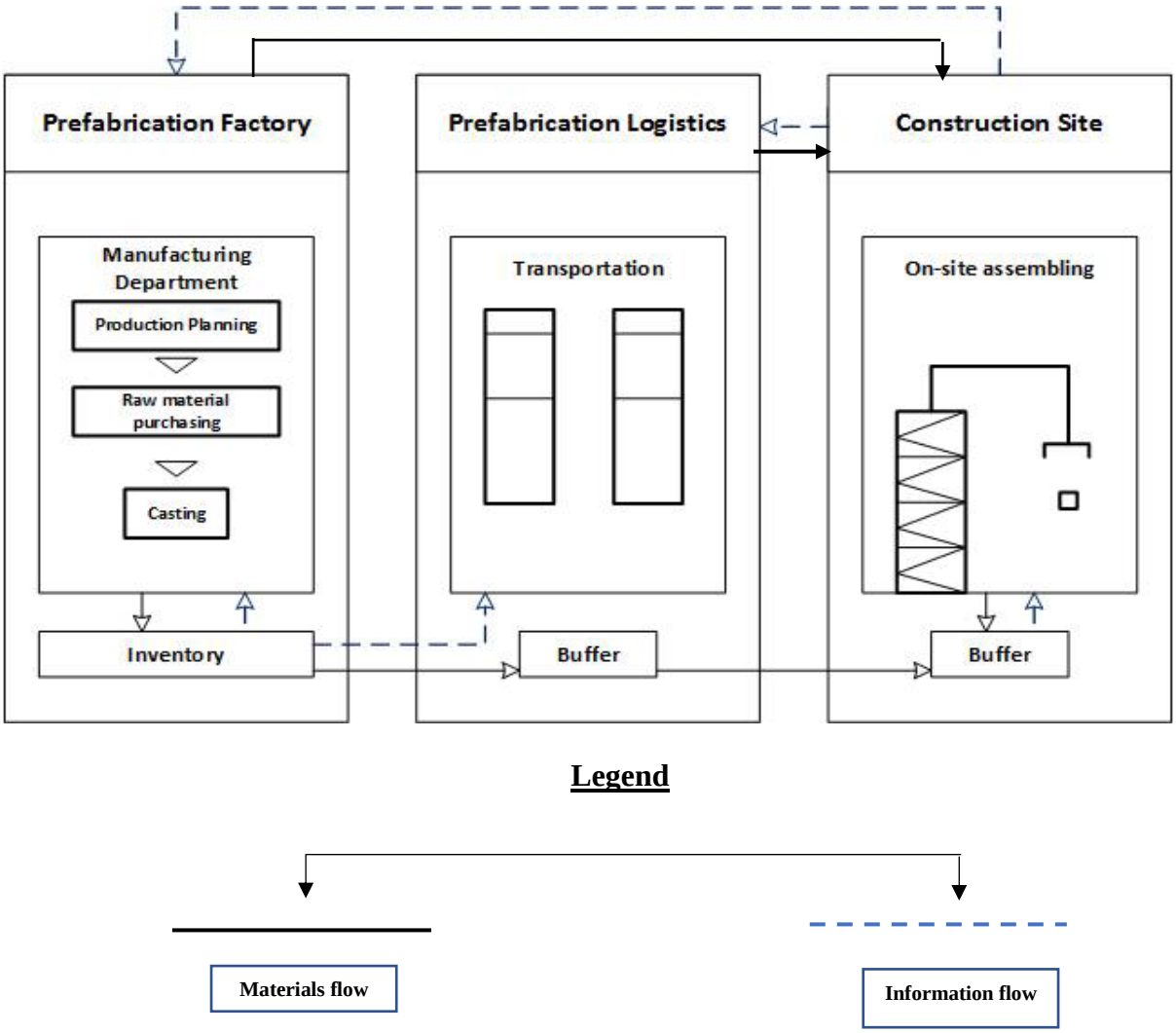


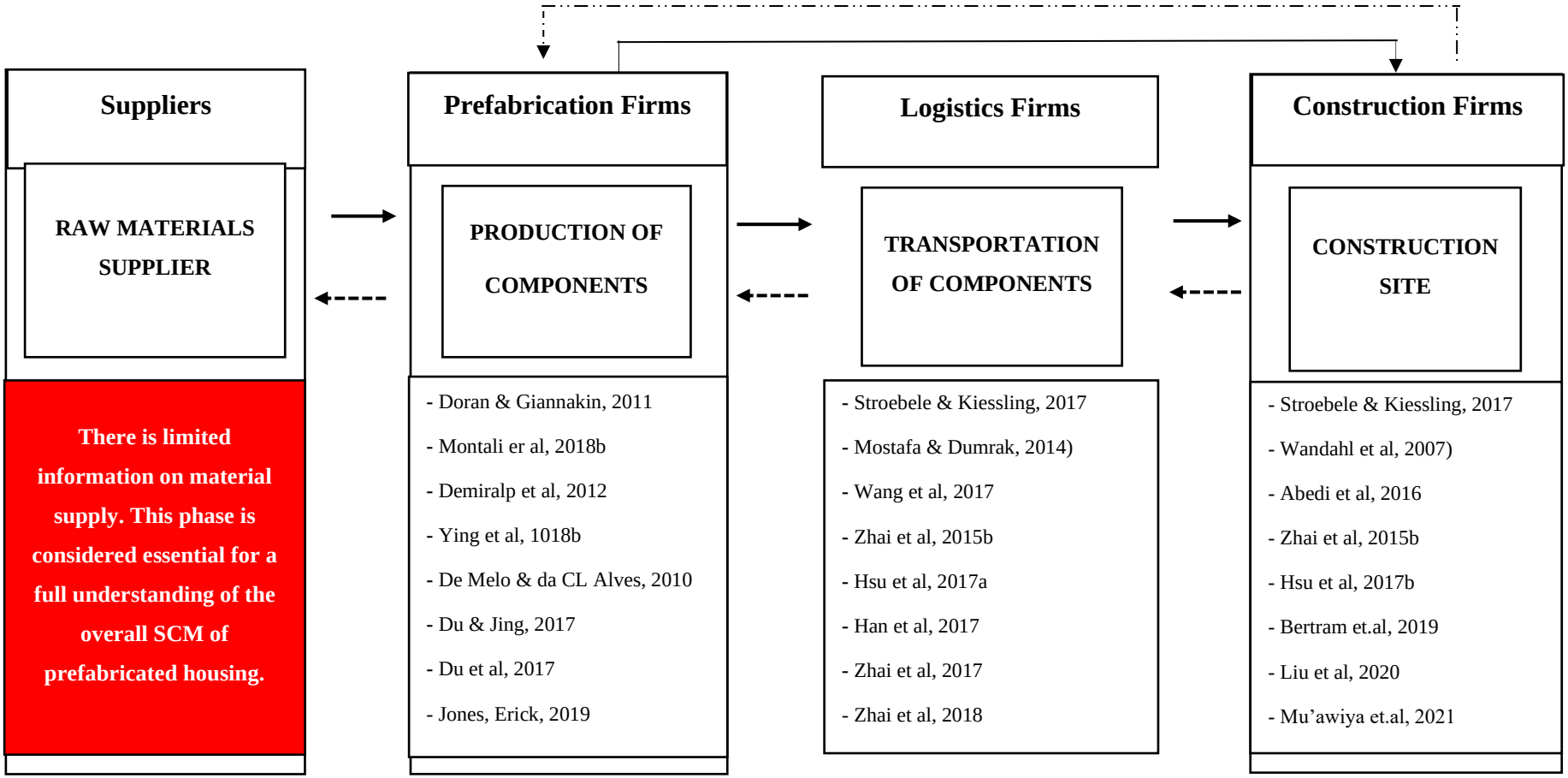
Figure 4.4: Stages in prefabricated construction supply chain.

Source: Adapted from (Zhai & Huang, 2017; Zhai et al., 2018) and (Stroebele et al., 2017)

Against the situation in Figure 4.4, early delivery of materials is advocated to mitigate the impact of supply chain uncertainties. Prefabricated components, on the other hand, are large and heavy when produced in modules. On-site storage of significant number of prefabricated components may be impractical. The is because of the possible space constraints on building sites, particularly in urban centres (Montali et al., 2018). If the site is congested, it will have a significant influence on the efficiency of site operations (Meng, 2010; Spillane & Oyedele, 2013). Transportation firms who have the equipment to move prefabricated components require a lot of parking spaces. This is not always possible in practice. Therefore, this necessitates the option of just-in-time delivery to guarantee on-time delivery of prefabricated components on project sites to guard against late delivery research methodology (Mitropoulos & Memarian, 2012).

To ensure the technique is adopted, regular production and distribution of prefabricated components is required(De Melo & Da Alves, 2010). As a result, an unrestricted access to raw materials by prefabrication businesses is a critical step in improving the supply chain network.

Thus, the study focuses on investigating the supply chain management of prefabrication building technology in Nigeria, with a particular focus of introducing the supplier's phase, which is responsible for supplying raw materials to the prefabrication firms, as seen in Figure 4.5. This is expected to contribute to the improvement in the delivery of prefabricated housing in Nigeria. This will subsequently encourage the overall acceptance of prefabricated housing as a good alternative for housing delivery in Nigeria.



Legend: --------- **Materials flow** ———— **Information flow**

Figure 4.5: Conceptual Framework

Source: Researchers construct, 2020

4.5.2 Transaction Cost Economic (TCE) Theory

From an economic standpoint, SCM is often viewed as a sequence of economic players, such as businesses purchasing from and selling to one another. (Segerstedt & Olofsson, 2010; Vrijhoef & de Ridder, 2007) give a concise explanation of the existence and structure of businesses, as well as the nature of supply chain coordination. Transaction Cost Economic (TCE) theory was first coined by Ronald Coase in his 1937 article "The essence of the company", for which he was awarded the Nobel Prize in 1991 (Ali et al., 2019; Piboonrungroj & Disney, 2015).

According to Bygballe et al. (2013), the TCE theory appears to be the most developed theoretically based model of economic organizations because it considers the utility of firms as well as the fact that firms collaborate with one another, influencing the logic of economic organizations. They added that the logic of most economic organizations' transaction costs indicates that economic operations are simplified to save money on constrained rationality while also protecting transactions against opportunistic risks. Based on this, the TCE successfully elucidates the existence of firms. There are different categories of firms that must strategically and successfully work together to guarantee the acceptance and sustainability of Prefabricated Housing Construction. In the actual world, there are not only production costs, but also transaction costs, according to the theory.

Aharonovitz et al. (2018) opined that transaction costs are comparable to the costs of interacting with business partners and ensuring the quality of outsourced operations. In this case, a company persists because the transaction costs are greater than the marginal advantages of outsourcing. While Oliver Williamson developed another component of TCE theory by paying attention to the economic actor's behavioural assumptions (opportunism and bounded rationality) and transaction feature (asset specificity, uncertainty, frequency, complexity and contestability (Vrijhoef & de Ridder, 2007; Williamson, 2010). They say that the TCE had examined the customer-supplier relationship in the contextual agreement.

The TCE hypothesis, developed by (Williamson, 2010), defines transaction cost as the expense of running an economic system. The connection between TCE management and organization theory was examined by Williamson. For Marroquín et al. (2017), transaction management deals with the best ways to handle coordination problems in the construction industry and the literature has adopted the TCE theory to a greater extent to understand how the industry functions and interacts with each party in its supply chain. TCE, for example, has been used to explain the widespread usage of subcontracting in construction (Bygballe et al., 2013). They also claimed that the lack of skilled labour in construction, along with the level of uncertainty contractors have in anticipating

future labour requirements, means neither the market nor hierarchical governance systems are working appropriately. Most importantly, the TCE theory examines customer-supplier relationships within the context of contractual agreement.

4.6 Characteristics of construction supply chains

Behera et al. (2015) have stated that supply chain approaches must match with product characteristics. Gosling et al. (2016) also argue that there is no longer room for a 'one-size-fits-all' approach to supply chain management. Companies have different types of supply chains based on their diverse uncertainty patterns. (Gosling et al., 2016) observe that the development of managerial processes must be tailored to address such patterns.

Supply chain structures generally reflect the characteristics of production strategies. Supply chain structures are concerned with the flow and control points along with the supply chain, and they are presented as buy-to-order, make-to-order, assemble-to-order, made-to-stock, and ship-to-stock structures (Gosling et al., 2016). However, these existing structures do not entirely match the characteristics of project-based production systems (Eriksson, 2013).

Gosling et al. (2013) discuss an emerging supply chain structure called the ETO supply chain. ETO supply chain structures can be found in supply chains where the order penetration point (OPP) is located at the design stage, which typically occurs in sectors related to complex project environments, such as those in construction and capital goods (Gosling & Nairn 2009). Heravi and Firoozi (2016) outline the task of managing construction supply chains as the coordination of discrete quantities of materials and specialty services to be delivered to specific project sites. Such an approach points to the idea of numerous individual supply chains servicing projects, which is the standpoint frequently adopted by construction companies. Although the construction industry has valued the importance of supply chain management in its business scenarios, research in this area can still be considered as immature (Gosling et al., 2013).

To characterize construction supply chain management (CSCM), six key features of construction supply chains are discussed below. These features are its project-based nature, network design, interfaces, supplier base, fragmentation, and demand forecast.

4.6.1 Project-based supply chains

Project-based production processes tend to have long-lasting programmes according to (Jones, 2005), mainly because of their long lead times for product delivery. Moreover, external considerations, such as inventory and crew logistics and procurement paths, are naturally affected

by such structures. Dallasega et al. (2018) emphasize how the movement of materials is considered in project-based production systems, which impacts on the implementation of converging logistics aimed at construction sites.

Koolwijk et al. (2018) propose that converging logistics require the planned confirmation of customer orders in which customization instructions are registered early for development at the design level. Dallasega et al. (2018) also support the idea of converging logistics in which the flow of materials and resources is directed to the construction site, where a fixed location layout is arranged for the construction factory. Supply chains presenting converging logistics are characterized by low volume, highly customized products. They also adopt a pull control system. Their success measures are generally in terms of quality, punctuality, and time of delivery (Ke et al., 2015). This is illustrated in Figure 4.6.

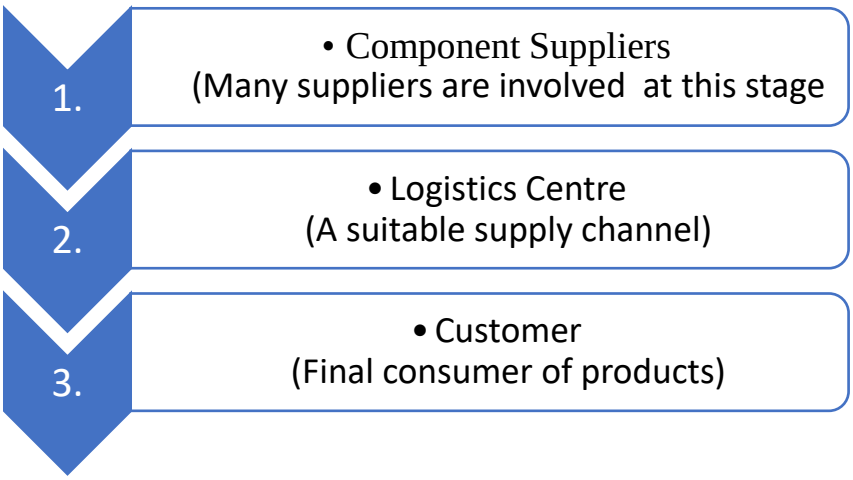


Figure 4.5: Converging logistics

Source: adapted from (Ke et al., 2015) and (Vrijhoef & Koskela, 2000)

Gosling et al. (2013) argue that transient organisational modes and site-based operations usually constitute supply chain structures. Morledge et al. (2009) argue that construction supply chains are viewed as temporary because various parties are concerned with completing their small, and sometimes distinctive, components in a project. Purvis et al. (2016b) also suggest that construction companies should seek increased supply chain flexibility, especially because it helps deal with temporary supplier networks. It is stressed that versatile networks can be easily reorganized, and 'low-cost penalties' are created by doing so (Purvis et al., 2016a; Scholten et al., 2020). This emphasis extends the transient existence of the projects into the supply chain, where the temporary management of the building supply chains has also taken place.

4.6.2 Network design of construction supply chain management

The typical design of a construction supply chain is complex and affects day-to-day activities and processes. Koolwijk et al. (2018) characterize the design of construction supply chains as having the main contractor at the centre of the network, and in which the construction company has different links with suppliers, clients, and designers, among other parties. It is worth mentioning that, from the perspective of a contractor, there are multiple and concurrent projects co-existing all the time (De Souza & Koskela, 2014),

The complexity in moving crews and materials from suppliers to projects sites is significantly amplified as the number of parties in the network is increased. In addition, Azambuja et al. (2014a) note that transient locations are a key characteristic in the structure of construction supply chains. The combination of multiple, concurrent, and widely spread projects contributes to the augmented complexity in the task of managing construction supply chains, as noted by (De Souza & Koskela, 2014).

When analysing the interfaces between site activities and the supply chain, (Vrijhoef & Koskela, 2000) highlighted the existing impact of supply chain variability on works on site. (Azambuja & O'Brien, 2009) discussed the problem of variability in CSCM and mapped three possible sources for the problem: supplier performance, the manufacturing process itself, and customer demand. On the side of supplier performance, (Vrijhoef & Koskela, 2000) considered the adoption of buffering initiatives. To respond to variability, managers might incorporate buffers throughout the different tiers of the supply chain.

The improvement of the total supply chain is recommended to increase dependability of deliveries (Koolwijk et al., 2018). By improving supply chain dependability, the direct and indirect implications (i.e., disruption of works, cost overruns) of poor delivery performance can be reduced or ultimately eliminated. Last minute schedule changes requested by customers are also listed as a root cause of common problems found in low volume supply chains (Dallasega et al., 2018; Gunasekaran & Ngai, 2005).

4.6.3 Construction supply chain interfaces

Construction supply chains comprising multiple organizations and embracing a set of activities have an increased level of complexity. Such activities occur in three streams, namely information flow, materials flow, and capital flow (Dallasega et al., 2018). For connecting such flows, there are different interfaces, which are the links between contractors, suppliers, and concurrent projects. Segerstedt and Olofsson (2010) argue that managing supply chain interfaces produces

significant improvement in project delivery due to enhanced information, materials, and capital flows. Problems located at interfaces interfere in the continuous flow, and consequently they generate waste (De Souza & Koskela, 2014).

Azambuja and O'Brien (2009) have characterized construction supply chain flows as slow, created and recreated several times during a project, and lacking in Information Technology (IT) tools for their support. Equally important, previous research has found the problems of construction supply chains are mostly located at the interfaces between different parties of the supply chain (Dallasega & Sarkis, 2018). The level of reliability regarding resource allocation is reduced at the interfaces between subcontractors. The understanding of supply chain interfaces in the construction sector can be linked to the Order Penetration Point (OPP) concept, where products are linked to a specific customer. Teimoury et al. (2012) apply these views to understand how the decoupling point of standardized components is positioned at the factory-supplier interface, which contributes to increased responsiveness according to their findings.

4.6.4 Construction supply chain supplier base

According to (Song et al., 2014), there are many possibilities for the types of supplier relationships in the construction sector. They underlined the myopic management and chaotic organization of construction supply chains as obstacles to problem-solving and creativity. Numerous transactional, price-based, and unstable relationships in which people lack confidence can be found in construction supply chains, which directly affects the characteristics of a supplier base (Hertz, 2006).

Ways to organise a reliable supplier base include suppliers covering a minimal range and aggregation of resources or products. Segerstedt and Olofsson (2010) point to the presence of low entry barriers in supply chains for prefabricated building components. Sacks et al. (2009) suggest that the allocation of jobs to fewer subcontractors should improve this. (Gosling et al., 2010) report results from a case study in which the overall supply chain network is organized into different supplier categories: accepted, preferred, and structured agreement. According to these authors, such categories are used as a way of standardizing sourcing decisions at both project and company levels in various industrial sectors, including construction. Cousins and Menguc (2006) studied supplier base reduction and its consequences. The authors stressed that, without considering factors such as market conditions and a reasonable evaluation of the costs and benefits involved, businesses generally follow various supplier base approaches (i.e., supply base reduction). It should also be highlighted that supplier with various manufacturing strategies occurs in construction supply chains.

4.6.5 Construction supply chain fragmentation

The supply chains for buildings appear to be fragmented (Bankvall et al., 2010). Bankvall et al. (2010) suggest that the management emphasis has been confined to the project environment due to the lack of uniformity in the pipeline of projects in construction (Gosling et al., 2016). These authors reviewed the literature and point to the 'slow' pace in which construction has introduced supply chain management practices. Gosling et al. (2016); (Mostafa et al., 2016; Mostafa et al., 2014a) stressed that the achievement of complete supply chain integration has been challenged by previous studies. The same authors point out the need for a contextualized system aimed at mitigating fragmentation in the supply chain framework.

Tommelein et al. (2003) have claimed that construction projects are less receptive to improvement efforts owing to their finite length. The project-by-project mentality found in the construction industry, which contributes to the generation of high levels of two-party contracts, was addressed by these authors. Usually, such contracts result in adversarial and price-driven choices (Tommelein et al., 2003).

Because of the contradictory existence of demand and supply in the industry, Cox, and Ireland (2002) indicated that fragmentation in construction is inherent. A historical number of complex power structures involving suppliers of materials and subcontractors are mentioned by these authors. As a source of fragmentation, the broad spectrum of goods and services (i.e., commodity parts and highly specialized services) are identified. Pan et al. (2007) suggest that by maintaining long-term relations with suppliers, such as those found in the manufacturing sector, construction companies can streamline their supply chains. Such a proposition is based on the observation that contractors appear to regularly repeat suppliers. Pan et al. (2007) reported negative attitudes within supply chain organizations about critical conditions for aligning processes, structures, and procedures to achieve improved efficiency. Their findings show a limited appetite for integrating the various parties in construction supply chains.

4.6.6 Construction supply chain demand forecast

Ireland (2004) points out that demand in the management of the supply chain is a key variable. This author notes that consumers sometimes do not know their own patterns of demand, so they face opportunistic actions in the market for contractors. Construction firms are defined by (Cox & Ireland, 2012) as 'integrators' of several supply chains. These supply chains include demand trends that are volatile, erratic, and customer-driven (Dagkakis & Heavey, 2016). Compared to those in the make-to-stock industries, there are restricted demand estimates for ETO supply chain systems

(Gosling et al., 2016). These authors emphasize that ETO supply chains have increased uncertainty caused, among others, by high levels of customization and project-specific designs. Difficulties in demand forecasting derive from the early OPP found in construction supply chains, in which works start only after an order is placed (Olhager, 2012). The OPP related to the ETO production strategy is pointed at the design stage of production activities. Under this proposal, businesses following an ETO development strategy are struggling with real demand because they do not prepare their production schedule based on demand forecasts. (Gosling et al., 2016) argue that conventional forecasting systems using demand smoothing could not be implemented in construction due to the complexity of the demand patterns of projects, and because infrastructure, industrial and commercial projects have declining levels of repeatability because they are highly customized.

4.7 Construction supply chains management characteristics

de la Fuente et al. (2008) have suggested a series of questions for future study by devising a standardized framework, such as a supply chain operations reference model (SCOR), promoted by the supply chain council. This was one of the first proposals for controlling supply chains in the manufacturing sector. One of these questions was put as a discussion guideline: are supply chain processes the same for all companies?

Christopher (2017) claimed that approaches to the supply chain must fit features of the product. Gosling et al. (2016) also suggest that there is no longer room for a one-size-fits-all supply chain management approach: businesses have different kinds of supply chains based on their varying patterns of ambiguity. Gosling et al. (2016) noted that the production of management processes needs to be adapted to take part in such a pattern.

In general, supply chain structures embody the features of production strategies. The structure is concerned with the movement and control points, together with the supply chain. They are presented as buy-to-order, make-to-order, assemble-to-order, made-to-stock, and ship-to-stock (Naim & Gosling, 2011). However, existing models do not completely fit the characteristics of production processes focused on projects.

Hicks and McGovern (2009) maintain that when compared with high-volume manufacturing sectors, such as electronics and automotive, there is minimal research in construction supply chain management, and in the Engineer to order (ETO) market. The major characteristics of supply chain management in construction is in Table 4.4.

Table 4.4: Major characteristics of construction supply chain management

Source: Adapted from: (De Souza & Koskela, 2014) and (Segerstedt et al., 2010)

Major Characteristics	Prominent issues	References
Project-based Chains	- Detail specifications - Covering logistics flows - Participation of suppliers in small and unique parts - Improved strategies supporting flexibilities - Temporary supply chain	(Eriksson, 2010; Gosling et al., 2013; Purvis et al., 2016b)
Specific Network Design	- Complexity because of simultaneous and various project sites - Performance of suppliers varies due to design - Intrinsic need for flexible strategies to increase competitive advantage	(Bankvall et al., 2010; De Souza & Koskela, 2014; Gunasekaran & Ngai, 2005)
Interfaces	- Existence of multiple interfaces - There are three essential flows: material, information, and capital - Problems at the interfaces	(De Souza & Koskela, 2014)
Supplier base	- Large and highly specialized - Different production strategies - Poor and unstable control - Transaction relationships and low entry barriers - Misunderstood guidelines	(Bankvall et al., 2010)
Fragmentation	- Fragmentation inherent to the business - This is structural and widely spread - Sources of fragmentation are known	(Bankvall et al., 2010; Gosling et al., 2016)

	- Fragmentation is not categorized - Project-by-project mindset and lack of regularity in the pipeline - Adversarial and pride-driven decisions - Short-term relationships	
Demand Forecast	- Key variable in construction supply chain - Volatile, unpredictable, and customer-driven - Increased uncertainty due to high levels of customization - Early Order Penetration Point - Traditional forecasting systems using demand smoothing do not work - Need for information sharing (inventories, specifications, work-in-progress, flow rate.	(Behera et al., 2015; Gosling et al., 2016)

4.8 Overview of supply chain practices in the Nigerian construction industry

According to Saka and Mudi (2007), the analysis of the activities and challenges of supply chain management by building contracting firms in the Lagos region showed that the management of material supply chains by building firms has taken the most realistic approach to source materials for their construction works. However, most contractors still suffer from the lack of an imaginative mindset in the management of the supply chain of materials, due to a lack of supply chain analysis work in the Nigerian environment (Saka & Mudi, 2007).

Table 4.5: General Information about Nigeria.

Source: Adapted from: NPC (2015) and UN (2019)

Area (Sq. Km)	Total of 923,768 km sq
Climatic Condition	Tropical Rainforest
Housing Deficiency	22 million Housing Units
Temperature	Min. 18°C in the North; 23°C in the South
	Max, 35°C in the North; 3 1°C in the South
Population	206,139,587 (2.64%) of world population)
Major Season	Raining season and Dry Season
Population Rank	7th most populous country in the world

Table 4.5 presents demographic data about Nigeria. The population strength and high record on housing deficiency reiterate the need for the provision of more housing.

Mafini and Loury-Okoumba (2018) also agree with the views of (Saka & Mudi, 2007) above, by arguing that in Nigeria's construction industry, the level of awareness of supply chain management is poor and that an awareness campaign would sensitize stakeholders in the construction industry. It can be generally deduced that in the Nigerian construction industry the main approach to supply chain management is largely due to ignorance on the part of the construction participants as well as lack of literature related to the Nigerian building environment. In addition, Olaniyan et al. (2015b) expressed hope for development when it comes to the deployment of supply chain management activities within the Nigerian construction industry, based on effective research conducted thus far. Supply chain management literature (SCM) is relatively limited in Nigeria (Adebayo, 2012; Amade et al., 2017;

Mafini & Loury-Okoumba, 2018). It can also be deduced from available literature that ignorance and lack of innovations are still factors plaguing SCM application in the construction industry in Nigeria (Ojo et al., 2014a; Saka & Mudi, 2007).

4.9 Constraints on the adoption of supply chain management in the Nigerian construction industry

Yadav and Ray (2015) found that the transient existence of customer–designer–contractor–subcontractor–supplier relationships is the key obstacle to the ability to incorporate SCM in construction projects due to the specific nature of each product. Several factors have been seen as constraining the adoption of supply chain management in the prefabricated construction sector in Nigeria. These are highlighted in Table 4.6.

Table 4.6: Constraints on the adoption of supply chain management

Source: Researcher's construct, 2020

Factors	**References**
High Cost.	(Akintoye et al., 2012b; Aloini et al., 2012b).
Deficiency of mutuality.	(Alamri, 2017; Amade et al., 2016; Simchi-Levi et al., 2015).
Unclear strategic benefits.	(de Melo & da CL Alves, 2010; Hsu et al., 2017a; Simchi-Levi et al., 2015)
Extent of project complexity.	(De Souza & Koskela, 2014).
Subcontractors and suppliers.	(Bankvall et al., 2010; de Melo & da CL Alves, 2010)
Lack of understanding by clients.	(Akintoye et al., 2012b; Aloini et al., 2012b)
Partners' low level of commitment.	(Gao et al., 2019; Zhai et al., 2017b)
Dearth of top management support.	(Bankvall et al., 2010)
Dearth of appropriate I.T. applications.	(De Souza & Koskela, 2014)
Inability to share information on project.	(Aloini et al., 2012a; Wang et al., 2017b)
Lack of common standard for collaboration.	(Aloini et al., 2012a; De Souza & Koskela, 2014).

Differences in the work culture of stakeholders.	(Akintoye et al., 2012b; Aloini et al., 2012b).
Short time project thinking and fear of loss of control.	(Goh & Goh, 2019; Ikudayisi & Odeyale, 2021)
Dearth of trust within and outside the organization.	(Simchi-Levi et al., 2018; Zhai et al., 2017b)
Inability to develop measures for monitoring alliance.	(Mostafa et al., 2014b; Zhai et al., 2015b)
Improper scheduling requiring flexibility in operations.	(Chen et al., 2014; Simchi-Levi et al., 2018)
Lack of appropriate supporting organizational structure.	(Bakhtiarizadeh et al., 2021; Zhai et al., 2019);
Lack of understanding of supply chain management concepts.	(Abedi et al., 2016b; De Souza, 2015; Okafor et al., 2021)
Ignorance of the contributions and needs of subcontractors and suppliers.	(Akintoye et al., 2012a; Aloini et al., 2012a)

4.10 Ordering prefabricated components for building construction

Prefabricated building construction has maintained some common characteristics with conventional building construction, but there are certain unique differences between the two methods (Mao et al., 2013). The development planning for prefabricated building is usually initiated by clients who will later engage an architect and hand over the design brief to him or her. Prefabrication firms will then be approached with the brief for the proposed project. The technical manager of the firm, assisted by the design architects, does the general scheduling. A meeting between the architect, the project manager and the client will be arranged to synchronize the project and arrived at a common point. Here, all relevant information and specific requirements concerning the project will be discussed and resolved (Cao et al., 2015; Mao et al., 2013).

The design and production documents for foundations and groundwork are later detailed and submitted by relevant professionals. Meetings are also held with the project group to refine and resolve areas of controversy. Prefabrication firms will establish a Manufacturing Order for the project. A manufacturing

Order is the term used when one or several product prototypes are to be mass-produced according to drawings. These can either be newly planned or replacement elements. A newly planned order can be for a new fixed or replacement item. A Manufacturing Order can be created for products that are defined in the product's basic data – a document containing all relevant details concerning equipment, colours, machines, etc. for a particular component (Baghchesaraei et al., 2015). This is an order required to manufacture items, and it is classified as an internal order (to be manufactured by the firm itself) and a subcontract order (to be manufactured by the subcontractors). The MO is used by the designers to establish the manufacturing drawings. Also, the purchaser uses the Manufacturing Order for all purchases. The design manager holds meetings with the production manager to inform him about the project and give other necessary detail specifications required to produce components (Yuan et al., 2018).

Manufacturing order processing (MOP) manages the transformation of planned manufacturing orders into final product delivery. It includes support for the entire production process from when the order is created to its point of delivery.

4.11 Component production

The manufacturing of components is planned based on the production drawings and MOs delivered to the prefabrication firm by the design team and the project manager. The factories have different production lines set up to achieve particular predetermined component types (Eastman et al., 2011; Yang et al., 2018a). Meetings are also held between the production manager and other relevant officers in the production line to sort out differences and ensure that production processes proceed as planned. They also agree on the production schedule against the following week to keep up the flow in production. The project manager is involved in the process until the volume elements are ready and leave the factory, after which control is transferred to the assembly manager (Yang et al., 2018a).

When the prefabrication firm receives an order for project development, the production department starts the preparation by inviting the project manager, who is guided by the concept of the owner/client. The production manager makes the overall production planning for the project. On completion of component production and before moving to the construction site, a meeting with the project manager, the client and the production manager is arranged where all details and unique circumstances for the specific project are viewed, discussed and resolved (Bataglin et al., 2020).

Design and production specifications for prefabricated housing projects are provided by consulting professionals, engaged by the client. The documents are later handed to the project manager who will oversee the project from the beginning to the end. The detail drawings are also synchronized among

relevant groups, including the prefabrication firm for production of components. The Manufacturing Order for the project, which contains all the details of components and other equipment needed for the project is thereafter presented to the prefabrication firm and in readiness for production and site installation.

4.12 Supply chain management best practices

Several studies have been carried out by other researchers over the years with the aim of assessing the performance and best practices for supply chain management (Okafor et al., 2021). Practice refers to the regular use of information by the organization, and often has a tacit dimension, embedded partly in individual skills and partly in collective social arrangements. The ten best practices for optimizing supply chain management include: Set up your supply chain link, establish an appropriately staffed supply chain structure, identify areas where technology can improve and streamline processes, maintain healthy supplier relationships, conduct performance measurement and benchmarking, manage supply chain risk, use flexible management, and implement information management. Others include: source suppliers strategically, and establish regular reviews to ensure efficiency and mitigate risks (Pishdad-Bozorgi et al., 2018).

4.12.1 Set up your supply chain link

Your supply chain will lack a defined plan for efficiency if this is not done. You may enhance cross-functional communication and demonstrate the benefits of an organized supply chain by supporting your supply chain with leadership and management, removing two major hurdles to supply chain success.

4.12.2 Establish an appropriately staffed supply chain structure

Your supply chain will be inefficient if you do not do this. You may enhance cross-functional communication and demonstrate the benefits of an organized supply chain by providing leadership and management support for your supply chain, removing two major hurdles to supply chain success.

4.12.3 Identify areas where technology can improve and streamline processes

A lack of supply chain visibility is frequently caused by manual procedures. This, as well as the uncoordinated nature of supply chain processes, may be solved through automation. Do not build your business operations around technology. Instead, examine procedures that aren't meeting expectations to identify areas where technology may help, and then select routing software to meet those needs. With the help of this you may more readily obtain accurate and thorough reporting data to inform the proper strategic planning and performance measurements with the right technology.

4.12.4 Maintain healthy supplier relationships

After you have closed a transaction, these ties should be nurtured and maintained. Buyers and sellers should communicate with one other to form the greatest partnerships. Your goals should include strategies to keep your relationships healthy, improve them, and resolve any disputes.

4.12.5 Performance measurement and benchmarking

In many scientific advancements, measures have been linked to competitive challenges (Garcia et al., 2012; Ketchen Jr & Hult, 2007; Krause et al., 2009). Competitive priorities are the important areas where a firm should concentrate its efforts to obtain an edge, and organized performance assessment methodologies should be used to achieve this.

According to Gopal and Thakkar (2012), performance measures often include both qualitative and quantitative data. Quantitative measurements are recommended for measuring SCM performance since they are less ambiguous than qualitative measures. Quantitative measures, on the other hand, may not accurately capture the performance of a process, and they can become erroneous or difficult to analyse (Gopal & Thakkar, 2012). Thus, one can infer that measuring supply chain performance is not an easy task. The initial competitive priority identified throughout the development of operations management theories was cost. Companies have concentrated their efforts on a cost-cutting strategy that includes inventory reduction, operations, process optimization, and so on.

Competitive priorities, according to (Gopal & Thakkar, 2012), are the dimensions in which a firm's operations are carried out, such as cost, quality, flexibility, and speed. The most frequently mentioned in the literature are time and delivery (Stonebraker & Liao, 2006). Along with cost, quality has been named as a second competitive objective. In this regard, businesses have been expected to provide items at minimal costs while maintaining good quality. Third, new competitive goals have been added to the list, such as speed, dependability, and adaptability.

Additional factors for gauging competitiveness offered by (Melnyk et al., 2014) include the levels of innovation, sustainability, responsiveness, security, and resilience. In this sense, it is appropriate to admit that extra competitive priority might be added or removed depending on the context of the organization. (Behera et al., 2015) look at supply chain management performance measurement and argue that the inherent, transversal, and multi-organizational character of supply chain management, in which several parties are engaged, results in complexity.

4.12.6 Supply chain risk management

The occurrence of events that interrupt inbound supply (Sidespin & Smith 2005) is known as supply risk. Different forms of threats are present. Such threats have numerous root causes and generate a wide range of consequences. analysed the consequences of unpredictable incidents in the automotive industry (i.e., super storms, factory fires) in terms of the disruption they caused. These effects are primarily focused on the evaluation of the time to recovery, which is the amount of time needed after a disturbance for a supply chain to be completely functional again (Simchi-Levi et al., 2014).

Zsidisin and Smith (2005) identified a range of different risk sources by conducting a case study in the aerospace sector. These risk sources include high costs, legal liabilities, quality issues, supplier capability limitations, prolonged product development times, inability to manage changes in product design, and issues with supplier organisational leadership. The threats of public-private collaborations in infrastructure projects have been assessed (Adeniyi et al., 2011). These authors have stated that there are intrinsic sources of risk in the project types mentioned above, including, but not limited to, documentation, funding, taxation, and technical information. In three contrasting fields, these examples illustrate how risk trends differ significantly

Pfohl et al. (2010) argue that risks of any sort are usually only measured at the first tier of supply. In the many stages of the supply chain, real risks exist upstream, according to this author. In addition, parties in the UK construction industry are still focused on their own individual companies, rather than sharing risks and working collaboratively, according to the Construction 2025 report (Russell et al., 2018). Tier-1 contractors appear to transmit risks to other levels of the supply chain, it has been reported, which will eventually contribute to potential legal debates (HM Government 2013).

Azambuja et al. (2014b) point to decreased stability and increased uncertainty in building supply chains as the root causes of operational risks. The allocation of inventory, power, and time buffers (Azambuja et al., 2014b) are traditional remedies for reducing such risks. Risks related to material obsolescence were described as another form of danger in supply chains by (Sun et al., 2021).

4.12.7 Flexibility management

Research on output assessment in supply chains has also grown in line with the proposal for the triple-A supply chain (Whitten et al., 2012). The essential elements for the performance of supply chain participants include mobility, adaptability, and alignment (Vidalakis et al., 2011; Whitten et al., 2012). Agility has been synonymous with responsiveness and time to market (Whitten et al. 2012) and has referred to its integration with supply chain management respectively(Sun et al., 2021). This involves providers' willingness to work together and adapt to consumer demand variations.

Whitten et al. (2012) and Lee (2004) describe adaptability as the ability to adjust the design of the supply chain to meet structural changes in markets, and to modify strategies, products, and technologies to supply networks. Power (2005) claimed that the adaptability of a supply chain is challenging, but that it is a critical problem for sustainable value delivery. In addition, (Huo et al., 2014). Whitten et al. (2012), considering the globalization of supply chains, attributed increased importance to adaptability. The ability to foster rewards for improved results in the supply chain has been referred to as alignment (Power, 2005).

4.12.8 Information management

The way information is managed across the supply chain has evolved significantly. A well-known development is the Collaborative Planning, Forecasting, and Replenishment (CPFR) methodology (Min & Yu, 2008). CPFR is described as a web-based tool used by supply chain partners to coordinate activities (i.e., production planning, purchasing, demand forecasting and inventory replenishment). CPFR implementation hurdles include lack of faith in information sharing, lack of cooperation in forecasting, technology availability and cost, fragmented information, and difficulty in aggregating information (Min & Yu, 2008). Participant-reported benefits include quicker and error-free purchases, decreased product losses, and fewer consumer encounters (Cassivi, 2006).

Dawood (2009) reported functional and geographical fragmentation, temporary organizational forms, and the enormous amounts of data (i.e., drawings, photos, cost analysis sheets, budget reports, risk analysis charts) as key barriers for effective information management in construction. To tackle such problems, (Pishdad-Bozorgi et al., 2018) highlight the role that Building Information Modelling (BIM) plays in information management in the construction industry. BIM capabilities regarding information management include continuous tracking of costs, integration of specifications, and design performance analysis (Eastman et al., 2011). BIM encourages a collaborative environment for supply chain parties to be incorporated into if models exchange relevant data in real time.

Rao and Holt (2005) carried out a survey with senior purchasing managers in the manufacturing sector to understand the techniques that would lead to maximising change efforts in supply chains. The key factors for increasing supplier participation in improvement include strong organizational engagement, intensive purchasing involvement, and decreased formality in supplier involvement decisions. These authors agree that these factors can differ between organizations, but in cases where they are absent, attempts to improve the supply chain are likely to fail.

The UK Highways Agency announced major improvement initiatives, as reported by (Dave, 2013). Such programmes are linked to the generation of value for money, and most of them are backed by the

theory of lean development. The UK Highways Agency launched an evaluation tool called the Highways Agency Lean Maturity Assessment Toolkit (Dave, 2013), to get the supply chain on board. The toolkit was developed to provide feedback and to determine to what degree suppliers have adopted lean approaches in their businesses. Examples of lean projects implemented with supply partners include smooth development of asphalt, enhanced preventive maintenance plans to minimize production interruptions, improved production scheduling, and just in time on-site material delivery (Dave, 2013).

Ahmed and El-Sayegh (2021) examined how benchmarking can test and enhance construction projects as a means of progress preparation and investigated a set of nine KPIs and a range of sub-indicators under each of the original KPIs. The business was able to cross-analyse outcomes and capture practices to achieve better efficiency by matching internal programmes with the schemes of various rivals (Ahmed & El-Sayegh, 2021).

Wang et al. (2019) introduced a diagnostic method to detect challenges, inefficiencies, or critical changes in supply chains. The proposal is used by third-party suppliers of logistics to identify solutions to be implemented in the supply chains of their customers. The instrument included a collection of 14 hierarchical problems to be defined in supply chains, such as interfaces, visibility of the pipeline, strategic business units, and real-time data, among others (Wang et al., 2019). It can be used as a support for the implementation of change plans, as the instrument was very detailed.

Wang et al. (2019) explored the possible advantages of joint supply changes in the automotive industry. These authors proposed a roadmap for joint supply chain development. The reported benefits include strengthened partnerships, reduction of safety shocks and scheduling uncertainty, decreased hurried orders, execution of consignment stocks, and more efficient deliveries, among others (Cassivi, 2006; Thomas et al., 2018).

4.12.9 Source suppliers strategically

This is at the heart of good supply chain management, and you'll achieve even greater outcomes if you work together. Talent, technology, internal and external cooperation, and change management are all important components of a successful supply chain. Collaboration is necessary for success. Participate in the decision-making process with your suppliers. Obtain feedback from them.

4.12.10 Establish regular reviews to ensure efficiency and mitigate risks

Your supply chain council and leadership team evaluate your processes and policies on a regular basis to ensure that they are up to date, efficient, and compliant. This can help you prevent problems like process bottlenecks and streamline your operations while lowering your risk of theft, fraud, and other

difficulties. When it comes to reducing risk in the supply chain, there are a few key measures to follow. You must identify yourself. You must identify all risk factors, assess their likelihood of occurrence, estimate the financial impact of an issue, and prioritize any risks for suitable monitoring and preventative actions.

4.13 Summary

An overview of the concept of Supply Chain Management (SCM) has been looked at in this chapter and research Objective 1 – "Review current supply chain management practices in the Nigerian construction industry and elsewhere" has been addressed. Different viewpoints and developments were reviewed from the literature, leading to a consensual view that SCM has evolved from a logistics approach to a multi-organizational complex process. In addition, these developments were analysed in terms of their fit into the template, as described by (Gosling et al., 2016).

The review also considered the two-known process-based frameworks for managing supply chains that have been researched within the manufacturing sector, especially in companies adopting the production strategy. The most relevant factor for supply chain management in the manufacturing environment is demand predictability. Supply chain management is driven by demand, and therefore it must balance, and schedule production based on demand patterns.

The two supply chain management frameworks differ in that one is process-based and the other process-oriented. Both propositions suggest a set of procedures, activities, methods, tools, techniques, and metrics to be adopted by companies. The frameworks are composed of internal elements, and these elements are structured into different parts, namely a system supported by metrics and managerial practices to be implemented by companies. It is recommended that the process is focused on supply chain flow, especially regarding material and information. Both frameworks fail to address supply chain elements within the flow, such as waiting and other inefficiencies. In addition, the process does not discuss how supply chains in a project-based company should be managed, such as those using the Engineer-to-Order (ETO) production strategy. ETO companies have their production system driven by orders, which require decisions to be made by the customer from the early design stages. From a SCM perspective, construction companies should not only develop and implement best practice, but also disseminate this in their supply chains. Six practices were noted from the literature: These include performance measurement and benchmarking, supplier relationship management, supply chain risk management, flexibility management, improvement planning, and information management.

The key characteristics of construction supply chains were summarized in six streams, as above. These include project-based chains, network design, interfaces, supplier base, fragmentation, and demand

forecast. Companies adopting the Engineer-to-Order production strategy face several challenges when managing production and ultimately supply chains. Such challenges include, among others, the variety of suppliers, the lack of demand predictability, and the uniqueness of projects.

Prefabrication in building construction has a clear potential to deliver housing more efficiently, but this potential has continuously been under-utilized. The literature has also pointed out several factors that are responsible for the slow adoption of the technology. It was also found that other researchers have worked on the different known factors, except for supply chain management of prefabricated construction, which has received less attention. Having identified the lack of supply chain management in prefabricated housing as a major factor, this chapter therefore conducted a systematic review of literature to address the aim and objectives of the research. The concept of supply chain management in prefabricated building construction was discussed. Current management issues concerning supply chains were also clarified. The Prisma flow diagram depicts the flow of information throughout the different phases of the systematic literature review. The Prisma flow diagram was later used to map out the number of records used for the study. Having extensively explored the position of other researchers, with the necessary information gathered. It is thus believed that Objective 1 of the study has been achieved and that the information gathered has been relevant and has given a better understanding of the fact. The next chapter discusses the supply chain barriers for prefabricated construction identified in the interviews to fulfil the second objective of the study.

CHAPTER FIVE

DISCUSSIONS OF SCM BARRIERS TO FULFIL OBJECTIVE 2

5.0 Introduction

This chapter presents a qualitative phenomenological analysis of the interview data. A total of 28 participants were recruited from the four groups of stakeholders (Prefabrication firms, Construction firms, Logistics firms and Materials suppliers) involved in supply chain management of prefabricated construction in Lagos, Nigeria. The interview process began by securing an appointment with the interviewees. Key technical officers or their representatives in the four groups with more than five years' experience in their domain, and who could provide answers to relevant questions, were targeted. They included: architects, civil or structural engineers, quantity surveyors, project managers, production managers and factory managers. They were all involved directly or indirectly in the successful delivery of prefabricated housing construction. Details of the interview participants are presented in Table 5.1. The interview sessions were conducted by the researcher, using an interview protocol guide (see Appendix ii), which provided the framework for conducting the interviews as well as the interview questions. The interviewees were asked the prescribed questions, as outlined in the guide, and the researcher recorded their responses to each question using a digital audio recorder. The consent of the interviewees was sought before the recording was made. The interviews were designed to elicit the multiple views of participants about supply chain management for prefabricated housing construction in Nigeria. The questions were carefully composed, with many being derived from information gathered from the literature review.

The interview contained two major parts (see Appendix ii). The first part seeks the participants to answer general demographic questions as a way of introduction into the purpose of the study. The second part required interviewees to respond to specific technical questions about their respective businesses.

To detect possible problems or challenges, a pilot survey was conducted before the final interviews. Assistance was obtained from an officer who met the basic inclusion criteria required to participate in the exercise. This person was engaged solely for the pilot study. The purpose of the pilot study was to pre-test the way interviews were to be conducted as well as the suitability of the actual interview questions. Having conducted the pilot survey, some questions were modified to avoid possible misunderstandings. Once these modifications had been made, the formal interviews were conducted in the field.

This chapter also describes the process for analysing the data. This involved two cycles of coding analysis. Initially, the transcripts of the interviews were coded manually. The data later went through a process of modification and codes were subsequently refined using computer aided analysis in NVivo 12 software. The first cycle of coding (Open Coding) helped the researcher gain familiarity with what was contained in the answers to the interview questions, as seen in section 5.1. Data were later interpreted based on the participants' comments and experiences about prefabricated housing developments and the challenges they had faced. The chapter presents the barriers the interviewees identified to the adoption and growth of prefabricated building construction. This therefore necessitates improved supply chain management to actualize the potential growth of prefabrication technology in the building industry. Each barrier is later discussed in detail. The barriers identified through the analysis include:

i. Limited level of awareness and potential benefit
ii. Heavy weight of prefabricated components
iii. Lack of incentives and motivation
iv. Dearth of prefabrication firms
v. Personal safety
vi. High and multiple levels of taxation
vii. Lack of policy support for the adoption and promotion of prefabrication technology in building construction
viii. Lack of compliance with standards for prefabricated components
ix. Stakeholder resistance to the prefabricated building technology
x. Prototype buildings decrease the value placed on the building
xi. Decay of major social infrastructure like electricity and good roads
xii. Technical know-how.

Table 5.1: Demographic information for interview participants

Source: Researchers Construct, 2020

Stakeholders	Interview participants	Age	Qualification/s	Yrs. of Exp
Prefabrication Firms	Factory Manager	52	M.Sc Building	15 years
	Production Manager	36	B.Sc, M.sc, ARCON Reg.	6 years
	Line Supervisor	27	Diploma Certificate	10 years

	Project Manager	45	B.sc, Msc, ARCON Reg.	8 years
	Technical Manager	41	B.sc, COREN Reg.	8 years
	Technical Manager	38	Bsc, COREN Reg.	6 years
	Resident Architect	44	B.sc, Msc, ARCON Reg.	5 years
	Head of Operation	50	B.sc, Msc, ARCON Reg.	10 years
Construction Firms	Structural Engineer	48	B.sc, COREN Reg.	12 years
	Civil Engineer	50	B.sc, Msc, COREN Reg.	12 years
	Project Architect	37	Bsc, Msc	14 years
	Architect/Project Manager	42	M.sc, ARCON Reg.	9 years
	Civil Engineer	46	B.sc, Civil Engr	5 years
	Structural Engineer	50	B.sc, COREN Reg.	6 years
	Quantity Surveyor	50	Bsc Quantity Surveyor	10 years
	Civil Engineer	43	B.sc Engr	5 years
	Project Manager		B.sc, M.sc Project Mgt	7 years
Material suppliers	Quarry Manager	39	B.sc Material/Met. Engr	13 years
	Sales Manager	40	HND Business Admin	18 years
	General Manager	43	B.sc Material/Met. Engr	12 years
Logistic Firms	Head, Operation	51	B. Tech, Automobile Engr	15 years
	Transport Manager	44	Bsc, Automobile Engr	15 years

	Administrative Manager	38	Bsc Business Admin	12 years
	Supervisor	38	Bsc, Business Admin	10 years
	Senior Driver	45	Senior School Certificate	15 years
	Loader	27	Senior School Certificate	5 years
	Loader	30	Senior School Certificate	6 years
	Protocol Officers	56	Diploma, Business Admin	14 years

5.1 Description of the process of analysis

Thematic analysis, grounded theory, and discourse analysis are some of the methods used to analyse qualitative data (Smith et al., 2017; Vaismoradi et al., 2013; Woods, 2011). Thematic analysis was however used to analyse the data obtained for this study to derive new meanings from the participants. Qualitative analysis is the process of transforming data into conclusions. Audio recorders, field notes, and a digital camera were used to capture raw data. Spoken words from an audio recording were later transcribed into written texts, according to the method outlined in (Marshall & Rossman, 2011), data from the four groups of participants were later classified, categorized, and transcribed (Creswell, 2013a). Responses and comments from the participants were read carefully and documented in a notebook for coding. The summary of the process is presented below:

i. Transcribing*:* What was said during the interviews was transcribed verbatim by entering it as text into a word processor. The resulting documents were saved as computer files.

ii. Initial reading*:* Transcripts were read to gain an impression of what the raw data was all about. At this stage, a rudimentary coding was completed using NVivo 12, a qualitative data analysis computer software application.

iii. In-depth reading*:* This stage was distinct from the previous stage. The transcripts were perused thoroughly and NVivo 12 was used for coding, organizing, linking, and exploring notes.

iv. Codes assigned and arranged into themes: Codes were assigned and grouped into themes, as seen in Table 5.4.

v. New codes assigned for further probing: At this stage, the first set of codes was subjected to further probing. This resulted in the creation of new codes to give a clearer understanding.

Four key stakeholder groups provided primary data in the form of interviews. Each of these participant groups has different functions and are individually contributing towards the effective delivery of prefabricated buildings in Nigeria. They individually made invaluable contributions to answering the semi-structured interview questions. They include Prefabrication firms, Construction firms, Logistics firms and Material suppliers. The groups and the numbers of stakeholders in each group are shown in Table 5.2.

To create a description of the participants and themes/categories, the coding procedure was conducted in two cycles of coding. These include the first cycle - structural and provisional, and the second cycle - pattern coding, to generate a description of the participants' themes, as seen in Table 5.5. Coding serves as a vital link between the data collected and the explanation of its importance. It is a method of organizing data in order to make the data's underlying meanings more comprehensible (Sgier, 2012). This step progressed to defining themes and relating them to numerous participant answers, which led to the formulation of results. The study's findings were then interpreted in the last step of the analysis (Basias & Pollalis, 2018; Espeland & Sauder, 2007; Yin, 2018).

For a small sample of participants, an deductive approach to data analysis is acceptable (Saunders et al., 2007). The drawback of this technique is that results cannot be generalised owing to the limited sample size (Yin, 2018). This study included deductive data analysis methods. Deductive analysis, according to (Guntara & Wilujeng, 2018) entails identifying patterns, themes, and categories in data. To explain patterns in the data and interpret conclusions, the deductive technique was used, which relies on essential concepts from literature (see provisional coding). Both techniques will ensure that participants' points of view are conveyed equally.

Table 5.2: The four stakeholder groups

Source: Researcher's construct, 2020

Stakeholders	**Participant firms**
Prefabrication firms (P)	8
Construction firms (C)	9
Logistics firms (L)	8
Materials Suppliers (M)	3

Total	28

To facilitate analysis of the interview data, and to ensure anonymity for participants, the four groups of stakeholders interviewed were de-identified, with letters P, C, L and M representing Prefabrication firms, Construction firms, Logistics firms and Materials suppliers, respectively. Q1, Q2, Q3 … were also used to represent the interview questions 1, 2, 3, etc. This was to help in generating codes for the transcription and for the analysis. There were different interview questions for each group, with a maximum of twelve questions for one group. The interview scripts were thus numbered 1-12, as presented in Table 5.3

Table 5.3 De-identification of Stakeholders group

Source: Researcher's construct, 2020

CONSTRUCTION FIRMS (C) **(8 Stakeholders)**	PREFAB FIRMS (P) **(9 Stakeholders)**	LOGISTICS & HAULAGE (L) **(8 Stakeholders)**	MATERIALS SUPPLIER (M) **(3 Stakeholders)**	RESPONSES
CS1Q1, Q2, Q3 …	PS1Q1, Q2, Q3…	LS1Q1, Q2, Q3…	MS1 Q1, Q2, Q3…	RESPONSES (**R**) ACCORDING TO EACH QUESTION
CS2Q1, Q2, Q3 …	PS2Q1, Q2, Q3…	LS2Q1, Q2, Q3…	MS2 Q1, Q2, Q3…	
CS3Q1, Q2, Q3 …	PS3Q1, Q2, Q3…	LS3Q1, Q2, Q3…	MS3 Q1, Q2, Q3…	
CS4Q1, Q2, Q3 ...	PS4Q1, Q2, Q3…	LS4Q1, Q2, Q3…		
CS5Q1, Q2, Q3 …	PS5Q1, Q2, Q3…	LS5Q1, Q2, Q3…		
CS6Q1, Q2, Q3 …	PS6Q1, Q2, Q3 …	LS6Q1, Q2, Q3 …		
CS7Q1, Q2, Q3 …	PS7Q1, Q2, Q3 …	LS7Q1, Q2, Q3 …		
CS8Q1, Q2, Q3 …	PS8Q1, Q2, Q3 …	LS8Q1, Q2, Q3 …		
	PS9Q1, Q2, Q3 …			

Legend:

RCS1Q1 - Response to question 1 for the first stakeholder from a construction firm

RPS1Q1 - Response to question 1 for the first stakeholder from a prefabrication firm

RLS1Q1 - Response to question 1 for the first stakeholder from a logistics firm

RMS1Q1 - Response to question 1 for the first stakeholder from a materials supplier

'S' - Respective Stakeholders

Interview scripts were later transcribed, categorized, coded, and analysed using thematic analysis with NVivo 12 qualitative data analysis software to identify the emerging themes and their relationships, as shown in Table 5.4. A total of 42 codes were generated from the interview transcripts. A refinement of the initial codes later reduced these to 18 codes. This helped in the formulation of the themes presented in Table 5.4 Codes were initially formed with NVivo software. A nodal folder was subsequently created to categorize code matching among the general codes. These codes were later grouped based on their meanings as sub-themes. NVivo software was thereafter used to run queries to identify the number of codes referenced to each file. It was also used for cluster analysis to. identify which codes and categories were mostly mentioned by participants. NVivo software was also used to run word clouds to identify key issues raised by research participants. These included words such as government, policy, societal attitude, awareness, costs related, as presented in Table 5.4 The study's findings were then interpreted in the last step of the analysis. Figure 3.6 depicts the processes for analysing the study's data, according to (Creswell & Poth, 2016).

Table 5.4: Table of generated codes from the interview transcriptions

Source: Researcher's construct, 2020

First Cycle Coding	No of 1st codes	Second cycle Coding	No of 2nd codes
Technical-know-how	14	Cost related	11
High cost of establishing prefabrication firms	9		
Some of the materials used are imported	12		

Ignorance	13	Societal attitude	14
Corruption problem among stakeholders	16		
Enabling legislation and enforcement are not effective	14	Weakened institutional policies	13
Lack of common standard for stakeholder collaboration	6		
Lack of appropriate supporting organizational structure	8		
Motivation and incentive from the government	13	Motivation and incentives	11
Differences in the work culture of stakeholders	10		
Lack of understanding of the supply chain management concepts.	13		
Non-flexibility of concrete components is a concern	11	Component's flexibility	10
Rigid and non-satisfying Architectural Design	9		
Heavy components	11		
Inability to develop measures for monitoring alliance	12	Materials availability	11
Materials for prefabricated components are heavy	10		
Inability to share information on project	14	Awareness	12
Low awareness and knowledge about prefabrication	16		
Improper scheduling requiring flexibility in operations	6		
Dearth of appropriate I.T. application	9		
Lack of research in prefabrication	12		
Lack of competition between prefabrication firms	10	Competition	11
Need for more prefabrication firms	12		

Lack of adequate transport infrastructure	14	Infrastructure	11
Electricity and other social amenities not available	10		
High investment in establishment of factory equipment	8	High investment	8
Inability to share information on projects	9		
Heavy weight of prefabricated components	7	Weight of components	8
Need for alternative and lighter materials for components	13		
Haulage and professional handling of components	8	Haulage	8
Inadequate social facilities	11		
Fear that customers will reject prefabricated components'	6	Fear of rejection	8
New and unpopular methods	14		
Environmental and social problems	10	Environmental problems	9
Anti-social behaviours (kidnapping and robbery)	7		
Dearth of prefabrication firms	7	Dearth of prefabrication firms	9
Communication problems	13		
Lack of trust between stakeholders	10	Lack of trust	12
Subcontractors and suppliers	14		
Awareness and benefit of prefabrication technology	9	Low level of awareness	9
Lack of understanding of the supply chain management concepts	9		
Ignorance of the contributions of and need for subcontractors and suppliers	14		
Space constraints on site during construction	8	Space constraints on site	8

Table 5.5 Forms of data coding

Adapted from (Saldaña, 2009)

Coding cycle	Coding Methods	Typologies	Description/Application
First cycle coding	Elemental methods	Structural coding	Applies content-based or conceptual phrase representing a topic of inquiry to a segment of data for coding and categorization purposes. Structural coding can be used as a general foundational work for further detailed coding. It is appropriate for virtually all qualitative studies particularly those involving exploratory studies.
		In vivo coding	Refers to coding with a word or phrase from the use of language found in recorded data. It is also labelled "Literal coding" or "verbatim coding" and particularly used in studies that prioritize and honour the participant's voice.
		Initial coding	Involves breaking down data into discrete parts by closely examining them in preparation for similarities and differences. Initial coding can also employ in Vivo coding and or process coding.
	Affective Methods	Emotion coding	Used when labelling recalled experiences or recalled emotions experienced by participants or inferred by the researcher by the participant. It is particularly useful for exploring intrapersonal and interpersonal participant experiences and actions,
		Provisional coding	This is an attempt to grasp basic themes in data by absorbing them rather than analysing them line by line and is preparatory approach to a unit of data before a more detailed coding or characterization process through first or second cycle methods. It

Second cycle coding			is useful for research that builds on or corroborates previous research and investigation.
		Computerised Technique	Raw data are analysed, automated software programs (Computer Aided Qualitative Data Analysis software) can be used for research analysis. When the number of interviews is minimal (less than ten people), manual coding is recommended as solely suitable for analysis. The computerized techniques is however advisable for use when interviews are more than ten (Kandel et al., 2012; Saldaňa, 2009).
		Pattern coding	Pattern codes are explanatory or inferential codes that identify an emergent theme, configuration, or explanation. They pull together a lot of materials into a more meaningful unit of analysis. It is appropriate for second cycle analysis of rules, causes and explanations in data, examining social networks and patterns, development of major themes from data, etc.

The coding process in qualitative data analysis comprises two primary cycles: the first cycle and the second cycle coding, as seen in Table 5.5. The researcher's decision on whether or not to employ a coding technique is influenced by the paradigm, idea, methodology, and other factors (Saldaña, 2021). The coding process in qualitative data analysis is divided into two phases. The researcher must evaluate the paradigm, topic, technique, and other factors while deciding whether or not to adopt a coding method (Belotto, 2018; Saldaña, 2021).

Structural coding, also known as open coding or subject coding (Richards & Morse, 2007), is a data-driven method. Sub-codes and sub-categories are generated from codes and categories. These are gathered for further coding and analysis. The categories are considered to have achieved saturation point when there are no further modifications in the codes.

The researcher started with structural coding. The reason for starting with structural coding is because of its relevance to this research, as higher lighted below.:

- Starting with structural coding helps the coder to become familiar with the contents and themes of the interview material.
- It is especially beneficial for multiple-participant interviews (semi-structural) and interview methods (Saldana, 2009).
- The codes can be used as an index, allowing for rapid access to the contents of the codes and to compare different replies from participants to the same interview questions and subjects.
- Because of its data-driven character, structural coding, improves the validity of the research (Gibbs et al., 2007).

Provisional coding varies from structural coding in that it is concept-driven (Gibbs et al., 2007). It is derived from theory (Marshall & Rossman, 2014), and deductive, whereas structural coding is data-driven (Gibbs et al., 2007), and deductive (Thomas, 2006). Provisional codes are pre-set and derived from a study's literature (Creswell, 2013b; Saldaňa, 2009). Pattern coding is also used to explain the data (Saldaňa, 2009). To produce emergent themes, pattern coding may be used to organize huge volumes of data, as well as codes and categories (Saldaňa, 2009).

Raw data can be manually analysed, or automated software programs (Computer Aided Qualitative Data Analysis software) can be used to do this. When the number of interviews is minimal (less than ten people), manual coding is recommended as solely suitable for analysis. The computerized techniques are, however, advisable for use when there are more than ten interviews (Kandel et al., 2012; Saldaňa, 2009).

According to Bazeley (2013) and qualitative data analysis software (QDAS) has grown in scope and applicability across a wide range of techniques.

The preliminary stages of this study involved interviews with 28 participants who are relevant stakeholders in the supply chain for prefabricated housing technology. Since the number of interview participants was more than ten, NVivo 12 computer aided software was used for the data analysis.

Participants responded to the interview questions as they understood the fact and based on their personal experiences. The barriers to the general acceptance of prefabricated building technology outlined in the following paragraphs are gathered from the participants' responses.

5.2 Lack of incentives and motivation through policy support for the adoption and promotion of prefabricated building construction

Nineteen participants out of 28 agreed that the government did not provide incentives to those interested in prefabricated methods of building construction. One of the participants said:

"The government has not been forthcoming with policies that will help in alleviating the housing problems of the citizen…." (RLS6Q1). Comment from the sixth participant on the logistics experience in moving prefabricated components from one location to the other.

This is presented in Table 5.6 Only nine participants, who make 22% of the total number, felt that the government did provide support and incentives to interest people in prefabricated methods of building construction. One of the participants affirmed that,

"The lackadaisical attitude of the government in this direction is highly discouraging. Aside from the cost of production of materials, the absence of basic social amenities has contributed greatly to the frustration being faced by the people" (RL6Q66), according to the 6th participant in response to the sixth question from the list of interview questions,

Most of the participants from all four stakeholder groups support this assertion. Other countries where prefabricated building technology has been supported through legislation, and is growing prominently, include Sweden, United States, Australia, Malaysia, New Zealand, Japan, India, and China (Jaillon et al., 2009; Li et al., 2017b; Persson & Engevall, 2008).

However, the situation is different in Nigeria, where there is no legislation that promotes the use of prefabrication technology for housing delivery (Fakere, 2020; Gyimah, 2020; Ogunde et al., 2016; Rahimian et al., 2017). In contrast, there is a general acceptance of prefabrication technology in building construction in some countries, such as Ethiopia, Iraq, China, and Singapore (Li et al., 2017a; Lou & Kamar, 2012; Saffar & Keraminiyage, 2020). Others include the United States, Singapore, Sweden, and Japan (Barlow et al., 2003; Rod et al., 2015; Zhang et al., 2020). These countries have established mature policy systems and legislation to support prefabrication technology in housing delivery. The UK government, for example, played a major role in the development of prefabrication in construction by sponsoring reports and putting policies in place to support and set up an organization (Blismas et al.) with the responsibility for promoting the uptake of building prefabrication within the construction industry (Gibb & Pendlebury, 2006; Zhang et al., 2014). The influential UK reports by Latham and Egan advocated that the UK construction industry embrace prefabricated components manufacturing for building construction (Egan, 1998a; Latham, 1994b; Wolstenholme et al., 2009b).

This resulted in greater demand for prefabrication technology in building construction. A summary of the participants' opinions in relation to this barrier is presented in Table 5.6

Table 5.6 Participants' views on incentives and motivation through policy support

Source: Researcher's construct (2021)

Stakeholders	Participants	Agreed	Disagreed	% Agreement
Prefabrication firms	8	6	2	75%
Construction firms	9	6	3	66.6%
Logistics firms	8	5	3	62.5%
Suppliers	3	2	1	66.6%
TOTAL	**28**	**19**	**9**	

The above can be likened to what was earlier reported by (Ejohwomu et al., 2017). They concluded that the government has a role to play to effectively encourage the use of prefabrication technology in building construction in a country. There is a need for government and other relevant stakeholders to support the option of prefabricated building technology to improve the overall success in prefabricated housing delivery. As recorded by (Tam et al., 2015), reducing all forms of statutory levies to encourage the growth of prefabrication technology is a supportive measure. This has been the practice in China and other developed countries, where a steady growth in prefabricated building technology has been experienced (Luo et al., 2020; Navaratnam et al., 2019a; Wang et al., 2020).

Conventional building construction has a number of complexities (Junyi, 2011) It also requires a set of skilled designers, builders and other site workers that have to work at different times. One job stage sometimes must wait for another job stage. This adds significantly to construction costs, compared with the prefabricated option, where components are already made to specification in the factory. The installers only come to the site for installation (Rahimian et al., 2017). If, however, prefabrication technology is embraced and replaces conventional construction methods, and with capital investment in industrial plants to manufacture components, the principle of economies of scale will set in, resulting in a lower cost price for a typical building project. Thus, prospective developers are likely to find the option of prefabricated construction to be economically viable. This should result in the delivery of more housing units to bridge the housing gap in the country.

Given adequate support, the option of prefabrication in building will have a positive effect on the rate of housing delivery by increasing the efficiency of production and installation of components, reducing

labour costs and decreasing the time taken for project delivery (Adebayo & Dixon-Ogbechi, 2019). Participants from the four stakeholder groups commented positively in this regard. A comment from a participant is presented below:

"On the issue of policy support from the government, I don't know of any policy in place to support prefabrication housing delivery except you may want to do further research on your own. We are [a] private firm in the business of building prefabrication. We build whenever we are called upon. However, prefabricated housing construction activities have been low for now. There is no regulatory policy to encourage the development of mass housing construction with prefabrication technology" - RC1Q10, said by the first participant from the construction firm in response to interview question 10.

Prefabrication in building, if adequately promoted, will yield a positive result in a developing country like Nigeria (Adebayo & Dixon-Ogbechi, 2017; Alagbe & Aina-Badejo, 2019, 2020). This may not be feasible unless the government enacts favourable policies that encourage the use of prefabricated components for building.

5.3 Limited awareness of the potential benefits

Reduction in cost and time are among the major advantages offered by prefabricated building construction when compared to conventional construction methods. Other benefits include improved quality and accuracy in manufacture and speed of installation on-site. Components can also be dismantled and re-used. Out of the 28 research participants who spoke on this issue, 19 (67%) agreed, while nine (33%) had a contrary view. This is presented in Table 5.7.

Table 5.7: Participants' views on limited awareness of the potential benefits of prefabrication

Source: Researcher's construct (2020)

Stakeholders	Participants	Agree	Disagree	% Agreement
Prefabrication firms	8	6	2	75%
Construction firms	9	6	3	66.6%
Logistics firms	8	5	3	62.5%
Suppliers	3	2	1	66.6%
TOTAL	**28**	**19**	**9**	

5.4 Dearth of prefabrication firms

Participants affirmed that very few firms engage in prefabricating building components in Lagos. There is a limited number of people that the available firms can serve, even at maximum production capacity (Ogunde et al., 2016). That a lack of prefabrication firms inhibited the widespread acceptance of prefabricated building technology was noted by 24 out of the 28 participants (Table 5.8). This represents 85.7% of the participants.

The participants suggested that new innovations were likely to be developed when more building prefabrication firms are established in the state. This suggests that competition between firms would, in turn, improve the performance of prefabricated housing delivery. It is believed that people would then be more informed about the technology. One of the participants said,

"We are on the lookout for cheaper but reliable materials that can be used as alternative components for prefabricated building construction" - RPS1Q2. Said in response to question two by the first participant from prefabrication firm.

Table 5.8 Participants' views on the dearth of prefabrication firms

Source: Researcher's construct (2020)

Stakeholders	Participants	Agreed	Disagreed	% Agreement
Prefabrication firms	8	7	1	87.5%
Construction firms	9	8	1	88.8%
Logistics firms	8	6	2	75%
Suppliers	3	3	0	100%
TOTAL	**28**	**24**	4	

Another participant from a prefabrication firm that produces concrete products (interlocking stones, kerbs, and concrete slabs) noted that the firm has been producing prefabricated components locally. The firm also import some prefabricated building components to complement local production and to enhance the delivery of quality prefabricated housing in Lagos State. One of the participants, who was the fourth person to be interviewed in the firm remarked in response to question five from the interview questions. He said:

"Some of our products are yet to be produced locally because of insufficient demand by the people. However, our parent company at Europe does, while we import directly from them whenever some special components are needed," - RPS4Q5.

Importation of prefabricated components requires several processes. This invariably increases the unit cost of components. Though more expensive than local production this is still within the reach of many. Those who cannot afford imported components can purchase those that are locally produced.

5.5 Personal safety

Participants from the four stakeholder groups felt that safety should be properly considered when moving prefabricated components from one place to another. Eighteen participants (64.3%) expressed how bitter their experiences had been in terms of the many uncertainties and frustrations they had encountered, and other unfavourable experiences they had had at the hand of robbers and others on the nation's highways. Their views on safety are presented in Table 5.9. It was noted that safety issues usually occur when travelling overnight to move components from production firms to the point of use. These views align with the position of (Amade, 2016b). This is also corroborated by (Hong et al., 2018). One of the participants observed:

"As the issue of bad roads is being considered there is also the need to be mindful of the activities of armed robbers and all other forms of attack during movement of components to the delivery site. As part of the effort to alleviate the risk and enhance safety, this has called for the need for insurance of the goods such that if anything happens to the goods in transit, the insurance company will come in for compensation (maximum of 20 million naira per carriage and 180 million naira per annum)" – RMS2Q5. a response to question five from a second participant from the raw materials supplier to the prefabrication firm. Insurance companies are usually involved when prefabricated components are moved from one place to another. This has become necessary because of the perceived risks and to have a support measure to fall back upon in the case of incidents. Another participant said thus:

"*If we have a good road network, we won't be spending days before we get to the terminal, as this is seen as a waste of time and resources. If you get to Apapa-Oshodi expressway now, you will see many of the drivers there, appearing very unkempt because most of them have stayed for several nights on the road on their way to the Apapa Port Authority to pick up imported components. In the cause of transporting materials to the point of usage and due to the bad condition of the roads, armed robbers sometimes attack, inflict them with wounds and make away with their personal belongings. We just must take care of them thereafter by giving them proper medical care. All this has resulted in putting*

extra cost on clients per unit cost of our products. Therefore, the personal safety of our staff while discharging their duties has always been a source of concern" - RLS3Q5.

Above is the response of the third participant in the movement of prefabricated components from the production firm to the locations where it will be used. This was also said to answer question five that was thrown at him. Thus, the movement of prefabricated components from the production site to the point of use imposes some safety concerns. The fact that there are a limited number of firms producing prefabricated building components has resulted in the need for components to be conveyed long distances with special vehicles to avoid the breakage of components. This has a negative effect on the building, as the cost of transportation usually contributes a substantial part of the overall project cost. This is summarized in Table 5.9.

Table 5.9 Participants' views on personal safety

Source: Researcher's construct (2020)

Stakeholders	Participants	Agreed	Disagreed	% Agreement
Prefabrication firms	8	6	2	87.5%
Construction firms	9	4	5	44.4%
Logistics firms	8	5	3	63.5%
Suppliers	3	3	0	100%
TOTAL	28	18	10	

5.6 High and multiple levels of taxation

Taxation affects investment decisions. There are many taxes and multiple revenue agencies in Nigeria. The government has enacted legislation for taxing companies when they commence business. These rules are complicated and result in double or sometimes multiple taxes. This is frustrating for companies at the initial stages of their start-up phase, especially as the costs of starting a business are considerable. Recognising this, argued that companies should be made to pay tax only on their actual profits from the time they start operations to the time the company is finally wound up. Twenty-one participants (78% of the total) mentioned the issue of taxation and expressed similar dissatisfaction about the government imposing multiple tax payments, as presented in Table 5.10 One of the interviewees noted,

"I remember I discussed this with some people some time ago, that if care is not taken, many companies in Lagos will soon fold up. You can see the information in the dailies of March 30th that Asiwaju Bola

Ahmed Tinubu (former Lagos State Governor) cautioned the Federal Government on the double taxation being imposed on the people. We pay state tax, we also pay federal tax, and what are we really gaining from the government? We pay for business registration every year, we pay education tax, and we pay direct assessment tax …. Just name it, on this same business how do they want us to survive, when we have all these taxes compiled, then how do they want the business to survive? It is good to pay tax, but there should be calculation on all these. If the tax payment can be centralized, it would be better. If it will be going to be only federal, it is better; look at what is happening, look at how viable companies are leaving the shore of Nigeria to other neighbouring countries because they are paying unbearable taxes. Yet, no light, no good road, nothing … So how do you expect them to survive?" - RS7Q1.

Table 5.10 Participants' views on high and multiple levels of taxation

Source: Researcher's construct (2020)

Stakeholders	Participants	Agreed	Disagreed	% Agreement
Prefabrication firms	8	7	1	87.5%
Construction firms	9	6	3	66.7%
Logistics firms	8	5	3	62.5%
Suppliers	3	3	0	100%
Total	28	21	7	

5.7 Lack of compliance with standards for prefabricated components

There are National Standards in Nigeria for building construction. Many are not known to the public. As a result, designers and practitioners mainly use British and American standards and codes as a guide for the design and construction of projects. It is often said that there are different local requirements. also noted that the methods for establishing standards are complex, slow, and fragile. One of the participants said,

"Regulations about construction materials standards for prefabricated housing are often absent in Nigeria" - RS1Q2.

Nigerian building standards should collate all applicable requirements for prefabricated construction projects, which should underpin quality control. Stakeholders in the Nigerian built environment lacks adequate knowledge of the required standards for materials for prefabricated building components.

As shown in Table 5.11, 24 participants, who represent 86% of the total of 28 participants across the four stakeholder groups, remarked positively on the need to have standards for materials used for prefabricated building components. They also expressed the need for the use of the standards to be enforced.

As one participant observed, *"Relevant regulations on the standard of materials usage must also be enacted to improve public confidence on the prefabrication technology"* - RPS1Q2

Table 5.11: Participants' views on lack of compliance with standards for prefabricated components

Source: Researcher's construct (2020)

Stakeholders	Participants	Agreed	Disagreed	% Agreement
Prefabrication firms	8	7	1	87.5%
Construction firms	9	8	1	88.8%
Logistics firms	8	6	2	75%
Suppliers	3	3	0	100%
Total	28	24	4	

The building prefabrication industry works to meet high demands by using experienced design teams and skilled labour in a quality-controlled environment to produce specified components, following prevailing standards. The design stage of prefabricated housing must consider structural stability, durability, and robustness, as well as aesthetic value.

The views of participants in this regard were captured in this quote by the third representative from prefabrication firm while responding first interview question, as proposed.

"The introduction and widespread implementation of relevant standards should lead to improvements in prefabricated housing delivery in Nigeria" - RPS3Q1

5.8 Stakeholder resistance to prefabricated building technology

Another major barrier considered by participants to be stunting the growth of prefabrication technology is people's resistance to the use of prefabricated components. This is a common situation. Of the prefabrication stakeholders, seven participants identified this as a barrier. The logistics and construction stakeholders have five and four participants in agreement, respectively, while only two from the supplier stakeholders affirmed this as a barrier. This result is presented in Table 5.12

Therefore, a total of 18 participants, representing 64.3% of the respondents, affirmed the resistance of stakeholders to prefabricated building components as one of the major barriers affecting the growth of prefabrication technology in Nigeria. This was summed up by one participant, who said:

"The people sometimes find it difficult to accept new technology. They always like to stick to conventional construction methods already known to them" - RPS4Q2.

Rather than embarking on mass production of prefabricated components, participants' responses indicated that caution is being exercised to limit the production level of common components to available orders. While some common prefabricated components can be produced in advance and always made ready, some require a definite job order and are subject to the architectural design and the client's desire. The participants also relayed that several exhibitions have been organized to inform and educate people about the option of prefabrication technology in housing construction. It is believed that the introduction and widespread implementation of relevant standards should lead to an improvement in housing in Nigeria. Though exhibitions are usually well attended, they appear to have had limited results.

"*There are little changes in the attitude of the people towards the technology. Therefore, we only produced majorly on the direct order from customers"* - RPS5Q1. This is the response and resolution, as opined by the third participant and his resolutions on the subject.

The participant emphasized how prefabricated construction methods have the advantages of quality job delivery, speed, and cost saving, implying that the continuous practical evidence of the method should convince the public to adopt prefabrication technology.

Table 5.12: Participants' views on people's resistance to prefabricated components

Source: Researcher's construct (2020)

Stakeholders	Participants	Agreed	Disagreed	% Agreement
Prefabrication firms	8	7	1	87.5%
Construction firms	9	4	5	44.4%
Logistics firms	8	5	3	63.5%
Suppliers	3	2	1	66.6%
Total	**28**	**18**	**10**	

5.9 Depreciation in the value of housing units

Prefabricated buildings are usually assembled with prefabricated components. These are components produced in the form of panels of various sizes and put together on site to produce the building units. As part of the effort to secure cost advantages, prefabrication technology is usually embraced where a mass housing project is to be developed. This often results in the construction of various building prototypes and multi-residential housing units. The occupants are initially happy to be allocated and to occupy the new prefabricated apartment. They are happy to live there for a few years. However, the satisfaction level derived from the buildings begins to decrease with time. Many of the original owners of the building either have to re-sell or re-allocate to tenants and look for alternative accommodation because of depreciation and the unpleasant experience of living in the buildings. Among other factors that are considered unpleasant is heat generation within the interior of the buildings. This has led to a reduction in the value attached to the buildings by many of the owners. As one of the participants noted,

''The use of reinforced concrete materials for the construction has the disadvantage of rigidity in design. It also keeps the interior hot during the day and at night. Among others, this has been one of the complaints and challenges we have here'' - RCS1Q3. This is as submitted by the first participant from the construction firm, responding to the third interview question. This was also supported by a few other participants.

A mass-housing estate made of precast concrete components was constructed in the early 1990s at Dolphin Estate, Lagos. This was carried out under a joint venture agreement and the company was able to deliver over 2,500 units of housing within a very short time. The people were happy to be allocated units in the building. However, the value that people had in the buildings decreased after a few years into its usage. This is because of certain factors, chief of which is lack of flexibility in the design and the inability of people to alter the design to express their personal taste, as seen in Figure 5.1. This motivated many of the original owners of some of the units to move out of their apartment and either rent it out or sell it off completely.

Figure 5.1: Residential layout (mass housing) constructed with prefabricated components

Source: CCI Group, 2021

Figure 5.2: Prefabricated panel stacked at the construction site during construction work

Source: vitapurinsulation.com, 2021

Figure 5.3: Prefabricated Mass Housing, Lagos, Constructed by HFP Engineering Ltd

Source: Author's field work, 2020

5.10 Limitation in design creativity and non-flexibility of components

Prefabricated components are pre-cut, pre-sized, pre-moulded or pre-shaped elements that are assembled on site, as seen in Figure 5.2. All wall openings are especially calculated and pre-designed with the unit panel in mind, such that they are easily coupled on site during installation. Aside from

concrete, a few other materials are being used for building prefabrication. These include expanded polystyrene and polyurethane (PU) products. Typical materials obtained are seen in Figure 5.4.

Figure 5.4: PU components ready for site

Source: Author's field work, 2019

Expanded Polystyrene (EPS) is a lightweight cellular plastic material consisting of small hollow spherical balls. It is the closed cellular construction that gives EPS its reliable structural characteristics. EPS is matched to various applications to optimize its performance and strength. Polyurethane (PUR and PU) is a polymer composed of organic units joined by carbamate (urethane) links. While most polyurethanes are thermosetting and do not melt when heated, thermoplastic polyurethanes do. Their physical and chemical properties make the materials a good component for prefabricated housing construction. These products come in standard sizes from the factory and are transported to the construction site for fixing. One of the participants (the fifth participant from prefabricated firm) answered the sixth interview question thus:

"Panellised components will usually arrive on site in readiness for direct assembly. They might form the building envelope, stair cores, internal load bearing walls, or lighter partitions. They might be open or closed panel systems, precast concrete panels, or other panel types, all created through a range of advanced prefabricated technologies" - RPS5Q6.

Prefabricated panels, sectional, volumetric or unitized systems are structural units which are combined at site with other units or systems or might comprise an entire small building. Prefabricated buildings are becoming an increasingly popular alternative to conventional building methods.

5.11 Technical know-how on the production and installation of components

Skills deficiency is a common barrier militating against the growth of prefabricated technology in building construction in Nigeria. There are a limited number of experts capable of delivering

prefabricated housing construction in Nigeria. Since patronage of these methods is low, people are generally not encouraged to further explore or promote the technology. As seen in Table 5.13, 20 out of the 28 participants, representing 70%, attested to this and maintained that bridging a knowledge gap in the execution of prefabricated construction is inevitable as part of the effort to guarantee patronage and effectiveness of prefabrication in building construction in Nigeria.

Table 5.13 Participants' views on technical know-how on the production and installation of components

Source: Researcher's construct (2020)

Stakeholders	Participants	Agreed	Disagreed	% Agreement
Prefabrication firms	8	7	1	87.5%
Construction firms	9	8	1	88.8%
Logistics firms	8	4	4	50.0%
Suppliers	3	1	2	33.3%
Total	28	20	8	

*"The ease with which [we] get personnel to work on project sites with conventional construction methods is usually not the same when prefabrication methods of construction are being used"- R*PS7Q3. This came upon a further probe of the seventh participant from construction firm to respond to the third interview question.

Therefore, effort needs to be expended in developing positive attitudes towards the promotion and development of prefabrication technology in building construction in Nigeria.

5.12 Heavy weight of components

The problem of heavy components has been a concern with prefabricated building construction particularly when the prefabricated components being used are of reinforced concrete The use of cranes and other articulated vehicles thus becomes essential to move components from the point of production to the construction site where the components will be installed. However, aside from reinforced concrete there are presently other reliable materials being used as components in the construction of prefabricated buildings. These materials are lightweight, thus posing fewer transportation challenges. A medium-size articulated vehicle can conveniently move sizeable quantities of prefabricated components from fabrication firms to construction sites for installation. Nineteen out of those

interviewed agreed to this while the remaining nine remained indifferent to the argument or disagreed. The result is presented in Table 5.14.

Table 5.14 Participants' views on the heavy weight of components

Source: Researcher's construct (2020)

Stakeholders	Participants	Agreed	Disagreed	% Agreement
Prefabrication firms	8	7	1	87.5%
Construction firms	9	4	5	44.4%
Logistics firms	8	5	3	63.5%
Suppliers	3	2	1	66.6%
Total	28	19	9	

5.13 High investment needed to establish prefabrication firms

Establishing the plant to produce prefabricated components requires a huge investment. Access to capital and credit has always been a difficult task. The Federal Government established the Bank of Industry (BOI) as a special bank that creates a level playing field and gives loans to prospective and qualified entrepreneurs as a form of encouragement to start and stay in business. The bank has failed in its responsibilities. As his contribution, the fourth participant of the prefabrication firm responded on the second question asked, thus:

"We started production of prefabricated components in our company about 12 years ago. We must operate within our limitation, as we are facing major challenges that has placed some limitations on us. Major among the limitations is lack of access to capital and credit facilities for expansion" - RPS4Q2.

The commercial banks are an alternative source of loans for establishing and expanding firms. However, they apply stringent conditions that are usually difficult to meet, including high interest rates. The moratorium periods before repayments are due are usually short and this further discourages developers from seeking funds from this source. As a result of this, it becomes impractical to rely on the bank for financial assistance. Out of the 28 participants, only two people did not lament this problem. They are suppliers, who bears the least risk in the whole process of delivering prefabricated housing projects. This result is presented in Table 5.15.

Table 5.15 Participants' views on high investment in establishing prefabrication firms

Source: Researcher's construct (2020)

Stakeholders	Participants	Agreed	Disagreed	% Agreement
Prefabrication firms	8	8	0	100%
Construction firms	9	9	0	100%
Logistics firms	8	8	0	100%
Suppliers	3	1	2	66.5%
Total	28	26	2	

5.14 Summary of qualitative interpretation of results

Focusing on the interpretation of multiple views of participants from the interviews conducted, Chapter Five has provided an analysis of the qualitative data relating to the barriers that impact the adoption of prefabricated building technology in Nigeria. These were drawn from the four stakeholder groups that were involved in the face-to-face interviews. The barriers that impede the growth of prefabricated building construction were revealed via semi-structured interviews. They include a lack of incentives and motivation, limited awareness of the potential benefits, dearth of prefabrication firms, personal safety, high and multiple levels of taxation, lack of compliance with standards for prefabricated components, depreciation value of housing units, limitation in design creativity and non-flexibility of components, technical know-how on the production and installation of components, heavy weight of components, and high investment needed to establish prefabrication firms. A description of the data analysis procedure is provided. A two-cycle analysis was carried out utilizing manual and computer-aided analysis (NVivo 12). The number of categories of codes, as provided with the help of NVivo software made provision for open (structural) and selected (provisional) codes. These are interpretations based on the experiences of the participants in relation to the barriers of adopting prefabrication technology in building construction from the four stakeholders were presented.

The next chapter proposes solutions to address these barriers. This will help to fulfil the third objective of the study and form the basis for the discussion. This will also contribute to the development of a framework aimed at improving the use of prefabricated building technology based on the key findings of the study.

CHAPTER SIX

PROPOSED SOLUTIONS TO ADDRESS THE IDENTIFIED BARRIERS AND FULFIL OBJECTIVE 3

6.1 Introduction

Having explored the barriers that militate against the general acceptance of prefabrication technology through the SLR in chapter four and semi-structured interviews in Chapter Five, Chapter Six proposes solutions to the identified barriers as presented by interviewees. For instance, a participant from the logistics stakeholder group (RLS7Q1), opined that the government should lead by example in the usage of prefabrication technology for building project delivery (for residential, commercial, or institutional buildings). The participant felt that this would serve as motivation to other corporate organizations, individuals, and the public. Such a government project would also be a good source of reference and an example to emulate. Such actions would also lead to increased accessibility to prefabricated building technology as well as to enhancing its popularity and therefore improving acceptance of the technology. The chapter identifies solutions to the barriers that have been identified, and how these solutions could be achieved. These are described and discussed below:

6.2 Lack of policy support through incentives, and motivation through policy support for the adoption and promotion of prefabricated building construction

A materials supplier who specializes in moving building components from the production factories to retail shops and construction sites believed that improvement to the condition of roads would help to reduce the cost of vehicle maintenance. The availability of reliable credit facilities would also help businesses cope with the high cost of maintaining vehicles and other equipment needed for the effective running of businesses. This would also improve the rate of patronage, as many prospective builders would have easy access to prefabricated components and relevant raw materials needed at site. There is an abundance of relevant materials, including timber and plastic, that could be processed to become useful materials for prefabricated building components. Relevant stakeholders should improve on the availability of local materials for use as materials for prefabricated building components. This, it is believed, would increase the popularity of prefabrication technology for building project delivery, to the advantage of all.

Other researchers have noted that higher costs have increased stakeholders' reluctance to adopt prefabrication and invest in the process. It has been estimated that the incremental cost of prefabrication

is higher than conventional onsite construction by at least 27%. The issues of cost, difficult technical requirements, high quality standards, necessity for a critical mass of components, tight schedules and limited industry resources all increase the complexity of adopting prefabrication technology. The suppliers of prefabricated components need to be able to provide high quality components and, in the quantities, required. These conditions are currently lacking.

Policy support from the government is required to cover the different activities that lead to the successful delivery of prefabricated buildings. Such support could be in the form of taxation, including reduction of taxes on some major components, resulting in cheaper material costs with an attendant positive impact on the total cost of project delivery.

One of the participants (the fourth participant from the prefabrication firm), in his response to the first interview question reiterated the need to develop technical education by inculcating prefabricated building technology into the relevant school syllabuses in secondary school and in tertiary education and suggested that this should be an important government policy (RCPs4Q1). Productive government relationships that ensure easy passage of new policies in this direction would be beneficial, as is practised in several countries. Governments are expected to take the lead in this context. They could mandate the use of prefabricated components for government building projects. Different levels of incentives could be introduced, for instance subsidising the unit cost (square metre) of prefabricated housing projects, as is being practised in China. The Singaporean government has spent millions of dollars to support the use of prefabricated building technology through favourable policies by the Building and Construction Authority (BCA) as a way of encouraging the use of prefabricated components for private building projects. Appropriate incentives and motivation, if introduced, would increase, and activate the interest of people in prefabricated technology in building construction.

6.3 Limited awareness of potential benefits

Stakeholders are less aware of the potential advantages of prefabricated methods of housing construction; hence, these are not taken into consideration when building work is initiated. If prefabricated building construction is to become popular, stakeholders need to be educated and re-oriented towards embracing the technology. As observed by the first participant from the prefabrication company, while responding to the fourth interview question: "*Having contact with the practical reality and clear benefit, creating an enabling environment for it to thrive, should be a serious problem*" (RPS1Q4). Housing is an essential part of human life. There is a need to introduce subjects on prefabrication as core components of building technology syllabi at the different levels of our education system. This should start early, with the national school curriculum. Students would then be familiar

with the technology and be prepared to recognise prefabricated methods of building construction. Students and, by extension, the public would gain an early understanding and awareness of the subject. Besides conventional education, special centres for training and retraining should also be supported. This would allow those already in the industry (the existing workforce) to be provided with guaranteed opportunities to update their skills. This would help to educate those working in the construction industry about the advantages and benefits of prefabricated methods of building construction. This would steadily increase people's awareness of the technology.

It has also been identified in the literature that embracing prefabricated construction methods reduces waste generation by up to 85 percent. This is a major consideration, since affordable housing delivery is much sought after and if stakeholders are made aware of this benefit it should help popularize methods of building that use prefabricated methods. Therefore, training and re-training of stakeholders and raising the awareness of the public about the cost advantages and waste management potential of prefabrication technology should be undertaken. This will, in turn, lead to more acceptance of prefabricated construction methods by stakeholders.

6.4 Dearth of prefabrication firms

The low numbers of prefabrication firms in Nigeria are unable to produce commercial quantities of prefabricated building components. This is despite the positive prospects for prefabricated methods of construction. The establishment of more prefabrication firms with the capacity to readily manufacture components will guarantee the availability of this construction method in Nigeria. Factors that provide such encouragement include customer activities, competitors and suppliers, and the supply of technological innovation. These are explored below.

6.4.1 Customer preferences

Efforts need to be put in place by all relevant stakeholders to market the use of prefabricated components for building construction. Nigerians are used to conventional construction methods that use sandcrete blocks and cement mortar (wet construction). It will be difficult to change their existing orientation and preferences and convince them to adopt prefabricated building construction methods. The establishment of more prefabrication firms will encourage competition, which should encourage innovation and new inventions. In turn, these should result in a re-orientation that will change customer beliefs by showcasing the advantages and benefits of prefabricated housing construction (Ogunde et al., 2016).

6.4.2 Competitors and suppliers

The acceptance of prefabricated methods of construction will present potential chances for competitors to enter the market. Different companies will strive to develop different strategies to attract customers. Prefabricated panels can be made out of various building materials, including concrete, timber, hybrid-timber, recycled timber, and structural insulation, among others (Adindu et al., 2020; Ogunde et al., 2016). This, in effect, will bring more innovation to the prefabrication industry and will subsequently make the prefabrication industry more popular (Blismas et al., 2010a).

6.4.3 Supply of technological innovation

The prefabricated housing construction industry is pressured by labour shortages, quality requirements, tight construction schedules and other onerous conditions. The establishment of more prefabricated building construction firms will be a positive way to address these problems. As one interview participant observed, "the deployment of innovative technology among stakeholders in the prefabricated building construction is not negotiable" (RPSQ3), as observed by the third participant of the prefabrication firm while responding to the third interview question. Improved technological innovations will be maximised in an environment of competitiveness (Naidoo, 2010). Technical innovations will be deployed to improve the capacity to produce and distribute prefabricated components. This will also bear directly on the unit cost of prefabricated components, and thereby reduce the cost of prefabricated housing delivery.

The acceptance and uptake of prefabrication in building construction will attract more demand, which will, in turn, result in the establishment of more prefabrication firms (Alazzaz & Whyte, 2014). This will naturally give rise to more innovation in diverse ways as firms will want to attract more customers. This will force down the unit price of prefabricated components, to the overall benefit of the people. It is likely that this will lead to a call for more attention to be paid to the development of technical and vocational education.

6.5 Personal safety

Safety is the state of being "safe". It is the condition of being protected from harm or other non-desirable outcomes (Walter, 2008). Safety can also be referred to as the control of recognised hazards in order to achieve an acceptable level of risk. The fact that a limited number of building prefabrication firms exist in Nigeria has a negative effect on the marketability of prefabrication products.

The Federal Road Safety Corps (FRSC), a federal government agency, is responsible for reducing the number and severity of crashes on Nigerian roads (Venkatraman et al., 2020). There is a need to be

strict in discharging this responsibility. Prefabricated components are generally heavy and require vehicles that are more substantial than usual to transport them from factory to site. The FRSC has a duty to ensure that only vehicles that are duly registered and approved for certain types of activities (loads/goods) are used for that purpose, as in the case of the delivery of prefabricated components by road. By obeying the traffic rules, the numbers of accidents on the roads will reduce. The safety intervention strategies put in place by FRSC include engineering, enlightenment, environment, education, enforcement, and evaluation. These must be regularly re-assessed to ensure safety on Nigerian roads (Femi, 2013; Gwamki et al., 2018). In addition, aggressive public enlightenment campaigns on the activities of articulated vehicles on the highways must be followed by strict compliance with the regulations by logistic firms. This must also come with the approval of accredited and special driving schools for the training and re-training of prospective drivers of articulated vehicles.

The establishment of more prefabrication firms in different regions of the country would bring services closer to customers, and therefore reduce the distances travelled by truck drivers who deliver prefabricated components to customers and construction sites. This, in turn, would reduce the number of accidents on roads in Nigeria.

6.6 High and multiple levels of taxation

The Nigerian tax system is basically structured as a tool for revenue generation. It is a legacy from the pre-independence government based on the 1948 British tax laws. These have been in operation since Nigeria gained independence in 1960. However, several amendments have been made, from the 1961 ITIMA Act through to the 1989 policy, which were aimed at achieving effective protection for local industries, greater use of raw materials, and generating increased government revenue, among other things. Attention was also focused on promoting exports for manufacturers and reducing the tax burden on individuals (Mamud, 2008; Okafor, 2012; Okolo et al., 2016). However, the problems of multiple forms of taxation, among other challenges, by the different levels of government in Nigeria has been widely discussed (Michael, 2014; Okolo et al., 2016). The tax system has been characterized by a lack of statistical data, poor tax administration and an inability to prioritize tax efforts. This has resulted in an increase in the underground economy. It has not helped the growth of industry, as several firms have experienced severe hardship and can no longer cope with the stress (Akinfala, 2018; Olokooba, 2019). This has resulted in their relocation to nearby countries for survival (Kadiri & Tosin, 2018). The fifth participant who was a project officer with a prefabrication firm said in his reply to interview question 10. He has this to say:

"Lagos State and the federal government's activities affect us more negatively than positively. What the government is known for is to always come around and bill us. We pay taxes and other levies to different government agencies: Lagos State Signage and Advertisement Agency (LASAA), Lagos State Emergency Management Agency (LASEMA), Lagos State Internal Revenue Service (LIRS), the Local Government, among others, in the name of one permit or the other. Most of these activities usually left us with frustration and discouragement to want to situate similar factories in Lagos" - RP5Q10.

This position is in agreement with the recommendations of another researcher who has advocated a unilateral tax system so that the problem of high and multiple levels of taxation in Nigeria could be addressed through autonomy, efficient and effective tax administration, the use of computer technology, strengthened auditing and public enlightenment (Mamud, 2008; Micah et al., 2012).

There should be a unified, effective and unbiased tax administration (a single tax system) with full representation from the three tiers of government to avoid the present situation in which the federal and state governments and local councils impose taxes and levies at will (Butler, 2020; Sanni, 2012). Room needs to be created for specialized tax judges in the courts to adjudicate on tax-related matters promptly and efficiently to foster compliance and to enhance respect for effective and unbiased tax administration (Micah et al., 2012).

6.7 Lack of compliance with standards for prefabricated components

The Nigerian National Building Code (NNBC) is a collection of laws, regulations, ordinances and other statutory instruments adopted by a government legislative authority that are involved in assuring the adequacy of the physical structures and healthy conditions of buildings (Fard et al., 2017), Building codes establish predictable, consistent minimum standards that are to be applied to the quality and durability of construction materials. They are documents that set out the basic standards of building construction in Nigeria (Iweka et al., 2010). The NNBC was designed to reduce the incidence of building collapse in Nigeria to the barest minimum and to promote safety and quality housing for every Nigerian. It was inherited from the UK building code (Adebara et al., 2014; Holt et al., 1995; Ogunbiyi, 2014). Nigerians respect the standards for building work contained in the NNBC. This document contains the basic standards for a project's conception, execution and delivery (Dahiru et al., 2012; Opara et al., 2012). However, the implementation of NNBC has not been strictly enforced over the years (Yakubu & Agapiou, 2016).

"The construction industry in Nigeria is characterized with problems which impair the standard of construction work as a result of the lack of strict adherence to the Nigerian National Building Codes" (RPS5Q5). The fifth stakeholder from prefabrication firm has said while answering the fifth interview

question directed to him. Nigerians do value building standards, and as one participant observed, *"Appropriate regulations on the standard of materials usage will serve, if enacted by national and states' legislators, to improve public confidence in the operation of prefabricated construction methods"* (RPP4Q5).

This has been revealed by a further probe on interview question 5, from the fourth participant from prefabrication firm. Efficient methods include those currently being practised in Singapore, where builders are required to meet a minimum score for 'buildability' as measured against the 3S Principles: Standardization, Simplicity and Single integrated elements (Ying & Pheng, 2007). Each of these explicitly favours the use of prefabricated building methods by mandating repetitive sizes and materials, uncomplicated construction, and the use of integrated offsite manufacture of materials (Rahim & Qureshi, 2018; Xu et al., 2020). This can have a positive impact on the development of prefabricated building technology (El-Abidi & Ghazali, 2015; Rahim & Qureshi, 2018). In Singapore's public housing systems, mandatory requirements for prefabrication are enforced indirectly through statutory compliance with buildability provisions. The Singaporean government has encouraged the private sector in the use of prefabrication as a vehicle to enhance construction performance through various policies.

With ample land mass and a large population, there would be an enviable result if the strategies employed in Singapore could be domesticated in Nigeria. There are potentially different forms of materials that could be developed for use as prefabricated components for building construction. The technical skills that appear currently considered insufficient could be developed over a period to meet the national requirement of human capital in this case.

6.8 Lack of compliance with standards for prefabricated components

As a result of a lack of adequate information about prefabrication technology, Nigerians find it difficult to shift from the conventional construction methods they have become familiar with over the years to prefabricated construction methods. However, there are several factors that could help in bridging the gaps. These include technical factors, management factors and market factors These factors were also attested to by the participants and are discussed below.

6.8.1 Technical factors:

Technical know-how is seen as an important factor in the acceptance and growth of prefabrication technology in building construction. Skill acquisition in prefabricated building construction will be improved when courses on prefabrication building technology are introduced to form part of the normal school curriculum from secondary schools through to technical colleges and university education

(Gerver, 2014). This also agrees with the position of some of the participants in their responses to the interview questions. One of the participants who was the second stakeholder from the Construction firm, while responding to the first question directed to him, remarked:

"The economic advantages of prefabricated housing have been made clear to us from time to time, but it is a construction method that we are not familiar with. Therefore, there is the need for concerted effort to train more experts in the prefabricated building technology, and for them to come up with different strategies to practically convince the people. Cheap and reliable prefabricated materials for buildings should be researched and used for prefabricated building construction to improve housing delivery to the people" - RCS2Q1.

6.8.2 Management factors:

Management factors include those that influence changes in strategic management (internal or external) to the business organization. Some of the factors include management functions, structural transformations, competition, socio-economic factors, laws, and technology. Thus, the management teams of prefabrication firms would have to take account of the above factors and apply them positively in the interests of prospective buyers or clients. Prefabrication firms may need to form relationships with one another to look further afield for diverse ideas to optimize strategic value. Firms with more diversified interests will need to pay special attention to relationship building within the prefabricated housing networks (Bygballe & Persson, 2015). A participant indicated a similar position in his remark on the collaborative effort needed to improve the presence of prefabricated buildings. The fifth stakeholder from the prefabrication firm have this to say while responding to the ninth interview question asked:

"Since prefabricated methods of building construction, though long in existence, [are] not yet popular in the Nigerian construction industry, it is considered a necessity that the few ones in the business of building prefabrication [need] to come together and form a formidable association such that the platform can be used to reach out to government and other relevant stakeholders with the views and strategies to upscale the construction technology" - RPS5Q9.

6.8.3 Market Factors

This involves a situation where companies buy the resources, they need to produce their own goods and provide their services. When consumers demand more goods and services, producers increase supply to meet expectations. Market forces between the supply of components for prefabrication and demands must strive to be balanced (Buehlmann & Schuler, 2013).

Prefabricated building technology has undeniable and significant benefits, including faster all-weather development and thus a faster return on investment for developers, lower operating costs for residents because of factory-driven precision, air-tight part joining, and superior insulating placement, a more secure working environment with no need to operate "at height" and a better environmental outcome for society. There are lower operating costs and greater waste minimization due to repeatable output at a fixed location (Hwang & Tan, 2012). A participant corroborates this view, suggesting that *"prefabricated house building would become cheaper than on-site production if concerted effort can be injected to make the prefabricated housing industry mature enough to gain economies of scale, that will later translate to an increase in the numbers of affordable houses for the people"* - (RPS3Q4). This was the response from the third stakeholders from the prefabrication firm while addressing the fourth question directed to him.

6.9 Monotonous design and depreciation in housing value

Monotonous and prototype building design has always been a major and general characteristic of prefabricated buildings in Nigeria (Kamali & Hewage, 2016). Prefabricated buildings have mostly existed in the form of mass housing to secure cost advantages and to meet the demand for housing large numbers of people. The prototype nature of such buildings usually makes them monotonous to the occupiers. This, in turn, leads to depreciating values for the buildings. This is one of the major reasons that people are discouraged from investing in prefabricated building technology.

One of the solutions, as stated by the first stakeholder from the construction firm, in response to the third question (RCS1Q3), is to encourage massive construction of different building prototypes in the form of mixed designs, where a particular set of buildings will be concentrated in an area while another set of prototypes will be built in another area in a well-planned manner. Another innovation, as mentioned by the same interviewee in response to the fourth question (RCS1Q4), is in the choice of material selection for finishes and external walls. According to him, a good understanding of the choice of materials will help in addressing this problem, because the way a building is built, the colour, and internal and external finishes, amongst other factors, changes people's perceptions of a building.

6.10 Limitation in design creativity and non-flexibility of components

The type of materials available for prefabricated components include reinforced concrete, portacabin, steel, panel, and timber. These materials place some limitations on how far the method can extend in building construction (Te Roopu Taurima, 2016; Zhukov et al., 2017). However, the introduction and encouragement of organised private sector and other relevant stakeholders to become involved in the

production of prefabricated components and the delivery of prefabricated buildings was remarked upon by the fourth participant from the prefabrication firm, while addressing a further probe on the fourth interview question for him (RPS4Q4). This also affirmed that new innovations will be developed by different prefabrication firms. This will, among others, give birth to different alternative materials and new technologies that will improve prefabricated project delivery at minimal cost (Burgan & Sansom, 2006; Li et al., 2011). Examples of such innovations include the choice of materials, including wood, steel/aluminium, and concrete (Navaratnam et al., 2019a). It is hoped that new inventions will be developed by various prospective registered firms to carry out building prefabrication projects. This will invariably result in improved performance of the technology.

6.11 Technical know-how on the production and installation of components

There is a dearth of competent personnel available to service the production and installation stages of construction that uses prefabricated components (Jiang et al., 2018). Since there are no provisions presently set out specifically to bridge the gap, this area will continue to present continuous challenges to the growth of the technology. In relation to this topic, fifth r participant from the Construction firm, in his response to the third question asked (RCS5Q3) suggested the need for the introduction of prefabrication in building technology as a course in the normal academic curriculum in secondary schools, universities, and other higher education institutions in the country. Trade organizations should also lead by example in this respect. These are seen as potential efforts to address this and some other barriers to prefabricated construction.

6.12 Heavy weight of components

The procurement of hoisting equipment is a basic necessity for a prefabrication firm (Tao et al., 2018; Thanoon et al., 2003). Heavy components need to be moved within and around the factory. They are also needed when components are lifted into position at construction sites from time to time. However, due to the limited numbers of prefabrication firms presently established in Nigeria, prefabricated components often need to be transported over a long distance to sites for installation (Knaack et al., 2012). According to the response from the first participant among the materials supplier while answering the fourth questions asked, *"This usually constitutes an additional financial burden on projects. No doubt, with increasing attention on prefabricated housing technology, new innovations on the materials used will be developed towards the production of components that are lighter in weight in the course of time"* - (RMS1Q4). Then the burden of heavy components will be no longer be a constrain on the development of the industry.

6.13 High investment in establishing prefabrication firms

The challenges posed by the high costs of establishing prefabrication firms are evident. It is the remit of prospective entrepreneurs to identify means and sources for money to establish such firms. To support the establishment and encourage the growth of such firms, it is necessary that governments ensure that certain provisions are in place (Fatoki, 2014). One participant from Prefabrication firm believed Government should enhance access to financial support in the form of loans for prospective entrepreneurs. This is to guarantee easy access to fund for the establishment of prefabrication firm. The participant also maintained thus:

"Existing sources of financing for industrial development should be strengthened while more sources should be created that can provide the financial requirement to support prospective entrepreneurs in the establishment and development of prefabrication firms, and all that will go with it, to have effective prefabricated housing delivery" - (RPS4Q2).

6.14 Summary of proposed solutions

This chapter has discussed solutions to each of the barriers identified in the previous chapter. The information gathered from literature, coupled with the information provided by participants and the analysis, as presented in the previous chapters, has informed the proposed recommendations for improvements in the supply chain management of prefabricated housing construction in Nigeria. This is fully presented in the next chapter.

CHAPTER SEVEN

RECOMMENDATIONS FOR IMPROVEMENTS IN THE SUPPLY CHAIN MANAGEMENT OF PREFABRICATED HOUSING CONSTRUCTION IN NIGERIA

7.0 Introduction

The findings from the interviews, narratives, and observations from the four categories of stakeholders in the supply chain management of prefabricated housing construction in Nigeria were considered and the following recommendations are proposed. These were also compared to what occurs in other countries in relation to the supply chain management of prefabricated construction components. Recommendations are proposed based on the findings of the study to guide policy formulation and to positively impact industry practice to improve the adoption of prefabricated housing construction in Nigeria. Recommendations are made for the different categories of relevant stakeholders. These include the government, who is the policy maker, prefabrication firms, construction firms, haulage and logistics firms, and raw materials suppliers. These are presented below:

7.1 Recommendations for policy makers (government)

Government has a major role to play if prefabricated building construction methods are to become popular in Nigeria. The following recommendations need to be considered.

- Enforcement of policies and regulations by government agencies in Nigeria is low (Umeokafor et al., 2014). However, the importance of the enforcement of policies cannot be over-emphasized. Hence, it is recommended that government and organizations rigorously enforce policies. Adequate systems must be put in place to enforce compliance through rewards, awards, recognition, and penalties, where necessary, as is practised in countries that are successful in the use of prefabrication technology in building construction. Examples include Japan, China, and Singapore (Chiang et al., 2006; Matsumura et al., 2019; Steinhardt & Manley, 2016). Therefore, this study recommends the development of a regulatory compliance and enforcement framework consistent with practices in other countries to improve the adoption of prefabricated housing in the Nigerian construction industry. For example, prefabricated construction methods have enjoyed favourable policies in Singapore as builders are required to meet a minimum score for 'buildability', as measured against the 3S Principles of Standardization, Simplicity and Single integrated elements. Each of these explicitly favours the

use of prefabricated building construction methods by mandating repetitive sizes and materials, uncomplicated construction, and the use of integrated offsite materials (Albus & Meuser, 2018; Rahim & Qureshi, 2018; Xu et al., 2020). Furthermore, factors that have contributed to the general acceptance of prefabricated construction in Singapore include mandatory regulations, financial support, and logistical support from the Singaporean government (Azman et al., 2012). Another example is Sweden, which is widely regarded as the home of prefabricated buildings, where stakeholders can maximize climate advantages to grow and protect trees to produce timbers suitable for prefabrication components. This method represents up to 80% of the country's overall housing market (Steinhardt & Manley, 2016). Nigeria's favourable weather similarly supports the growth of trees. A favourable policy is needed to protect forests to produce trees for use in prefabrication in building technology. Practical examples in countries including the United Kingdom, Sweden and Singapore provide a guide in this respect (Rahim & Qureshi, 2018).

- A top-down approach to policy implementation is popular in most African countries, including Nigeria. However, since policy enforcement and compliance have been rated as poor (Oyebode, 2018) the general populace and those on low incomes should be involved in formulating policy to improve effective execution (Tezera, 2019). It is suggested that bottom-up approaches can provide a better understanding in this regard (Udofia & Abasilim, 2015). Since current laws do not directly address supply chain management in prefabricated housing construction, both the government and organizations should develop policies that encourage the use of prefabrication methods and thus contribute to alleviating housing problems in Nigeria. These recommendations should also promote widespread adoption of prefabricated construction among construction stakeholders. Furthermore, the application of a bottom-up approach should ensure that the recommendations are accepted by all, with minimal need for enforcement.
- Training and re-training are vital components of skill growth. Emphasis on prefabricated methods of construction may be developed in educational curricula, from secondary school through to relevant tertiary education programs. It is also recommended that construction stakeholders engage in compulsory periodic training to improve their knowledge of the benefits of prefabricated construction. Preparation talks, toolbox talks, orientation programs, conferences, workshops, and motivational events are examples of formal and informal training that ensures that practitioners are better informed. Embracing such recommendations should help keep Nigeria abreast of standard practices in other developed nations (Howarth, 2006).
- Efforts should also be made by professional bodies in the field of construction to attach more importance to Continuing Professional Development (CPD) (Nel, 2013) as a means of

educating and informing stakeholders about prefabricated construction technology to remain informed of international developments. Construction professionals could thus regularly upgrade their skills and knowledge of supply chain management in prefabricated construction as the building and construction industry continues to evolve. Due to advances in technology, changes in regulations, and increasing specialization, CPD has been made compulsory for stakeholders in the construction industry in Sweden and Singapore, where prefabricated building construction is popular (Friedman et al., 2013; Kwofie et al., 2018). A similar approach to CPD applies in construction industries in the United Kingdom, Sweden, and Australia (Steinhardt et al., 2020). To promote participation, some CPD courses could provide flexible access to prospective participants – online, in-house, in the classroom, or via correspondence. It is also important that CPD programmes or courses are not just available and convenient, but also affordable for all concerned (Nel, 2013). Life-long learning has become a crucial part of development in any field of endeavour.

There is a need for the government to further develop policies to support industrialization in Nigeria (Athukorala & Sen, 2015; Ogbuagu et al., 2014). At present, infrastructural decay and other factors continue to frustrate the growth of industries in Nigeria, and prefabrication firms are no exception.

Barriers identified by different stakeholders, together with suggested recommendations to address these barriers, are summarized in Table 7.1.

Table 7.1: Matching the identified barriers with suggested recommendations

S/N	Identified Barriers	Recommendations to address barriers	Engagement required by
1.	Lack of policy support through incentives and motivation through policy support for the adoption and promotion of prefabricated building construction.	▪ Develop a regulatory compliance and enforcement framework consistent with practices in other countries to improve the adoption of prefabricated housing construction (Albus & Meuser, 2018; Rahim & Qureshi, 2018; Xu et al., 2020). ▪ Individual and corporate organizations should engage with policies that encourage adoption of prefabrication construction methods in the construction industry**.**	▪ Government ▪ Construction firms ▪ Prefabrication firms ▪ Logistics ▪ Raw materials suppliers
2.	Limited awareness of potential benefits.	▪ Efforts should be made by relevant professional bodies in the field of construction to attach more importance to Continuing Professional Development (CPD) (Nel, 2013). ▪ Training and re-training are vital components of skill growth. Emphasis on prefabricated methods of construction should be made in school curricula. It is also recommended that construction stakeholders undertake periodic training to improve their knowledge of the efficiencies and strength of prefabricated construction methods. This would follow recognized practice for construction professions in developed countries (CIOB; RICS	▪ Government ▪ Professional bodies ▪ Relevant professionals ▪ Other stakeholders in prefabricated building construction.

		and MBA) as far as their continuing professional development programme (CPD) is required. ▪ Prompt information dissemination has a direct effect on the quality of a prefabricated housing project as delivered, affecting the project's overall success. Therefore, quality information transmission across the whole chain should be given due attention.	
3.	Dearth of prefabrication firms.	▪ There is a need for the establishment of more component prefabrication firms to meet production demands by the public. In addition to new firms, existing prefabrication firms will have to increase production to full capacity to meet public demand.	▪ Relevant professionals ▪ Prefabrication firms ▪ Other stakeholders in prefabricated building construction ▪ Government ▪ Entrepreneurs
4.	Personal safety.	▪ Efforts should be made by professional construction bodies to attach more importance to Continuing Professional Development (Nel, 2013). This would be a positive way to educate and inform relevant stakeholders about prefabricated construction technology, and to enable them to keep up with the latest developments around the world. This way, construction	▪ Relevant professionals ▪ Relevant workers in prefabrication firms ▪ The public (consumers)

		professionals can invest in personal growth by regularly upgrading their skills and knowledge of supply chain management in prefabricated building construction. This is as the building and construction industry is constantly evolving (Loveridge, 2019). With advances in technology, changes in regulations, and increasing specialisation, CPD has been made compulsory for stakeholders in the construction industry in Sweden and Singapore where prefabricated building construction is popular. The same approach to CPD applies in construction industries in the United Kingdom, Sweden, and Australia (CPD, 2021; Loveridge, 2019; Steinhardt et al., 2020). Therefore, to promote participation to all concerned, CPD courses will provide more understanding to prospective participants – online, in-house, in the classroom, or via correspondence. It is also important that CPD programmes are not just available and convenient. They have to be affordable to all concerned (Nel, 2013). Life-long learning has become a crucial part of development in any field of endeavour. ▪ Trust is the bedrock upon which collaborative inclinations such as partnerships grow. ▪ It is recommended that prefabricated housing stakeholders organize to provide a framework for collaboration to achieve	

		supply chain management goals in building prefabrication. There is a need for trust building amongst stakeholders, as cooperation will help partners to achieve individual goals in supply chain management.	
5.	High and multiple levels of taxation.	▪ There is a need for the government to review the tax system to encourage industrialization in Nigeria (Ogbuagu et al., 2014). At present, infrastructure decay and other factors are frustrating the growth of industries, including prefabrication firms, in Nigeria.	▪ Government
6.	Lack of compliance with standards for prefabricated components.	▪ It is also recommended that government should be firm in policy enforcement, to ensure compliance through rewards, awards, recognition, and penalties where necessary, as is the case in other countries where prefabricated construction technology is successfully implemented, including Japan, China and Singapore (Chiang et al., 2006; Matsumura et al., 2019; Steinhardt & Manley, 2016). ▪ It is recommended that component prefabrication firms, construction firms, and other relevant stakeholders should meet more regularly. This will provide opportunities for interaction and cooperation amongst stakeholders, to generate ideas and initiatives to improve the efficiency and effectiveness of operations.	▪ Government ▪ Prefabrication firms

7.	Monotonous design and depreciation in housing value.	▪ The implementation of information technology software is highly recommended to enhance flexibility in materials usage. Construction firms must be able to engage with this idea to compare more favourably with developed countries where prefabrication technology is popular. This aspect was emphasized by one of the participants, who said, *"Our components are produced in modules with standard sizes. We also adjust the construction drawings in line with our modules. Therefore, we always have issues with the architectural/construction drawings whenever it is supplied directly by clients (through their architects). This usually resorts to a lot of adjustments being made on the drawings before it can work well with our prefabricated components".* - RP5Q10.	▪ Relevant professionals ▪ The public ▪ Raw material suppliers
8.	Limitation in design creativity and non-flexibility of components	▪ Construction firms that embrace the use of prefabricated components should adopt a common collection of SCM procedures. According to , these procedures should be determined in accordance with each company's overall plan. Application of consistent supplier selection and assessment requirements, introduction of production training for components fabricators, use of supplier performance records in new projects, standard and timely participation of supply chain	▪ Government ▪ Prefabrication firms ▪ Relevant professionals ▪ The public ▪ Raw material suppliers

		actors in projects, and incorporation of design team members and professional consultants to downstream suppliers should all be covered by SCM procedures (Liu et al., 2020; Sun et al., 2020). In this connection a stakeholder observed that. ▪ "Prefabrication construction firms should have a list of raw materials suppliers that they rely upon for raw material supplies. It will then be the duty of individual suppliers to have moved around and sourced standard and acceptable materials to the prefabrication firm. This way, firms will rest assured of stand-by suppliers, hence it becomes easy to project production rates ahead"It is recommended that stakeholders in the prefabricated construction supply chain gain better understanding of information communication technology (ICT) resources (Abedi et al., 2016a), since the design team and other stakeholders communicate through relevant installed software. *"This will promote information sharing and thus help in the successful delivery of building projects"* - (RPS4Q2), said another participant. Research funding returns social benefits to diverse stakeholders (Rull, 2014). It is therefore recommended that grants should be further facilitated for research into the broader range of alternative and reliable materials for prefabricated building construction. In addition, governments should take	

		proactive steps to ensure that the use of prefabricated components is encouraged in public building projects, to offer a source of attraction to the public.	
9.	Technical knowledge and skill in production and installation of components.	▪ It is recommended that stakeholders in the prefabricated construction supply chain gain better understanding of information communication technology (ICT) resources (Ejohwomu et al., 2017). Design teams and other stakeholders will communicate more conveniently using relevant computer software. ▪ *"This will promote information sharing and thus help in the successful delivery of building projects,"* another participant said. Supply chain actors should have access to on-the-job training and retraining opportunities. This will aid in ensuring a better understanding of architectural design production by the design team, along with ease of editing, provision of drafts for possible comments, implementation, and other supply chain factors, as well as training that may be needed to encourage collaborative knowledge sharing. ▪ Early collaboration between supply chain actors is highly recommended. Therefore, clients, design team, contractor, and expert consultants should collaborate from the early stages of a building project through to completion. Early input from	▪ Government ▪ Prefabrication firms ▪ Relevant professionals ▪ The public ▪ Raw material suppliers

		different stakeholders from the outset of a project can eliminate or reduce challenges during the prefabrication of components, and upon their installation on site.	
10.	Heavy weight of components	▪ Haulage and logistics firms are important for successful delivery of prefabricated buildings, to ensure that shipping, delivery, and supply chain management works as efficiently as possible. This should lead to improved operational efficiency in prefabricated housing delivery. • It is recommended that modern and suitable equipment such as cranes, fork-lifts, barges, and similar are acquired to increase workplace efficiencies. Available equipment for loading and delivering prefabricated components, as observed in most logistics firms visited, reflects outdated and inadequate logistics: *"A few components get destroyed in the course of movement from the prefabrication firms to the construction site. A few of our vehicles have fallen off the road to manoeuvre around the spoilt section of the road"*.	▪ Prefabrication firms ▪ Logistics firms
11.	High investment in establishing prefabrication firms.	▪ There is a need for the government to put necessary factors in place to encourage industrialization in Nigeria (Athukorala & Sen, 2015; Ogbuagu et al., 2014). Infrastructure decay and many other factors continue to frustrate the growth of industries in	▪ Government ▪ Commercial banks

		Nigeria. Prefabrication firms are no exception. Embracing these recommendations will keep Nigeria abreast of standard practices in other developed nations.	

In summary, the key recommendations for each of the relevant stakeholders towards improvement in the supply chain of prefabricated housing construction are presented in Figure 7.1. The position of the government influences all other stakeholders, hence the need to locate government at the top of Figure 7.1.

7.2 Recommendations for prefabrication firms

- Improved cooperation between project participants is needed to enhance sharing of information and creation of relationships to achieve shared objectives of prefabricated building construction uptake. This is particularly necessary where relevant professionals are not direct employees of the prefabrication firm. Failure and disappointment may be mitigated if prefabricated construction companies engage sufficient in-house professionals to carry out the different stages of building projects from time to time. This aspect was emphasized by one interview participant, who said,
- It is recommended that stakeholders in the prefabricated construction supply chain improve their understanding of information communication technology (ICT) resources. Design teams and other stakeholders can communicate more effectively using relevant computer software. "*This will promote information sharing and thus help in the successful delivery of building projects*" - (RPS4Q2, as another participant has said. Supply chain actors should also have access to on-the-job training and retraining opportunities. This will ensure better understanding of architectural design production by the design team and other supply chain actors, while also allowing ease of editing and provision of drafts for possible comments and implementation, as well as further training that may be needed to encourage collaborative knowledge sharing.
- It is also recommended that government and organizations enforce policy relevant to this area more firmly. Adequate systems need to be put in place to encourage and support compliance through rewards, awards, recognition, and penalties where necessary, as is the case in other countries that have successfully implemented prefabricated building construction technology, such as Japan, China, and Singapore (Chiang et al., 2006; Steinhardt & Manley, 2016).
- There is a need to grow the number of prefabrication firms (Adindu et al., 2020). Unfortunately, the necessary basic facilities to encourage the establishment of such enterprises are not adequately provided at present (Dano et al., 2020; Olufemi et al., 2013). Therefore, there is a need for general improvement of basic public utilities (Dano et al., 2020). Concerted effort should also be made by prefabrication firms towards having sufficient professionally qualified

personnel in their firms, to synthesise and produce construction drawings, to guard against after-thought tendencies at construction stages, and to reduce delay and wastage at this stage.

7.3 Recommendations for construction firms

- Construction firms that embrace the use of prefabricated components should adopt a common collection of SCM procedures. According to Xuejian and Shusheng (2019), these procedures should be determined in accordance with each company's overall plan. Application of consistent supplier selection and assessment requirements, introduction of production training for components fabricators, use of supplier performance records in new projects, standard and timely participation of supply chain actors in projects, and incorporation of design team members and professional consultants to downstream suppliers should all be covered by the procedures. In relation to this, a stakeholder observed that,

  "*Prefabrication construction firms should have a list of raw materials suppliers that they rely upon for raw material supplies. It will then be the duty of individual suppliers to have moved around and sourced standard and acceptable materials to the prefabrication firm. This way, firms will be rest assured of stand-by suppliers, hence [it] becomes easy to project production rates ahead*" - (RPS5Q3).

- Relationship management and trust development among stakeholders in the prefabrication building project is important for the success of a particular venture. It is therefore recommended that construction firms, prefabrication firms, and other relevant stakeholders should endeavour to improve their opportunities to effectively interact and cooperate with one another in handling a typical prefabricated housing construction project. This can allow them to brainstorm together, producing ideas and initiatives that can be used to improve the efficiency and effectiveness of their operations.

- It is recommended that stakeholders in the prefabricated construction supply chain gain better understanding of information communication technology (ICT) resources. Since the design team and other stakeholders communicate through relevant software, "*this will promote information sharing and thus help in the successful delivery of building projects*" - (RCS3Q5), as another participant has said. The supply chain actors should have access to on-the-job training and retraining opportunities. This will aid in improving understanding of architectural design production by the design team, increase the ability to edit drawings, facilitate the inclusion of possible comments, implementation, and other involvement of supply chain actors,

as well as indicating further training that may be needed to encourage collaborative knowledge sharing.

7.4 Recommendations for haulage and logistics firms

Haulage and logistics firms are important for the successful delivery of prefabricated buildings, since they enable shipping, delivery, and supply chain management work to be as efficient as possible, leading also to improved operational efficiency.

Since part of supply chain activities involve the movement of prefabricated components from one location to the other, it is important that attention is given to roads. The present deplorable condition of Nigerian roads, posing significant dangers to the public, has been identified as one of the factors retarding the growth of prefabricated building technology.

- It is recommended, therefore, that more firms are registered to provide prefabricated building services and are provided with adequate modern equipment to increase workplace efficiencies. Equipment for loading and delivering prefabricated components in most of the logistics firms visited appears old and inadequate, and while logistics management can be complex and time-consuming, suitable equipment can make service delivery both easier and more profitable. A stakeholder in the haulage and logistics firm lamented that:

  "*A few components get destroyed during movement from the prefabrication firms to the construction site. A few of our vehicles have fallen off the road to manoeuvre around the bad section of the road*".

7.5 Recommendations for raw material suppliers

There can be strategic alignment and commitment among prefabricated construction supply chain members from the start of a building project until the end of a typical construction project, as occurs in USA, Sweden, and China (Li et al., 2018). For instance, information flow must be established between the design team and technical team in the prefabrication firm (Dallasega et al., 2018). This should be in the form of partnership with strong relationships and proven evidence of working across multiple projects (Li et al., 2018). Working together and understanding the roles of other participants from the outset should ensure strong continuing relationships. As noted by one participant, "*the mutual understanding among stakeholders will help in the delivery of prefabricated buildings with less stress*" (RLS6Q1).

- It is also recommended that there should be a structural foundation for managing prefabricated construction supply chains. Here, the roles of clients, project managers, materials suppliers, and other stakeholders in the prefabricated construction process will be clearly defined. When a standard design and construction process for prefabricated construction is in place, the public can then be appropriately guided through the process of prefabricated housing delivery.
- A significant number of raw materials suppliers to the prefabrication firms are small and medium-sized enterprises, often with limited management expertise. Relying on these supply chain actors may not guarantee continuous production. It is therefore recommended that opportunities be created for middlemen, between local materials suppliers and prefabrication firms, to enhance timely availability of raw materials. This can guarantee reliable availability of materials for continuous production. Long-term partnerships between prefabrication firms and material suppliers should also be encouraged.
- Research funding returns social benefits to all involved individuals and entities (Rull, 2014). It is therefore recommended that more grants should be facilitated for researchers to conduct research into different alternative and reliable materials for prefabricated building construction. Government may also take proactive steps in ensuring or encouraging the use of prefabricated components in public building projects. This can serve as a source of attraction for the public.

Early collaboration between supply chain actors is highly recommended. Therefore, clients, design team, contractor, and expert consultants need to work together from the early stages of a building project through to completion. Early input from different stakeholders can reduce or eliminate challenges during the prefabrication of components and during their installation on site. As one participant said, "*mutual understanding among stakeholders will help in the delivery of prefabricated buildings with less stress"* - (RLS6Q1).

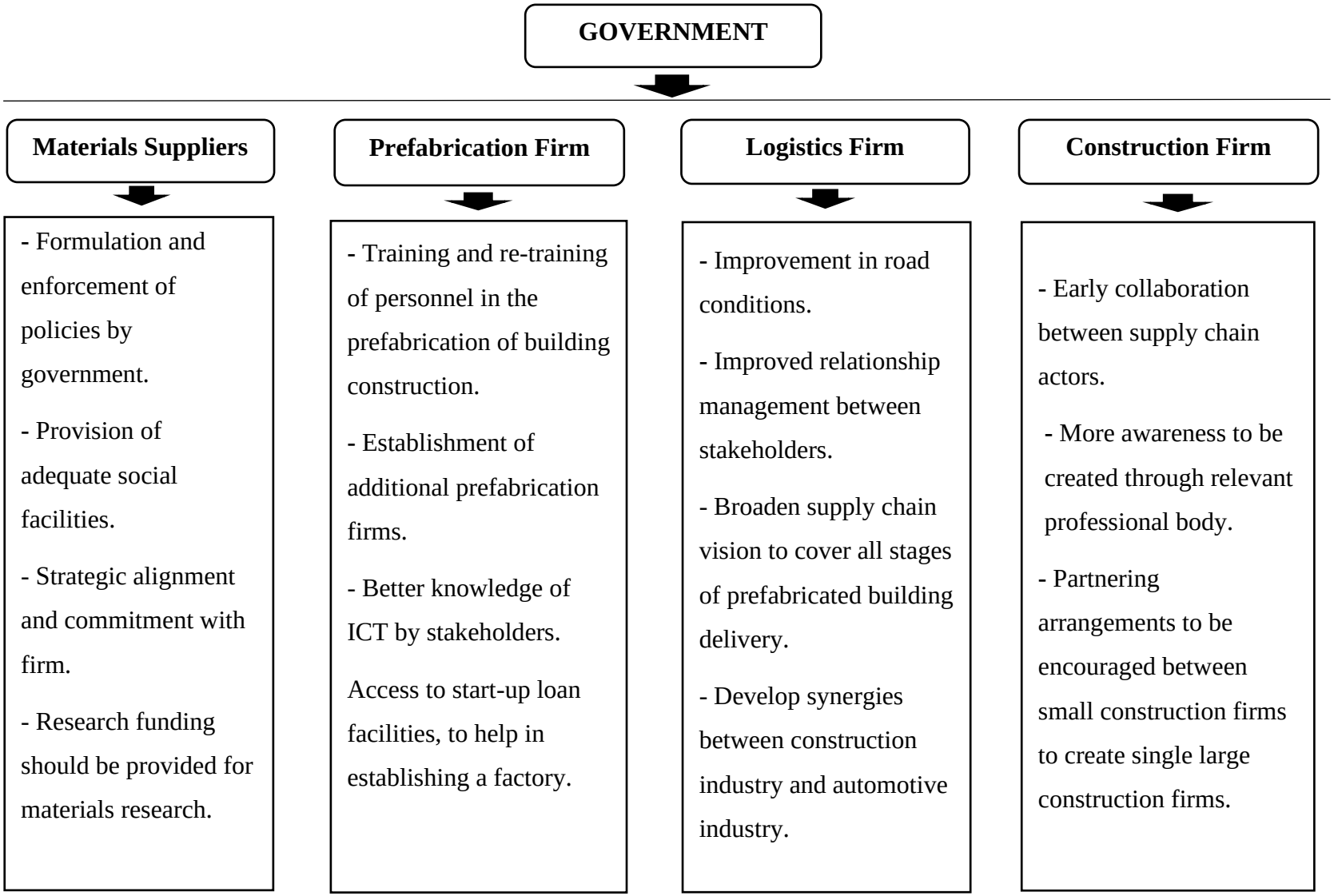
7.6 Summary of key findings

The following key points summarize the data gathered, examined, and discussed above.

- Lack of understanding of the supply chain management concept, unclear strategic benefits, lack of trust within and outside an organization, lack of a common standard for collaboration, and failure to broaden the supply chain vision or product distribution are all major barriers to supply chain management adoption/application in prefabricated building construction in Nigeria.
- Most participants agreed that there is a widespread lack of knowledge about supply chain management as it applies to prefabricated building construction in Nigeria.

- Disseminating quality information across relevant stakeholders, deploying web-based and other software and portals supported by internet use, and ensuring that the level of service and price of suppliers are competitive, are all factors for successful supply chain management in prefabricated construction projects.
- This research has thus made contributions to supply chain management in prefabricated housing construction. Recommendations were also suggested for improvements in supply chain management for prefabricated building construction in Nigeria. The above recommendations, if adopted, should help to develop a framework to improve the understanding and acceptance of prefabricated housing construction in Nigeria. It will also help further research in related fields into the adoption of prefabricated housing construction in Nigeria.

Figure 7.1: Key recommendations for improvement in the supply chain stakeholders for prefabricated housing construction



CHAPTER EIGHT

CONCLUSION

8.1 Introduction

This chapter gives an overview of the study, reviews its aim and objectives, and examines how each one was met. It sets out how the research aim was met, which later helped to answer the research question **"How can supply chain management for prefabricated construction in Nigeria be enhanced?"** The investigation's findings are also provided, along with their limitations and suggestions for future research in this area.

8.2 Research Review

The aim of this study was "to explore barriers and solutions to enhance the supply chain management for prefabricated housing construction in Nigeria", with a specific focus on making recommendations for improved supply chain management for prefabricated housing delivery in Nigeria. The following were the objectives of the study:

i. Review current supply chain management practices in the Nigerian construction industry and elsewhere.

ii. Investigate the barriers affecting the supply chain management of prefabricated housing construction in Nigeria.

iii. Propose solutions to improve the SCM of prefabricated housing construction in Nigeria.

Understanding that prefabricated housing construction, despite its several advantages, has been much limited in practical application in Nigeria, and with respect to Figure 4.4, three phases involved in prefabricated building construction are defined: component prefabrication factory firms, logistics firms, and construction firms. Less attention is, however, given to each of the phases to promote the general acceptance of prefabricated building construction. Less is said about construction materials for prefabricated buildings. However, the commonest material types presently being used as components for prefabricated projects in Nigeria include reinforced concrete, steel, and wood. Polystyrene materials are also being used to a limited extent. Reinforced concrete is characteristically heavy and less flexible during the construction stage of building projects. Steel has its limitations and wood is relatively scarce. Therefore, concerted research effort

is needed to locate other possible materials for prefabricated building components and to maximise the potential of those already identified.

Having identified different options for the possible materials for prefabricated building components, materials will be supplied to prefabrication firms by suppliers for processing. Finished components will be moved by the logistics firms to construction sites for direct installation and effective housing delivery. Depending on the types of components and agreements between the logistics firm and the prefabrication firms, some prefabricated components are moved to retail outlets through different means of communication, where the components can be picked up at will by construction firms and other relevant contractors

The construction firms work with the project consultants (the project manager, architects, and other relevant engineers) to get the detail drawings for the project, under the guidance of the project manager. Different project computation software is used at this stage to enhance mutual communication within the group. The whole process is graphically described in Figure 8.1

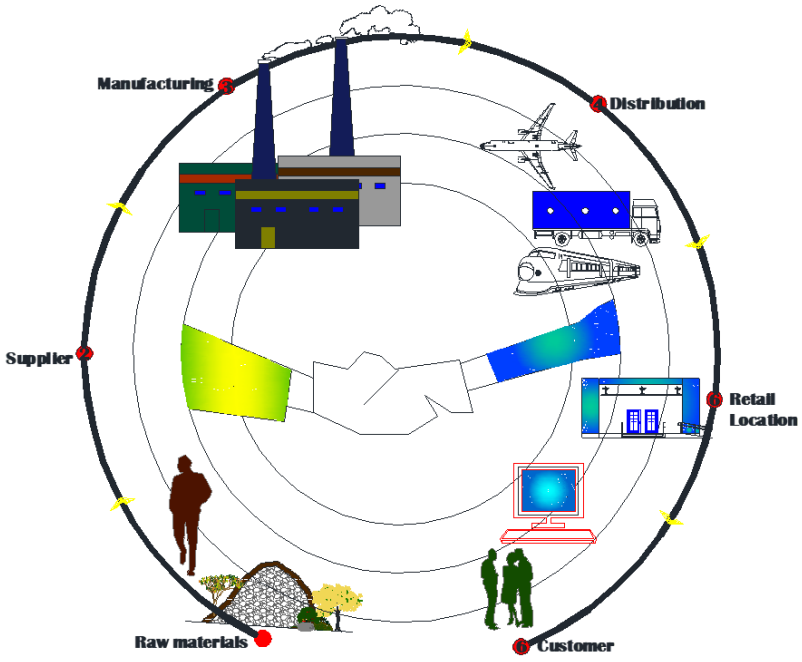


Figure 8.1: Framework Development

Source: Researcher's Design, 2021

8.3 Objective 1

i. A systematic literature review was employed to address the first objective of this study – to review current supply chain management practices in the Nigerian construction industry and elsewhere. This search involved the use of six online databases, including the Web of Science, Emerald Insight, Scopus, ProQuest, EBSCO, and ASCE, using different categories of relevant keywords. Google Scholar was also used to locate additional records where necessary. Each database was scanned to filter and retrieve the most relevant papers for review. Articles were sourced from journals, conferences, technical reports, and other related publications in the fields of architecture, building construction project management, the built environment, housing development, housing, supply chain management practice, and development studies. The views of different authors were extracted, compared, and contrasted. Research into prefabricated building construction is not new, as confirmed by considerable number of studies carried out by other researchers around the world on prefabricated construction and closely related topics (Ryan et al., 2009; Yin, 2015).

Findings from the systematic review revealed that:

- The construction industry in Nigeria continues to rely largely on conventional methods of building construction, while a huge and growing housing deficit presents a constant challenge to the people of Nigeria, as housing constitutes a basic human need.
- Prefabricated methods of construction have been identified and largely accepted as an alternative way of delivering housing in countries other than Nigeria. Prefabrication presents many advantages, including construction efficiency and cost effectiveness. It was also discovered that some of the developed and developing countries of the world are leveraging the advantages of prefabricated building construction to improve their domestic housing stock.
- The literature review showed that despite a deficit of about 22 million housing units in Nigeria today, and despite the potential and promise of prefabricated construction methods, only a very small section of the housing market uses or explores prefabrication technology.

  The literature also shows that several factors are responsible for stakeholders not engaging with this improved technology for housing delivery. Yet while many of the identified factors have been thoroughly investigated by other researchers, the supply chain management of prefabricated building construction has received less attention.
- The review reveals that the construction sector in Nigeria has been slow to adopt and implement supply chain management principles, even though some other industries have done so.

- Some researchers have conducted research in the field of construction supply chain management (Ojo et al., 2014a). This includes the management of the flow of goods and services between businesses and locations and also includes the movement and storage of raw materials, of work-in-process inventory, and of finished goods, as well as end-to-end order fulfilment from point of origin to point of consumption (Ojo et al., 2013).
- It is also revealed that while most building contractors obtain their raw material supplies locally, yet there are no formal supplier relationships in place. Other significant results also include the under-use of information and communication technologies in tracking raw materials supply. Major problems of the material supply chain include import tariffs and security, foreign exchange, fraudulent and late deliveries, poor road infrastructure, taxes and high logistics costs (Saka & Mudi, 2007). This situation has arguably impeded the growth of prefabricated building construction in Nigeria.
- In summary, SCM, which aims is to apply manufacturing-based techniques, is still regarded as a new area of practice in the Nigerian construction industry, where construction firms have been hesitant to adopt it as a management practice (Forsman et al., 2012b; Liu et al., 2020).
- The findings, as stated above, were subsequently considered, and informed the development of recommendations that answer the over-arching research question of this study.

8.4 Objective 2

To investigate the barriers affecting the supply chain management of prefabricated housing construction in Nigeria, **s**emi-structured in-depth interviews were conducted. This field research is appropriate for exploring this fact. Semi-structured interviews are also common method of collecting qualitative data (Yin, 2011). Semi-structured interviews can be conducted face-to-face (personal interview), via telephone or by video call. Face-to-face (personal) interviews were, however, adopted for this study. They provide opportunities to probe for rich data and to capture verbal and non-verbal input, including emotions and behaviours. Challenges frequently connected with telephone and video call interviews were minimized with face-to-face interviews (Rahman, 2015). The interviewer and interviewees were both comfortable with the language, which made communication throughout the interviews much easier. Four groups of stakeholders in the Nigerian prefabricated construction supply chain were identified. Participant information statements and the semi-structured interview questions were sent to 40 participants in advance for face-to-face interviews. The interviews were later conducted with 28 participants drawn from the four stakeholder groups. At this point no new information was provided, and data saturation was reached.

Relevant information was obtained about the interviewee's awareness, attitudes, perceptions, and knowledge of factors affecting the adoption of prefabrication technology in building construction. A visual inspection of the natural environments of some of the stakeholders' facilities was also considered as evidenced in some photographs (Holmes, 2013). The following points summarize the findings from the interviews from the four groups of stakeholders:

- Lack of adequate understanding of the supply chain concept in the Nigerian construction industry. This approach ought to optimize the way prefabricated building projects are delivered, for example, through synchronizing the client's requirements with materials and information flows during project planning, until a balance between client satisfaction and cost is reached. While this process might be expected to improve coordination of prefabricated building project delivery, there appears instead to be a widespread lack of understanding of prefabricated housing delivery amongst relevant stakeholders.
- Lack of confidence in prefabricated building components, resulting in a general low level of acceptance of the concept of prefabricated building and its subsequent patronage.

  The general populace in Nigeria is used to conventional methods of building construction. It will take a concerted effort to re-orient or convince people of the benefits of the use of prefabrication technology. In addition, people have less confidence in prefabricated building construction components, retaining a belief that prefabricated components could not be as strong as construction using cement, sand, and blocks, which are the primary components of conventional building construction in Nigeria.
- The strategies to be adopted in optimizing supply chain management are yet to be made clear, since prefabricated building construction remains an emerging technology.

8.5 Objective 3

The proposed solutions to improve the SCM of prefabricated housing construction in Nigeria. Information gathered from Objectives 1 and 2 was combined to inform the following suggested solutions:

- Finding various alternative and reliable materials for prefabricated materials for building construction should be promoted via research. Furthermore, governments should make determined efforts to lead by encouraging the use of prefabricated construction technology in public building projects as a source of encouragement to the people.

- Strategic alignments and commitments should be developed among prefabricated construction supply chain stakeholders to form partnerships with solid relationships and a track record of collaboration (Braglia et al., 2020; Schoenwitz et al., 2017).
- The public should be adequately guided through the process of prefabricated housing delivery once a standard design and construction methodology for prefabricated construction is in place. The responsibilities of customers, project managers, materials suppliers, and other stakeholders should all be well defined when it comes to managing the prefabricated building supply chain.
- Nigeria is a country blessed with timbers. Wood technology should be thoroughly considered and researched as a leading material option in prefabricated housing delivery.
- It is also suggested that supply chain participants collaborate early on a typical project. Prospective clients, design teams, contractors, and specialist consultants ought to collaborate from the beginning to the end of a construction project. Involvement of stakeholders from a project's beginning can minimize later difficulties during component prefabrication, delivery, and installation on site.

It is believed, therefore, that the application of prefabrication technology in housing delivery would be improved if these recommendations could be accepted and adopted.

8.6 Contributions of the research to practice

The findings of the study presented in this thesis have made major contributions to knowledge, both in theory and practice. These are as presented below. Recommendations for further research are also presented at the end of the study. The research aims and objectives are believed to have been justified. This study has been able to achieve, among other things:

- The outcomes of this study may contribute to closing the gap between homelessness and housing in Nigeria by demonstrating how the concept of prefabricated building construction may be utilized to increase housing delivery.
- The research has provided insight into the integration of prefabricated construction with the building industry in Nigeria.
- The study is intended to help construction industry supply chain stakeholders in Nigeria to improve their relationships and to identify key areas for future improvement.

- The study proposes recommendations for improvements in supply chain management in prefabricated housing construction.

8.7 Contributions of the research to theory

- Identification of possible barriers and possible solutions to integrating prefabricated construction into the industry.
- Indication of the need to embrace prefabricated construction as a positive alternative construction method to combat the growing deficiency of housing in Nigeria.
- The study makes recommendations to inform relevant stakeholders of the prospects of prefabrication as a method of delivering housing in Nigeria. Therefore, it is hoped that prospective clients and developers will also consider and embrace prefabrication as an effective alternative in building construction.
- Additions to the available literature, considering the very few studies in the field of supply chain management applications in the Nigerian construction sector.
- The research has also contributed to knowledge of the barriers to supply chain management adoption and application in Nigerian building prefabrication construction. Certain measures have also been noted for alleviating identified barriers in prefabricated housing construction in Nigeria.
- The research has also increased understanding of the barriers to supply chain management adoption in prefabricated housing construction in the Nigerian construction industry, resulting in recommendations for approaching the challenges faced by the Nigerian construction sector.

8.8 Recommendations for further research

Future researchers in this field can work further to extend the present research. The following may be achieved:

- Further research may be conducted to determine how logistics, a subset of supply chain management, might help with the effective delivery of building projects.
- Nigeria is a country blessed with timbers. Future researchers in this field should consider the feasibility of locally available timber as a leading material option in prefabricated housing delivery.
- The development of a framework model to help in the effective management of the supply chain for prefabricated housing construction, aimed at improving housing delivery in Nigeria, could be

carried out by future researchers in this field. Such a framework could also be subjected to rigorous validation by relevant stakeholders.

- The above if undertaken, may also contribute to improved understanding of supply chain management strategies in prefabricated housing construction in Nigeria.

8.9 Ethical Considerations

Any research conducted with or about people must have ethics approval before it can begin. The University of Newcastle's Human Research Ethics Committee (HREC) is responsible for ensuring that effective processes are in place to review the ethical acceptability of human research proposals and ensure approved projects are compliant with regulatory and legislative requirements.

After careful consideration, this study has gained the approval of the University's Human Research Ethics Committee, with approval No; H- 2018-0508, as presented in Appendix 1. The committee is also monitoring the progress of the study through the yearly appraisal, until the study is fully completed.

APPENDICES

Appendix i: Participant's information statement

H - 2018-0508

Information Statement to Organizations for the Research Project, titled: Investigation and recommendations for enhancement of Supply Chain Management in Prefabricated Housing Construction in Nigeria.

Document Version 1; dated (29/01/2019)

Research Team:

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Attention: Technical Head/Project Manager/Director/Assigned Officer

Your organisation is invited to participate in the research project identified above which is being conducted by Associate Professor Patrick Tang, Associate Professor William Sher and Igbayemi Daniel Akeremale (PhD Candidate) from the School of Architecture & Built Environment, University of Newcastle, Australia.

The research is part of Daniel's doctoral studies, and he is supervised by Associate Professor Patrick Tang and Associate Professor Willy Sher. We are conducting research to investigate and develop a supply chain management concept for prefabricated housing construction in Nigeria. Our interest is to explore ways of increasing the adoption of prefabrication for housing delivery in Nigeria, with the hope of reducing the housing deficit thereby alleviating the suffering of the people. Your organisation, being one of the stakeholders in the building prefabrication industry, is invited to participate in the research. This document contains information about the research.

Why is the research being done?

The primary aim of this study is to develop a conceptual framework for the supply chain management of prefabricated building construction in Nigeria. As part of the effort to address the housing problems in Nigeria, there has been a continuous call for alternative construction methods. Several studies have identified the potential advantages of prefabrication for housing delivery. Prefabricated building technology has been embraced, and is growing in many developed countries including USA, Australia, Malaysia, New Zealand, Sweden, Japan, India, and China. This method has not been rigorously explored in Nigeria. A lack of supply chain management has been identified as an aspect that requires further detailed investigation. Our study will concentrate on developing a supply chain management framework,

with the overall expectation of improving the adoption of prefabrication in building construction in Nigeria.

Who can participate in the research?

Participants need to be relevant stakeholders in the prefabricated building construction industry in Lagos. We wish to interview representatives from the following four stakeholder groups:

- Well-established firms producing prefabricated building components
- Organisations supplying raw materials to the building prefabrication firms
- Construction firms with experience of constructing buildings using prefabricated components
- Logistics companies that provide transportation services to prefabrication firms

You are invited to participate in this study as one of the stakeholder groups noted above.

What will you be asked to do?

- Please read and understand this information statement of the research.
- If you agree to participate, kindly sign and return the enclosed consent form to the researchers.

The interviews will be conducted (face-to-face) at the participants' convenience and at an agreed location during business hours.

What choice do you have?

Participation in this research is entirely voluntary. Only the organisations and people who give their informed consent will be included in the project. Whether or not you decide to participate, your decision will not disadvantage you. If you do decide to participate, you may also withdraw from the project at any time without giving a reason. You also have the option of withdrawing any data which identifies you during the project. The information supplied by participants will be de-identified and no identifiable reference to your organisation will be made in any of the outcomes of this study.

How much time will it take?

It is expected that an interview will take between 45 and 60 minutes, during which the structured interview questions are expected to be answered and possible further questions will also be addressed.

What are the risks and benefits of participating?

No risks and/or discomfort are anticipated for anyone participating in the study. We anticipate that stakeholders will find value in the proposed conceptual framework. Their understanding of the supply chain will be extended, thereby improving prefabrication in building construction in Nigeria.

How will your privacy be protected?

The audio recorded interviews will be transcribed. All data gathered through the interview discussions will be treated with the strictest confidence. All identifiable features of participants will be removed and assigned codes. Participants will be provided with an opportunity to review, edit or erase recorded interviews and transcripts. Only the research team will have access to the personal identifiable data collected. All data will be stored in the University cloud-based storage in password protected files. Once the project is completed, the information will be stored for a minimum of five years and be accessible only to the Principal Investigator. All data will be destroyed after five years, according to the University of Newcastle ethics rules.

The interview transcripts will be analysed, and emerging themes and their relationships will be identified, categorised, and coded using a specialist software. The results, together with information from the literature will inform the preliminary conceptual framework for the supply chain for prefabricated housing construction in Nigeria.

How will the information collected be used?

Interviews will the conducted with relevant stakeholders. Non-identifiable data may be shared with other parties to encourage scientific scrutiny, and to contribute to further research and public knowledge, or as required by law. Interviews will be coded, transcribed, and analysed, to inform the development a supply chain management framework. The outcomes of this study will be published in conferences and scientific journals as well as in public exhibitions. A summary of the study will also form a major part of a PhD thesis to be submitted by Igbayemi. It will also be made available to interested participants on request. Therefore, if you wish to receive a copy of the research outcome, kindly register your interest in the Consent Form. Alternatively, please contact the Chief Investigator.

What do you need to do to participate?

Please read this Information Statement and be sure that you understand its contents before you consent to participate. If there is anything you do not understand in relation to the information statement, please contact the Chief Investigator. Should you choose to participate in the study, please complete the attached Consent Form and return to the researchers.

Further information: Please contact Associate Professor Patrick Tang, through his contact as detailed above.

Thank you for considering this invitation.

About this research

This project has been approved by the University's Human Research Ethics Committee, Approval No. [H-2018-0508]. Should you have concerns about your rights as a participant in this research, or you have a complaint about the manner in which the research is conducted, it may be given to the researcher, or, if an independent person is preferred, to the Human Research Ethics Officer, Research Services, NIER Precinct, The University of Newcastle, University Drive, Callaghan NSW 2308, Australia, telephone (02) 4921 6333, email Human-Ethics@newcastle.edu.au

Appendix ii: Interview Guide

Research Title: Investigation and recommendations for enhancement of Supply Chain Management in Prefabricated Housing Construction in Nigeria

INTERVIEW GUIDE

To improve housing delivery in Nigeria, prefabricated construction methods have been argued to be a good alternative approach to the traditional method. The approach has not been maximally explored because of some barriers. Most of these barriers has been investigated by previous studies. However, the supply chain management of prefabricated construction is found to be one of the major barriers that has received less attention. Thus, we are interested in knowing your views (on the questions listed below) on the supply chain management for prefabricated method in housing construction in Nigeria.

With your agreement, I will be recording our conversation to get all the details and at the same time be able to carry on an attentive conversation with you. I assure you that all comments will remain confidential. If you agree to this interview and the recording, please sign this consent form (Attached).

There will be five sets of interview questions (a-e). The demographic questions (a) to ascertain the background of the respondents and the business questions (b-e) for the four groups of respondents on the four phases of prefabricated building supply chain management. While demographic questions are common to all the groups, business questions for the four groups of respondents are on the different phases of building prefabrication supply chain management. These include:

a) Demographic/Background information - These questions are common to all participants.

i. Could you please give a brief introduction of your background: age, education, work, and years of experience?

ii. Could you provide the following information about the firm you are representing?

- Year of establishment of the firm
- Current capacity in terms of staff strength and production (in m2 and tonnage)
- Past executed projects and their locations
- Current projects, if any and their locations

(b) Raw materials supplier

i. How do you ensure that raw materials are delivered on-time into the prefabrication firm?

ii. How do you ensure that the quality of the raw materials supplied to the prefabrication firms is of a high standard?

iii. What other difficulties do you experience while supplying raw materials to the firm, and how do you think these could be addressed?

iv. How do the activities of the Lagos State government, and by extension, the Federal government affect the activities of your firm?

c) Prefabricated firm

i. Could you briefly explain what takes place when someone in your organization places an order for the supply of raw materials until these are received?

ii. What prefab components do you normally produce?

iii. How do you decide on a production sequence for components? Why have you answered the way you have?

iv. How do you cater for unforeseen circumstances (e.g., breakdown of machines), that may arise during the production process?

v. How do you ensure that the quality of the prefabricated components your firm produces is always of a high standard?

vi. How reliable are your raw materials suppliers in keeping up with your firm's demands such as: timely delivery, quality of raw materials and aspirational goals?

vii. How do you evaluate prospective raw material suppliers?

viii. What are the possible options during delivery failure with your choice of raw materials suppliers?

ix. What other difficulties do you experience in manufacturing components, and how do you think these could be addressed?

x. How do the activities of the Lagos State government, and by extension, the Federal government affect the activities of your firm?

d) Logistics/Haulage firm

i. What components do you usually transport?

ii. What specialized equipment do you need to transport these components?

iii. How do you establish the route to be followed to site? (Route planning)

iv. How are components loaded and off-loaded?

v. What difficulties do you experience in moving prefabricated components from the firm to construction sites? In your opinion, what is responsible for these difficulties, and what suggestions do you have for improvements?

vi. How do the activities of the Lagos State government, and by extension, the Federal government affect the activities of your firm?

e) Construction firm

i. What are the major difficulties of handling prefabricated components on site during construction?

ii. What other difficulties do you experience in manufacturing building components?

iii. How do you think these could be addressed?

iv. What are the problems associated with prefabricated components storage on site?

v. What is the usual sequence you follow in installing components?

vi. How does this affect the storage of components on site?

vii. How do you accommodate late delivery of components?

viii. How do the activities of the Lagos State government, and by extension, the Federal government affect the main goal of your firm?

End of Interview

Thank you!

Appendix iii: Participants consent form

Consent Form for the Research Project:

Research Title: Investigation and recommendations for enhancement of Supply Chain Management in Prefabricated Housing Construction in Nigeria

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H-2018-0508

I fully understand the research project which has been explained to me and for which I have agreed to participate and willingly give my consent freely.

I understand that the project will be conducted as described in the Information Statement, a copy of which I have retained.

I understand that my participation is voluntary and that I can withdraw at any time without giving any reason and this will not affect me now or in the future.

I consent to participating in an interview and having it recorded Yes/No

I understand that my personal information will remain confidential only to the researchers Yes/No

I will have the opportunity to have questions answered to my satisfaction. Yes/No

I understand that I can review and edit my recording if I desire Yes/No

I would like to receive a copy of the research findings Yes/No

Print Name: ……...……

Contact Details: ……..

Phone: ……

Signature/Date: ……

Appendix iv: Sample raw interview data

CONSTRUCTION COMPANY – (C)

C - HFP ENGINEERING NIGERIA LTD

CS1Q1: What are the major difficulties of prefabricated component on site during construction?

CS1Q2: What are the other difficulties you usually experience in the cause of manufacturing of components?

"One of the major difficulties we use to experience while manufacturing of components is the use of space. We usually produce in large quantity and all relevant materials for production must be on ground and at easy reach. If you don't have enough space because of the volume we need, that's a problem on the delivery of materials. We have issues with our suppliers of raw materials sometimes because raw material must have been booked early enough for us to be able to have our demand to meet a production target per time. The chance for disappointment from material suppliers is high if we don't pay and book for materials early. They will tell you "We must supply for customer that have booked earlier. One will then have to wait for his turn. So, this has been one of the major problems we normally encounter in manufacturing of components. Thank you very much" - RCS1Q2

CS1Q3: What are the problems associated with prefabricated components storage on sites, and how do you think these cabs be addressed?

"Problems associated with prefabricated components on site are many. They include:

All sites must have the safety caution that will guide workers in the discharge of their responsibilities. The heavy weight of components (where reinforced concrete is used) will demand for a standby lifting equipment on the site. There is also the need for technical men to coordinate the safe and effective delivery of prefabricated components. Where component is not discharged into the station position, it usually stressful to lift and position appropriately whenever it is needed. The problem of flexibility in prefabricated materials is also a common one" - RCS1Q3

CS1Q4: What is the usual sequence you follow in installing components?

"The sequence is easy. Just like the conventional building construction, we follow the sequence thus: - Binding from the foundation base, putting the normal foundation for the structure, prepare foundation slabs, and to the walling. You can decide to do first the first structures which contain columns and slabs

before going to do the walling and it can also be done simultaneously. So, it depends on the construction methods used before we determine the work sequence. Therefore, I can say that there is no standard sequence to follow. It varies on individual project, and it is a function of the immediate situation around the project" - RCS1Q4

CS1Q5: What is the usual sequence you followed during component installation?

"This rests on the peculiarity of the site and the nature of the project. The construction team will meet over this, and the leader of the team will take a decision. For example, in a building of two floors, if we are to follow the first structures, we make sure that the materials meant for the first floor are gradually brought to the site. What you want to use tomorrow should now be in the fore front it should be stocked where it will be easily accessible. Accessibility of materials depend on the sequence that's what we must follow, and you will now arrange materials properly on site" - RCS1Q5

CS1Q6: How do you accommodate late delivery of components?

"For us at HFP, we like to guide against this as much as possible. One of the measures used is to be sure that all the relevant department (Civil, Electrical, Mechanical …) that require to work on a particular component fully carry out their job on that component at the casting stage of the component. After hardening, all the necessary section of every component is already featured within the component. Therefore, the chances of having to be waiting additional work on components, and thereby waiting for the delivery of such is very rare. Where it is inevitable, those concern would have been briefed and given sufficient time to respond to such need" - RCS1Q6

CS1Q6a: In some of the prefabricated buildings that you have constructed in the past, how has been the feedback from the occupants or from the client?

"The feedback has been tremendous because for you to have such a successful scheme, you want to have feedback of how the occupants feel and what they want you to improve upon in the event of similar assignment. The feedback we have been getting from the first scheme has been that it's kind of hot from the inside when the sun is hot during the dry season and during raining season it's quite fine. So, because of that when we now came into Victoria Garden City (VGC), we now did what we called block pour system. We did the first structure alright using precast to work it faster than you now have contractor that make blocks on the externals and internals so that there will be freedom of expression in terms of interior flexibility that you can make more spaces making international standardize which we normally use" - RCS1Q6a

CS1Q7: How did the activities and policies of the Lagos state government and by extension the federal government affect the main goal of your firm?

"We are private construction firm. We also take commission (contract) from Lagos State Government, but by and large the government has not been forthcoming with policies that will help in alleviating the housing problems of the citizen. A case in hand is that of Dolphin Estate an estate originally made of prefabricated mass housing). There is need to relocate and to solve an issue over-flooding. We took an inventory of the people residing there and did an analysis shown how much it would cost as a four story unit we decided to increase it so that it will be other extras we take care of the needed gain that needed to be generated from the exercise and that's why we came up with the system and the dolphin unit has been very successful because it now open the eyes of the people that thousands of housing units can be made within a very short period of time in as much as it is precast, but it's still the same dimensions and the sizes of spaces that were taking from them is what was put back.

On the issue of policy, I don't know of any good housing policy in place from the Government, except you may want to do further research on your own. We are private firm when we are called to build, we built. However, housing construction activities has been low for sometimes. There is no policy on mass housing for now. What Lagos state is doing is that they are the one seeing how they can provide housing for the citizen by having any little land they have. They built what they call Lagos home scheme. It is such that four-family unit will occupy a plot of land. They want to build it for an average of 400 people or 100 housing unit. It's been very difficult in getting that size of land to do that development for sometimes. So, the policies are not affordable" - RCS1Q7

C - MICAD CONSTRUCTION

CS2Q1: Now, over your years of experience in this business, what are the major difficulties of prefabricated component on site during construction?

"Thank you. I came across prefabricated elements in the City of Lagos, I happened to see the prefabrication project with polystyrene materials along the Oshodi express way. It was interesting to me because as I happen to have earlier used polystyrene materials for construction work before. In my own aspect as a professional, I usually use polystyrene for an expansion joint, but as time went on, as development went on, I then came across a project that the components are made completely of polyester with wire mesh, which made me to be more interested in what I saw. I later made an enquiry, fully knowing

that those materials will be available in Nigeria then I was fortunate enough to identify the source of the material. It's a product being produced by CITEC Company in Abuja. They have their office in Idu Industrial Layout. Now, I personally visited the factory and saw the components, being produced in their numbers. Asides the polystyrene being produced, I also got to know that they produce other innovative materials for prefabrication construction works. I also got to know that the same polytene materials that I use for expansion joint can serve as a block wall. It can also serve as a unit of building component. My further findings later revealed that part of the concrete facials that I produce on site can also be substituted with polystyrene; not only that polystyrene material can also be used as an acoustic material. So, I was challenged and thus concluded to patronize CITEC whenever I had a project where I must procure the materials, to practically allow it on my site and the truth about it, there is no magic about it. It comes in various sizes provided the wire mesh is there as a binding material that is rendered on it. I think I very much cherish it and love what I saw because I have used it based on what I saw, and I can testify that's a good product" - RCS2Q1

CS2Q2: What are the other difficulties you usually experience in the cause of installation of building components?

"When I started initially, I brought those components to the site with my skilled workers, I left with them to see how it can be used as part of the construction materials, using their past experiences. There are specific tools which are necessary basically if you want to enjoy this project. The welders you see at the roadsides sometimes played a very important role in the connectivity matters. The wire mesh that serves as a binder that covers the polystyrene with the other adjoining wall need to be joined together. So, the constraints are not much that way because basically it's a smooth prefabrication method that is easy to carry out. The challenges are not much. A major factor that one must consider is that precision matters a lot because just as the way you set your blocks, you carry out levels, you set your bricks, and then there's nothing different when it comes to prefabrication project. So, the challenges are not much provided there are good hands there" - RCS2Q2

CS2Q3: What are the problems associated with prefabricated components storage on sites, and how do you think these cabs be addressed?

"I have difficulties in getting technical men for the job. However, I was opportune to identify myself with a technical staff of CITEC, knowing fully well that he's a highly skilled staff and that Engineering is all about concept. I made a private arrangement and worked with a staff of CITEC for a couple of times, and on some light projects. Components was put together and Tao-lining carried out. I used the opportunity to have some orientation and training in the use of the materials. I later arranged an official training with CITEC and two of my technical men. No sooner, we picked it up the technology. We are gradually developing on it. So, there's nothing much about it as far as you are a skilled worker, it is a simple technology. If one has been working in a similar position in the building industry, one will not need much stress to adhere to this system of building. With a little guidance one can easily pick it up and continue to use" - RCS2Q3

CS2Q3a: You made mention of a particular language Tyrolin. Can you please explain in detail what this word means?

Tyolin is a combination of cement, water and partially sand in a semi-liquid form that will at least give it a rough face, which in a nutshell will serve as a binder that is receiving the mortar that is coming to the other components you are using. Apart from polystyrene, we use tarolin in other areas. Tarolin has a lot of uses. You can see in properties of some buildings that you don't necessarily need to render it or plaster it; you just tarolin the walls. It's a choice from an individual or client - RCS2Q3a:

CS2Q3b: Are you saying Tyrolin is the same thing as plastering?

"No. There are differences. Plastering is a combination of cement, plaster sand and water that has a smooth surface at the end of the job, your result is a smooth surface while tyrolin is not a smooth surface, it's a rough surface, a text-coat surface or a binder. So, they differ. Tarolin is a binder between the two components, between the polystyrene and the plaster that is coming on top. Basically, when you are to apply a plaster on the polystyrene, the binding effect is not going to be 100 percent efficient but with the binder - the taro line, one will achieve a 100 percent efficiency" - RCS2Q3b

CS2Q4: Agreed that getting installers and other people to work on the materials is not the problem. What are the other problems associated with prefabricated components storage on site? Unlike the conventional construction methods, where for instance 3,000 out of the 5,000 blocks needed on a site are supplied and

stored close to the construction point then you move other things like iron rods or reinforcement bars to the place. Can similar things be done with prefabrication construction methods; how do you manage to store your components on site during construction?

"Whenever you say storage, you're talking of space, my personal experience with this product is as stated here. I think it's water-resistant, it's easier to store prefabrication components and other materials on the site because the logistics involved is moving it from the factory to the site, that is, the end position where you intend to use it. So, in terms of storage, I don't think we have many challenges because it is assumed that whatever you're bringing for storage, you first estimate the quantity needed for the project then you make available space that you intend to use for store it because in terms of damages, I think they have minimal damage in terms of external factors during haulage. If care is being taken enough during the haulage handling and safe-keeping I think it's more economical in terms of storage and safer based on my own approach to the product" - RCS2Q4

CS2Q5: How did you sort out the issue of moving components from the production factory to the construction site for installation?

"Basically, it is an issue with haulage. The factory will usually give the option of transporting the components to the desired delivery point, of which payment will be included to the cost of purchasing the items. Alternatively, another option is for one to have a personal arrangement to transport the components to site. With this, no transportation bill will be included in the total payment to the prefabrication firm. In loading components, there is no challenge from the company because they have different kind of loading equipment, and they monitor their products being loaded into the truck. However, in terms off-loading components at the endpoint, it is usually done either manually or with arranged crane. We usually have supervisors with relevant experience on ground to guide the delivery. They are handled with care, taking into consideration that these materials were purposefully bought for an intended project. So, monitoring and supervision of loading and off-loading is a factor that must be given attention. There is nothing special in terms of the quantity and specifications. It's liked the normal way. It's matter of given the calculated project area to the prefabrication firm. They have their standard sizes and the panels come in those sizes. When you have your own design, it's a matter of checking the length by the width, you see the area. So, you place your order based on the quantity needed, taking into consideration that there are cuts and ways where you're supposed to have doors and windows, those are normal arithmetic. It's like when you want to buy something in the market, you go to the market with #10,000 and you know exactly what you want

to buy, so it's not a challenge in terms of materials. The only thing is for one to be assured … check the quantity and quality of materials in conformity with the design specification so that you don't have much wastage" - RCS2Q5

CS6Q6: How do you accommodate late delivery of prefabricated components on site?

"*Late arrival of components will have a negative effect on project delivery. But delay is usually caused by somebody. Sometimes when we have such type of delay for too long, we make arrangement for alternatives. But now the word delivery means that it already on its way. So, if we are using alternative items, those items will tend to be wasted on the site at the end of time. Therefore, what we do most times is to meet with big companies that are also into similar business like ours and perhaps with other projects running alongside possibly where these specified materials are also been used in their projects. We go for other projects with similar materials but have not gotten to the stages of using those materials, we collect those materials and use. We will later replace when ours arrived. So that is the advantage of dealing with companies that have big store and are in the same line of business. The materials may not be useful, though that's for this site, but since it has not been delivered and we have same specified materials been used on another site and has been delivered but has not gotten to that stage, we can easily collect and once they come, we replace"* - RCS6Q6.

CS2Q6a: In some of the prefabricated buildings that you have constructed in the past, how has been the feedback from the occupants or from the client?

"*Just as you have said, you're trying to know the effects of an ongoing prefabrication project being temporary discontinued because of paucity of funds or other challenges. We have the advantages and the disadvantages. On the construction project that I was involved in that has to do with polystyrene, I handled and completed it to 100 percent. Asking whether it is an economical way of construction. Where I see the challenge is sensitizing the people about this product. A lot of people are not aware of the industry as well as the products. So, I look at it that more is needed to be done in terms of sensitization. We are only used to wet construction, mud, blocks, and bricks. Anything outside that is nothing"* - RCS2Q6a

CS2Q7: How has the government activities affected the use of this method and in what way has the government encourage or discourage the use of construction methods for housing delivery?

"The Government has been a big issue. Those in the construction industry mostly have the challenges of unfavourable government policy. What do I mean with government policy? You may have a building construction project going on now in the industry and the government will come out with a policy, an instruction…that this is what the government does, it affects the project. On the issue of the use of polystyrene, if government can look to the issue, identify with, and encourage its application through favourable policy, then prefabricated building method will go a long way. In my own understanding, whatever one is doing without the support of the government, it is going nowhere because government can encourage the industry by identifying with them, giving them projects, incentives, and other things, I think it's going to have a lead way, leading to a wider acceptance of the technology" - RCS2Q7

C - SEISKKOL CONSULTANTS

CS3Q1: What are the major difficulties of prefabricated component on site during construction?

"*Basically, when you talk in terms of the scope of work for which largely, I have been involved, the areas of prefab components are nominal so to speak but that notwithstanding, I think if there is any major problem, it has always been in the material handling and the delivery. Even when you have semi-finished or finished products, expectancy, delivery to your site to complement in-situ construction, most often, if the process is not well managed, it will end up not achieving the purpose for which you have planned. Basically, a question of the haulage - the materials handling aspect of it. Other issue might be… may be late delivery and so on. The one that you must contend with in most instances when you look at the mode of procurement of that kind of contract in Nigeria is not well fathomed. There's nobody you can hold on to in terms of maybe indemnity or insurance and all that. They will deliver it to you and believed they've delivered. You will say why this one (like) this is, they attribute it to maybe problems of our road conditions, or even the type of people they have deployed to move those materials down to point of use; excuses that are not possible, which at the end of the day will still have one or a part of the quality of the product tarnished…. Looking at it from the angle of education. The level of education of our workmen in that area of construction is very low. They are used to the traditional methods of construction. Prefabricated construction methods, to some of them, is an avenue to throw them out of market and in the real sense of it, most of them don't even know... The Technical Know-how, most of them don't have. So, if the technology is to be given a lead, private developer and Government must map out aggressive orientation programme the people. Training of our people right from (Technical Colleges/Polytechnic/University) and re-training must be ensured. We need to engage in serious*

educational programmes, sell the idea and train the people so that they can have the capacity to deliver effectively. Presently, there are only very few firms that are engaged in it and there's is a maximum number of people that such firm can accommodate at any point in time-in terms of being on their pay roll. So, the Government they need to key into that picture and enable/give the people sufficient orientation and education so that there will be enough hands/personnel for the technical know-how of our people to increase" - RCS3Q1

CS3Q2: What are the other difficulties you do observe or experience during installation of building components and how did you think this can be addressed?

"There is energy crisis in Nigeria today. We are in this office now and there's no light. First and foremost, you would see that one, the production is affected in terms of power and that translates into using alternative energy, which is too expensive to cope with. This is reflective on the units cost of anything we do. What is the economic power of the people that want to have it? So, the houses may become non-affordability. So, energy is key to the manufacturing Industry, and that is one of the areas that is militating against prefabricated building construction. Even though, we claim to have standards organization which is the statutory body saddled with ensuring compliance, but I doubt and that is why we have all sorts. Another factor is that I don't know most often times, you are almost at the point of concluding with a high level of certainty that they don't make use of feedback from their customers you are into a finished product. This is one of the units in my own trade line, by the time there is a recurring problem associated with it, when you tell them, most of the times you don't want to really sit down and look at… O.K. how do we improve on the construction detailing to address problem these people are saying. At the end of the day, it out-price or in fact it pushes most of them out of the market. Any bad news spreads like forest fire and before you know it, everybody knows; oh! That product from that Company; you better don't buy it o for after two (2) years, these are the symptoms. So, in one way or the other, they also have that problem which is also adding something negative in them. Apart from now hampering the commission period. When you do programme of work, you might have assumed some things. And you just buy it, and you come and fit. But if at the end, you've gotten so much background information that is telling you not to go that way and you now want to go through the process of making sure that you are the one that want to personally go into it, procuring all the base materials to fabricate it yourself, that may extend completion period. And in instances where they have liquidated and certain damages clause with all the implications on demand,

those are some of the other issues that need to be addressed. Because they have to make it attractive- so for me to want to buy into something, I must see the merit outweighing the demerit if any at all" - RCS3Q2

CS3Q3: What are the problems associated with prefabricated components on site particularly as regards storage?

"The problem usually encounter on that has to do with a non-performing or unreliable program of work otherwise there is no point calling for a prefabricated components when they're still going to feature at the site and have some idle time. It should have been programmed such that as it's been delivered, it's been moved to points or final resting place because in the process of storage, so many things can come up; accident happens everywhere, I mean they have to now grapple with that, if per-adventure something happens and some of those components are affected it may become unusable which means the projected completion period will not be met and the overall completion costs will increase. So, as far as Iam concern, if in truth and indeed we want to go into that, then the programme of work must follow some critical path network. This may be delivered on an agreed date and time. Installation will also be commencing immediately. Not that you are coming, and you are starting, where you are starting it, external work ought to have commenced. These are the problems because like I've mentioned earlier, even product packaging is as important as the manufacturing. You can have a finished product when manufactured but if it must move out of the factory to the point of use, you have to deploy some technologies that would make an effective delivery and retain its originality state from the factory right to the point of fixing. So that is the problem" - RCS3Q3

CS3Q4: What is the usual sequence you follow in installing prefabricated components?

"The sequence is easy. Just like the conventional building construction, we follow the sequence thus: Binding from the foundation base, putting the normal foundation for the structure, prepare foundation slabs, and to the walling. You can decide to do first the first structures which contain columns and slabs before going to do the walling and it can also be done simultaneously. So, it depends on the construction methods used before we determine the work sequence. Therefore, I can say that there is no standard sequence to follow. It varies on individual project, and it is a function of the immediate situation around the project" - RCS3Q4

CS3Q4a: What you are saying in essence is that construction firms should bother less about storage of prefabricated components on site during construction?

"*Yes. But at placing order is a process; unless they order and give them the delivery date. But components delivery dates should have been keyed into your own programme of work such that your building is almost ready to receive the components. For example, let's assume we place order for doors, there's no point when they bring doors, they are still packing it somewhere - say in a makeshift site storage that will not be conducive. Arrangement would have been such that as soon as the doors are being delivered, they are just taken to the rooms and other locations, with the hinges, iron monger and all other things already set to receive the doors"* - RCS3Q4a

CS3Q5: How does this affect the storage of components on site?

"We like to guide against this as much as possible. One of the measures used is to be sure that all the relevant department (Civil, Electrical, Mechanical…) that require to work on a particular component fully carry out their job on that component at the casting stage of the component. After hardening, all the necessary section of every component is already featured within the component. Therefore, the chances of having to be waiting additional work on components, and thereby waiting for the delivery of such is very rare. Where it is inevitable, those concern would have been briefed and given sufficient time to respond to such need" - RCS3Q5

CS5Q6: What is the usual sequence you followed during component installation?

"*It should be known that the traditional wet works cannot be totally avoided. Even if you are going to have a prefabricated building, there will be certain aspects of the work that one will have to rely on wet works to have perfect results. You know foundation for instance, all those wet works should naturally have been completed so that you don't deface your prefabricated components. When you are talking about these prefabricated components, your walls should come in first, your walls, your floor system, then your roofing; all these things should have been put in place before you start bringing doors, windows, and other fittings in sequential order. So, your wet works first, your walls, your roof system should all come in place to shield other fittings from exposure to weather"* - RCS3Q6

CS3Q7: How do you accommodate late delivery of prefabricated component in such a situation like Architect has rightly said it?

"Like I said, it's all part of construction management. If you follow your programme of works strictly, then you will know when you expect your wet works to be completed. You know your construction planning, from your programme of works, you will know when your wet works should be completed, so that adequate timing can be given to the manufacturers on when components are expected to be supplied. Taking care of the problems with the logistics, you must build in logistics, all those factors have to be put in place because; I mean if you finish a product, if you need a product tomorrow, you don't start asking for it today. So, you should carry your manufacturer along whenever a project is to commence. What time is it going to take to build the pre-fabrication of those products so that you key that in right from the day one on your work schedule, so once you carry the manufacturer along, the logistics and all that will flow well. So, one will not need to keep the prefabricated components unnecessarily under the site storage" - RCS3Q7

CS3Q8: How does the policies of the Lagos State Government and by extension the Federal Government affect the primary activities of your firm?

"The main thing is "What the objective/main goal of the firm is?" We are in the built industry; we want to design, we want to deliver functional, structurally stable, and cost-effective project to our clients, and we can only do this if the Government policies are friendly. To a large extent, it is not too bad for now and like I said, it's not a one man show. Government policies are being anchored by Government Agents, we all should come together as a team; we should all see ourselves as a team and not as competitors and not as somebody witch-hunting the other. So long as, if you have a harmonious relationship between the Government, the people and the people in the construction industry, relationship in most system will work as the Government policies are standing by. But whatever we do, we submit them for government approval. For instance, if government policy says one can only have two (2) floors in a particular location, I will not endeavour as an Engineer or Architect to go and design (10) floors, against the Government policy says. Lagos State Government will need to do more in sanitizing the indiscriminate patronage of quacks to carry out professional activities in Architectural and other Engineering services. I can assure you today if you use the same planning regulation of last month to design this month, you will be surprised they might have changed against your drawing - policy summersault. They will give you 1001 comments why that drawing will not fly, whose fault? Most of these policies changes is not known to the construction sector that are the direct consumers, acting as representative to the clients. A client will tell you 'I want this and

that on my land'. If the design consultant is rightly informed, he will be able to tell you it is not achievable because that is not permissible, the planning permit will not be granted. They keep on changing it, I don't know when to expect every one of them to be coming to their offices. The other time, I went to Lagos State Urban & Physical Planning Headquarters at the Old Secretariat for a different thing, lo and behold, while sitting at the reception, I just saw a pamphlet, I stood up, went up to meet the receptionist, he said it is free. Could you believe me, when I was going through, it is something that is a paradigm shift from what used to be the handbook - the compressed version for all the planning regulations since the time of Gov. Fashola (a former Governor of the State). The new planning rules just came out this January, I doubt whether most Architects have it. Then they are not doing too much around Model City Development Plans. During Fashola, they were on it. They did for a few places like Ikeja, VI (Victoria Island) and Ikoyi. You know, what that one means is if you have that document, once you have a Survey plan from a client and you know the street, you can go to that Model City Development Plan because it is for a period of 25-40 years projection. Gradually, they moved some roads to become high street where they can accommodate mixed development. Do you know that it is even good for prospective Real Estate Investment? Somebody can invest into it getting to know that; O.K., this road you want to use a link bridge now across the gorge, to leave this road for this somebody can buy into that credible information and said yes, this road now will become a commercial axis later. You can go there now and buy into it and those are some of the things… many times may affect the goal of an Architectural firm in terms of what would be your turn over if somebody had bought a piece of Land with the intention of having a shopping Complex and it's not possible or because nobody knows, all you know is the General Planning Index; ok, if it is this square meter, your shopping Complex cannot be more than two floors measuring total square meter like this once you are able to achieve a parking capacity of this. But you know there might be caveats that you can't even have that kind of development in that area. So that kind of a person will be interested. That's why the Government needs a lot of awareness, they don't do it as often as they should and that's why they are always having problems with the Developers and their own whole Association. You know before, Lagos State Policy Law is that you must have a title deed on your Land before you can even submit your drawings for approval that is either a Governor consent or a C of O for lands that had been acquired long before now, the deed of conveyance. But do you know that there are so many problems associated, some people have been processing Governor's consent for seven (7) years even the development proposal that you wanted to get the permit for will require financing. Do you think any Bank will give you money and for seven years it is yet to be put into use? How do they start to even get the repayment? So, at the end of the day, by the time the approval is ready, the financial institution is saying they are no longer interested.

That's why for now they've come up with an ad hoc arrangement that one can have provisional approval. How that one will work, I don't know. And then, the idea of making the approval process rocket science is killing. What is the basic thing in submitting drawing, pay all the statutory levies, be tax compliant and let them assess the drawing and get it approved? They can do it but for reason best known to them, they keep frustrating the people. For over one year, the approval will not be out. And they keep telling you "You can't start construction work without obtaining development permit". In that case the man is into commercial housing delivery, they are going to hamper his turnover, and he would not be operating at optimal capacity even for the revaluation of his personnel. So those are the basic problems on the side of the Government" - RCS3Q8.

C - RADELYNE CONSTRUCTION

CS4Q1: What are the major difficulties of prefabricated component on site during construction?

"It depends on the materials to be used. Some companies don't prefer concrete as the material for the building. Certain issue aroused over the use of reinforced concrete as prefabricated components where I was indirectly involved. The cost implication was enormous, and the project must be suspended. I think what we need to look out for is a cheaper, but reliable materials that can be used as component for prefabricated building. The Demographic study in Nigeria shows that the poor are the ones mostly affected in the housing affordability issue. Therefore, the use of concrete as prefabricated components will be expensive and not at the easy reach of the poor. We need a house for the poor that can be achieved and affordable to the poor" - RCS4Q1

CS4Q2: What other difficulties you usually experience in the cause of installation of building components?

"The government is not against prefabricated building construction. It is the wrong perception of the people about the construction methods that has been the major issue. What we need to consider is how to make adequate factories available to meet production demand of the people. The need for standard training schools for the training and re-training on the use of prefabrication methods of construction can also not be over-emphasized. These and several other factors need to be considered by the Government" - RCS4Q2

CS4Q2a: It is observed that in developed countries where prefabrication technology in building is more popular (China, Singapore and in the United State), the government made favourable policies and regulations to encourage the growth of prefabricated building construction. How did you think that the use of prefabrication technology can be encouraged in housing development in Nigeria?

"There is nothing like that in Nigeria for now. There is no subsidy in any form. Besides, no special attention from the Government in the use of prefabricated methods in building construction" - RCS4Q2b

CS4Q3: What are the problems associated with prefabricated components storage on sites, and how do you think these cabs be addressed?

"The usual problems with the storage of prefabricated components on site is lack of adequate space for storing materials. Whenever there is an ongoing construction project and prefabricated components are brought into the construction site. They are put in a particular space within the building - in a room, store, car pack, depending on the size of space and the quantities of the prefabricated materials. Now that area you are putting those materials will be finished with time, it has a finishing time limit, and the prefabricated materials might not have been fully used before one gets to the room where they are stocked. So, one now has problem of space where the components are to have put them, and you start carrying them from one place to another. Some of them may not be installed at the same time since we have various time for installation. There is a work program for every construction project. With the work program, one will know the time for the different stages of the work and when to bring in those materials. Some of the components will be brought to site a few dates before being used. This will therefore call for the need to store them in a convenient place within the project site. So, what we normally do in most cases is to get big companies like with central stores, so we take them to our main stores and keep them. But still there are problems of haulage and probable damage to fragile materials. So, this are all the problem associated with storage of prefabricated components on site" - RCS4Q3

CS4Q4: What is the usual sequence you follow (on site) in installing prefabricated components?

"There is no definite formula. Sometimes it depends on the type of project, but as much as possible we work such that a particular stage of work will not disturb or delay the other" - RCS4Q4.

CS4Q5: How does this affect the storage of components on site?

"We ensure that the different sections that are expected to work on a particular component (Civil, Electrical, Mechanical ...) reasonably complete their job on that component at the production factory. After hardening, all the different section already featured within the component. Therefore, the chances of having to be waiting for additional work on components, is reduced. They are only needed at the finishing stage where special finishes are to be applied on the building components" - RCS4Q5.

CS4Q6: How do you accommodate late delivery of components?

"We usually put measures in place to avoid components coming into the site late. Factors that are likely to cause this are usually considered and addressed in advance. However, when such occur, we make arrangement for alternatives. If we are using alternative items, those items will tend to be wasted on the site at the end of time. Therefore, what we do most times is to consider where we have similar project going on and perhaps where the material in question have been delivered to other sites, and to be used for other similar projects with similar materials, but project have not gotten to the stages of using those materials, we collect those materials from such site and used. We will later replace when we get the delivery of our requested one" - RCS4Q6

CS4Q7: How did the activities and policies of the Lagos State Government and by extension the Federal Government affect the main goal of your firm?

"Aside the standard testing laboratory in Oshodi, Lagos State. Lagos also has the State Building Control Agency. They come for the test of materials from time to time. This has to do with the strength and suitability of materials – (Steel, Concrete ...) for a particular project. They visit construction sites at random to take samples of materials. On the discovery that a component did not to meet up with the specifications, a non-compliant notice will be sent. Further legal action may also be taken. Here in our firm, we sometimes go as far as going for chemical tests, abrasion tests among others to be able to ensure we meet specifications for construction projects. If the test laboratory can be properly equipped, it will go a long way to assist the building industry because their major job is to be strict with job and materials specifications before giving approvals. You have a specific project that is to be put up in a particular place, say in Lagos Island, it is a condition, for instance that building should not be greater than 110 meters in height and 201 meters long is an existing condition. There are other strict rules guiding the

number of flat per square meters or that can be built in an acre. We have numbers of flat, all these are part of the specifications put in place by the state" - RCS4Q7

C - ITB NIGERIA LTD

CS5Q1: What are the difficulties you experience in handling prefabricated components on site during construction?

"*Yes, in any field of engineering or in any field you find yourself, there are challenges. When I started initially, I brought those components to the site with my skilled workers to see what we can do with it. There are specific tools which are basically needed. The welders at the roadsides sometimes play an important role within the scope of their duty. It's easier to store this component material in the site because the logistics involved is moving it from the factory to the site that is the end point. So, in terms of storage, I don't think we have a challenge, because it is assumed that whatever you're bringing for storage should be estimated as what's needed for the project and then you make available space where you want to put it, then you store it. I think it's more economical in terms of storage and self-keep"* - RCS5Q1

CS5Q2: What are the other difficulties observed during installation of building components?

"*I have difficulties in getting technical men for the job. However, I was opportune to identify myself with a technical staff of CITEC, knowing fully well that he's a highly skilled staff and that Engineering is all about concept. I made a private arrangement and worked with a staff of CITEC for a couple of times, and on some light projects. Components was put together and Tao-lining carried out. I used the opportunity to have some orientation and training in the use of the materials. I later arranged an official training with CITEC and two of my technical men. No sooner, we picked it up the technology. We are gradually developing on it. So, there's nothing much about it as far as you are a skilled worker, it is a simple technology. If one has been working in a similar position in the building industry, one will not need much stress to adhere to this system of building. With a little guidance one can easily pick it up and continue to use"* - RCS5Q2

CS5Q3: What is the usual sequence you follow in installing prefabricated components?

"*Thank you. Just as you have said, you're trying to confirm the negative effects of an ongoing project being suspended because of funds or other challenges. Basically, in life we have advantages and disadvantages. On my own part, in the whole project that I was involved in that has to do with polystyrene, I handled and completed it to 100 percent. Asking whether it is an economical way of construction. Where I see the challenge is sensitizing the people about this product. A lot of people are not aware of the industry as well as the products. So, I look at it that more is needed to be done in terms of sensitization. We are only used to wet construction, mud, blocks, and bricks. Anything outside that is nothing"* - RCS5Q3

CS5Q4: What are the problems associated with prefabricated components on site particularly as regards storage?

"*The problem usually encounter on that has to do with a non-performing or unreliable program of work otherwise there is no point calling for a prefabricated component when they're still going to feature at the site and have some idle time. It should have been programmed such that as it's been delivered, it's been moved to points or final resting place because in the process of storage, so many things can come up; accident happens everywhere, I mean they have to now grapple with that, if per-adventure something happens and some of those components are affected it may become unusable which means the projected completion period will not be met and the overall completion costs will increase. So, as far as I'm concern, if in truth and indeed we want to go into that, then the programme of work must follow some critical path network. This may be delivered on an agreed date and time. Installation will also be commencing immediately. Not that you are coming, and you are starting, where you are starting it, external work ought to have commenced. These are the problems because like I've mentioned earlier, even product packaging is as important as the manufacturing. You can have a finished product when manufactured but if it must move out of the factory to the point of use, you must deploy some technologies that would make an effective delivery and retain its originality state from the factory right to the point of fixing. So that is the problem"* - RCS5Q4

CS5Q5: What is the usual sequence you followed during component installation?

"*It should be known that the traditional wet works cannot be totally avoided. Even if you are going to have a prefabricated building, there will be certain aspects of the work that one will have to rely on wet works to have perfect results. You know foundation for instance, all those wet works should naturally have been*

completed so that you don't deface your Prefabricated components. When you are talking about these prefabricated components, your walls should come in first, your walls, your floor system, then your roofing; all these things should have been put in place before you start bringing doors, windows and other fittings in sequential order. So, your wet works first, your walls, your roof system should all come in place to shield other fittings from exposure to weather" - RCS5Q5

CS5Q6: How do you accommodate late delivery of prefabricated component in such a situation like Architect has rightly said it?

"*Like I said, it's all part of construction management. If you follow your programme of works strictly, then you will know when you expect your wet works to be completed. You know your construction planning, from your programme of works, you will know when your wet works should be completed, so that adequate timing can be given to the manufacturers on when components are expected to be supplied. Taking care of the problems with the logistics, you must build in logistics, all those factors have to be put in place because; I mean if you finish a product, if you need a product tomorrow, you don't start asking for it today. So, you should carry your manufacturer along whenever a project is to commence. What time is it going to take to build the Pre-fabrication of those products so that you key that in right from the day one on your work schedule. So, once you carry the manufacturer along, the logistics and all that will flow well. So, one will not need to keep the prefabricated components unnecessarily under the site storage"* - RCS5Q6

CS5Q7: So, when you have a project to be built with prefabrication materials, how do you communicate with the prefabrication firm such that they produce the exact materials required for the job and that there are no excesses or shortfall of expectation?

"*The design details of the project in question will usually be given the calculated project area to the prefabrication firm. The pre-fabrication firms have their standard sizes and the panels come in those sizes. When you have your own design, it's a matter of checking the length by the width, you see the area. So, you place your order based on the quantity needed, taking into consideration that there are cuts and ways where you're supposed to have doors and windows, those are normal arithmetic. It's like when you want to buy something in the market, you go to the market with #10,000 and you know exactly what you want to buy, so it's not a challenge in terms of materials. The only thing is for one to be assured … check the quantity and quality of materials in conformity with the design specification so that you don't have much wastage on site"* - RCS5Q7

CS5Q8: How does the activities of Lagos State Government and by extension the Federal Government affect the main objective/goal of your firm?

"*The issue of Government has been a big issue. Those in the construction industry mostly have the challenges of unfavourable government policy. What do I mean with government policy? You may have a building construction project going on now in the industry and the government will come out with a policy, an instruction…that this is what the government does, it affects the project. On the issue of the use of polystyrene, if government can look to the issue, identify with, and encourage its application through favourable policy, then prefabricated building method will go a long way. In my own understanding, whatever one is doing without the support of the government, it is going nowhere because government can encourage the industry by identifying with them, giving them projects, incentives, and other things. I think it's going to have a lead way, leading to a wider acceptance of the technology"* - RCS5Q8

C - CRANEBURG CONSTRUCTION LTD

CS6Q1: What are the major difficulties of prefabricated component on site during construction?

"When I started initially, I brought those components to the site with my skilled workers, I left with them to see how it can be used as part of the construction materials, using their past experiences. There are specific tools which are necessary basically if you want to enjoy this project. The welders you see at the roadsides sometimes played a very important role in the connectivity matters. The wire mesh that serves as a binder that covers the polystyrene with the other adjoining wall need to be joined together. So, the constraints are not much that way because basically it's a smooth prefabrication method that is easy to carry out. The challenges are not much. A major factor that one must consider is that precision matters a lot because just as the way you set your blocks, you carry out levels, you set your bricks, and then there's nothing different when it comes to prefabrication project. So, the challenges are not much provided there are good hands there. Like I said earlier, prefabricated components have their own challenges because of owners' specifications, which comes in after the initial design stages. The prefabricated components may no longer be useful as expected after alterations. Sometimes, at the construction stage, some of the buildings are already sold. Now when clients come in, there are variation in taste. Effort to make possible alterations by the new owners usually becomes a difficult, as the changes will inform a case of difficulty in installation. As construction continue site, a project phase must be tidy up to pave way for another phase. Equipment used at the prefabrication installation stage; equipment used at the structural stage of the project will not have to be there when it is time for finishing. For instance, a tower crane occupies part

of the building space and after sometimes will have to be removed to pave way for the finishing of the building. The same things with Haulage materials. What happens is that, if this prefabricated materials with their heavy weights are not brought in as at when due, there is always the challenge of lifting them up again to the required position. Though some of them could use service lift, but it becomes a challenge because access to a service lift is limited. The towers there can swing 360 degrees and one can go to any location to pick it up. So, if components are not delivered on time, there may be challenges in taking them back to the production firm. Besides, it requires careful handling during transportation. There have been cases we have glasses got cracked during transportation, and that results to loses to both the client and the company or agent responsible for the materials. Then one must be careful and tolerance while dealing with prefabricated components than when on a project casted in-situ. The entire components cannot be prefabricated during building construction. Several things are usually prepared on the site (in-situ). One will only have to bring the prefabricated components to be fitted into the appropriate places of already prepared members during construction. When prefabricated component with certain measurement are to be fixed on a particular site, the dimension/measurement of the component must have been known to the people on site to prepare them in advance and to meet the precision on site, which is usually very high. Then sometimes it is considered cheaper to cast on site in-situ than to bring in prefabricated materials. The reason why prefabricated materials are been considered because with this special mode, one can use concrete to achieve them, fine and good, but sometimes because of the special materials that would be used, one cannot cast them. Just like when we have fibre materials, fire materials are not materials you can cast on site. However, where one decided to use them, they cannot be casted to form good shape like concrete. So, what is needed to be done is to get a prefabrication factory with your workshop drawings, which must be well detailed and made available to the prefabrication firm. Many of the prefabricated element used are imported from Germany, UK, and some from Italy. Though bought with a reasonable amount, the cost of shipment and clearing at the seaport, is much, and as a result make the components expensive. These forms additional cost on the project. It could have been easier if they were here, but in a construction project, one doesn't always get all the needed materials in a proximity to the site. Some still must be prefabricated and brought from the countries where they are easily available. There are many items like wooden works, that are prefabricated and brought to the site for installation, and one must have a good knowledge of what is been brought to site and the technical know-how for the installation. They must have been grounded and prepared because there are different methods of installation. Therefore, high-tech professionals are needed for installation on site. Thank you" - RCS6Q1

CS6Q2: What are the other difficulties you usually experience in the cause of installation of building components and how do you think this can be addressed?

"*Yes, that is part of the reasons that specification is important in construction project. Sometimes there is a communication gap between the manufacturers and those that are taking measurement on site, depending on who is handling the workshop drawing. If that gap is not properly handled, this could result into bringing materials that are not in line with the specification into the project. Like I said, sometimes when one is on a construction project, perhaps a space of say 5m is to be maintained, there could be an error, and a space of 4m is maintained. Now you have the default drawing with you on site already that is the default drawing that came from the initial start of the project. There is a workshop drawing. It is expected that one come to site with physical measurement and prepare the workshop drawing and sent to the office or to the manufacturers for use in the production of some specific components. But sometimes if they did not have that workshop drawing, it will still work if one take the default drawing for measurement. Maybe there might be some site constraint that would have made them to change the dimension. So, at the end of the project, there is what we call as-built drawings that will be prepared, taking into consideration all the corrections and adjustment made during construction. It is possible you don't build in line with the initial drawing may be due to one or two site constraint or something that came up on site. Now you prepare your workshop drawing and sent out to the manufacturers. The manufacturers are expected to build or construct up to those specifications, if not they bring the item to the site and you discovered that they don't fit, what do you do? So that communication between the site and the manufacturer must be cordial and should be well coordinated at every point a time. Then apart from that like I said if they are packaging this already manufactured item for shipment, there is also a problem of assembling. Sometimes some container will be arrived, you will discover that they are trying to couple a particular unit, you will be discovered that this container that arrived came with materials from different unit, you say the top of the cabinet did not come is in the other container, so that is the problem we sometimes encounter. We are trying to couple this screen and we discovered the top is in the other container. It will come with the next shipment. Now coming with the next shipment indicate that there is going to be a delay in the project completion time, because you can't do anything. That is incomplete items that has been coupled. So, assembling of the items is also a challenge that must be critically investigated. That is why I said there must not be communication gap between the manufacturers and workshop drawing on site. Because the assembling of those items to meet up with specifications materials matters a lot"* - RCS6Q2

CS6Q3: What are the problems associated with storage of prefabricated materials on site?

"*A major problem with the storage of prefabricated components on site is 'space'. Whenever there is an ongoing construction project and prefabricated components are brought into the construction site. They are put in a particular space within the building - in a room, store, car pack, depending on the size of space and the quantities of the prefabricated materials. Now that area you are putting those materials will be finished with time, it has a finishing time limit, and the prefabricated materials might not have been fully used before one gets to the room where they are stocked. So, one now has problem of space where the components are to have put them, and you start carrying them from one place to another. Some of them may not be installed at the same time since we have various time for installation. There is a work program for every construction project. With the work program, one will know the time for the different stages of the work and when to bring in those materials. Some of the components will be brought to site a few dates before being used. This will therefore call for the need to store them in a convenient place within the project site. So, what we normally do in most cases is to get big companies like with central stores, so we take them to our main stores and keep them. But still there are problems of haulage and probable damage to fragile materials. So, this are all the problem associated with storage of prefabricated components on site*" - RCS6Q3

CS6Q4: What is the usual sequence you follow (on site) in installing the components?

"Like I said, the work program is usually produced. When you have a work program, it will tell you when a particular stage of the work is due. It also guides the overall management of the project" - RCS6Q4

CS6Q5: How does this affect the storage of components on site?

"*We like to guide against this as much as possible. One of the measures used is to be sure that all the relevant department (Civil, Electrical, Mechanical…) that require to work on a particular component fully carry out their job on that component at the casting stage of the component. After hardening, all the necessary section of every component is already featured within the component. Therefore, the chances of having to be waiting additional work on components, and thereby waiting for the delivery of such is very rare. Where it is inevitable, those concern would have been briefed and given sufficient time to respond to such need"* - RCS6Q5.

CS6Q6: How do you accommodate late delivery of prefabricated components on site?

"Late arrival of components will have a negative effect on project delivery. But delay is usually caused by somebody. Sometimes when we have such type of delay for too long, we make arrangement for alternatives. But now the word delivery means that it already on its way. So, if we are using alternative items, those items will tend to be wasted on the site at the end of time. Therefore, what we do most times is to meet with big companies that are also into similar business like ours and perhaps with other projects running alongside possibly where these specified materials are also been used in their projects. We go for other projects with similar materials but have not gotten to the stages of using those materials, we collect those materials and use. We will later replace when ours arrived. So that is the advantage of dealing with companies that have big store and are in the same line of business. The materials may not be useful, though that's for this site, but since it has not been delivered and we have same specified materials been used on another site and has been delivered but has not gotten to that stage, we can easily collect and once they come, we replace" - RCS6Q6.

CS6Q7: How does the policies of the Lagos State Government and by extension the Federal Government affect the primary activities of your firm?

"Government policies, to a great extent have direct and indirect effect on the activities of the firm. The truth is most of the materials we use for construction work are supposed to pass specification test. Now like Lagos state we have the Lagos state Building Control Agency. They come for the test of materials from time to time. This has to do with the strength of materials - Steel, Concrete, or whatever materials. They visit construction sites at random to take samples of materials and once one is discovered not to meet up with the specifications, a non-compliant notice will be sent. Further legal action may also be taken. Here in our firm, we sometimes go as far going for chemical tests, abrasion tests among others to be able to ensure we meet specifications set by the government. If they are playing their roles as expected, it will go a long way to assist the building industry because their major job is to be strict with the specifications before giving approvals. You have a specific project that is to be put up in a particular place, say in Lagos state. It is a condition that your building should not be greater than 110 meters in height and 201 meters long. There are strict rules guiding the number of flat per square meters or that can be built in an acre. We have numbers of flat, all these are part of the specifications put in place by the state" - RCS6Q7.

CS6Q7a: What reason can you adduced to why there are lots of collapsed buildings in recent time in Nigeria?

"Yes, the reason we have collapsed building is essentially because of failure on the part of Government. There are problems in the process of building approval and monitoring during construction. If all building projects are being properly monitored the way a few ones are monitored, the problem will be reduced. Some projects. You know, you go to a project you don't even check specifications, all you just want is give me something and let me go. That one is a factor too. Using quacks to supervise the building construction because of personal influence has been a major challenge. It doesn't make any sense if you are not using the right personnel for the supervision, then you are not carrying out your regular checks on the expectations. Somebody should give approval. They don't just go and start building an imaginary structure. The building to be built must have been conceptualize by an Architect, worked on by building or Structural Engineers, and possibly carried out the soil test. As a structural Engineer, I cannot build a structure without giving me the soil test result. You must have carried out the soil Investigation, we need to know the soil strength and a lot of other things. And after that, you bring a structural engineer as a sign and you started the building, even at that you don't follow specifications. There are lots of compromises. The steel they brought to the site, are they up to specification? This is what Lagos state government supposed to do. You go round and check all these structures before you can come back and say this is not fit. These are problems we are facing now" - RCS3Q7a.

CS6Q7b: A common observation is during routine inspection of Town Planning Officials, a stop-work order will be placed on an ongoing project discovered to have no approval. The people just tear-off or erase the order and continue with the building project. What do you think is responsible for this?

"Yes, you see the problem is this, the person that puts stop of work was supposed to follow up. Two, mostly, the monitoring and control department of the ministry has no logistics support for such monitoring. No good vehicles, No motorcycles, and not enough personnel. Hence, monitoring becomes very difficult. It is usually the monitoring team that went there to put the stop of work order that should monitor closely until the correct thing is done. Because the monitoring team from the town planning office went there and put the stop of work order, somebody came and erase it. The problem is that they are being paid for the job they don't do. They don't do their work effectively, but they return to the coffee shop too early. They will go back to the office to say they have worked for the day, and nobody is getting report back from anybody. If there is proper documentation of all these things, we should be able to go back to the Lagos State office

and say X, Y this structure is built in a particular street, and I want to see the approval for the concrete work and other test carried out on the structure. You will be surprised that you can't find it anywhere, because they are not properly documented in the office. So why won't there be corruption and collapse? There are bosses on the site, who always want to maximize profit at the expense of the society and subordinates must keep quiet or he is shown the way out. Laxity of the government has been encouraging quackery to strive. We have building agencies, we have COREN which are responsible for council of engineers in Nigeria, and we have ARCON, Architects Registration Council of Nigeria. What are they doing? Nobody is doing anything. There are some members of COREN and ARCON, who didn't even know the length and breadth of what they are doing. They just bribe their ways through to get the certificate and bear the professional title. So, people should be put into the suited test, so that right people will be in the right place and with that the degree of corruption will reduce. Though there are collapsed building in other part of the world due to earth movement and several other natural disasters. When it comes to technical deficiency, I think Nigeria is worst hit" - RCS6Q7b.

C - DARAPLUX LIMITED

CS7Q1: What are the major difficulties of prefabricated component on site during construction?

"Prefabricated components are in different categories. There are some structures that are fully made of prefabricated materials. There are some that are partially prefab. Some are just only the partitioning that are made of prefabricated members. Like let me come from the idea of a containerized structure in which I'm presently involved. Here, the container structures have already been built. The only challenge there is to bring it to site and in bringing it to site, there is a limit to what the load bed truck can carry. A load bed truck is recommended to carry a maximum container of forty feet at once. Another challenge is that the location to road that can allow a forty feet container to drive in and drop that container. The second one is the site you want to use. Can the container be driven into the site, or they must drop it by the roadside and the contents move inside gradually. Those are the difficulties in moving that kind of prefabricated components to site. Like where we are having this interview now, for us to move in this container and build all this office you are seeing. We must be removing some part of the roof to provide temporary cover for us to place one on top of each other. So that is part of the difficulty of using it on site" - RCS7Q1

CS7Q2: What are the other difficulties you usually experience in the cause of installation of building components and how do you think this can be addressed?

"In recent times, most of the components of prefabrication are imported. For instance, very few companies are producing polystyrene materials in Nigeria. The one that was used at a recently completed site was made in a mould, wherein wet concrete was mixed with sawdust and poured in a mould. The mould must be imported from outside the country. When we talk about production in the factory. Because the machine has the number of quantities, they can produce per time for them to have a breakthrough in their cost of production. If the quantity they are to be producing is not much, then, the time of delivery is always delayed. They must wait for other people to buy from the production. This takes time, there is an increase in the cost of production on a unit per time, because of the capacity of the machine that they are using and the cost of production so that they can maximize profit. That is one of the problems of manufacturing prefabricated component in Nigeria. This, among others has also responsible for its low patronage" - RCS7Q2.

CS7Q2a: Sir, you made mentioned of polystyrene and containerized materials. Are there instances where only concrete is made used as element for building prefabrication project?

"There are instances where concrete is used as prefabricated element. Example of this can be found in Dolphin Estate, where we are presently carrying out some renovation works. All the walls are prefabricated. The component was brought in prefabricated and installed by using higher learning of cementation components to join them together. There on itself and was pile because of the location and the storage of concrete materials that is prefabricated are on prepared foundation at the Dolphin Estate. We even have it at Ebute-Meta and Maryland here in Lagos" - RCS7Q2a.

CS7Q2b: Looking at the Dolphin Estate, Lagos, which am aware was built with prefabricated components by HFP Engineering about thirty years ago. Comparing those buildings in the Estate with those built with the conventional methods around, and that are of same age; what are your major observation and comment?

"Dolphin Estate, Lagos is a full prefabricated construction. Individual occupants are trying to re-structure it to reflect individual interest, and to get them what is satisfying. Because it is a full prefabrication project, it is thus rigid that one cannot easily remodel to one's satisfaction. It is because it is rigid. Because it is difficult to be re-structured. People are moving out to put up" - RCS7Q2b

CS7Q3: What are the problems associated with storage of prefabricated materials on site?

"A major problem with the storage of prefabricated components on construction site is 'space allocation'. Prefabricated components will constitute a nuisance and stand as an obstruction if dropped on the site while construction work is on-going. There will always be the problem of space. It is not also good to move component from one place to another. Some of them may not be installed at the same time since we have various time for installation. Only the immediately needed components are expected to be moved to site. The component will also be installed immediately. This will reduce the instances of the crane over and over on the same component. There is a work program for every construction project. This should be followed strictly. The problem with prefabrication storage on site is very straight forward because we usually must put polystyrene on site. The first thing is that you must get the site ready before bringing the components to site. If you bring in components ahead, there is a high chance of damages to be recorded because of fragile nature of the component before installation. This will result into higher cost of construction. If one is not careful then, what one is trying to run away from, would have been incurred in replacing the damaged members on site. Prefabricated component as I earlier said is in various types. We must now find a way of going back to the type we are discussing because the source is not just one material. We have the expanded polystyrene, we have the containerized, we also have the one that they used concrete with mixture to get a lite concrete, we have the concrete that we have to use periwinkles to be the aggregate so as to get the building lite so at this point, we have to actually narrow it down to the kind of prefabricated materials we are talking about, so that we can know how to address the components per site storage. If you are talking about containerized, the storage on the site is not a problem because it is a still material. But when we talk about expanded polystyrene, that is a delicate material that with just minimal impart, it is damaged. So, for containerized materials, storage materials will be spaced it has to make sure that it makes reliable impart so that is the problem with storage on site" - RCS7Q3.

CS7Q4: What is the usual sequence that you usually follow in installing prefabricated components from experience?

"From experience the first thing is to design after designing you get the sign off from the client and we go to structural design because there is no bill that thus not have structural input. And the first thing is to check the soil type of the location where we investigate the capacity of the soil to withstand the building load. And immediately that is established, and the foundation type is chosen for the intended load that will be coming from the building and once that is completed and adopted, the first thing to do is the foundation

after the foundation weather is a containerized structure have a base where the position it or inability to carry to carry the columns and the beams and a b cannot be an expanded polystyrene the slab now makes up the floor. It has to be concrete so they would have put up a structural frame after that that is when you started the expanded polystyrene as it was for cladding and partitioning all the rest that is the process and after wards the which in most cases has to be shredding materials that is plaster of Paris material to screed it even before skedding the doors in which the even in concrete don't system is always adopted because you can't be chiselling the wall that you want to take pipe into the wall block wall. Don't system will be adopted to marcher the M&E conducting so that is that method after the shredding painting tiling the house is ready for occupation? But it must be emphasized on the effective management of the mechanical and all the electrical installation, dotting system is always advisable because of the more sensitivity of the walls" - RCS7Q4.

CS7Q5: How does this affect the storage of components on site?

"We like to guide against this as much as possible. One of the measures used is to be sure that all the relevant department (Civil, Electrical, Mechanical ...) that require to work on a particular component fully carry out their job on that component at the casting stage of the component. After hardening, all the necessary section of every component is already featured within the component. Therefore, the chances of having to be waiting additional work on components, and thereby waiting for the delivery of such is very rare. Where it is inevitable, those concern would have been briefed and given sufficient time to respond to such need" - RCS7Q5.

CS7Q6: How do you accommodate late delivery of prefabricated components on site?

"Late arrival of components will have a negative effect on project delivery. But delay is usually caused by somebody. Sometimes when we have such type of delay for too long, we make arrangement for alternatives. But now the word delivery means that it already on its way. So, if we are using alternative items, those items will tend to be wasted on the site at the end of time. Therefore, what we do most times is to meet with big companies that are also into similar business like ours and perhaps with other projects running alongside possibly where these specified materials are also been used in their projects. We go for other projects with similar materials but have not gotten to the stages of using those materials, we collect those materials and use. We will later replace when ours arrived. So that is the advantage of dealing with

companies that have big store and are in the same line of business. The materials may not be useful, though that's for this site, but since it has not been delivered and we have same specified materials been used on another site and has been delivered but has not gotten to that stage, we can easily collect and once they come, we replace" - RCS7Q6

RCS7Q7: How has the activities of the Lagos State and by extension, Federal Government been affecting the main objective of your company, either positively or negatively?

"You know the way this profession is structured in this country, there are lots of quackery because the construction industry has been allowed to be too porous. A politician that is not an engineer will claim to be a contractor and it has to do with government policy. If not for what is been signed by the president on the issue of empowering the regulations of engineering profession in Nigeria to empower them to resist quack. Anybody can just go into construction. A doctor you hear is going into construction. So, the policy over the year, we have not been able to evaluate the one that is been signed into implementation over time but the one over the year have protected the industry that is why we have building collapse almost all the time and, in most places, because they have let the industry opened for anybody to come in and practice and to take it further, the nature of construction of building is left open. A professional does not register the building for construction. Client can just enter the office and take the building plan for approval. And will say give me architectural sewing and structural drawing for approval and register and start building which is very porous. It is a professional that will register the building for construction. In other profession, it is the Professional person that will register at the building and answer for that building as time goes on. So, in terms of government policy and their effect on this profession it has been 50% it has not really protected it. It has affected that's why it difficult for professional body to sell construction ideas to clients, because you are not in position to choose for the client the client has to choose for you. Is like 5% of client will rely on professionals to choose what they want to do and that is one of the major loopholes in the industry. Even in the physical planning there is no planning anywhere. People build anyhow, there is no set back because it is the client that goes and say he registered a building. He can go there and do wherever he likes. But if government has empowered the professionals, like we can look at the surveyors. You can't see anybody waking into the government agents and say he owns a land survey. A surveyor must do that for you so in way that aspects of documentation of landed property is protected. You can't get a land survey without surveyor. You must go to surveyor the surveyor will go to government to register it. So, everybody has that understanding and by the time you see survey, you must see the name of the person

that register it on it. Even if you need hundred copies, they still must refer to that person for you to get a copy. In a way that one is protected. The policy in that angle is somehow right" - RCS7Q7.

CS7Q7a: If an Estate was built about thirty years ago with several negative remarks now, don't you think there is the need for improvement on the project to make it more compliant with the modern-day need? If a similar project is to be developed, I'm of the opinion that people must have learnt some lessons from the existing ones and as such make effort to work on the grey areas in the new proposal?

"Observation shows that in the recent times, some companies have come up with selling prefabricated fencing components. All it requires is for one to just go to the company, make payment and pick the prefabricated concrete component for the fencing work and install those fences for you. You don't need to put blocks. The problem is that when there is a change in the arrangement of the compounds those walls must be wailed because you cannot just break them like you break the conventional block-walls and remould them. So, the rigidity of prefabricated component can be compared to the expanded polystyrene. Imagine, you have done a wall with the expanded polystyrene, and you need to make an extension. That means you must remove that section and now rebuild, because once you started cutting into it, those area of cut is weaken. You will see the pictures in the once I will send you, they must put wire mesh to reinforce it so that it will not just be ordinary polystyrene, they put wire mesh those still net that are structural effect to increase the security capacity of the wall" - RCS7Q7a.

C - ELANLAN

CS8Q1: What are the difficulties you experience in handling prefabricated components on site during construction?

"Now, handling prefabricated have their own challenges due to owner specifications, which most times comes in after the initial design and needs. The prefabricated items may no longer be useful due to this alteration. You know after you might have constructed or during construction stage, some of this structure, buildings, houses are already sold out for outright purchase and during construction some people come in to buy. Now when clients come in, all don't have sand taste there are always different in taste. So, this prefabricated components that has started before the project or during the cause of the project will now be having challenges because of change in specifications by the owners of the apartments that is one. Two apart from the changes that will be coming we also have the case of difficulty in installation. You know by

the time they arrive, some time you discovered that as you construct, there are some items you remove towards the end of the equipment that you start bringing out of the site. Equipment's you used at the prefabrication stage; equipment used at the structural stage of the project will not be there when you finished the project. like tower chain for instance. Your tower Crane occupy part of the building and that tower chain after sometimes must be removed because you have to finish the building. The same things with Haulage materials. What happens is that, if this prefabricated materials with their heavy weights are not brought in on time, there is always a problem or challenge of lifting them up to their required position. Some of them could use service lift, but it becomes a challenge because access to a service lift is not as open as we think. The towers there can swing 360 degrees, you can go to any location to pick it, but the lift that you are going to use you must lift them to the lift position, in which in most cases some of entrances, some of the accesses must have been restricted due to some other construction work. So, if they are not delivered on time, there may be challenges in taking them back to their local positions. Three, it requires careful handling while transporting them. Like glass for instance, there are cases you have crack glasses. They were not cracked in the factories; they were cracked during the cause of transportation and that results to loses to both the client and the company itself or the company or agent responsible for the materials. So, when you now have such a fragile item, prefabrication becomes a difficult thing because it became very careful to handle. Then sometimes talking about cost, most cases like most of us who are civil engineers, you discovered that you have more tolerance when you are having a prefabricated item than when you are having an item that will be cast institute your degree of tolerance or precision in your construction work. Because you cannot prefabricate everything in building, there must be some things that must l be institute they must be there. You bring in those fabricated items to fit in into those stuff. Now if you are bringing a prefabricated item that has a particular dimension, you must know what you want to fix into it. The precision on site is very high. Is not that you what to install it and be saying that break this wall, expand it. So, your level of precision from the word go, must be very high, you must consider that. Then two sometimes it becomes shipper to cast on site institute than to bring in prefabricated materials. The reason why prefabricated materials are because with this special mode you can use concrete to achieve them, fine and good, but sometimes because of the special materials that would be used. You cannot cast them. Just like when we have fiber materials, fiber materials are not materials you can actually cast on site, you can have a site where you are casting it, but they can be cast in good shape like concrete, so what you need to do is you get a good factory where your dimension are taking to, your workshop drawing like I use to say before prefabrication is taking out, your workshop drawing must be well detailed and sent to workshop where prefabrication will take place and eventually brought to site. So, it increases

the cost too, because what you are doing on site and what you are doing outside the site of course the cost of transportation to site is another cost, you are increasing the cost of the project. Like most of the components of this project you are looking at are fabricated in Germany, UK, and some from Italy. They are others from different parts of the world. The cost of shipment, the cost of clearing the items at seaport, the cost of transportation to the site. These are additional cost on the project itself. It could have been easier if they were here, but construction wise. You don't always get your materials on site; some still must be prefabricated. There are so many items like wooden works, most times they are prefabricated and brought to the site for installation, and you must have a good knowledge of what is been brought and you must have a good knowledge of installation procedure otherwise, that is why you need a more skilful workers to do the on. Not just bringing any artisans to do the installation. They must have been prepared because there are methods of installation, manuals are coming along site with it, and so you need high tech professional to do installation on site. Thank you". - RCS8Q1

CS8Q2: What are the other difficulties you do observe or experience during installation of building components and how did you think this can be addressed?

"Yes, sometimes you discovered that specification matters a lot. Sometimes there is a communication gap between the manufacturers and those that are taking measurement on site, depending on who is handling the workshop drawing. If that gape is not handled, there will be bringing materials that are not in line with the specification and Communication gap in the sense that it can come from dimension. Like I said, sometimes when you are doing construction, you discovered that maybe you are supposed to keep a space of 5 metres, someone might accidentally keep a space of 4meter, 800m making that 200mm out of it. Now the guy that came to site, you have the drawing already that is the default drawing that came from the initial start of the project. There is a workshop drawing we expected that you come to site with physical measurement and prepare the workshop drawing and sent to the office or sent to the manufacturers which they will now use. But sometimes if they did not have that workshop drawing and you take the default drawing and you just take your measurement. Maybe there might be some site constraint that would have made them to change the dimension. So, at the end of the project, there is what we call out built drawings and why are they taking out but drawing, it is possible you don't build in line with the initial drawing may be due to one or two site constraint or something that came up on site. Now you prepare your workshop drawing and sent out to the manufacturers. The manufacturers are expected to build or construct up to those specifications, if not they bring the item to the site and you discovered that they don't fit, what do

you do? So that communication between the site and the manufacturers must be cordial and should be well coordinated at every point a time to know. You know there are sometimes that the manufacture may be far from the site very far away so it might be when they have shipped it, you now say oh we have made a mistake, what do you do because is already in ship and in every mistake, you made you have to pay for it either in time or in cost you must pay for it, that one is sure. Then apart from that like I said if they are packaging this already manufactured item for shipment, there is also a problem of assembling. Sometimes some container will be arrived, you will discover that maybe they are trying to couple a particular unit, you will be discovered that this container that arrived came with materials from different unit, you say ha the top of the cabinet did not come is in the other container, so that is the problem we encounter. We are trying to couple this screen and we discovered the Top of is in the container is oh it will come with the next shipment. Now coming with the next shipment indicate that there is a delay in the project because you can't do anything. That is incomplete items that has been coupled. So, assembling of the items is also a challenge that must be critically investigate. That is why I said there must not be communication gap between the manufacturers and workshop drawing on site. Because the assembling of those items to meet up with specifications matters a lot" - RCS8Q2.

CS8Q3: What are the problems associated with prefabricated components on site particularly as regards storage?

"You know as we do construction job, there is no part of the buildings that must not be finished. So, when you bring in this prefabricated material, you put them in a particular area of build maybe in the room or in the store or car pack depending on where you are putting those materials. Now that area you are putting those materials will be finished with time, it has a finishing specification, and this material may not be used before you get to the room where they are stocked. So, you now have problem of space where you are going to put them, and you start carrying them from one place to another. Because some of them may not be installed at the same time till, we have various time of installation most cases they will say such item should not be submitted now, we want to reserve this item now in your major store, you submit in due course. There is a work program for every construction project. With that work program, we should know when just like we are having it in glass building at the point of excavation you are going to damage those glasses or you are bringing in at a point when they are still doing rendering or fixing glasses, so with work program you should know when to bring in those materials. Even as at the time of all come within the same work program me. And some of them are the once that will come in one or two days to the day of

commissioning, so you need to store them in the site. So, what we normally do in most cases is we try to get big companies like ours we have mixed stores central stores, so we take them to our main stores and keep them. But still there are problems of haulage and probably damage to fragile once, so this are all the problem associated with storage of prefabricated materials on site" - RCS83.

CS8Q4: What is the usual sequence you follow in installing prefabricated components?

"*Like I said the work programmed when you have a work program, it will tell you when a particular item comes in and it also guide on when you start fabrication. The one of the containers you mentioned that a particular container has been delivered, only to see that a particular component is not completed there like about two, three components all this component will not come at the same time. Like is said if there is misplacement of item, it will delay the project because there are some items that must come first"* - RCS8Q4.

CS8Q5: What is the usual sequence you followed during component installation?

"*It should be known that the traditional wet works cannot be totally avoided. Even if you are going to have a prefabricated building, there will be certain aspects of the work that one will have to rely on wet works to have perfect results. You know foundation for instance, all those wet works should naturally have been completed so that you don't deface your Prefabricated components. When you are talking about these prefabricated components, your walls should come in first, your walls, your floor system, then your roofing; all these things should have been put in place before you start bringing doors, windows and other fittings in sequential order. So, your wet works first, your walls, your roof system should all come in place to shield other fittings from exposure to weather"* - RCS8Q5.

CS8Q6: How does this affect the storage of components on site?

"We like to guide against this as much as possible. One of the measures used is to be sure that all the relevant department (Civil, Electrical, Mechanical…) that require to work on a particular component fully carry out their job on that component at the casting stage of the component. After hardening, all the necessary section of every component is already featured within the component. Therefore, the chances of having to be waiting additional work on components, and thereby waiting for the delivery of such is very

rare. Where it is inevitable, those concern would have been briefed and given sufficient time to respond to such need" - RCS8Q6.

CS8Q6: How do you accommodate late delivery of prefabricated component?

"Late delivery of components is already delaying the project, but things are not perfect, delay will be caused by somebody. Sometimes when we have such type of delay and is taking too much time, we look for very close alternatives. But now the word delivery means that it already on its way" - RCS8Q6.

CS8Q7: How does the policies of the Lagos State Government and by extension the Federal Government affect the primary activities of your firm?

"We are in the built industry; we want to design, we want to deliver functional, structurally stable, and cost-effective project to our clients, and we can only do this if the Government policies are friendly. To a large extent, it is not too bad for now and like I said, it's not a one man show. Government policies are being anchored by Government Agents, we all should come together as a team; we should all see ourselves as a team and not as competitors and not as somebody which hunting the other. So long as, if you have a harmonious relationship between the Government, the people and the people in the construction industry, relationship in most system will work as the Government policies are standing by. whatever we do is to submit them for government approval. For instance, if government policy says one can only have two (2) floors in a particular location, I will not endeavour as an Engineer or Architect to go and design (10) floors, against the Government policy says. Lagos State Government will need to do more in sanitizing the indiscriminate patronage of quacks to carry out professional activities in Architectural and other Engineering services. I can assure you today if you use the same planning regulation of last month to design this month, you will be surprised they might have changed against your drawing - policy summersault. They will give you 1001 comments why that drawing will not fly, whose fault? Most of these policies changes is not known to the construction sector that are the direct consumers, acting as representative to the clients. A client will tell you 'I want this and that on my land'. If the design consultant is rightly informed, he will be able to tell you it is not achievable because that is not permissible, the planning permit will not be granted. They keep on changing it, I don't know when to expect each one of them to be coming to their offices. The other time, I went to Lagos State Urban & Physical Planning Headquarters at the Old Secretariat for a different thing, lo and behold, while sitting at the reception, I

just saw a pamphlet, I stood up, went up to meet the receptionist, he said it is free. Could you believe me, when I was going through, it is something that is a paradigm shift from what used to be the handbook - the compressed version for all the planning regulations since the time of Gov. Fashola (a former Governor of the State). The new planning rules just came out this January, I doubt whether most Architects have it. Then they are not doing too much in Model City Development Plans. During the time of Governor Babatunde Fashola as the Governor of Lagos, they were on it. They did for a few places like Ikeja, VI (Victoria Island) and Ikoyi. You know, what that one means is if you have that document, once you have a Survey plan from a client and you know the street, you can go to that Model City Development Plan because it is for a period of 25-40 years projection. Gradually, they moved some roads to become high street where they can accommodate mixed development. Do you know that it is even good for prospective Real Estate Investment? Somebody can invest into it getting to know that; O.K., this road you want to use a link bridge now across the gorge, to leave this road for this somebody can buy into that credible information and said yes, this road now will become a commercial axis later. You can go there now and buy into it and those are some of the things… many times may affect the goal of an Architectural firm in terms of what would be your turn over if somebody had bought a piece of Land with the intention of having a shopping Complex and it's not possible or because nobody knows, all you know is the General Planning Index; ok, if it is this square meter, your shopping Complex cannot be more than two floors measuring total square meter like this once you are able to achieve a parking capacity of this. But you know there might be caveats that you can't even have that kind of development in that area. So that kind of a person will be dis-interested. That's why the Government needs a lot of awareness, they don't do it as often as they should and that's why they are always having problems with the Developers and their own whole Association. You know before, Lagos State Policy Law is that you must have a title deed on your Land before you can even submit your drawings for approval that is either a Governor consent or a C of O for lands that had been acquired long before now, the deed of conveyance. But do you know that there are so many problems associated, some people have been processing Governor's consent for seven (7) years even the development proposal that you wanted to get the permit for will require financing. Do you think any Bank will give you money and for seven years it is yet to be put into use? How do they start to even get the repayment? So, at the end of the day, by the time the approval is ready, the financial institution is saying they are no longer interested. That's why for now they've come up with an ad hoc arrangement that one can have provisional approval. How that one will work, I don't know. And then, the idea of making the approval process rocket science is killing. What is the basic thing in submitting drawing, pay all the statutory levies, be tax compliant and let them assess the drawing and get it approved? They can do it but

for reason best known to them, they keep frustrating the people. For over one year, the approval will not be out. And they keep telling you "You can't start construction work without obtaining development permit". In that case the man is into commercial housing delivery, *they are going to hamper his turnover, and he would not be operating at optimal capacity even for the revaluation of his personnel. So those are the basic problems on the side of the Government. So, if you are using Alternative items, those items will be wasted at the end time goes on. So, what we do sometimes like big companies that are into the building industries like ours. What we do is that we have other projects running alongside and some of these specified materials are also been used in other project, so what we do is we quickly go to other project that we need similar materials for, so that if they have not gotten to the stages of using those materials, we collect those materials and when they come, is just a matter of replacing. So that is the advantage of dealing with companies that have big store and are in the same line of production .The materials may not be useful, though that's for this site, but since it has not been delivered and we have same specified materials been used on another site and has been delivered but has not gotten to that stage or they are just at that stage and they are not using all, we can easily collect and once they come, we replace* - RCS8Q7

SCS8Q7a: It is observed that on several projects under construction, where there is a stop of work order, people just clear it off and continue with the building project. What can you say about this?

"The problem is this, the person that puts stop of work was supposed to follow up. Two, they have monitoring them. It is the monitoring theme; it was the monitoring theme that went there to put the stop of work order. Now what is the monitoring theme do when the person continues the structure and wipe away the stop order? Because the monitoring theme went there and puts the stop of work order, somebody came and erase it. It was not there before they put it. Is just like sometimes when you write on paper you erased it, now you that wrote it you know what you wrote there and when you came back somebody as continued his work. What where you doing, then are you sleeping? The problem is that they paid for the jobs they can't do. They don't do their work effectively and they will go back to the office and say they have worked, and nobody is getting report back from anybody. If there is proper documentation of all these things, we should be able to go back to the Lagos state office a say X, Y this structure is built in a particular street, and I want to see the approval for the concrete work another test they carry out on that structure. You can't find it anywhere, because is not documented anywhere why won't there be corruption and collapse. There is expert on the site, who wants to maximize profit at the expense of the society, and somebody is quiet. It is the laxity of the government that is making quack to strive. We have building agencies, we have

COREN which are responsible for council of engineers in Nigeria, we have NCE, Nigeria Civil of Engineer, what they doing? Nobody is doing anything. There are some members of COREN and members of NCE, who didn't even know the length and breadth of what they are doing. They just bribe the certificate and call their selves member just to have government appointment. So, people should be put into the suited test, so that right people will be in the right place and with that the degree of corruption will reduce. Though there are collapsed building in other part of the work due to earth movement of which we can guide against earth movement as a natural disaster, but when it comes to technical efficiency, I think Nigeria should come up there" - RSCS8Q7a.

Appendix v: Ethics Approval Certificate

HUMAN RESEARCH ETHICS COMMITTEE

THE UNIVERSITY OF NEWCASTLE AUSTRALIA

APPROVAL TO CONDUCT HUMAN RESEARCH

To Chief Investigator or Project Supervisor:	**Associate Professor Patrick Tang**
Cc Co-investigators / Research Students:	**Associate Professor Willy Sher** **Mr Igbayemi Akeremale**
Re Protocol:	**Investigation and Development of a Supply Chain Management Concept for Prefabricated Housing Construction in Nigeria**
Date:	**10-Jun-2021**
Reference No:	**H-2018-0508**

Thank you for your recent application to the University of Newcastle Human Research Ethics Committee (HREC) for approval of the protocol identified above.

Details of previous approvals for Initial, Renewal and Variation applications are available upon request.

A *Certificate of Approval* is enclosed.

THE *CERTIFICATE* AND THIS ADVICE ARE TO BE RETAINED
THEY ARE IMPORTANT DOCUMENTS

- Note any comments related to the approval.
- **Where the HREC is the lead or primary HREC, if the research requires the use of an Information Statement, ensure the Reference No. is inserted into the complaints paragraph in the approved document(s) prior to distribution to potential participants.**
- Where the research is the project of a higher degree candidate, it is the responsibility of the project supervisor to ensure that the candidate receives this approval advice.

Conditions of Approval

This approval has been granted subject to you complying with the requirements for *Monitoring of Progress*, *Reporting of Adverse Events*, and *Variations to the Approved Protocol* as detailed below.

PLEASE NOTE:
In the case where the HREC has "noted" the approval of an External HREC, progress reports and reports of adverse events are to be submitted to the External HREC only. In the case of Variations to the approved protocol, you will apply to the External HREC for approval in the first instance and then Register that approval with the University's HREC.

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