FACTORS FOR THE ADOPTION OF MODULAR CONSTRUCTION/OFF-SITE CONSTRUCTION IN KLANG VALLEY MALAYSIA

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FACTORS FOR THE ADOPTION OF MODULAR CONSTRUCTION/OFF-SITE CONSTRUCTION IN KLANG VALLEY MALAYSIA

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A project report submitted in partial fulfilment of the requirements for the award of Master of Project Management

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December 2023

DECLARATION

I hereby declare that this project report is based on my original work except for citations and quotations which have been duly acknowledged. I also declare that it has not been previously and concurrently submitted for any other degree or award at UTAR or other institutions.

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APPROVAL FOR SUBMISSION

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ACKNOWLEDGEMENTS

I would like to thank everyone who had contributed to the successful completion of this project. I would like to express my gratitude to my research supervisor, Assistant Professor Ts Dr Toh Tien Choon for his invaluable advice, guidance and his enormous patience throughout the development of the research.

In addition, I would also like to express my gratitude to my loving parents and friends who had helped and given me encouragement throughout the research. Besides that, I would like to express my gratitude to UTAR for providing this project as a fulfilment of the requirement for the Master of Project Management. It is a great opportunity for future living in the research learning. Lastly, I am glad and honoured to have all the helping hands throughout the process of this research project.

ABSTRACT

In Malaysia, the adoption of modular construction/off-site construction is still low in the construction industry. This may be due to several reasons such as high capital costs, poor technical integration, lack of knowledge and expertise, as well as low market shares. Therefore, this research study aims to investigate the factors for the adoption of modular construction/off-site construction to achieve more efficient construction and sustainable construction goals. First of all, a questionnaire survey was used to obtain opinions from developer, consultant, and contractor firms in Klang Valley, Malaysia. The respondents were asked to rate a total of 18 factors of TOE framework to the modular construction/off-site construction adoption. The data collected from questionnaires survey were analysed by using mean ranking analysis and factor analysis. Besides that, the findings from mean ranking analysis show that "top management support", "managerial support", "relative advantage", "perceived ease of use", and "technological capability" are perceived as the top five adoption factors among the eighteen factors. Furthermore, the eighteen factors could be grouped into five underlying common components by factor analysis, namely component 1 – adoption intention, component 2 – organisational capability, component 3 – technology dependability, and component 4 – technology robustness. Due to little study has been conducted on Klang Valley, Malaysia. Hence, this study closes the knowledge gap by investigating the TOE framework and generating statistical correlations between the variables. Therefore, the findings of this study have the potential to close the theoretical gap related with modular construction/off-site building, which is currently seldom acknowledged, particularly in Malaysia's Klang Valley. Lastly, the findings can also help the industry practitioners to better understand the prioritising important factors for the adoption of modular construction/off-site construction in Klang Valley, Malaysia.

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LIST OF SYMBOLS / ABBREVIATIONS

1D	One-Dimensional
2D	Two-Dimensional
3D	Three-Dimensional
OSC	Off-Site Construction
IBS	Industrial Building System
AEC	Architecture, Engineering, and Construction
CIBD	Construction Industry Development Board
BIM	Building Information Modelling
HS	Health and Safety
SPSS	Statistical Package for Social Sciences
TMS	Top Management Support
EFA	Exploratory Factor Analysis
PCA	Principal Component Analysis
KMO	Kaiser-Meyer-Olkin
TOE	Technological-Organisational-Environment
W	Weighting

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CHAPTER 1

INTRODUCTION

1.1 General Introduction

The concept of prefabrication and modular construction/off-site construction are not new, but recent technology innovations, economic demands, and changing mindsets of construction companies have attracted an unprecedented wave of interest and investment (McKinsey, 2019). There are three categories of prefabricated construction which are 1D single element, 2D panelised system, and 3D volumetric system. But only panelised and volumetric construction are known as modular construction. It is the most efficient type of prefabricated construction since it allows for 70% to 95% of a building structure to be constructed in a factory.

Besides that, due to the scarcity of global resources, the construction industry has the responsibility for reducing energy consumption (Olubunmi, Xia and Skitmore, 2016). Building activities with high energy consumption have proved to contribute to various environmental issues (Luo, Zhang and Sher, 2017). modular construction/off-site construction offers significant benefits on low environmental impacts. This green construction method has been highly promoted and adopted by construction companies recently. To a large extent, this allows the construction companies to response to the environmental degradation by performing sustainable development in terms of reduced onsite waste and faster construction (Wu, Yu and Poon, 2019).

On the other hand, construction industry in developing countries is encountering several problems, especially low productivity caused by conventional on-site construction method and labour shortages caused by increasing demand and unforeseen circumstances. Hence, it is vital to look for a new approach that can improve the productivity and address labour shortages in the construction environment for remain competitive in the market. Modular construction/off-site construction is expected to provide faster building completion with fewer dollars (Thomas, 2019). As a result, modular construction/off-site construction is the modern method of construction that can be adopted in the construction projects.

Furthermore, there are several advantages of adopting modular construction/off-site construction have been reported, such as fast construction, for

example, reduce construction period by 50 – 60 percent (Ferdous et al., 2019), decreasing weight of construction waste up to 83.2% (Loizou et al., 2021), lower construction cost at around 10 - 25 percent (Hořínková, 2021), and less labour requirement up to 30% (Wuni & Shen, 2019). Therefore, the conventional construction method can be ideally replaced by modular construction/off-site construction in addressing all the challenges and problems faced by the construction companies in the construction industry.

Lastly, in the Malaysian construction sector, the prefabrication concept is referred to as an "Industrial Building System" (IBS). Hence, IBS is a construction process that used prefabricated building components that produced in a controlled environment. The Malaysia government has team up with Construction Industry Development Board (CIDB) to promote and address the IBS agenda in Malaysia construction industry. They have introduced plans and policies to encourage the implementation of IBS (Musa et al., 2016). Therefore, this proposed thesis is focusing on examine the factors which can influence on the adoption of modular construction/off-site construction in Klang Valley, Malaysia.

1.2 Research Background

Modular construction/off-site construction has transformed the construction methods of completing a project. It was inspired by the manufacturing industry, modular construction/off-site construction is a modern method of construction where a specific number of construction modules are produced in a factory, then deliver to the building site and on-site assembly. Hence, the adoption of this method will result in faster completion, reduce construction waste, and reduce labour requirement. As a result, the better performance of construction industry can contribute significantly to global economic growth.

Moreover, the adoption of modular construction/off-site construction can shift the construction method to “knowledge-based” industry instead of labour-intensive industry (O'Neill & Organ, 2016). Low productivity due to the traditional cast in-situ process has affected many construction projects in facing several issues such as project delay, budget overrun, and labour shortage. Thus, modular construction/off-site construction has been recognized by many construction companies as the perfect alternative method for traditional construction methods.

Furthermore, modular construction/off-site construction offers a variety of advantages to the building projects. When compared to conventional on-site methods of construction, the use of modular construction/off-site construction has the following benefits such as improved quality, better productivity, improved structural dependability, shortened construction time, and less labour and material waste (Cao et al., 2015). Thus, prefabrication has been introduced in the construction industry and gaining accepted among the construction companies.

Besides that. the adoption and development of modular construction/off-site construction has acquired steady and growing interest within the architecture, engineering, and construction (AEC) industry since the beginning of the 21st century (Arashpour et al., 2017). Also, the construction industry consistently falls behind in adopting technological innovations, which has made it difficult to utilize and enjoy the benefits provided by modular construction/off-site construction. As a result, researchers play a vital role in promoting this modern method of construction as a great alternative to traditional construction methods.

However, due to the high capital costs, limited market shares, and inadequate technological integration and coordination, construction companies are reluctant to adopt and implement the modular construction/off-site construction (Hong et al., 2018). But this shortcoming has been acknowledged by the construction companies, and research on modular construction/off-site construction is currently receiving significant attention (Arashpour et al., 2016). Therefore, several review studies have been conducted, and abundance of published papers have been emerged within off-site construction research (Hosseini et al., 2018).

In a nutshell, one of the hot research topics in the field of prefabrication is the identification of factors that are driving or influencing the modular construction/off-site construction development (Alzahri et al., 2020). Thus, the growing interest on this modern method of construction has made the researcher to conduct quantitative research on the related topic to help identity and examine the factors for the adoption of modular construction/off-site construction. Consequently, this has made the objective for this present study.

1.3 Problem Statement

In Malaysia, the adoption of modular construction/off-site construction approach is still low. This may be due to barriers such as, high capital costs, poor technical

integration, and low market shares (Hong et al., 2018). Recently, architects, contractors, and developers have strong interest in adopting prefabrication and modular construction, such as using modular units and prefabricated components in their building projects (Musa et al., 2016). Therefore, the challenges for the adoption of modular construction/off-site construction must be addressed.

Besides that, many previous studies have done on identifying the factors of modular construction/off-site construction. According to Nabi and Eladaway (2020), this study has investigated the elements influencing decision-making in a modular building project in the United States. Fifty elements were classified into eight groups: cost and profitability, time and quality concerns, quality issues, safety issues, environmental issues, design and engineering, resources and technology, and regulatory and organisational aspects. As a result, guidance and improvements for the successful implementation of modular building may be offered by identifying the essential success elements.

However, the research studies that focus on Malaysia are still limited and also it is worth mentioning that little study has been conducted on Klang Valley, Malaysia. Hence, the findings of this study have the potential to close the theoretical gap related with modular construction/off-site building, which is currently seldom acknowledged, particularly in Malaysia's Klang Valley. This study's adoption variables are based on the TOE Framework, which has three components: technological, organisational, and environmental dimensions. The TOE Framework model has been frequently used to assess the preparedness of a complicated invention for adoption, but no one has examined it in the context of modular construction/off-site construction. As a consequence, the findings of this study can contribute empirical data to the usage of the TOE Framework in modular building/off-site construction adoption.

1.4 Research Questions

- What are the factors driving the construction companies in pursuing modular construction/off-site construction practices in Klang Valley, Malaysia?
- What are the underlying factors for the adoption of modular construction/off-site construction in Klang Valley, Malaysia?

1.5 Research Aim

The aim of this study is outlined as follow:

- To investigate the factors for the adoption of modular construction/off-site construction to achieve more efficient construction and sustainable construction goals.

1.6 Research Objectives

The specific objectives of this study are outlined as follows:

- To rank the factors for the adoption of modular construction/off-site construction.
- To examine the underlying structure caused by latent factors for the adoption of modular construction/off-site construction.

1.7 Research Scope

This research study is focused on the factors for the adoption of modular construction/off-site construction in construction companies in Klang Valley, Malaysia. The definition of modular construction/off-site construction and its adoption factors have been investigated in this study. The data collection of this research was limited to construction companies in Klang Valley, Malaysia, hence construction companies which are outside of Klang Valley were not considered. All data were gathered from questionnaire survey method. However, this study will not discuss how to execute the modular construction/off-site construction. Instead, this study provides viewpoints as a starting point for further adoption of modular construction/off-site construction.

1.8 Research Justification

First of all, environmental degradation has become a serious global concern in recent times, highlighting the urgent need for sustainable solutions worldwide (Olubunmi, Xia and Skitmore, 2016). Based on research, construction sector produces around 30 - 40% of all solid wastes and 35% to 40% of carbon dioxide, as well as consumes 40 percent of total energy production, 12% to 16% of all water available, 32% of renewable and non-renewable resources, 25% of all timber, and 40% of all raw materials (Darko, Zhang and Chan, 2017). Also, the rapid urbanization and related

development projects in emerging areas can intensify the environmental impacts associated with the construction of buildings (Shi, Yu and Zuo, 2015). Therefore, massive housing construction projects is expected to continue in the future.

Besides that, construction companies in developing nations confront a number of challenges, including low productivity caused by the traditional construction approach (Teng et al., 2017). Thus, traditional building methods not only have many performance issues, such as time, cost, and quality issues, but they are also incompatible with the goals of increasing environmental sustainability. Therefore, it is critical to discover a new construction method that can meet performance targets and also mitigate the environmental impacts caused by conventional construction methods.

Moreover, with requirements of environmental sustainability and better project performance, conventional onsite construction is no longer suitable for nowadays construction industry. Hence, modular construction/off-site construction has been introduced in the construction industry. It is an environmentally friendly construction approach that generates lower levels of environmental pollution and offers greater productivity compared to traditional on-site construction (Wu, Yu and Poon, 2019).

In addition, the adoption of modular construction/off-site construction can result in a 50% decrease in construction waste, a 35.82% reduction in resource consumption, a 6.61% decrease in safety issues, and a 3.47% reduction in harm to ecosystems (Wu et al., 2021). Thus, the advantages of using modular or off-site construction are important, as they can address the problems confronted the construction industry through shortening project durations, enhancing safety and health, minimizing the need of on-site labour, and improving environmental aspects (Wuni & Shen, 2019). Therefore, the adoption of prefabrication has been widely acknowledged as a promising approach to foster the sustainable development of the construction industry (Jeong et al., 2017).

Notably, the over dependence on foreign workers is known as one of the most serious issues in Malaysia’s construction industry (CIDB, 2016). Hence, government of Malaysia is encouraging the use of modular or off-site construction because it will help reduce the number of foreign labourers in the construction industry. Now, foreign labourers are comprised approximately 90% of workers in construction industry and many of them are unskilled. Hence, the adoption of modular

construction/off-site construction will help the construction industry to cap foreign labour dependency.

However, the adoption of modular construction/off-site construction is remained limited, with approximately 42% of public projects and 70% of private projects implementing it (CIDB, 2016). A primary factor is the shortage of expertise and knowledge in the field. This is because the skill level of these workers is more demanding compared to the conventional construction methods. Hence, construction companies must attempt to restructure their human resource in term of more intensive training programmes on the specialised skills likes modular system integrating or components assembling.

In conclusion, addressing the environmental impacts and project performance issues in the construction industry is important to upskilling the whole industry. As a result, the researcher aims to investigate the factors for the adoption of modular construction/off-site construction to achieve more efficient construction and sustainable construction goals. Also, the issue of foreign labour dependency in Malaysia can also be reduced by the using of modular construction/off-site construction. Therefore, construction companies can reduce the number of workers required and save in labour costs through the adoption of modular construction/off-site construction in their projects.

1.9 Research Design and Methodology

This study aims to investigate the factors for the adoption of modular construction/off-site construction to achieve more efficient construction and sustainable construction goals. Hence, the factors were identified through literature review and then a questionnaire survey is developed by using a 5-point Likert scale (i.e., 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree). Then, the collected data will be used for data analysis process to rank the factors and examine the underlying structure caused by latent factors for the adoption of modular construction/off-site construction. Therefore, the mean rank method and factor analysis method were employed for data analysis in this research.

Besides that. the questionnaire will be distributed to construction companies such as, developer firms, consultant firms, and contractor firms in Klang Valley, Malaysia. Hence, all the project players of these construction companies such as consultants, contractors, builders, architects, civil engineers, project manager, and

site supervisors will be allowed to take part in the survey process. The sample size of this study will not less than 50 due to the basic requirements of factor analysis process (de Winter*, Dodou and Wieringa, 2009).

1.10 Chapters Organization

This research is divided into five chapters, which are as follows:

1. **Introduction to the Research:** An introduction, background of this research, research problem and identifying the theoretical gap, research aim and objectives, research justification, and the scope of the study will be discussed in this chapter.
2. **Literature Review:** Modular construction/off-site construction and the Technological-Organisational-Environmental Framework will be explained in the first section of this chapter. Then follow by the discussion of factors for the adoption of modular construction/off-site construction. The next section highlights the project performance of modular construction/off-site construction in the construction industry.
3. **Research Methodology:** This chapter addresses all major steps in the research process, such as the research technique, research process, data collection instruments, procedure and data analysis methodologies, and research ethics.
4. **Quantitative Data Analysis:** This chapter analyses the data gathered during the administration of the questionnaire survey.
5. **Conclusion:** Conclusions will be derived from the findings of the quantitative analysis methods in this chapter.

1.11 Conclusion

Malaysia construction industry has faced many challenges and issues, including labour shortage, project delay, bad weather, environment degradation, and so on. Thus, this study has introduced modular construction/off-site construction as a solution to help construction companies in overcoming these problems. This research aims to identify the factors for the adoption of modular construction/off-site construction. Moreover, the research objectives to rank the factors and examines the underlying structure caused by latent factors for the adoption of modular

construction/off-site construction are achieved to provide validated findings that can be used to improve the execution of modular construction/off-site construction in Klang Valley, Malaysia. Consequently, the research outcome of this study is helpful for the construction companies to avoid any potential pitfalls and enhance the successful rate of implementation.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The first section of this chapter discusses modular construction/off-site construction and the various related terms. The adoption factors related to modular construction/off-site construction are explained in this section. After that, the construction project's performance in the construction industry in Malaysia along with the conventional method or modern method of construction will be discussed.

2.2 Modular Construction/Off-Site Construction

Modular construction is also known as off-site construction. It is a construction technique in which prefabricated and standardized components are produced in a factory, then transported to project site for assembling (Sutrisna, Ramnauth and Zaman, 2020). Hence, this unconventional construction method has been used by many developed and developing countries due to its advantages and benefits. Also, buildings that constructed by using modular units or modules that produced off site in a manufacturing facility is considered as modular construction/off-site construction (Musa et al., 2018).

In addition, modular construction/off-site construction involves 60% to 90% of structures manufactured in a factory-controlled environment before it is constructed, transported, and assembled (Mohammad et al., 2016). In Malaysia construction industry, construction companies can adopt modular construction/off-site construction through Industrialized Building System (IBS) approach. IBS is defined as the used of off-site manufacturing or prefabrication in the construction industry (Azman et al., 2010). Therefore, IBS is the term more frequently used in Malaysia (CIDB, 2016).

Last but not least, Malaysia is currently in the phase of adopting a hybrid system and undergoing the evolutionary process of adopting modular construction/off-site construction methods (Azman et al., 2010). The Malaysia government launched the IBS roadmap and mandated the adoption of the IBS system to all public works in the nation through the Construction Industry Development Board (CIDB). As a result, sooner modular construction/off-site construction will be

adopted in all the development of construction projects. For example, a wide variety of commercial building projects, such as healthcare facilities, university buildings and dormitories, public buildings, low-rise office buildings, and warehouses can be built by using prefabrication and modular building processes (SmartMarket Reports, 2011).

2.3 Technology-Organisation-Environment (TOE) Framework

Despite Technology Acceptance Model (TAM) is an effective adoption theory that has been employed in a number of research projects, but this model considers only perceived usefulness and perceived ease of use as the primary reasons for adoption (Bryan and Zuva, 2021). Hence, user's assumption is only based on perceived usefulness and perceived ease of use which is not enough to provide essential data for achieving the objectives of this research study. Based on this constraint, TOE framework has been selected since a generic set of factors of technology adoption was proposed.

In addition, the TOE framework considers three contexts: technological, organisational, and environmental. Thus, this framework can provide an essential data in clarifying the adoption of technology. Also, Technology-Organization-Environment (TOE) framework will be used to analysis the content of selected articles. This framework has been widely embraced in research related to innovation in the construction industry (Xue et al., 2017). Based on this framework, there are eighteen factors for the adoption of modular construction/off-site construction were grouped into technological dimensions, organizational dimensions, and environmental dimensions.

In conclusion, modular construction/off-site construction provides significant benefits, but its development is still remained slower than anticipated (Gan, Chang and Wen, 2018). To explain the adoption factors, related journals and conference articles were searched in online databases using keywords such as "factors", "offsite construction", "prefabricated construction", "modular building", "modern methods of construction", "industrialised building" and "offsite prefabrication". Therefore, with the TOE framework, this study can provide a more extensive outcome to develop a predictive focal points of technology adoption that can encourage and improve the adoption processes.

2.4 Adoption Factors

There are 18 adoption factors have been grouped into three dimensions, which are technological, organizational, and environmental dimension factor. This framework will be discussed widely in this section.

2.4.1 Technological Dimensions

In this section, eight factors under technological dimension will be discussed.

2.4.1.1 Perceived Usefulness

Perceived usefulness is defined as the subjective likelihood that adopting a system or using a system would improve users' work performance within the context of the company (Lee, Kozar and Larsen, 2003). modular construction/off-site construction can enhance project performance, productivity, and overall effectiveness in achieving specific goals (Thirunavukkarasu et al., 2021). This is because the components of modular construction/off-site construction can be customized, and their standardization will not result in monotonous building designs (Wuni and Shen, 2019).

Additionally, even though the modular construction/off-site construction has maintained its uniformity and consistency in standardizing the design and modules for modular construction projects, but the standardized modules can also create highly individualized and diversified construction projects. Thus, this allows for efficient allocation of resources in many diverse projects. As a result, these technologies will attract key stakeholders to adopt modular construction/off-site construction as it can help them to gain competitive advantage among the industry.

Furthermore, customers are always demand for value for money products. Hence, the adoption of modular construction technology, organization can reduce their operating costs. This is because bulk quantities of standardized modules are produced using the same materials, tools, and procedures, thus the standardization often will lower the production costs (Wuni and Shen, 2019). Due to the mass production, worker specialization, and production process automation, it can also increase the efficiency of making the modules. Other than that, OSC can reduce site wastes of building materials by 10% as compared to traditional on-site construction (Blismas, Pasquire and Gibb, 2006). As a result, less wastage has been identified as the potential to lower the construction cost of building.

Lastly, construction time constraints are considered as an inevitable factor in many construction projects. By adopting the modular structures will enhance the productivity and speed of building completion and reduce negative consequences on site process. For example, weather conditions that will affect the progress of on-site construction can be avoided by adopting modular construction/off-site construction (Sutrisna, Ramnauth and Zaman, 2020). Also, when modular parts are produced concurrently with site work, projects definitely can be finished more quickly than when using the traditional construction method. As a result, these prefabricated modular components have fastened the delivery of projects by over 20% to 70% as compared to traditional on-site construction method (Thirunavukkarasu et al., 2021).

2.4.1.2 Perceived Ease of Use

The degree to which a person believes that utilizing a new system or technology would be effortless is referred to as perceived ease of use (Davis, 1989). In off-site construction or modular construction, modular components are designed to be customizable. (Thirunavukkarasu et al., 2021). As a result, the modular structures may be disassembled, renovated, and reused. Due to the modular construction/off-site construction is movable and flexible, hence, its standard components can be separated easily into part by part during the process of deconstruction of the building and move to another location for new purposes (Musa et al., 2018).

Additionally, this method can increase the material utilization efficiency and cost effectiveness because modules can be refurbished in meeting the new need. For example, mobile home uses the modular principle but often uses lighter materials and a metal chassis as part of the floor structure, allowing for frequent and simple moving. Therefore, modular or off-site technologies are easy to use by construction companies in achieving their project goals in the competitive industry environment.

Moreover, in modular construction/off-site construction, modules are created as 2D panelized system, entire 3D box-like (volumetric) portions, multi-section units, and stack-on units (Boafo, Kim and Kim, 2016). Most of the interior and exterior finishes are installed in the factory. Hence, when they leave the plant, they are between 80 and 95 percent finished. Also, modules are designed to be simple to put together. As a result, this technique can satisfy the increasing requirements of the modular construction project by reducing reliance on skilled labors and onsite resources such as materials and equipment (Sutrisna, Ramnauth and Zaman, 2020).

Last but not least, modularization reduces a system's complexity by integrating its smaller subsystems, or modules, which typically need to be broken down into a number of smaller components that allow to be transported to the project site (Wuni and Shen, 2019). Then, the modular parts will be assembled and sealed on site to form one completed building. However, the location of the project, the movement of materials, the availability of workers, and the physical characteristics of the site (soil characteristics, groundwater level, and terrain) will affect the project's nature and determine the amount of work and technology required for completing the project (Thirunavukkarasu et al., 2021). Therefore, if modular construction techniques are applicable for the project, its perceived simplicity of usage will convince the key stakeholders to accept and adopt it.

2.4.1.3 Technology Optimism

One of the potential advantages that will attract and motivate construction companies to adopt modular construction/off-site construction is they are able to differentiate their products and services through the delivery of higher quality buildings with a high level of standardization in construction, the capabilities of the process and technologies, quicker delivery times, as well as reduced reliance on the foreign labor (Sutrisna, Ramnauth and Zaman, 2020). As a result, all of these can be a source of competitive advantage for the organizations.

Besides that, modular construction/off-site construction has been viewed as a strategy that theoretically lessens reliance on skilled trades by employing semi-skilled or lower-skilled workers because construction companies can benefit from the higher degrees of standardization and repetition in the production and integration of modular components. Also, the use of modular components had reduced the number of foreign workers required for completing the project as compared to traditional on-site construction, therefore this can reduce the outflow of Malaysia currency to overseas countries (Azman et al., 2010).

In addition, modular construction/off-site construction can offer some advantages, such as shorten construction period, improved quality outputs, greater tolerances, lower prices, and less labor reworks on-site (Goulding, Rahimian and Arif, 2012). Not only that, OSC method can reduce site wastage of resources besides providing good quality output for end-users (Othuman Mydin, Sani and Taib, 2014).

Hence, OSC might provide "affordable quality homes" and solve some of the key issues associated with the traditional method of construction.

Due to the limitations of traditional construction techniques in meeting the demand for housing and in accelerating the completion of projects on time. As a result, the Malaysia government has decided to expand the usage of pre-cast building materials in the construction sector (Othuman Mydin, Sani and Taib, 2014). This is because the constructions of prefabricated components are concurrent constructions which can proceed even when the foundations of the construction sites are still under construction or when site is still involved in earthwork. Also, the production processes are not affected by climate conditions because the manufacture of the components is done in a controlled settings at factories. Therefore, this method helps in reducing the risks of project delays and unnecessary expenditures.

Finally, worker shortage is common in Malaysia, as Malaysia's construction industry is heavily reliant on migrant workers from nearby nations like Indonesia, Bangladesh, and Vietnam. Thus, by adopting this method, the required number of workers on site can be reduced. This is because each modular project only requires at most five modular component installers (Othuman Mydin, Sani and Taib, 2014). Consequently, this method provides higher productivity and cost saving for the organisations.

2.4.1.4 Technology Capability

First of all, there is a significant use of machineries in adopting of modular construction/off-site construction. Usually, these machineries are operated and maintained by well-trained personnel. Hence, the availability of a workforce with the skills and knowledge necessary to operate and maintain the technology is essential. Also, the assembly process of modular components will be significantly impacted if there are any damages to the machineries. As a result, it is crucial for the organizations to ensure they are possessed these kinds of skilled operators before making their moves to adopt modular construction/off-site construction.

However, construction companies who are lack of experience and technical understanding of modular construction/off-site construction method can cause them higher costs due to their non-effectiveness in managing the procedures. Some of the contractors are unable to compete with their counterparts who widely adopted and applied the OSC method because they lacked the necessary technology and

appropriate knowledge relative to controlling quality issues, productivity, and safety (Othuman Mydin, Sani and Taib, 2014). Especially, when the contractors are lacked the assembly technique of modular construction. For example, the prefabricated prefinished modules are required jointing techniques at the site. Hence, it is important for contractors to upgrade technical skills and capabilities to adopt the new changing technologies to remain competitive.

Not only that, but many of the construction companies are still decided to continue using the conventional method of construction. This was due to many factors, such as lack of infrastructure, lack of skills and knowledges, and lack of innovation (Rahimian et al., 2017). In nations where modular or off-site construction is already well-established, such as the UK, US, and Japan, these problems are less noticeable because of the presence of a stable supply chain in such nations, which includes factories that can produce components in supporting the modular construction market.

Lastly, only a small number of factories supply modular components in Malaysia. Hence, this will influence the use and deployment of OSC and modular construction in Malaysia. Therefore, there are many current studies have demonstrated the value of modular construction/off-site construction for developing the Malaysian construction sector. In order to transition from the conventional building method to the contemporary way of construction and sustainable construction approach, the Malaysian construction industry must choose a new and improved construction process (Musa et al., 2018).

2.4.1.5 Compatibility

modular construction/off-site construction offers many different functions. Modular building system provides value-added benefits, such as quality, portability, and flexibility. Also, modular construction provides the same purposes as conventional construction method. For example, not only single-story and low-rise buildings, but modular construction may also be used for multi-story and high-rise buildings. Therefore, without any limitations, this modern method of construction can be adopted by organizations in constructing all kinds of building projects.

However, the use of modular building system is still in its early stages in Malaysia's construction sector (Musa et al., 2018). Hence, hybrid method will be preferred by many organizations to let the modern and traditional method to function

together harmoniously and effectively. Due to the modular construction system is still in the developing stage in Malaysia, hence organizations can proposal certain parts of their work scope to be built by modular components. As a result, modular components are compatible with on-site construction method.

On the other hand, the modular building industry has started to grow and improve with the development of computers and Computer Aided Design (CAD) software. This is because the compatibility between modular system and software applications can ensure that the integrated or assembly system can be operated without issues. Thus, with the advancement of computer design and modular technology, the design and functionality of modular buildings and structures can be unique and different with those of any traditionally built construction, and it also enables the success construction of modular houses or buildings.

In conclusion, modular construction/off-site construction is compatible with the new technological developments such as Building Information Modelling (BIM) software have made the integration of modular units, delivery systems, and personnel much more convenient in handling and managing the process of construction (Musa et al., 2018). As a result, architects, contractors, and developers have recently made significant movement to the utilization of prefabrication and modular construction technology, exploring the new applications for the technology beyond the single-family house, as now high rise or tower can be built from modular units and prefabricated components. Therefore, nowadays modular construction system is widely adopted in the construction sector.

2.4.1.6 Relative Advantage

Modular construction/off-site construction can increase project efficiency because modular structures and components can be constructed simultaneously with the site. Based on research, projects involving modular construction can be finished 30% to 50% faster than those involving traditional method of construction. This is because 60 to 90% of the building structures are done inside of a factory, hence the possibility of delays by uncertainty event such as bad weather is reduced.

Besides that, three-dimensional (3D) or modular parts are constructed by utilizing high-quality materials and QA/QC management and control is using in the manufacturing process (Musa et al., 2018). Thus, the structural performance of modules can achieve and meet the higher standards. Also, the same building

standards that apply to conventional constructed structures on a site are used in modular buildings. The same building materials, such as timber, concrete, and steel are used to produce modular structures (Thirunavukkarasu et al., 2021). Therefore, this can show that the quality and safety of the buildings can be remained.

Moreover, modular building is movable and flexible in every aspect. The modular building can be relocated easily by removing the joints and connections since it is made up of three-dimensional (3D) parts or 2D-panelized. Also, modular components are modifiable, thus these units can be reused and moved to another location for refurbishment work or new projects development. As a result, these prefabricated modular components have reduced the amount of building material waste on the site by 10% as compared to conventional method of construction (Thirunavukkarasu et al., 2021).

Finally, competitive advantage has been used as one of the global business strategies and tools, including in construction industry (Tan, Shen and Langston, 2012). In order to achieve competitive advantage, construction firms can implement different techniques to compete in the competitive situations. By adopting modular construction, organizations can provide distinctive goods or services that are sufficiently different from those of their rivals and able to positively affect a buyer's choice (Sutrisna, Ramnauth and Zaman, 2020). This is because modular construction can offer higher-quality building structures with high levels of standardization, faster completion times, and less reliance on the skilled trades who are becoming harder to employ. Therefore, the adoption of modular construction/off-site construction is known as a source of competitiveness for the organizations (Sutrisna, Ramnauth and Zaman, 2020).

2.4.1.7 Trialability

Trialability is also considered as one of the factors that can influence the adoption decision of organizations. Trialability measures how much a potential adopter can test out and play around with the innovation before making a choice to adopt it (Sagini, Dianga and Mbiti,2016). Hence, a new technology or new method is more quickly accepted if it is available for the potential adopters to carry out experimentation. As a result, trialability can determine the rate of adoption of modular construction/off-site construction and it will be affected by how easily it can be tested before a decision to adopt it.

Besides that, trialability is the extent to which an innovation can be tested out on a small scale (Scott et al., 2008). Thus, partially prefabricated system is most suitable to be implemented in the trial stage, so organizations can try use and examine the modular construction method in terms of quality, compatibility, and feasibility. For example, hybrid buildings in Japan now builds 40% of its new buildings by adopting modular construction/off-site construction method and remaining 60% built by traditional site-built structure (Rahman, 2014). This is because a portion of the building may be difficult to pre-assemble in the factory, hence traditional site-built should be integrated (Rahman, 2014). For example, Japan now builds 40% of its new buildings by adopting modular construction/off-site construction method (Rahman, 2014).

Moreover, modular construction/off-site construction can be implemented completely or only in part is depending on the specific situation of site, such as site accessibility (Patelia, Pitroda and Bhavsar, 2013). Due to the size of the parts and modules for modular construction, some project locations with restricted access and limited on-site space would not be appropriate for this method. Also, modular construction method is not appropriate for smaller projects due to the high cost of transporting the larger constructed modules to the site. Others than that, modular manufacturer is limited, thus certain project locations can be far from the closest one. As a result, the requirement for long distance transportation of the huge and heavy components results in high transportation expenses, which will lead to higher overall costs than traditional methods.

In conclusion, the IBS pilot project was established by the Malaysian government with the goals to reduce uncertainty, accelerating adoption rate and achieving sustainability (Xue et al., 2021). As a result, the benefits of adopting modular or off-site construction can be observed by the construction companies. Therefore, this can also increase the confident level of organizations in implementing this modern method of construction since innovation require spending of time, energy, and money.

2.4.1.8 Observability

Observability is the extent to which an innovation’s outcomes are visible to the adopters (Scott et al., 2008). As a result, the invention is more likely to be adopted if it produces observable benefits after being implemented into practice. The

introduction of prefabrication has improved the worldwide construction industry. Many countries have recognized the benefits of modular construction/off-site construction. For instances, reduced waste, defects, costs, schedule, hazards to health and safety (HS), and negative environmental effects are all advantages of modular or off-site construction (Rahman, 2014). Therefore, modular construction/off-site construction has known as a promising new industrialized technology in construction industry.

Nowadays, many countries are adopting modular construction/off-site construction on a wider scale. This is because it has been proved to provide better value by improved quality and performance, minimized materials wastage and onsite modification, as well as decreased construction timeline by 30% to 50% (Farhana et al, 2015). In addition, the added values provided by modular construction/off-site construction method includes higher quality, higher flexibility, and movability (Ali et al, 2022). Also, it is applicable to all type of buildings, such as high-rise and multi-story building projects, single-story and low-rise buildings, office buildings, educational, and hospital facilities (Thai, Ngo and Uy, 2020).

Furthermore, modular construction/off-site construction has complied to the same building code requirements as traditional construction methods and the same building materials and standards are used to produce each module (Farhana et al, 2015). Also, all modules have proved to fulfil the building, safety, and occupancy code standards and in many situations these modular structures surpass the local building specification. However, the successful of this technology requires the integration of the manufacturers through a good collaboration and coordination.

Lastly, due to the worker shortage in Malaysia, the government has decided to start using pre-cast building materials in the construction sector (Othuman Mydin, Sani and Taib, 2014). It is mandated that at least 50% of the IBS technique be used in all civil construction projects, which result in cost savings, increased productivity, enhanced structure quality, and fasten completion time. Therefore, it is crucial for all project players in the building sector to get ready and start making efforts to maximize the potential of this modern method of construction.

2.4.2 Organisational Dimensions

In this section, six factors under organizational dimension will be discussed.

2.4.2.1 Organisational Scale

Organisation scale has been founded as one of the organisation factors that can influence on the adoption of modular construction/off-site construction. Organisation scale is defined as the organisation's resources, transaction volumes, or workforce size. Also, the adoption of modular or off-site construction is a continuous organisational process rather than a one-off occurrence. Therefore, the scale of the organization played a significant role in the adoption process of innovation (Lind, Zmud and Fischer, 1989).

Besides that, much previous research on organisational innovation have shown that organisational size has a favorable impact on an organization's capacity to adopt new technology. For example, large organizations have more complex and diversified facilities that support adoption (Lee and Xia, 2006). In contrast, small firms have limited resources, such as limited budgets, a lack of trained and skilled staff, a lack of knowledge and experience, and short-term management viewpoints, which results in increased barriers to the adoption of new technology. Therefore, the adoption of innovation is more often happen in large organizations than smaller organizations.

Moreover, the absence of qualified manufacturers producing modular components are forcing the organisations to produce those modular components by themselves, which has increased both the financial burden and managerial complexity. In this case, large organisations have an advantage over small firms because they can take on the risks involved in adopting new technologies, such as project cost overrun (Molinillo and Japutra, 2017). Conversely, small organisations may not be able to adapt new technologies, despite their diversity and dynamic nature. This is because small organisations may lack of fund in producing or sourcing these modular components. Therefore, there is a definite association between organisational size and the adoption of new technology (Ali et al., 2015).

In conclusion, it is argued that large organisations have more required resources for quicker technology adoption while small organisations have less bureaucracy and structural complexity that can also speed up the adoption of technology (Han et al., 2020). Also, due to the high initial costs of adopting this technology, an organisation's annual revenue, total assets, or market capitalization may also have an impact on the use of modular construction/off-site construction

(Rahman, 2014). Therefore, the size of the organisation directly influences on the adoption of innovative technology.

2.4.2.2 Organisational Readiness

Organisation readiness is also known as organisational preparedness which is described as having the necessary organisational resources available for adoption of innovation (Iacovou, Benbasat and Dexter, 1995). Any organisation's decision to adopt an innovative technology is influenced by certain organisational factors, such as the size of the organisation and the availability of resources (Chatterjee et al., 2021). Also, readiness includes technology infrastructure, necessary skills and human resources, as well as managerial commitment to embrace and integrate the new technology into existing organisation's operations (Maali et al., 2020). Hence, these are crucial factors that play a key role in evaluating organisational readiness for the adoption of modular construction/off-site construction.

Besides that, the readiness factor acts as a vital predictor of the adoption of new system in organisations, thus managers should clearly define the adoption strategy, ensure organization is ready to such adoption. To gain strong and committed sponsorship and active support from top management are important to ensure that the new system is reliable, actionable, and effective operate in the organization. Also, managers must keep key stakeholders informed on the urgency of such adoption. This is because employees will feel confined in their use of new technology if an organisation itself is not ready to use it, and they won't be able to see the value of adopting the new system (Chatterjee et al., 2021).

Moreover, the adoption of modular construction system in Malaysia is still at an initial stage, construction industry players are less aware and experienced. Hence, the lack of skilled workforce may be hindering the adoption of modular or off-site construction system among the construction firms and developers. Also, research shows that the need to address the skills shortage is stated as a significant barrier to the adoption of modular construction/off-site construction. According to Alonso-Zandari and Hashem (2017), the study shows that skilled labor shortage was the second most often chosen barrier, with 87% of people considering it to be a substantial barrier. Therefore, fewer people will want to learn about the modular building concept because there is less project take-up of such system.

In conclusion, it is essential to provide training programs related to the modular construction/off-site construction and also in the project management method for personnel within construction firms that are embracing this modern method of construction. Also, organisation can improve the management of modular or off-site construction projects by increasing funding to foster expertise, encourage technical innovation, and build information platforms. Therefore, these can impact on the organisation readiness for the adoption of modular or off-site construction.

2.4.2.3 Absorptive Capacity

In a competitive and changing environment of construction industry, continuous innovation is an important strategy for ensuring the survival of organisations. The absorptive capacity allows organisations to transform their acquired knowledge or technologies into new products or processes to improve their market position by responding to the different competitive challenges offered by the competitors (Sancho-Zamora et al., 2022). Hence, it is necessary for organisations to absorb new information from the external environment and use it internally to generate greater competitiveness in the industry.

In addition, the pressures from intense competition have also urge organizations to improve their processes and products in order to compete with one another in the industry. For example, advancement of construction method will also trigger the stakeholders to increase their investment on assimilating and exploiting the new technologies that can generate innovation benefits for the organisations (Kostopoulos et al., 2011). Thus, absorptive capacity has the potential to stimulate innovation and promote innovative achievements within organisations, thereby exerting a positive influence on their innovative performance (Mikhailov and Reichert, 2019). As a result, companies with a greater absorption capacity make better use of the information they receive from outside and improve their capacity for innovation (Sancho-Zamora et al., 2022).

Furthermore, absorptive capacity is necessary to be developed by organisations because it can help them to promote innovation and improve their performance by leveraging external knowledge sources (Kostopoulos et al., 2011). The examples of external knowledge sources include the transfer of skills and technology, the exchange of business practices, or the acquisition of tacit knowledge. Therefore, organisations must recognize, assimilate, and exploit these incoming

external knowledge flows to generate tangible benefits which can result in gaining increased competitive.

Finally, a high degree of absorptive capacity can help organisations to achieve exceptional innovation performance along with first mover advantages, short consumer response times, and the avoidance of "lock-out effects" and "competency traps" (Kostopoulos et al., 2011). Also, organisations that consistently invest in enhancing their business's absorptive capacity are more likely to capitalize on the changing environment of construction industry through developing commercialized output that can meet the demands of emerging markets (Zahra and George, 2002). Therefore, absorptive capacity enables organisations to adopt modular construction/off-site construction successfully.

2.4.2.4 Top Management Support

Top management support (TMS) is concerned with the level of commitment and resource support given by senior management to facilitate the adoption of new technologies. According to studies, senior management is aware of the significance of implementing modular construction/off-site construction that can provide benefits on project such as cost saving, improve quality, and shorten construction time. Other than financial aid, TMS is more concerned with allocating of human resources, promoting technology competence, and developing internal knowledge on new technology (Villaluz and Hechanova, 2019).

Besides that, studies have shown that top management support is positively connected to technology adoption given a variety of organisation factors most likely to impact it (Reyes, Li and Visich, 2016). Due to the integration of necessary resources and activities, senior managers play a crucial role in the adoption process of modular construction/off-site construction. For example, proper planning, coordination, and communication between various relevant project players engaged from the beginning of the project must exist for a modular construction project to be successful (Musa et al., 2016). Hence. the client, consultants, manufacturer, contractor, and supplier must all be involved from the start of a modular building project.

Furthermore, the long-term cost savings of modular construction/off-site construction are obvious, but some developers are more concern about the initial investment in machineries and training (CIDB, 2016). Also, due of high borrowing

rates and low profit margins of projects, developers are extremely careful with their expenses. Thus, the burden of investing in labours retraining or buying expensive equipment may seem like a barrier for the adoption of modular construction/off-site construction. Especially in Malaysia that employing foreign labour is cheap. As a result, the degree of top management support is a factor in determining modular construction/off-site construction adoption.

Lastly, the senior management should make sure that commitments are made to help those involved in adopting innovation to grow their internal competence. This is because organisations need management support to pursue new business models in their operation (Nguyen, Le and Vu, 2022). Hence, TMS is a vital booster for the adoption of modular construction/off-site construction. Therefore, top management support is considered as a key factor in determining whether a new system installation can be successful or unsuccessful (Sargent, Hyland and Sawang, 2012).

2.4.2.5 Human Resources

Human resources are included of internal resources and external resources of the organization. According to the research, the lack of knowledge and expertise of an organization is considered as one of the major barriers to the adoption of modular or off-site construction (Gan, Chang and Wen, 2018). The organization's internal expertise is referred to the qualified human resource of the organization who can help them to embrace new technologies. On the other hand, the adoption of modular construction/off-site construction will also be affected by the manufacturers and suppliers of modular components, which are consider outside of the organisation’s control. Hence, internal and external resources have been identified as factors of human resources that will impact on modular construction/off-site construction implementation.

Moreover, the lack of knowledge and expertise is mostly due to the fact that existing civil engineering and architectural programs rarely give comprehensive study of modular or off-site construction (Gan, Chang and Wen, 2018). In Malaysia construction industry, even though employees have the necessary skills, they must also update their knowledge, especially in shifting from traditional approaches to new modular building processes (CIDB, 2016). This is because inadequately qualified project members may cause serious issues to modular construction such as poor structural performance and cost overrun (Polat, 2008). Therefore, all project

players must understand and agree that the new building approach is the most efficient way to boost productivity and improve overall project performance.

In addition, the government of Malaysia is also encouraging the use of modular construction/off-site construction. This is because the adoption of this new technology can help reduce the number of foreign workers in the Malaysia construction industry. Around 90% of the construction workforce is made up of foreign employees (CIDB, 2016). Thus, the Malaysian government aspires to limit foreign labour reliance to 15% by 2020, and the utilization of the modular or off-site construction is expected to aid in attaining this objective within the construction industry. As a result, the push for adoption of this new building approach in the construction industry is likely driven by the objective of promoting local employment and skill development while addressing the challenges posed by foreign labor dependency.

Last but not least, the restructuring of human resource in an organisation in terms of training and education is required for the transformation process (CIDB, 2016). Hence, enhanced training programs are required to develop specialized skills in areas such as system integration and assembly for the modular construction/off-site construction. This is because the approach to modular construction/off-site construction is differ significantly from traditional on-site construction, leading to confusion and occasional hesitation among project owners, architects, and construction professionals and contractors. Consequently, the required knowledge and expertise of modular construction/off-site construction are important in the new technology implementation process.

2.4.2.6 Managerial Support

As compared to conventional construction approach, the implementation of modular construction/off-site construction demands more time and effort in pre-project preparation and stakeholder requires to early involvement (Gan, Chang and Wen, 2018). Thus, it is critical that the client, consultants, manufacturer, contractor, and supplier get involved in the beginning stage of a modular building project. This is because amendments made in the middle phase of a construction project will be problematic and costly, especially in the modular construction project (Musa et al., 2016). For example, mechanical and electrical (M&E) services must be designed before the production has been started because any adjustments made beyond this

point will be expensive and time consuming. Thus, a high degree of integration among relevant parties is necessary for the adoption of modular construction/off-site construction because multiple stakeholders are involved (Arashpour et al., 2016).

Besides that. one of the main obstacles to implement this new technology has been identified as the inadequate coordination as a result of the nature of building industry. Construction sector involves 13 types of stakeholders which includes developers, supervisors, designers, manufacturers, government, contractors, researchers, financial institutions, lawyers, consultants, the public, suppliers of material & equipment, and logistics enterprises. The quality assurance and project progress will be affected by lacking timely and efficient of information communication. Thus, intense coordination is significant to ensure that high information exchange is achieved (Wu et al., 2021). As a result, organisation can overcome the difficulty of developing a collaborative relationship between stakeholders by creating an information exchange platform to facilitate communication among stakeholders (Gan, Chang and Wen, 2018).

Furthermore, the opinions provided by each of the project stakeholders working together to act or make decisions in a meeting while following to the shared rules, contracts, and structures are important to ensure the successful implementation of new technologies (Gan, Chang and Wen, 2018). However, this collaborative process will be affected by various factors such as different concerns, conflicting opinions, and complicated of relationships between the stakeholders. Hence. it is important to understand the importance of each stakeholder since the success of participant cooperation is mostly depends on harmonizing the opinions of the many stakeholders in achieving the consensus.

Last but not least, collaboration among stakeholders is the only way to gather the knowledge, information, technology, and other resources needed to overcome the difficulties faced during the adoption process of modular construction/off-site construction. However, it is challenging to manage numerous stakeholders to implement modular construction/off-site construction because each stakeholder possesses own interests that may oppose with one another. Therefore, communication channels among stakeholders should be improved by organisation to promote similar principles and attitudes towards the adoption process, so that they can provide an effective assistance in ensuring successful implementation (Gan, Chang and Wen, 2018).

2.4.3 Environmental Dimensions

In this section, four factors under environmental dimension will be discussed.

2.4.3.1 Market Demand

In accordance with international efforts to protect the environment, a new green policy that promote the use of modular components are promoted by the Malaysia government (Musa et al., 2016). The modular components that produced in a controlled environment can achieve sustainability in the construction industry. For example, since the modular units are produced in factories, modular construction can reduce waste by effectively managing their inventories and protecting their building materials. Therefore, the adoption of modular construction/off-site construction will be increasingly adopted by organizations because it has a positive environmental impact, eliminate waste, greatly reduce site activity and disruption, and inherently promote sustainability.

In addition, environmental policy such as precast rate limitations, financial support, and reduce harmful environment have risen the market demand for modular or off-site construction projects (Xue et al., 2021). However, the demand for prefabricated houses will be affected by the customers' resistance and doubt on modular components. This is mainly because they are not aware of the advantages about modular construction/off-site construction. Also, the problems with social acceptance which prefabricated housing is seen negatively by public. As a result, the market environment served as an essential factor for advancing modular or off-site construction development.

Furthermore, the market environment where there are insufficient demand and support will also restrict the adoption of modular construction/off-site construction (Gan, Chang and Wen, 2018). Due to the little demand from the market, the adopters seem like extremely difficult to get their return on investment, which may make it difficult to get finance from financial institutions. Thus, construction projects that adopt modular construction/off-site construction did not always result in earnings (Sutrisna, Ramnauth and Zaman, 2020). For instances, the lack of consistent demand, organisations may be unable to achieve the anticipated level of efficiency from using it.

In conclusion, the Malaysian government is taking the initiative to modernise and achieve sustainability in the building sector (Musa et al., 2018). Thus, Malaysia

construction industry must opt for an improved construction technique by shifting from a conventional building method to a sustainable construction approach. The adoption of modular or off-site construction is consistent with and appropriate for the government's objective in Malaysia. Therefore, it can help to promote sustainability by generating less waste, better-quality goods, and less harm to the environment and ecosystems.

2.4.3.2 Competitive Pressure

The market requirement was essential for the development of modular construction/off-site construction because it can influence the developers' behaviors through market signals rather than through policy control (Xue et al., 2021). Developers may be forced by the fierce rivalry to adopt modular or off-site construction to compete for market share in the construction industry. Organizations who adopt modular construction can gain competitive in the market, thus developers will actively contribute and put more effort into promoting this technology. Also, the large market demand of this technology is a significant indicator for developers to start investing in new construction technology. As a result, the intense rivalry in the market requires adaptive strategies from developers for adapting to the new methods of construction.

Besides that, social concerns of government or society on modular or off-site building projects will also lead the construction companies to adopt this new technology. For example, recently the establishment of demonstration and trial projects is the main strategy used by the Chinese government to promote this modern method of construction (Gan, Chang and Wen, 2018). While in Malaysia, government has established a requirement stipulating that government projects valued at RM10 million should incorporate 70% of IBS components (Azman et al., 2010). Therefore, developers are encouraged to study the market requirement because government can optimise the market structure by adjusting the implementation of promotion policy, market demands, and prospective earnings (Xue et al., 2021).

Moreover, the rapid development of the construction industry has a negative impact on the environment. As per the International Energy Agency, the construction industry is responsible for the highest energy consumption and carbon dioxide emissions (Jiang et al., 2019). The construction projects that still using traditional

methods is no longer appropriate for sustainable projects (Wu et al., 2021). Also, stakeholders were compelled to adopt modular construction/off-site construction method through regulations and rules that demanded the utilization of cutting-edge materials and imposed restrictions on carbon emissions (Luo et al., 2021). Thus, modular or off-site construction is well-suited for promoting sustainability efforts (Hosseini et al., 2018).

Finally, the Malaysian government is actively engaged in modernizing and striving for sustainability within the construction sector. However, the situation of the Malaysia's construction industry is not consistent with the future direction of Malaysia. This is due to the poor quality, low productivity, lack of environmental friendliness, lack of safety, and over-reliance on non-skilled foreign labours (CIDB, 2003). As a result, modular construction/off-site construction has increasingly gained attention and been pushed in the construction sector for meeting the rising need for environmental protection, sustainable development, and modern buildings.

2.4.3.3 Government Support

The government of Malaysia is aware of how critical it is to have a capable construction industry that is supported by innovative building technologies (Azman et al., 2010). Hence, Malaysia government has collaborated with Construction Industry Development Board (CIDB) on leading the industry to adapt the fundamental use of IBS components and carried out awareness campaigns on application of IBS. They promote the adoption of IBS through multiple programs, including the accreditation of IBS courses, organising seminars to raise awareness about IBS, offering assistance for training, and endorsing its application in construction projects (CIDB, 2016).

Besides that, government may also provide incentives like tax reduction measures or cost-cutting initiatives for public building projects (Zhang, Skitmore and Peng, 2014). In Malaysia, firms who employed modular construction/off-site construction on projects will be given tax incentives (CIDB, 2016). For example, the governments of Beijing and Shanghai are prioritizing tax incentives and obligatory regulations because the increase in construction costs can be ignored due to the high housing prices (Xue et al., 2021). Therefore, public policies and regulations are essential in promoting the adoption of modular construction/off-site construction.

Furthermore, the construction industry has been seen as a low-technology sector with limited investment in research and development operations. Thus, additional research funding should be allocated by the government to support researchers who specialize in construction innovation. Also, the OSC approach is often not chosen by developers due to its high initial expenses, inadequate technical integration, and limited market acceptance (Hong et al., 2018). As a result, guidelines and incentives provided by the authority play a crucial part in raising the development of modular construction/off-site construction.

Others than that, government should initiate modular construction/off-site construction's pilot project to minimize uncertainties, and they mandated a predetermined precast usage rate in public projects to encourage stakeholders to adopt this new construction method (Luo et al., 2021). For example, by 2020, the precast rate should reach 30% in a number of significant cities in China, including Beijing and Shenzhen. Also. the government of Malaysia has launched a pilot project for the industrialized building systems (IBS) with the goal of accelerating project delivery. Not only that, in the 2016 Budget, the Malaysian government committed to provide RM500 million in soft loans to developers and contractors who embrace this construction approach (CIDB, 2016).

In a nutshell, differentiated policies should be implemented by the government in the construction industry. This is because government policies have the potential to enhance stakeholder engagement in the development of modular or off-site construction (Wu et al., 2021). For example, to encourage developers to choose OSC techniques, a variety of policies have been developed, including legislation, regulations, tax allowance, financial incentives, support for land development, and aid with trial projects. Therefore, by providing financial subsidies can lead to a reduction in the increase of construction costs that can simulate developers' willingness to adopt the modular construction/off-site construction method (Xue et al., 2021).

2.4.3.4 Trading Partner Readiness

Since the beginning of the 21st century, there has been a consistent and increasing interest within the architecture, engineering, and construction (AEC) sector towards adopting and advancing modular or off-site construction (Hosseini et al., 2018). However, most of them are lack of understanding of the fundamental principles

behind modular construction/off-site construction. Thus, this technology in current construction industry is still small, immature, undeveloped, and slow. Also, the extensive use of modular construction/off-site construction requires a shift in people, method, working culture, communication, and business models (Hosseini et al., 2018). As a result, these have posed the challenge of adopting modular construction/off-site construction.

First, based on the research, the main obstacles faced by the trading partners are lack of knowledge and expertise and the predominance of traditional project management method (Gan, Chang and Wen, 2018). Also, this is supported by (Luo, Zhang and Sher, 2017), there are lacking expertise and experience of industry professionals in design, construction, or management of modular or off-site construction. Hence, the adoption of modular or off-site construction might present a considerable obstacle for trading partners who possess expertise primarily in the traditional cast-in-situ approach.

Besides that, the completion timeframes of off-site project are significantly impacted by the level of resource availability of trading partners (Arashpour et al., 2016). This is because availability of required resources can decrease completion time and increase workflow continuity in off-site projects. In modular or off-site construction projects, equipment and materials are considered as critical resources and laborers such as machine operators and skilled labours are often contributed to the production and assembly of modular components. For example, in a contractor firm with many projects in progress, their supervisors will compete frequently with one another to get the capable personnel for their own project. Therefore, the level of resources availability of an organization will affect the performance of off-site projects.

Furthermore, the risk aversion behaviour of trading partners will also affect the adoption of modular construction/off-site construction. Some organizations are willing to absorb the impact of various risks such as late completion risk and investment risk while other company intends to be very risk averse to minimize the risk of taking up modular or off-site construction (Arashpour et al., 2016). The deepening design cost, risk of modular components' transportation and installation, as well as costs of machine and skilled labours are responsible for the high capital cost. Hence, the adoption of OSC requires higher capital expense than the traditional construction methods.

In conclusion, as modular construction/off-site construction technology is still evolving, there are certain existing technical challenges, such as transportation, logistics, and structural performance problem (Wu et al., 2021). So, it is important to ensure a seamless sequence of fabrication, transportation, and erection in minimizing any potential delays and cost overrun. For instances, the inspection of modular production for the building project can be difficult because the modular components are manufactured in factories. Therefore, it is critical to determine the experience of manufacturers through reviewing their past projects, expertise, and licenses to ensure that they have the necessary skills for the building project.

2.5 Project Performance

Many organisations report that the productivity benefits of decreased project schedules, reduced project budgets, and improved quality are the key drivers that affect the adoption of modular construction/off-site construction (SmartMarket Reports, 2011). This is because construction companies who can achieve time saving and even small cost reductions will have a significant impact on the performance of their construction projects, especially when profit margins are reduced by the labor-intensive and higher cost of onsite construction method. Therefore, modular construction/off-site construction can provide the elements of productivity in terms of project schedule, cost, and quality.

Besides that, the increasing demand for speeding up project delivery, cost reduction, and quality enhancement of building projects have boosted the adoption of modular construction/off-site construction. This is because this method has satisfied these three key requirements. Also, modular construction/off-site construction is considered as one of the prefabrication methods that is gaining popularity around the construction sector in the world. The construction sector is increasingly using these prefabricated structures in response to the increasing demand on improving construction efficiency (Hořínková, 2021). Therefore, many construction projects are planning to implement modular construction/off-site construction method because they see cost, schedule and quality benefits.

2.6 Conclusion

In a nutshell, the most important driver to the current usage of prefabrication and modularization is the ability to improve productivity and enhance environmental

sustainability. Hence, construction companies are starting to implement modular construction/off-site construction in their existing construction system. Also, the requirements of building projects are getting more complicated in terms of time, cost, and quality. Thus, on-site traditional construction method is no longer suitable for meeting the high level of requirements of today's building projects. So, the modular construction/off-site construction has been introduced in the construction industry and adopted by many construction companies around the world. However, the factors which can influence on the adoption of this method is important to be identified in order to improve the implementation process. Therefore, TOE frameworks have been used to discuss the adoption factors of modular construction/off-site construction.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

The logical process of research methodology involves the formulation of essential philosophical assumptions and values (Morenikeji, 2006). Research methods are considered as important tools used by researchers to collect data (Nieuwenhuis, 2016). Hence, research methodology outlines and assesses methods to gain a deeper comprehension of its assumptions and research findings (Igwenagu, 2016). As a result, this chapter will discuss research methods, research process, data collection methods, data analysis methods, and research conclusions.

3.2 Quantitative Versus Qualitative Research

Research methods include quantitative and qualitative (Maree, 2016). Qualitative methods typically focus on non-numeric data, whereas quantitative methods primarily analyse a context using numerical data and depend on various statistical analysis techniques (Creswell, 2014). Quantitative research methods enable the numerical gathering of data, which is then organized and subjected to statistical analysis, often using a questionnaire survey as the data collection instrument (Saunders et al., 2016). On the other hand, thematic analysis is used in qualitative research methodologies to uncover themes and trends among the research respondents, which in turn develop a more in-depth understanding of research variables and their relationships (Creswell, 2014). Often, interview questions will be adopted in qualitative research.

3.3 Survey as the Research Method

A quantitative measurement of variables from a field survey was the most appropriate approach that has been adopted in this research study. This is because the validity and reliability of research can be achieved by the employment of this methods (Saunders, Lewis and Thornhill, 2012). The questionnaire survey was developed to collect data from the developer, consultant, and contractor firms in Klang Valley, Malaysia.

Besides that, an appropriate research method can help to quantify research variables to measure their individual responses in a research study. For example, questionnaire that enables the economically efficient collection of high-quality data from the population and effortless comparison of collected data is more appropriate for a survey (Saunders, Lewis and Thornhill, 2012). Especially in a study aiming to get feedback from a larger group of respondents, a questionnaire survey has been recognised as the most appropriate method of data collection (Robson, 2011).

3.4 Research Process

The necessity for study on this topic was formed as a result of the issues of the construction sector that were clearly outlined in the problem statement, with the theoretical gap highlighted. After that, the research process is consisting of literature review and data collection method. The first phase is a discussion about literature review. Researcher will study the related literature and articles on the topic of this research. The second phase is data collection. In this phase questionnaires were being done among the developer, consultant, and contractor firms to gain the research objectives.

3.4.1 Literature Review

Literature reviews play an important role as a foundation for various form of research projects. Through reviewing literature, it allows the researcher to understand the current state in the research area that is related to the ongoing research topic and to identify research gaps. In this research, it was used to investigate and identify the potential factors for the adoption of modular construction/off-site construction in construction sector around the world. Additionally, a literature review is also a great way to identify research areas that require further investigation, which is essential for developing theoretical frameworks (Snyder, 2019).

3.4.1.1 Purposes of Literature Review

The purpose of conducting a literature review is to provide the background to and justification for the research being conducted. The aim of the literature review is to describe the previous research to map and assess the research area to justify the research question (Snyder, 2019). Thus, a comprehensive literature review was used to determine the relevant factors for the adoption of modular construction/off-site

construction. A total of 18 adoption factors and their relevant explanations for each factor was identified after the literature review process. In addition, the secondary source data from the literature was also used to supplement the primary data during analysis. As a result, literature reviews are useful to provide an overview of a certain issue or research problem by advancing knowledge and facilitating theory development.

3.4.1.2 Literature Review Development

In literature review, the right procedures must be followed for guaranteeing the review is accurate, precise, and reliable. In this research, two rounds of screening were carried out after the collecting of relevant articles to this research topic. The first step is to scan the article title and abstract to filter the data for ensuring that content of this article is matching to the research scope. The second step is to read the content of article to identify the relevant data that can be used in the research. In this study, the focus is on examining modular construction/off-site construction in the construction industry. In the end, a sum of 59 articles was gathered to undergo further analysis. As a result, the 18 adoption factors have been identified and explained from the literature analysis.

3.4.2 Questionnaire

The survey questionnaire is considered as the most appropriate data collection method when research is aiming at collecting input from a broader range of respondents. Due to questionnaire survey can cover a wide range of data scope and data collected can be analysed through statistical analysis, the method of questionnaire survey has been employed by several previous research as an efficient tool for gathering stakeholders' thoughts and opinions relevant to modular construction/off-site construction implementation (Zhang, Skitmore and Peng, 2014).

3.4.2.1 Purposes of Questionnaire

The survey questionnaire in this research was designed to better understand the factors for the adoption of modular or off-site construction in construction organizations within Klang Valley, Malaysia. It is aimed to determine the opinions of construction firms, including developers, consultants, and contractors on the adoption factors that might increase the likelihood of modular construction/off-site

construction implementation in construction projects. Also, the critical factors influencing the adoption of modular construction/off-site construction in Klang Valley, Malaysia will be classified in this survey. This is because the identified factors will be quantified for data analysis purposes.

3.4.2.2 Selection of Questionnaire Respondents

In this research, Klang Valley was selected as the study area due to the high development of housing project in this area. The questionnaire survey is specifically focused on developer, consultant, and contractor firms within the construction industry as its target respondents. Construction firms were randomly selected form the study area and project players in each of the selected firm was administered with questionnaires. Hence, in this study, the snowball sampling method was utilised. This method is very helpful when the needed respondents must have relevant expertise in certain sectors since it enables the approach to a broad population through the respondents' social networks (Luo et al., 2015). For example, this sampling technique allows the respondents to suggest additional potential respondents to participate in the survey. Hence, it allows the participant population growth while still maintaining the population's credibility measures.

Questionnaire was distributed among the developer, consultant, contractors who have possess abundant knowledge and experience in construction industry. Online searches were used to establish the target participants in the sample sets. For instance, company websites and LinkedIn were used to identify job roles and valid email addresses for targeted employees. Thus, those employees with senior or managerial positions within development, consultant, and construction were targeted. After completing the questionnaire, these respondents were encouraged to disseminate it to their colleagues. Therefore, it allows researchers to efficiently and cost-effectively gather a relatively large number of completed questionnaires in a shorter timeframe as snowball sampling method is selected.

In conclusion, this study uses a non-probability sampling approach because it is difficult to discover the accurate population size of the respondents. When the overall population number cannot be determined, this strategy is typically used (Saunders, Lewis and Thornhill, 2012). The used of snowball sampling approach is a kind of non-probability sampling method that is often used when it is difficult to

identify the intended target population. Hence, by using this approach the respondents can find other professionals who share their characteristics, which qualifies and allows them to take part in the study.

3.4.2.3 Questionnaire Development

A well-structured questionnaire was generated for primary data collection and result analysing process. The questionnaire involves a brief demographic part, and 18 questions were asked on each factor of the TOE framework on modular construction/off-site construction adoption.

In this study, the full questionnaire consists of two main parts. The first part focused on respondent's demographic information in terms of organisational types, category of work, respondent's position in the firm, and years of working experience. Demographic information was collected to understand the background of respondents who completed the questionnaire in order to reduce the risk of bias impacting results. The second part asked respondents the extent to which they agreed with statements regarding the 18 adoption factors that influence on modular or off-site construction adoption by using a 5-point Likert scale (i.e., 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree). In order to get respondents' opinions on a variety of assertions, a Likert scale is suitable (Collins, 2010).

Besides that, a pre-test was accomplished to enhance the survey instrument's reliability. The participants in this pre-test will contribute to the improvement of the survey's content, breadth, question structure, and answer scales. In this research, a pre-test was conducted with 2 professionals from each group that was taken into consideration, including 2 of those experts coming from developer firms, 2 from consultant firms, and 2 from contractors' firm to make sure the respondents could understand the questionnaire. Therefore, the results of the pre-test demonstrate that the questionnaire is reliable and clear enough for general respondents.

The questionnaire assessed 18 factors of TOE framework that were summarized into three perspectives, including technological dimensions, organisational dimensions, and environmental dimensions. 1) technological dimensions, including perceived usefulness, perceived ease of use, technology optimism, technological capability, compatibility, relative advantage, trialability, and observability. 2) organisational dimensions, including organisational scale,

organisational readiness, absorptive capacity, top management support, human resources, and managerial support. 3) environmental dimensions, including market demand, competitive pressure, environment support, and trading partner readiness. All the above factors were measured by using the five-point Likert scales with the response options: strongly agree (5) to strongly disagree (1).

3.4.2.4 Questionnaire Administration

In this research, the administration of the structured questionnaire that was created in a standard format has been delivered to the developer, consultant, and contractor firms in Klang Valley, Malaysia. Due to the time advantage of automated data collection, an online platform was used to distribute the questionnaire survey. However, paper-and-pencil surveys were also conducted in this research for respondents that are not technology savvy, such as older people who has abundant experience in construction industry. The structured questionnaire was distributed through electronic means (Google Forms) and offline surveys through snowball sampling technique amongst the construction industry professionals in Klang Valley, Malaysia. Also, the survey was sent out through email with a Google Form Link attachment to enable online replies.

The questionnaires were distributed in Klang Valley, Malaysia from November 1st, 2023, to November 20th, 2023. It is impossible to determine the exact number of distributions because the potential respondents were asked to give the questionnaire to anybody else that they believed would be appropriated. In this survey, a total of 63 were received. These 63 responses were used to assess the adoption factors of modular or off-site construction in Klang Valley, Malaysia. The sample size of this study is regarded as appropriate for factor analysis process as small sample size is adequate and has the potential to provide satisfactory results (de Winter*, Dodou and Wieringa, 2009).

3.5 Data Analysis Procedure

Data analysis procedure is a process that needs to analyse the data collected from survey. In this research, quantitative analysis was undertaken on the data gathered from the questionnaire survey. Hence, Statistical Package for Social Sciences (SPSS) software (version 26) will be used to analyse the data collected from the questionnaire. All the collected data will be evaluated, summarized, and presented to

describe a situation. Results from SPSS will be showed in tables through descriptive method. This is because huge quantities of data can be generalized and filter into simple statistics (William, 2020).

In this research, mean rank method and factor analysis method were employed to identify and analyse the results from the questionnaire survey. The analysis of the questionnaire results which involving of 5-point Likert scale (ranging from Strongly Disagree to Strongly Agree) was conducted by allocating the values of 1, 2, 3, 4, and 5 respectively to the weighting (w) with. The targeted respondents expressed their perceived agreement on a scale from 1 (strongly disagree) to 5 (strongly agree) on 18 adoption factors to the modular construction/off-site construction. Therefore, data gathered with questionnaire survey can be analysed in a descriptive manner.

3.5.1 Analysis and Ranking of Factors

In this research, all the data gathered from the survey questionnaire was subjected to an extensive statistical analysis. Three expert groups, namely developer's companies, consultant's companies, and contractor's companies within Klang Valley, Malaysia were being known as the targeted respondents for this study. The data collected from the survey questionnaire was summarised by the researcher using descriptive statistics. The mean scores of each factor were calculated to rank the eighteen factors. The reason for choosing descriptive statistics were because the developed questionnaire is ordinal (five-point Likert scale) and hence statistical tests are especially efficient when illustrating quantitative data. This approach has been adopted in various studies to rank the factors in the research study (Olanrewaju et al., 2021). For instances, the 2 main types of descriptive statistics which include the measures of central tendency (mean, median, and mode) and measures of dispersion (variation and standard deviation). Therefore, these approaches can provide a broad view of dataset in identifying trends and relationships.

3.5.2 Conducting the Factor Analysis

Exploratory factor analysis (EFA) is selected in this research study due to it is not limited by priori information. EFA is employed in this study to analyse the collected data and identify several common components (also known as common latent

variables) through dimension reduction and classification (Goretzko, Pham and Buhner, 2021).

Finally, a formal exploratory factor analysis is implemented. The extraction commonality of each variable in the exploratory factor analysis is more than 0.5. As a result, the principal component method of extraction and varimax rotation was applied (Hinton et al. 2004). So, eigenvalues greater than 1 for the extracted components were considered. This is because an eigenvalue less than one indicates that the component can only explain no more than one original observable variable. Hence, the selected components can be known as the common components or also called as the common factors or the common latent variables. In addition, factor loadings greater than 0.30 were considered to represent any considerable relationships between the extracted components in the varimax rotation method (Howard, 2016).

3.6 Research Ethics

Research Ethics is referred as the code of conduct or ethical behaviour when conducting research (Bodla 2006, p. 25). Thus, ethical behaviour should be remained in each step of the research process, which including data collection, data analysis, reporting, and distribution of questionnaire. To ensure accuracy as well as maintaining ethics in conducting research, the required ethical approval forms of the well-structured questionnaire was submitted and approved to gain ethics clearance. The Head of Department and Ethics Committee at the University of Tunku Abdul Rahman approved this form.

Besides that, all the data will be collected in a transparent manner without any prejudices. Also, it was made clear to all the respondents that they were under no obligation to take part in the research and might withdraw at any moment. This is due to the fact that all participants are offered the option of participating in the study questionnaire. In addition, information that may be used to identify respondents was kept privately with the research. Hence, all participants will be remained anonymous throughout the study. Lastly, only the researcher for this study had access to the records of the information submitted for this research project. All information will be kept confidential to avoid any harm or risk.

Conclusion

All the collected data will be analysed before it will be concluded. The entire research design and process of this study will be shown in this phase. In order to achieve the research objectives, the adoption variables were determined, and a questionnaire survey was created. Questionnaires will be distributed to the targeted respondents for collecting data that will be analysed by quantitative methods. Therefore, the analysis of data can help to draw conclusions of the research objectives.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Introduction

In this chapter, data collected from survey questionnaire has been analysed by Statistical Package for the Social Sciences (SPSS) software. The brief description of the respondent demographics and reliability test result for the three sections of the questionnaire will be present and discuss. Also, quantitative analyses conducted the mean ranking, Kaiser-Meyer-Olkin and Bartlett's test, total variance, and rotated component matrix to determine the factors for the adoption of the modular or off-site construction. Lastly, a short conclusion will be summarized in the end of this chapter.

4.2 Respondent's Demographic

There are altogether 63 sets of questionnaires were collected from developer, consultant, and contractor firm through LinkedIn, email and social media. In this survey, 3 types of construction companies have been targeted as the target respondents. Less than one month was spent for gathering the data. The survey data were gathered and tabulated in table 4.1 and it shows the construction companies' frequencies and percentage across four different categories of attributes. There are 23.8% from developer firm, 33.3% from consultant firm, and 42.9% from contractor firm. Besides that, 71.4% of respondents are involve in building work and 28.6% of respondents are involve in non-building work. Table 4.1 also revealed that 15.9% of respondents are from upper management, 60.3% are from middle management, and 23.8% are from lower management. Moreover, most of the respondents (69.8%) have less than 5 years of working experiences, while the remaining 30.2% of respondents have working experiences over 5 years in the construction industry. Lastly, the data collected for this study are regarded as adequacy as the sample used as much as 50 already meet the Measure of Sampling Adequacy (Istiyono, 2019).

Table 4.1: Demographic of sample of 63 Respondents

General Information	**Frequency (n)**	**Percentage (%)**
Type of organization		

Developer	15	23.8
Consultant	21	33.3
Contractor	27	42.9
Category of work		
Building	45	71.4
Non-building	18	28.6
Position in the firm		
Upper management	10	15.9
Middle management	38	60.3
Lower management	15	23.8
Years of working experience		
Less than 5 years	44	69.8
5 years and above	19	30.2

4.3 Mean Ranking

In this section, the mean value collected from the respondent's overall rating scale in as a measure of importance of the factors of TOE framework towards the adoption of modular construction/off-site construction will be presented and discussed.

4.3.1 Descriptive Statistics on Factors for the Adoption of Modular or Off-site Construction.

Table 4.2: Ranking on the factors of TOE framework for modular construction/off-site construction *adoption*

Factors	Mean	Std. Deviation	Ranking
F12: Top management support	4.2063	1.00256	1
F14: Managerial support	4.1270	1.00791	2
F06: Relative advantage	4.0476	.77102	3
F02: Perceived ease of use	3.9841	.85179	4

F04: Technological capability	3.9524	.81178	5
F15: Market demand	3.9365	.87755	6
F01: Perceived usefulness	3.9206	1.02078	7
F10: Organisational readiness	3.9048	1.01146	8
F18: Trading partner readiness	3.8889	1.01776	9
F09: Organisational scale	3.8730	.88886	10
F05: Compatibility	3.8571	.77993	11
F03: Technology optimism	3.8413	80735	12
F07: Trialability	3.8413	.84637	13
F13: Human resources	3.8413	1.01927.	14
F08: Observability	3.8254	.90767	15.5
F16: Competitive pressure	3.8254	.90767	15.5
F11: Absorptive capacity	3.7778	.86964	17
F17: Government support	3.7778	1.06928	18

Based on Table 4.2 above, it has shown the result of mean value to rank the factors of TOE framework towards the adoption of modular or off-site construction. The higher the value of mean indicates the higher extent that respondents agree on the factors are important towards the adoption of modular construction/off-site construction. Also, respondent agreement is consistent with the reported mean value when the standard deviation value is less than 1.0. (Field, 2013).

According to table 4.2, eighteen factors for the adoption of modular construction/off-site construction are identified and analysed from the perspective of developer, consultant, and contractor firms, and the top five adoption factors are “top management support” (mean value = 4.2063), “managerial support” (4.1270), “relative advantage” (4.0476), “perceived ease of use” (3.9841), and “technology capability” (3.9524). Hence, the top management support is the primary factor affecting the modular or off-site construction adoption. This is because existing managers are mostly transferred from on-site construction method to modular buildings, thus lacking the experience to manage the modular buildings (Yuan et al., 2020).

Besides that, managerial support is also important as managers are the key to the success of a task, especially in construction industry (Yuan et al., 2020). Hence, in order to increase the capability of managers and employees, internal training or

external recruitment is suggested. Next, the relative advantages of modular or off-site construction will also influence the adoption intention of organisations. This is because the features of modular construction method can enhance the existing practice, hence the chances to be adopted will be increased.

Moreover, as we all know the simple and user-friendly technologies will be more likely to be adopted by organisations. Hence, when modular construction/off-site construction can be perceived as simplicity, the adoption rate will be increased. According to Khemthong and Roberts (2006), adoption uncertainties and risks are the critical adoption predictor which can be reduced by perceived ease of use. The fifth factor is technology capability. Technology capability of an organization can influence on the utilization of new technologies. Hence, costs can be reduced while improving quality, delivery, and flexibility as new technologies can be performed well in the organisation's daily operations.

Furthermore, the adoption factors that rank 6^{th} to 11^{th} are "market demand" (3.9365), "perceived usefulness" (3.9206), "organisational readiness" (3.9048), "trading partner readiness" (3.8889), "organisational scale" (3.8730), "compatibility" (3.8571). Market demand and perceived usefulness will also influence on the adoption of modular or off-site construction as they can increase the competitiveness of organisations in the marketplace. Factors that rank 8^{th} to 11^{th} still require improvements in terms of management and training for innovation.

In addition, the factors that rank 12^{th} to 14^{th} are "technology optimism" (3.8413), "Trialability" (3.8413), and "human resources" (3.8413). According to Field (2013), when there is same mean value on factors, the lower standard deviation represents higher of importance of factor. Hence, the rank of these 3 factors will be determined by their value of standard deviation. Technology optimism and trialability may require by the modular construction/off-site construction method to increase their probability to be implemented by an organisation. While human resources of an organisation will also affect the adoption process because qualified labours are important to manage the system efficiently and effectively.

Other than that, observability and competitive pressure are ranked as 15.5^{th}. As these two factors share the same mean value and standard deviation value, hence they need to share the ranking by implementing shared rank method (Naoum, 2019). According to Jilani et al (2022), the greater the observability of a technology, the higher probability it will be adopted by an organisation. Hence, observability can

attract an organization to implement a new technology. Whereas competitive pressure may also motivate an organization to adopt modular construction/off-site construction to avoid falling behind competitors.

Last but not least, absorptive capacity and government support are ranked as second lowest and lowest among the eighteen factors. This may be due to organizations are less focus on these two factors. Absorptive capacity can determine the level of organisations in learning and applying new technologies that are outside of the organisation (Naqshbandi, 2017). And government support will also promote the adoption of modular construction/off-site construction, such as financial aids and pilot projects. Therefore, government support can also play an important role in encouraging the construction companies to adopt modular construction/off-site construction.

4.4 Results of Factor Analysis

In this section, the result of Kaiser-Meyer-Olkin and Bartlett's test, total variance, and component matrix to all adoption factors of modular construction/off-site construction technology will be presented and discussed.

4.4.1 Kaiser-Meyer-Olkin and Bartlett's Test

The data of the 18 factors were analysed by SPSS 26.0 for further analysis. The extraction commonality of each variable in the formal exploratory factor analysis is more than 0.4 which are considered stable (Guadagnoli and Velicer, 1988). Hence, no variable has to be removed. Based on table 4.3, the analysis results show the value of Kaiser-Meyer-Olkin (KMO) is 0.841 and associated significance level is 0.000, showing that the population correlation matrix is not an identity matrix (UI Hadia, Abdullah and Sentosa, 2016). This value is adequate as KMO value cannot less than 0.5 in factor analysis (Field, 2013). Therefore, the results of the two statistical tests revealed that the survey data was eligible for factor analysis.

Table 4.3: KMO and Bartlett's Test

Parameter	**Value**
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.	.841

Bartlett's Test of Sphericity	Approx. Chi-Square	633.860
	df	153
	Sig.	.000

4.4.2 Rotated Components Matrix

Based on table 4.4, varimax rotation of principal component analysis produced a four-common component with eigenvalues larger than 1.0, including component 1, component 2, component 3, and component 4. Each factor belongs only to one of the components, with the loading value on each factor exceeding 0.30 is considered as acceptable (Howard, 2016). The common components are often referred to as the common factors or the common latent variables. As shown in table 4.4, that the four common components account for 66.684% of the total variance explained, which is greater than 60% necessary for adequate construct validity (Williams, Onsman, and Brown, 2010).

Besides that, in order to be used for subsequent exploratory factor evaluation, the four common components must have specific names and contents. Hence, the eighteen factors are correspondingly classified into the four common components through the varimax rotation method. Table 4.4 indicates the varimax rotation approach simplifies component structure while maintaining the cumulative percentage of the four common components.

According to table 4.4, the four common components can be renamed as: adoption intention (component 1), organization capability (component 2), technology dependability (component 3), and technology robustness (component 4). Hence, these named common components will be further interpreted in the following section.

Table 4.4: Component matrix after varimax rotation

	Component			
	1	2	3	4
F17: Government support	.834			
F18: Trading partner readiness	.804			
F12: Top management support	.648	.434		.404
F14: Managerial support	.605	.474		.468
F15: Market demand	.555			.396

F16: Competitive pressure	.521		.418	
F09: Organisational scale		.828		
F10: Organisational readiness		.759		
F08: Observability		.681	.386	
F13: Human resources		.679		
F03: Technology optimism	.379		.729	
F02: Perceived ease of use			.703	.314
F04: Technological capability	.332		.596	.314
F07: Trialability		.390	.540	
F11: Absorptive capacity	.470	.416	.537	
F06: Relative advantage				.754
F05: Compatibility	.377			.594
F01: Perceived usefulness		.411	.450	.548
Eigenvalues	3.534	3.344	2.827	2.298
Percentage of variance explained	19.632	18.579	15.708	12.764
Cumulative percentage of variance explained	19.632	38.211	53.919	66.684

4.4.2.1 Common Component Description

Component 1: Adoption Intention

The "adoption intention" consists of "government support", "trading partner readiness", "top management support", "managerial support", "market demand", and "competitive pressure", which are all in relation to the adoption intention of construction companies in modular or off-site construction. As referred to table 4.4, this component accounts for 19.632 percent of the total variance explained among all identified factors. Also, all factors in this component have a factor loading that exceeding 0.500. Therefore, adoption intention is critical for the adoption of modular or off-site construction in an organization.

Government support is a significant factor to the promotion of modular construction/off-site construction in Malaysia. Malaysia government has been keen to promote the modularisation and standardisation in building processes. For example, Malaysian government's 2016 Budget pledging RM500 million in soft loans to developers and contractors who adopt the modular or off-site construction method (CIDB, 2016). Also, tax incentives were offered to construction companies

which used m modular construction/off-site construction in projects. Therefore, the effort of government in promoting modular or off-site construction is important to increase the adoption intention of organisations (Xue et al., 2021).

Besides that, trading partner readiness will also affect the adoption intention of organizations as the readiness of partners such as contractors or sub-contractors can influence on the efficiency of modular construction/off-site construction adoption (Hosseini et al., 2017). Next, market demand will be influenced by the construction companies because when they can see the benefits of adopting modular construction/off-site construction, the demand will rise. As a result, when the demand rise, the adoption intention of organisations will also rise.

Last but not least, the other two factors in this component are all in relation to internal stakeholders of an organization. Human factors play an important role in assisting and managing a new technology implementation process (Neumann et al., 2021). Hence, top management support and managerial support are important to influence the adoption intention of an organization in adopting modular construction/off-site construction into the current operation system.

Component 2: Organisational Capability

This component comprises "organisational scale", "organisational readiness", "observability" and "human resources". This component accounts for 18.579 percent of the total variance explained among all the factors (see Table 4.4). Large organisations are usually have more complex and diversified resources to support the adoption of new technology than small organisations (Lee and Xia, 2006). Hence, organisation size has an impact on organisation's capability to adopt innovations.

Besides, organisational readiness is significant in driving modular construction/off-site construction adoption. This is because the people, processes, technology, and management of an organization can influence on the success of implementation process (Abubakar, Ibrahim and Bala, 2013). Thus, organisational capability can be enhanced when it can be ready in all aspects for innovations (Maali et al., 2020).

Next, modular construction/off-site construction adoption is influenced by how effortlessly management team of an organisation can observe the favourable results provided by this new system. This is due to the fact that when organisations can see the benefits or advantages of the new system, they may decide to employ it.

As a result, the higher the observability of modular construction/off-site construction, the higher the adoption rate from the organisations (Ali et al., 2023).

Finally, human resources will also influence on the organisational capability in accepting innovations (Gan and Yusof, 2019). The efficacy and quality of people are critical in determining the success of adoption. For example, unqualified labours may cause serious issues to modular construction such as poor structural performance (Polat, 2008). Hence, organisational capability is heavily influenced by the quality of human resources.

Component 3: Technology Dependability

The component "technology dependability" includes four factors, namely "technology optimism", "perceived ease of use", "technology capability", "trialability", and "absorptive capacity". As referred to table 4.4, this component is responsible for 15.708 percent of the total variance explained.

Except for "technology capability", the other three factors categorized in this component is all in relation to technology itself. Modular construction/off-site construction provides benefits such as, shorten project period, cost savings, and quality enhancement. Besides that, modular construction/off-site construction is known as simple and easy to use method (Musa et al., 2018). Also, modular or off-site construction adoption will be influenced by their trialability as construction companies' intention is to minimized uncertainty in adoption processes.

Moreover, technological compatibility can have an impact on technological dependability. This is because the organisation's ability to execute any necessary technical functions will influence on the adoption intention of new technologies (Tsai, 2004). For example, the quality of modular components will be significantly impacted if there are any damages during the assembly and integration process. Therefore, the technology dependency has allowed organisations to accomplish more in less time, which results in higher productivity and efficiency.

Component 4: Technology Robustness

The last component "technology robustness" includes "relative advantage", "compatibility, and "perceived usefulness". This component accounts for 12.764 percent of the total variance explained among all factors (see Table 4.4). This component emphasizes the strength of modular construction/off-site construction.

The relative advantages provided by this method are important driver of adoption (Tornatzky and Klein, 2012). This is because organisations will be convinced by the significant advantages offered by modular construction/off-site construction. Besides, the compatibility can greatly affect the implementation of new method as an invention's compatibility with existing system is an important concern (Musa et al., 2018).

In addition, perceived usefulness will increase the intention of organisation to adopt modular construction/off-site construction, especially when it can improve the current construction process (Thirunavukkarasu et al., 2021). As a result, the higher the usefulness of modular construction/off-site construction, the higher the desire of the organisations to adopt it. Organisations should be properly aware of the impacts of technology robustness of modular construction/off-site construction on effective adoption processes.

4.5 A proposed framework for improving modular construction/off-site construction adoption processes in Klang Valley, Malaysia

The aim of this section is to propose a framework that incorporates all potential factors for the adoption of modular construction/off-site construction. Figure 4.1 shows the proposed framework, which includes four modular or off-site construction adoption factors component, namely "adoption intention", "organisational capability", "technology dependability", "technology robustness". These four components are correlated to the factors discovered by factor analysis.

Organisational capability is significant in assisting the successful adoption of modular construction/off-site construction in Klang Valley, Malaysia, since this plays an important role in encouraging the adoption of new modern method of construction. It can contribute not just to the implementation process, but also provide the confident aimed at raising practitioners' adoption intention. Besides that, increased technology capability may subsequently lead to enhanced site activity performance, as well as additional benefits such as, shorten construction period and enhanced quality. Hence, these may influence the adoption intention of organisations.

Lastly, the adoption of modular or off-site construction has greatly improved the performance of construction companies. Hence, they can stay competitive in the highly challenging construction industry. Developers, contractors, architects, engineers, and others industry players are growing interest in the adoption and

development of modular construction/off-site construction. Therefore, the highly reliable and resilient of modular construction/off-site construction has positively influenced the adoption intention of construction companies.

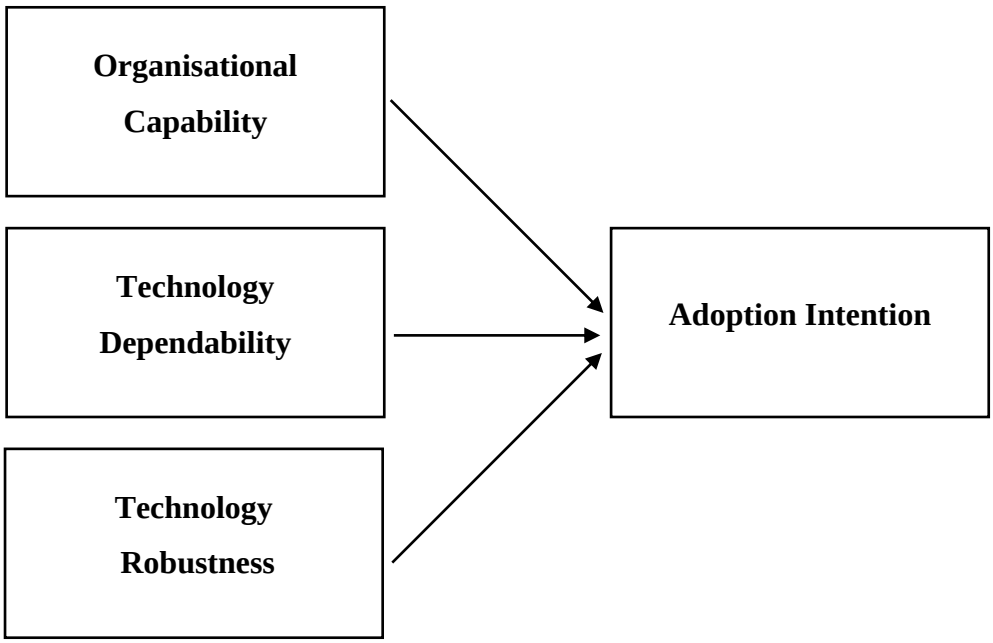

Figure 4.1: A framework for effective adoption of modular construction/off-site construction in Klang Valley, Malaysia

4.6 Chapter Summary

To conclude, the findings of this study were based on the data and responses received from 63 respondents from developer, consultant, and contractor firms in the construction sector in the Klang Valley, Malaysia. Mean Ranking and Factor Analysis are the statistical approaches utilised to examine the data.

Besides that, the top five factors of TOE framework that are significant for modular construction/off-site construction adoption in the mean ranking test are top management support, managerial support, relative advantage, perceived ease of use, and technology capability. In addition, factor analysis was used to successfully identify and extract 4 underlying structures caused by eighteen latent factors from the TOE framework aspects that are crucial for the adoption of modular construction/off-site construction. These 4 underlying structures are adoption intention, organisational capability, technology dependability, and technology robustness.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

This chapter summarises and consolidates the content of the previous chapters to provide a summary and conclusion to this research study. This chapter will begin by evaluating the objectives of this research and determining how each was achieved. Also, research contributions and research limitations will be discussed in this chapter. Thereafter, this chapter ends with recommendations for a variety of future research directions.

5.2 Achievements of Research Objectives

The accomplishments of the research objectives are summarised in the following sections.

5.2.1 Research Objectives 1 – To rank the factors for the adoption of modular construction/off-site construction.

The primary goal of this study is to rank the factors influencing the adoption of modular or off-site construction. In the survey, respondents from developer, consultant, and contractor firms ranked the 18 factors of TOE framework variables that are crucial for modular or off-site construction adoption. The data found that the five key drivers for adoption were (1) top management support, (2) managerial support, (3) relative advantage, (4) perceived ease of use, and (5) technology capability. Hence, to achieve the first objective, these findings were obtained using The Mean Ranking test.

5.2.2 Research Objectives 2 – To examine the underlying structure caused by latent factors for the adoption of modular construction/off-site construction.

To achieve the second goal of this study, factor analysis was used to identify the underlying factors that are relevant for modular construction/off-site construction adoption. The four underlying structures were selected from the 18 factors of TOE

framework variables that are crucial for the adoption of modular construction/off-site construction. Adoption intention, organisational capability, technology dependability, and technology robustness are the four underlying structures. As a result, all of these exhibited underlying structures have the potential to provide deeper insights to construction companies in order to encourage and boost the adoption of modular construction/off-site construction. Therefore, the Factor Analysis accomplishes the second research objective.

5.3 Research Contributions

This research contributes to the body of knowledge of modular or off-site construction implementation by giving validated findings on this form of building method while also categorising and ranking important factors for adoption of modular construction/off-site construction. Also, this study specifically addressed the factors for the adoption of modular or off-site construction in Klang Valley, Malaysia. As a result, this study makes an important contribution because there is little literature in the Klang Valley, Malaysia.

Besides that, the findings of this study will provide great benefits to both researchers and industry practitioners. This is because researchers might utilise the underlying structures as a solid foundation for developing modular construction/off-site construction that is adapted in Klang Valley, Malaysia. Also, the findings aid in facilitating the industry practitioners' awareness of the main adoption factors that should take into consideration when adopting modular construction/off-site construction, hence they are allowed to determine and focus on addressing them.

Moreover, the government is also playing an important role in facilitating the implementation of modular building. This research might help statutory bodies draft suitable rules and regulations to support modular building. It also allows regulatory authorities to establish necessary regulations and standards to assist construction companies in the implementing processes. As a result, the government may take necessary actions by recognising the obstacles faced by construction companies in order to better assist them in adopting modular construction/off-site construction.

5.4 Research Limitations

Although the research objectives were achieved, it should be highlighted that some constraints were encountered throughout the research study. The following limitations were discovered during this study:

1. The data collected is narrowed to the construction companies in Klang Valley, Malaysia, and therefore the study's findings may not be applicable to other states or countries in considering of modular construction/off-site construction adoption.
2. The quantitative data acquired in this study may be less precise since they may not accurately reflect respondents' beliefs because numerical responses ignored the thoughts, behaviours, or feelings of the respondents.
3. Another restriction is a lack of preceding study and literature in terms of knowledge and statistical data on modular or off-site building in Klang Valley, Malaysia. As literature review is an important part of any research study since it helps to determine the research scope.

5.5 Recommendations for Future Research

The following are suggestions for further research on this scope. Future scholars should focus into the following aspects:

1. Future research might use case studies to analyse and capture the aspects that have led to the successful transition from traditional on-site building methods to modular construction/off-site construction methods. The research should uncover the key elements that have proven critical in this transformation process in order to build a more realistic and complete roadmap for Malaysia's construction sector.
2. To be more specific of the study fields, emphasis research on solving the cost difficulties, such as examining the whole lifespan cost of adopting modular or off-construction in a construction project.
3. Instead of quantitative method, future research can employ qualitative approach by conducting interviews with qualified modular or off-site contractors who can provide accurate and thorough data based on their actual expertise.

5.6 Conclusion

The methods used for achieving all of the research objectives is summarised in this chapter. The contributions and limitations of the research are also examined and explained. Last but not least, research recommendations are stated for future research.

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APPENDICES

APPENDIX A: Questionnaire Survey

Modular Construction/Off-Site Construction Adoption Questionnaire

Section A: Demographic Information

Please select only one answer for each item.

DI01) Type of organisation:

1) Developer

2) Consultant

3) Contractor

DI02) Category of work:

1) Building

2) Non-building

DI03) Position in the firm:

1) Upper management

2) Middle management

3) Lower management

DI04) Years of working experience:

1) Less than 5 years

2) 5 years and above

Section B: Technological Dimension

To what extent do you agree or disagree that the following technological dimension factors are important for the adoption of modular construction/off-site construction in your organisation?

1) Strongly disagree

2) Disagree

3) Neither agree nor disagree

4) Agree
5) Strongly agree

F01) Perceived usefulness
F02) Perceived ease of use
F03) Technology optimism
F04) Technological capability
F05) Compatibility
F06) Relative advantage
F07) Trialability
F08) Observability

Section C: Organisational Dimension

To what extent do you agree or disagree that the following organisational dimension factors are important for the adoption of modular construction/off-site construction in your organisation?

1) Strongly disagree
2) Disagree
3) Neither agree nor disagree
4) Agree
5) Strongly agree

F09) Organisational scale
F10) Organisational readiness
F11) Absorptive capacity
F12) Top management support
F13) Human resources
F14) Managerial support

Section D: Environmental Dimension

To what extent do you agree or disagree that the following environmental dimension factors are important for the adoption of modular construction/off-site construction in your organisation?

1) Strongly disagree

2) Disagree

3) Neither agree nor disagree

4) Agree

5) Strongly agree

F15) Market demand

F16) Competitive pressure

F17) Government support

F18) Trading partner readiness