

**UNIVERSITI TEKNOLOGI MARA**

**INTEGRATING TECHNOLOGY-  
ORGANIZATION-ENVIRONMENT  
(TOE) AND TECHNOLOGY  
ACCEPTANCE MODEL (TAM)  
FRAMEWORKS FOR DISRUPTIVE  
TECHNOLOGY ADOPTION IN THE  
CONSTRUCTION INDUSTRY  
(ConTech-AF)**

**NUR SYAMILAH BINTI BUJANG  
HASSIM**

**MSc**

**August 2026**



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**NUR SYAMILAH BINTI BUJANG HASSIM**

Thesis submitted in fulfillment  
of the requirements for the degree of  
**Master of Science**  
**(Business Management)**

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I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the results of my own work, unless otherwise indicated or acknowledged as referenced work. This thesis has not been submitted to any other academic institution or non-academic institution for any degree or qualification.

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## ABSTRACT

The construction industry plays a significant role in Malaysia's economic development. Adopting disruptive technology is crucial for enhancing efficiency, productivity, and overall industry competitiveness. In the context of this study, disruptive technology refers to emerging construction technologies that transform or improve existing systems and processes by enhancing project efficiency, decision-making, and resource management in response to the evolving needs of the construction industry. Despite advancements and government initiatives, the adoption rate remains relatively low (10 – 13%), particularly in Sarawak. Understanding the factors influencing adoption is essential to improve the industry's performance. This study aims to determine the influence of technological, organizational, environmental, and government factors on the adoption of disruptive technology in the construction industry. This study also examines the mediating role of perceived usefulness in the relationship between technological, organizational, environmental, and government factors and the adoption of disruptive technology in the construction industry, focusing on companies in Bintulu, a rapidly developing region. This study proposes the Construction Technology Adoption Framework (ConTech-AF), a conceptual framework developed by integrating variables from the Technology-Organization-Environment (TOE) and the Technology Acceptance Model (TAM) frameworks to provide a comprehensive understanding of disruptive technology adoption in the construction industry. The variables from the TOE framework capture external factors, including technological, organizational, and environmental dimensions, while the TAM variables capture perceived usefulness (PU) as a mediating variable. By incorporating the government as an additional factor in the framework, this research acknowledges the varying roles of government policies and support in influencing technology adoption. A quantitative research approach has been adopted. The data were collected from 141 respondents representing 91 construction companies and analyzed using the Statistical Package for the Social Sciences (SPSS) software. The findings reveal that organizational, technological, and environmental factors significantly influence disruptive technology adoption, whereas government-related factors have no significant effect. Additionally, perceived usefulness (PU) serves as a mediator in the framework, mediating the relationships between government, organizational, and technological factors and actual use, but not the relationship between environmental factors and actual use. This study contributes to the literature by extending the application of TAM and TOE frameworks within the construction context and by providing practical insights for industry practitioners, government agencies, and technology providers to support the successful implementation of disruptive technologies.

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## LIST OF SYMBOLS

### Symbols

|               |                             |
|---------------|-----------------------------|
| $\alpha$      | Cronbach's Alpha            |
| $\beta$       | Beta Value                  |
| $\varepsilon$ | Error Term                  |
| $n$           | Sample Size                 |
| $p$           | p-value (Significant Level) |

## LIST OF ABBREVIATIONS

### Abbreviations

|            |                                            |
|------------|--------------------------------------------|
| BIM        | Building Information Modelling             |
| CIDB       | Construction Industry Development Board    |
| CMB        | Common Method Bias                         |
| ConTech-AF | Construction Technology Adoption Framework |
| PU         | Perceived Usefulness                       |
| TAM        | Technology Acceptance Model                |
| TOE        | Technology-Organization-Environment        |

# **CHAPTER 1**

## **INTRODUCTION**

### **1.1 Introduction of the Chapter**

This chapter provides a comprehensive introduction to this research. This chapter begins with an overview of the study's research background, including details about the construction industry and its current technologies. In addition, this chapter provides the research questions and objectives, highlighting the problem statement, current issues, scope of study, and the significance of this research. Thus, this chapter provides an overview of this research.

### **1.2 Research Background**

The construction industry is important for Malaysia's development and growth. Nowadays, disruptive technologies are being introduced to improve the construction work process. However, not all construction companies adopt these technologies at the same level. Therefore, this section explains the background on the Malaysian and Sarawak construction industries, the adoption of disruptive technologies, the challenges, and the government initiatives to support technology adoption in this study.

#### **1.2.1 Construction Industry in Malaysia and Sarawak**

The construction industry is an economic activity that encompasses the entire construction process, from the production of raw and manufactured building materials and components. The construction industry also provides professional services, from design development and project management to on-site physical work (Pheng & Hou, 2019). The construction sector is one of the most important sectors of any country's economy, ensuring the development of all types of economic activities, from production, housing, road transport, and others, which largely determines the

possibilities of development in the country (Filatov, 2023). The construction industry is a key driver of Malaysia's economic development, contributing significantly to the gross domestic product, increasing employment opportunities, and enhancing the overall social well-being of the population (Masyhur et al., 2024).

In 2024, the Gross Domestic Product (GDP) from construction in Malaysia totaled RM 66.58 billion, representing an increase from RM 56.66 billion in the previous year. Figure 1.1 shows the Gross Domestic Product (GDP) of the construction industry in Malaysia from 2015 to 2024. The data is from the Department of Statistics Malaysia (2025). As shown in Figure 1.1, the highest GDP in the construction industry was recorded in 2024 at RM 66.58 billion, followed by 2019 with RM 66.45 billion, while the lowest was in 2021 at RM 50.84 billion.

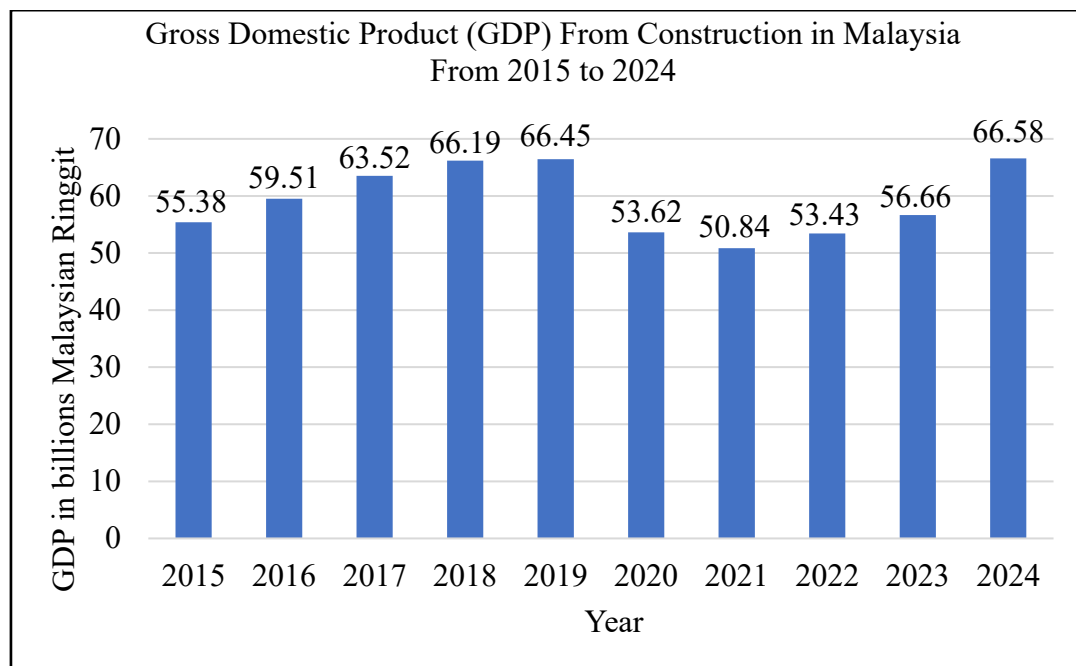


Figure 1.1 Gross Domestic Product (GDP) in the Construction Industry in Malaysia from 2015 to 2024

Source: Department of Statistics Malaysia (2025)

There was a significant decrease in GDP in 2020 compared to 2019, primarily due to the COVID-19 pandemic and the movement control orders that were enforced (CIDB Malaysia, 2022c). The implementation of movement control has led to financial difficulties, delays in project delivery, and interruptions in the import and export of construction materials (CIDB Malaysia, 2020b). The construction industry is then able

to withstand and recover from the challenges, and the GDP returned to steady growth in 2022. The recovery of the construction industry is driven by resilience and its strong capacity to rebound from the previous decline in GDP (CIDB Malaysia, 2024b).

According to the Department of Statistics Malaysia (DOSM), Sarawak's GDP in 2024 recorded RM 148.2 billion, an increase of 3.9% from the previous year. Figure 1.2 shows Sarawak's GDP from 2018 to 2024 from the DOSM report. Sarawak's economy was mainly driven by the Services sector (38.6%), followed by the Manufacturing sector (25.8%), the Mining and Quarrying sector (21.0%), the Agriculture sector (10.2%), and the Construction sector (4.1%) (Ministry of Economy, 2025). Despite the relatively small contribution of construction to Sarawak's GDP, the sector remains important due to its involvement in large-scale infrastructure projects that increasingly require advanced technologies and innovative construction practices.

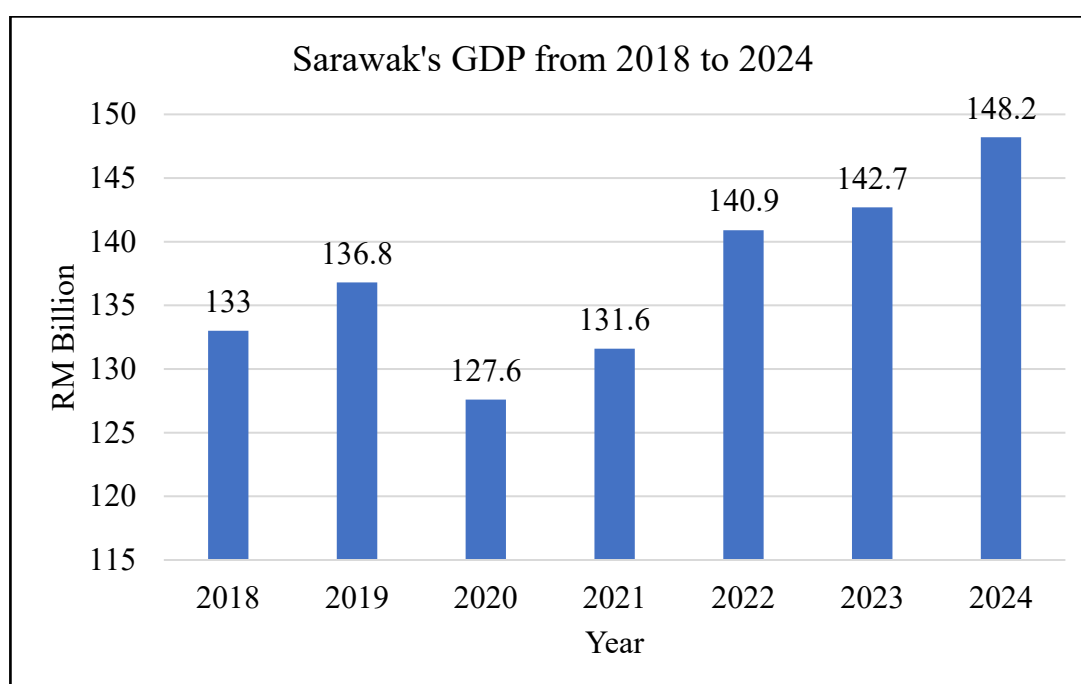


Figure 1.2 Sarawak's GDP from 2018 to 2024  
Source: Department of Statistics Malaysia (Ministry of Economy, 2025)

The Pan Borneo Highway and the Autonomous Rapid Transit (ART) system are among the major infrastructure projects that contribute to Malaysia's economic development and future growth. These projects serve as a foundation for social development, enabling access to education and healthcare, and reducing the gaps between regions (CIDB Malaysia, 2023). The ART system is planned to begin

operations in Kuching and Kota Samarahan, with future expansion to Bintulu. The expansion aims to support growing economic activities in Bintulu, such as medical innovation and a technology hub (Wong, 2024). Such large-scale projects, which require advanced technologies, highlight the need for digital transformation and innovative construction approaches to improve efficiency and project delivery.

The Subsector Productivity Report on Construction and Build Environment by the Malaysia Productivity Corporation (2023) noted that Malaysia's economic growth relies heavily on the construction sector, so it must overcome significant challenges and seize opportunities for any construction projects. The report identified several challenges, including an insufficient workforce, regulatory barriers, and financial constraints. Challenges within this sector can be attributed to factors such as difficulty meeting workforce demand, slow technology adoption, and regulatory barriers impacting project implementation.

The persistence of these challenges suggests that traditional construction practices have become limited in their ability to meet the changing needs of the construction industry. Therefore, digital transformation and the adoption of disruptive technologies have become important in enhancing productivity, improving project performance, and ensuring long-term industry competitiveness.

### **1.2.2 Digital Transformation and Disruptive Technology in Construction**

The construction industry is currently undergoing a significant shift towards digital transformation, driven by the adoption of disruptive technologies to enhance productivity, quality, and efficiency in construction projects. Qiu et al. (2023) define disruptive technology as a new technology that changes the current system or existing system to improve it, in parallel with the construction industry's needs. Understanding disruptive technology is important for businesses and policymakers, as it has a big effect on industries and society (Kong et al., 2023). In the context of this study, disruptive technology refers to emerging construction technologies that transform or improve existing systems and processes by enhancing project efficiency, decision-making, and resource management in response to the evolving needs of the construction industry. Disruptive technologies in construction include Building Information Modelling (BIM), Artificial Intelligence (AI), Internet of Things (IoT), drones, cloud computing, and

advanced data analytics. These technologies significantly improve project outcomes by enhancing decision-making, optimizing resource allocation, and monitoring progress in real time (Government Sarawak, 2020). Disruptive technologies can improve efficiency, effectiveness, and productivity in the construction industry. Fully utilizing technology in the construction industry can reduce costs and improve sustainability (Musarat et al., 2023).

However, despite these benefits, the adoption of disruptive technologies in the construction industry remains low, with only approximately 10-13% of companies having implemented them, as reported by Ashraf et al. (2021) and Othman et al. (2021). These are due to factors such as high costs, slow technological adoption, and reliance on traditional methods. Moreover, the Malaysian construction industry has long lagged in adopting and adapting new technologies due to the limited best practices, reliance on low-income foreign labor, and high cost of technology, contributing to lower productivity rate (dropped 15.6%) compared to other sectors (agriculture = -1.8%, mining and quarrying = -7.9%, manufacturing = -2.6%, construction = -15.7%) (CIDB Malaysia, 2022c; Department of Statistics Malaysia, 2022). This suggests that limited technology adoption has been one of the factors influencing industry productivity performance. However, recent studies indicate an improvement, as Malaysian construction companies now actively use an average of 6.9 technologies in construction projects, which is 50% higher than the Asia-Pacific average, reflecting increasing integration of advanced technology and traditional construction practices (CIDB Malaysia, 2024a).

Figure 1.3 shows the productivity performance of the Malaysian construction industry from 2019 to 2024, with labour productivity per person (RM) shown as bars and productivity growth rate (%) as a line. The highest productivity recorded is in 2024, at RM 47225 per person, an increase of 16.5% from RM 40552 in 2023. In contrast, the lowest productivity was recorded in 2021, at RM 36669 per person, showing a negative growth rate of -4.3%. The result shows that the increasing integration of those technologies has contributed to improving productivity performance. The Malaysia Productivity Corporation (2024) reported that the recent improvement is linked to better use of technology and reduced operational constraints such as project delays and labor shortages, suggesting that further improvements depend on more consistent and widespread adoption of technologies across the industry.

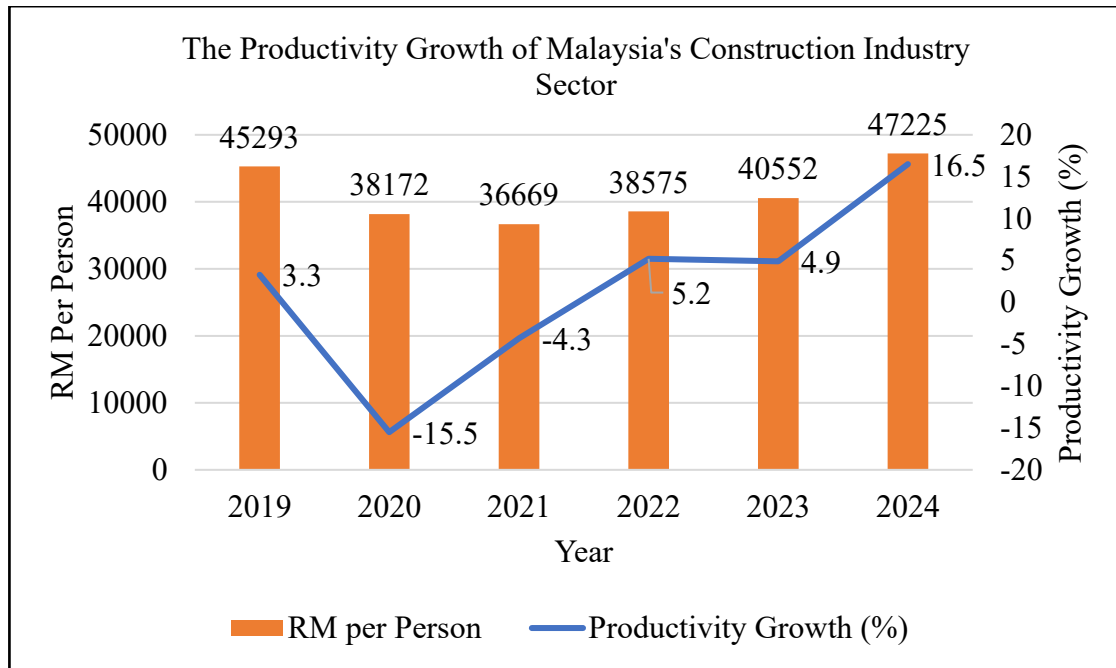


Figure 1.3 The Productivity Growth of Malaysia's Construction Industry Sectors from 2019 to 2024  
Source: Department of Statistics Malaysia (2021, 2022, 2024)

### 1.2.3 Challenges and Government Initiatives for Disruptive Technology Adoption in the Construction Industry

It is undeniable that the implementation of technologies offers many opportunities for the digitization of the construction industry throughout the entire construction process and has significant benefits such as cost reduction, increased production efficiency, and increased quality of the construction industry (Setaki & Timmeren, 2022). However, these benefits cannot be fully realized unless users accept and adopt these technologies, as user acceptance plays a critical role in determining actual technology use. The successful adoption of disruptive technologies depends not only on their technical capabilities, but also on users' perceptions, acceptance, and willingness to incorporate these technologies into construction practices. Therefore, a study by Pangriya & Priya (2021) stated that it is critical to understand users' acceptance of technology as it determines the success of technology implementation, while insufficient acceptance often leads to implementation failure.

Despite the benefits of disruptive technologies, the adoption within the construction industry remains challenging, including organizational culture barriers and economic incentives (Musarat et al., 2023). From a technological perspective, the

industry continues to rely heavily on manual processes, traditional work practices, and reluctance to adopt new technologies (Abioye et al., 2021; Amir et al., 2024). From an organizational perspective, resistance to change, preferring traditional work practices, and reluctance to learn and adopt new technologies remain major barriers to adoption (Abioye et al., 2021; Lee et al., 2022). Furthermore, from an environmental perspective, low awareness, weak policies, and insufficient policy support further constrain the implementation of disruptive technology (Musharavati, 2023; Al-Raqeb et al., 2024). The limited enforcement and lack of government support further hinder adoption in Malaysia's construction industry (Malaysia Productivity Corporation, 2023; Jalil et al., 2025).

To address these challenges and support long-term development, the Sarawak government has introduced the Post COVID-19 Development Strategy 2030 (PCDS 2030), which aims to position Sarawak as a developed state and a digitally driven economy by 2030. The PCDS 2030 serves as a long-term plan to support economic growth, social well-being, and a sustainable environment (Zulkeffeli and Morhalim, 2023). The PCDS 2030 was introduced following the largest decline in GDP growth in Sarawak. The construction sector experienced a significant decline during the COVID-19 period, with the construction output decreasing by 19.4% and unemployment rising from 3.3% in 2019 to 4.8% in 2020 (Government of Sarawak, 2020), highlighting the urgency for transformation in this sector.

Digital transformation has been identified as one of the key enablers to achieve the objectives of PCDS 2030. Digital transformation is the adoption of digital technologies to improve services and businesses, increasing efficiency and productivity. Under these initiatives, Sarawak aims to implement 100% end-to-end digital government services and strengthen economic sectors through digitalization. This includes encouraging the adoption of technologies such as big data, the Internet of Things (IoT), and blockchain technology (Government of Sarawak, 2020).

Similarly, at the national level, the Construction Industry Development Board (CIDB) Malaysia, in collaboration with the Ministry of Works, has introduced and implemented the Construction Strategy Plan 4.0 (Construction 4.0) to enable smart construction for the future of Malaysia's construction industry. The goals of the strategy plan are to reduce workplace accidents and increase productivity and work quality in the construction industry (CIDB Malaysia, 2021). The Construction 4.0 plan identifies 12 disruptive technologies that will change the game in the construction industry (CIDB

Malaysia, 2022c). The definition of disruptive technologies is explained in Appendix G, Page 140.

The actual level of adoption of disruptive technologies among the construction industry companies remains relatively limited (10-13%) despite these strategic initiatives and government policy. This suggests a gap between policy implementation and practical implementation within the construction industry context. Therefore, further investigation is required to understand the factors influencing the adoption of disruptive technologies, particularly from technological, organizational, environmental, and individual perspectives.

### **1.3 Problem Statement**

The Malaysian construction industry continues to face significant challenges in adopting disruptive technologies, which influence its productivity and competitiveness. The Technology Acceptance Model (TAM) is widely recognized as a foundational framework for explaining and predicting users' acceptance and use of technology (Or, 2024). The model proposes that two primary variables in this model, which are perceived ease of use and perceived usefulness, determine an individual's adoption of the new technology (Davis, 1989). Despite its widespread application, TAM has been criticized for oversimplifying technology adoption behaviors by focusing primarily on individual perceptions while overlooking broader organizational and external influences (Sepasgozar, 2023).

Meaning that factors such as organizational culture, management support, and external pressures are often underrepresented in TAM-based studies. This limitation is particularly relevant in the construction industry, where technology adoption decisions are influenced not only by individual users but also by organizational structure and external stakeholders. Moreover, various studies have reported that factors such as a lack of management support and organizational readiness (Abioye et al., 2021; Jackson & Allen, 2024; Amir et al., 2024), insufficient financial resources (Othman et al., 2021), and competitive pressure within the industry (Malaysia Productivity Corporation, 2023) influence the adoption of disruptive technologies in the construction industry.

Therefore, the TAM alone is insufficient to explain the complexities of adopting disruptive technologies in the construction industry, highlighting the need for a more

comprehensive approach that considers organizational and environmental factors. The studies by Weerapperuma et al. (2022) and Nguyen et al. (2024) address TAM's limitations by combining it with frameworks such as Technology-Organization-Environment (TOE), incorporating organizational, environmental, and innovation-specific factors. Thus, there is a need to extend the investigation beyond individual perceptions by examining these broader contextual factors.

The Technology-Organization-Environment (TOE) framework has been widely applied to examine technology adoption across various industries. The framework has a solid theoretical basis and potential applications to information system innovation domains through three specific factors that have been identified, known as technological, organizational, and environmental factors (Oliveira et al., 2011). Although previous studies have consistently demonstrated the significance of these factors, most research has been conducted in different industrial and geographical contexts. For example, studies from Katebi et al. (2022), Wang et al. (2022), Na et al. (2022), Qin et al. (2020), and Yuan et al. (2019) are all from Iran, China, and Korea. This proves that few articles use the frameworks in the context of the construction industry in Malaysia. Moreover, an article by Na et al. (2022) noted that future research should broaden the studies to encompass diverse geographical locations and technological contexts. Given the unique characteristics of the construction industry and low level of adoption, further investigation is needed to determine whether the TOE framework is relevant within the construction context.

Furthermore, the role of government in influencing disruptive technology adoption within the construction industry remains insufficiently explored. While government agencies play an important role in promoting digital transformation through policies, regulations, training programs, and industry development initiatives, previous studies have reported mixed evidence regarding the significance of government support. For example, Lee et al. (2022) emphasized the importance of government involvement in enhancing Building Information Modelling (BIM) implementation in the Sarawak construction industry, whereas Zaini et al. (2020) found that government-related factors are less influential compared to other adoption determinants. The Malaysia Productivity Corporation (2023) found that insufficient policy implementation, limited guidance, and weak enforcement are barriers to technology adoption. These findings indicate that the influence of government on disruptive technology adoption remains unclear and needs further investigation. Therefore, this study incorporates government context as

an additional factor to better understand its role in influencing disruptive technology adoption in the Sarawak construction industry.

#### **1.4 Research Questions**

The research questions of this research are:

1. How do technological, organizational, environmental, and government factors influence the adoption of disruptive technology in the construction industry?
2. Does perceived usefulness mediate the relationship between technological, organizational, environmental, and government factors and the adoption of disruptive technology in the construction industry?

#### **1.5 Research Objectives**

The objectives of this research are:

1. To determine the influence of technological, organizational, environmental, and government factors on the adoption of disruptive technology in the construction industry.
2. To examine the mediating role of perceived usefulness in the relationship between technological, organizational, environmental, and government factors and the adoption of disruptive technology in the construction industry.

#### **1.6 Scope of the Study**

This research focuses on factors influencing the adoption of disruptive technologies in the construction industry, specifically by integrating the Technology-Organization-Environment (TOE) and Technology Acceptance Model (TAM) frameworks, along with government-related factors. The study is limited to selected

determinants, namely technological, organizational, environmental, and government factors, as independent variables, while perceived usefulness acts as a mediating variable in explaining technology adoption behaviour, and actual use as a dependent variable.

Geographically, this research is limited to the Bintulu district in Sarawak. This selection is justified by Bintulu's rapid industrial and infrastructure development, particularly driven by major energy and economic activities such as the Kasawari Gas Field and Patinggi Ali Shoal in the South China Sea Exclusive Economic Zone (EEZ) (Berita Harian Online, 2023). In addition, Bintulu has been identified as a strategic growth area expected to experience significant development within the next five years (Bernama, 2024), making it a relevant context for examining technology adoption in a fast-growing construction environment.

Furthermore, Bintulu presents a unique socio-economic context, including a relatively high cost of living and increased inward migration for employment opportunities (UKAS Sarawak News, 2023). As one of Sarawak's major industrial and economic hubs, Bintulu continues to experience active construction development, making it an appropriate location for investigating disruptive technology adoption in the construction industry.

In terms of data scope, the study focuses only on construction companies registered under the Construction Industry Development Board (CIDB) Bintulu. As of 2024, there are 649 construction companies registered in the Bintulu district, which represent the target population of this study. The data will be collected using a structured bilingual questionnaire (English and Bahasa Melayu) distributed electronically to selected respondents within these companies.

However, the findings of this study are limited to the selected variables, frameworks, and geographical area. The results not fully generalizable to other regions in Malaysia or to other industries due to differences in economic conditions, technological readiness, and organizational structures.

## **1.7 Significance of the Study**

The study of the disruptive technology adoption in the construction industry is crucial to the long-term success of its implementation. It benefits not only the

construction industry but also society and the government. In addition, understanding the factors influencing the adoption of disruptive technology can help to overcome barriers, enhance strategic planning, improve users' acceptance, and prepare for future trends.

### **1.7.1 Society**

This research can yield significant societal benefits, as construction contractors can serve society better and increase efficiency in construction development. Disrupting advanced technology leads to safer construction sites and more resilient buildings, benefiting community safety. Society will be satisfied with the development of construction, as it is completed within the time frame. Thus, exploring these factors can provide society with improved infrastructure, enhanced quality of life, and access to safer, more efficient construction.

### **1.7.2 Academia/Researchers**

This research can provide a basis for further research on technology adoption and innovation in construction. In addition, the study's findings will benefit academia and researchers by helping them develop effective strategies to accelerate the adoption of disruptive technology in the construction industry. This study can also serve as a basis for future theoretical advances, contributing to increased knowledge of disruptive technology advancement.

### **1.7.3 Government**

The government can take proactive measures to help design effective incentive programs that promote technology adoption among contractors. Moreover, the government can use the findings to develop policies and regulations that encourage technology adoption in construction. The study can also support government agencies in identifying barriers to adoption and addressing them through targeted funding,

training programs, and regulatory frameworks that improve the adoption of disruptive technology in the construction industry.

#### **1.7.4 Industry**

For the construction industry, this study's findings offer valuable insights into identifying the key adoption factors that can help companies gain competitive advantages by integrating and disrupting technology. Additionally, the industry can increase productivity and reduce costs by optimizing the use of disruptive technologies. The construction industry can improve its project management and decision-making by implementing disruptive technology to increase efficiency.

### **1.8 Conclusion of the Chapter**

In conclusion, this chapter has outlined the research background, problem statement, objectives, and scope of the study. It highlights the importance of examining the adoption of disruptive technologies in the construction industry, using the Technology Acceptance Model (TAM) and Technology-Organization-Environment (TOE) frameworks, with the inclusion of government-related factors. The study focuses on selected determinants (technology, organization, environment, government) influencing technology adoption, with perceived usefulness as a mediating variable, and is limited to CIDB-registered construction companies in Bintulu. Overall, this chapter establishes the foundation and direction of the research, which will be further supported by a detailed literature review in the next chapter.

## **CHAPTER 2**

### **LITERATURE REVIEW**

#### **2.1 Introduction of the Chapter**

This chapter provides a comprehensive review of previous studies related to the adoption of disruptive technologies in the construction industry. The chapter begins with the discussion of the concept of disruptive technology adoption in the construction industry, followed by a review of the current adoption situation. The chapter then discusses the factors influencing disruptive technology adoption and presents an empirical review of previous studies related to these factors. Next, relevant theoretical frameworks are discussed, followed by a comparison and justification of the selected framework adopted in this study.

#### **2.2 Concept of Disruptive Technology Adoption in the Construction Industry**

Disruptive technology is an emerging technology that significantly replaces existing technologies, leading to changes in construction industry practices and market dynamics (Ganguly et al., 2011). Over time, disruptive technologies evolved from small, less capable innovations into powerful enough to replace the old way of doing things (Kong et al., 2023). It is important to understand the nature and benefits of these technologies for business and policymakers, as they can have significant impacts on industries and societies (Kong et al., 2023). The adoption of disruptive technologies in this industry can lead to significant improvements in productivity, efficiency, and sustainability (Nassereddine et al., 2019). In the context of this study, disruptive technology refers to emerging construction technologies that transform or improve existing systems and processes by enhancing project efficiency, decision-making, and resource management in response to the evolving needs of the construction industry. Therefore, a comprehensive understanding of the nature and implications of disruptive technologies is essential for industry practitioners and policymakers to effectively

support technological transformation and sustain competitiveness within the construction industry.

Adoption, on the other hand, can be defined as a physical or behavioral characteristic that helps us to survive in a new environment. This behavioral characteristic focuses on how an individual's behavior interacts with, accepts, and influences the new environment (Hefviahervin, 2022). In the context of disruptive technology, adoption extends beyond the implementation of technological tools, but it also involves developing the necessary skills, knowledge, and capabilities to utilize the technology effectively. This is important in the construction industry, where successful technology adoption depends not only on the availability of advanced technologies but also on the readiness of the workforce to adapt to changing work processes and the industry environment (Annual Report CIDB, 2022). Therefore, the adoption of disruptive technologies requires both technological transformation and workforce development to support long-term industry growth.

As mentioned before, CIDB has launched the Construction Strategy Plan (2021-2025) to transform Malaysia's construction industry through smart construction for a future society (CIDB Malaysia, 2022c). The plan identifies 12 disruptive technologies that are expected to reshape Malaysia's construction industry. Among these technologies, Building Information Modelling (BIM) and Industrialized Building Systems (IBS) have been actively implemented in the industry for the past few years. Other emerging disruptive technologies include autonomous construction, augmented reality and virtual reality, cloud and real-time collaboration, 3D scanning and photogrammetry, big data and predictive analysis, internet of things, 3D printing and additive manufacturing, advanced building materials, blockchain, and artificial intelligence (CIDB Malaysia, 2022c). The definitions of these disruptive technologies, derived from previous studies, are provided in Appendix G (page 140) to support a comprehensive understanding of each technology.

### **2.3 Current Adoption of Disruptive Technology in the Construction Industry**

The construction industry is currently undergoing a significant transformation, driven by the adoption of disruptive technologies to enhance productivity, quality, and efficiency in construction projects. In Malaysia, this transformation is supported by

initiatives such as CIDB's myBIM Centre, which promotes the adoption of Building Information Modelling (BIM) through training and resources for industry players (Jaafar, 2017). These initiatives align with the transformation agenda of the Fourth Industrial Revolution (4IR), which emphasizes the integration of advanced disruptive technologies to enhance the digitalization of business procedures and activities, where traditional systems are progressively replaced by more advanced systems (Na et al., 2022; Shahzad et al., 2023).

In the context of the Fourth Industrial Revolution (4IR), the construction industry should prioritize the adoption of disruptive technologies such as Artificial Intelligence (AI), the Internet of Things (IoT), blockchain, cloud computing, big data analytics, advanced materials and technologies, as these technologies serve as key enablers for the deployment and optimization of other 4IR technologies (Economic Planning Unit, 2020). For example, Artificial Intelligence (AI) and big data analytics are used to forecast project risks, support budget planning, and optimize construction processes. Augmented Reality and Virtual Reality (AR and VR) support the project design and offer detailed visualization (Jaafar et al., 2024). The adoption of blockchain technology can distribute the data because it is decentralized, traceable, transparent, and reliable (Wang et al., 2022). The Internet of Things (IoT) can provide effective control, better quality, and time-saving in decision-making by providing real-time data analytics (Gamil et al., 2020). Advanced materials and technologies provide detailed information about the project site, which can help with efficient alignment planning and optimized design projects (Mohamad et al., 2022). Overall, these initiatives and technologies show that the construction industry in Malaysia is moving toward digital transformation and improving efficiency, in parallel with national development goals and the objectives of the Fourth Industrial Revolution.

Over the years, CIDB has implemented two major technologies to help construction businesses remain competitive and deliver projects on time and within budget. The two disruptive technologies are Building Information Modelling (BIM) and Industrialized Building System (IBS). When both technologies are implemented together, they effectively transform the construction industry. BIM is a 3D visualization model that shows the process for preparing and sharing various information used by all parties in a project to achieve the objectives of project implementation. BIM can reduce costs and speed up construction projects. Currently, in Sarawak construction, BIM is being used for the MRSM Lawas construction project (CIDB Malaysia, 2022a).

In Sarawak, the first BIM implementation project was in 2016 for the Pan Borneo Highway Sarawak. The project used a combination of BIM and Geographical Information System (GIS) (Lee et al., 2022). In Bintulu, Sarawak, BIM is currently used for construction projects, namely “*Kuarters Gunasama Persekutuan Bintulu*”. This project has been identified by the Malaysian Public Works Department (JKR) for implementation with the adoption of BIM, progressing to Level of Development 500 (the final, real-world version of the building model, showing exactly what was built). The contractor needs to implement this project by adopting the BIM method across the planning, design, and construction phases up to the project handover phase (Malaysian Public Works Department, 2022).

IBS is a system or method for preparing or producing construction products under controlled conditions, whether in a factory or on a construction site. Once done, the product will be transported and installed with minimal on-site worker involvement. IBS contributes to the construction industry by reducing construction material waste, shortening construction time, and improving cost efficiency (CIDB Malaysia, 2022b). In Bintulu, the application of IBS technology has been demonstrated through projects such as Bintulu Hospital, which utilized IBS technology to support the accommodation and treatment needs of chronic patients, particularly those from outside Bintulu who seek treatment at the hospital (Su’ud, 2021). Additionally, an IBS-based housing project in Jepak, Bintulu, was introduced to enhance the durability and quality of housing development, as stated by Prime Minister Datuk Patinggi Tan Sri Abang Johari Tun Openg (Ratani, 2024).

Despite various initiatives introduced by CIDB to promote the adoption of disruptive technologies, evidence suggests that the adoption rate in the Malaysian construction industry remains relatively low. For example, BIM adoption has been reported at only 10-13%, with studies consistently identifying lack of awareness, high implementation costs, and limited technological readiness as key barriers (Ashraf et al., 2021; Othman et al., 2021). These findings indicate that government initiatives and awareness programs alone are insufficient to encourage widespread adoption. Similarly, Jaafar et al. (2024) found that many contractors continue to rely on traditional construction methods due to financial constraints, suggesting that organizational and resource-related factors continue to hinder the adoption of disruptive technology.

This challenge is further reflected in Malaysia’s slower progress compared to more digitally advanced countries such as Singapore, where technology adoption has

occurred at a significantly faster pace, according to Kong & Jie (2024) findings (adoption in Malaysia was 49 percent in 2019, but Singapore had already reached 71 percent in 2015). In addition, Malaysia's adoption rate of BIM is slower compared to other countries (the United Kingdom (80%), followed by Australia (76%), Germany (70%), Malaysia (55%), and Japan (46%)) (CIDB, 2021), mainly due to the lack of trained professionals, which limits the efficiency and effectiveness of the technology in construction projects (Malaysia Productivity Corporation, 2023). Therefore, the findings indicate that disruptive technology adoption in the Malaysian construction industry is influenced by a combination of technological, organizational, and human resource factors, highlighting the complexity of the adoption process. Furthermore, as the construction industry continues to evolve and technology adoption levels change over time, there is a need for more recent empirical evidence to reassess the current state of disruptive technology adoption and the factors influencing its adoption.

Despite ongoing efforts to promote digital transformation, the implementation of BIM in the Sarawak construction industry remains relatively low. Although CIDB has introduced various BIM-related training programs, awareness campaigns, and conferences to encourage adoption, the level of implementation has yet to reach a satisfactory level (Zaini et al., 2020). The evidence suggests that BIM adoption in Sarawak is still at an early stage, with most organizations having only recently implemented the technology. This situation indicates that barriers such as limited awareness, high implementation costs, and inadequate infrastructure continue to hinder wider adoption (Zaini et al., 2020). The situation is further reflected in Sarawak's BIM adoption rate, which remains among the lowest in Malaysia at only 6% (Myint Naing et al., 2022). These findings suggest that significant challenges remain in achieving widespread technology adoption within the construction industry, although the efforts to promote technology are increasing.

In summary, the literature highlights that disruptive technologies offer significant potential to improve productivity, efficiency, and sustainability within the construction industry. However, both Malaysia and Sarawak continue to experience relatively low adoption levels despite various initiatives introduced by the government, CIDB, and other stakeholders to promote digital transformation and increase the adoption of disruptive technologies. The persistence of these challenges suggests that the successful adoption of disruptive technologies is influenced by multiple factors beyond the availability of the technology itself. Therefore, it is important to examine

the factors that influence the adoption of disruptive technologies in the construction industry, which are discussed in the following section.

## **2.4 Factors Influencing the Adoption of Disruptive Technology**

The adoption of disruptive technologies in the construction industry is influenced by a combination of human, organizational, technological, and environmental factors. Understanding these factors is essential because they determine the extent to which companies are willing and able to integrate emerging technologies into their operations. Although disruptive technologies offer significant benefits in improving productivity, efficiency, and project delivery, their implementation within the construction industry remains uneven and often slower than expected.

Human factors are consistently identified as one of the most critical determinants of technology adoption. Numerous studies highlight that resistance to change remains a significant barrier, particularly among construction professionals who are familiar with traditional work practices (Abioye et al., 2021; Yahya et al., 2022). Similarly, Guangbin et al. (2020) argued that user resistance is often the underlying cause of unsuccessful technology implementation in organizations. The challenge is further worsened by limited knowledge, inadequate digital skills, and insufficient awareness of emerging technologies among industry practitioners (Raslim et al., 2024; Ding et al., 2025). Next, studies on Virtual Reality (VR), Building Information Modelling (BIM), and modular construction demonstrate that employees are more likely to adopt new technologies when they perceive the technology as useful, maintain positive attitudes towards technological changes, and feel confident to use the technology (Thoti, 2024; Musarat et al., 2025). These findings suggest that technology adoption is not solely a technical issue, but largely depends on users' willingness and readiness to embrace change.

Organizational factors also play a crucial role in supporting technology adoption. Several studies emphasize that successful implementation requires significant spending in software, hardware, employee training, and skilled personnel (Ashraf et al., 2021). Organizational support, particularly from top management, has been repeatedly identified as a key enabler of technology adoption because it provides the resources, leadership, and strategic direction necessary for digital transformation (Mehdipoor et

al., 2022; Wong et al., 2022). Furthermore, Sallehuddin et al. (2022) found that employee capabilities and organizational support are essential for overcoming challenges related to technology adoption, including technostress arising due to the job complexity. This suggests that organizations must not only invest in technology but also create supportive environments that facilitate employees' adaptation and continuous learning.

Technological factors represent another important dimension influencing adoption decisions. While disruptive technologies provide significant operational advantages, their complexity often discourages implementation. Almashjary et al. (2020) identified difficulties related to data management and the need for extensive workflow changes during BIM implementation. Similarly, Asrul et al. (2022) reported that technological complexity and accessibility issues can hinder user acceptance. These findings indicate that technologies perceived as difficult to use or requiring major changes to existing work processes are less likely to be adopted successfully. This observation aligns with the Technology Acceptance Model (TAM), which emphasizes perceived ease of use and perceived usefulness as key determinants of technology adoption.

Beyond internal organizational considerations, environmental and industry-related factors also influence disruptive technologies adoption in the construction industry. Financial constraints, particularly among Small and Medium Enterprises (SMEs), often limit investment in advanced technologies despite their potential benefits (Mehdipoor et al., 2022). Many construction industries are also slow to adopt new technologies because they prefer to wait and see competitors use them successfully before making their own investments (Malaysia Productivity Corporation, 2023). Similar trends have been observed in the implementation of prefabrication and modular construction, where stakeholder reluctance, limited readiness, and inadequate industry knowledge continue to hinder adoption (Osman et al., 2018; Yusof et al., 2023).

Moreover, government and institutional support have become important factors influencing the adoption of disruptive technologies in the construction industry. Unlike other industries, the Malaysian construction industry sector relies heavily on regulatory guidance, industry standards, and government initiatives to support technological transformation. The CIDB has actively promoted digitalization through training programmes, awareness campaigns, BIM initiatives, and strategic roadmaps to increase technology adoption among industry stakeholders (Yahya et al., 2022). Similarly, the

Malaysia Productivity Corporation (2023) emphasized that limited awareness and understanding of disruptive technologies remain significant barriers, highlighting the need for stronger support from government agencies and related institutions. These findings suggest that government support should extend beyond policy formulation and include financial support and industry guidance that encourages construction companies to adopt disruptive technologies.

Therefore, government support is considered a critical factor in driving technology adoption, particularly in developing countries where industry transformation is often driven by public-sector initiatives. Moreover, although many studies identify human, organizational, and technological factors as the primary determinants of adoption, these factors alone are insufficient in the construction industry without supportive government intervention. This is because construction activities are highly regulated and are strongly influenced by industry standards, certification requirements, and national development policies.

Overall, the literature demonstrates that disruptive technology adoption in the construction industry is influenced by a combination of human, organizational, technological, environmental, and government-related factors. Although technological capabilities continue to advance, successful adoption depends largely on user acceptance, organizational commitment, and industry readiness. Across the literature, human-related issues, particularly resistance to change, lack of awareness, and inadequate skills, are consistently identified as the most persistent challenges. Furthermore, the literature highlights the crucial role of the government and construction stakeholders in creating an enabling environment for technology adoption. These findings indicate that efforts to promote disruptive technology adoption should focus not only on technological investment but also on strengthening workforce readiness, organizational support, effective change management, and supportive government initiatives. Therefore, a comprehensive understanding of technology adoption in the construction industry requires consideration of both internal organizational factors and external environmental influences.

## **2.5 Empirical Review of Previous Studies on Factors Influencing Adoption of Disruptive Technology**

Several studies have explored factors influencing the adoption of technology. Based on the studies, various models and frameworks have been developed to examine users' acceptance of technology. It includes the Unified Theory of Acceptance and Use of Technology (UTAUT), the Technology Acceptance Model (TAM), the Technology-Organization-Environment (TOE), and an intensive literature review. Reviewing these empirical studies is important to understand prior findings and identify research gaps. Table 2.1 summarizes selected empirical studies on technology acceptance in the construction industry across countries and their framework development.

Table 2.1

## Literature Summary of Studies Conducted Regarding Technology Acceptance in the Construction Industry

| No. | Title of Research                                                                                                                                          | Framework<br>Developed                                     | Factors                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Sector            | Authors                      |
|-----|------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|------------------------------|
| 1   | BIM Adoption for Cost Engineering Consultant: A Case Study of Southern China                                                                               | Unified Theory of Acceptance and Use of Technology (UTAUT) | <ul style="list-style-type: none"> <li>- Awareness and perception of BIM technology</li> <li>- Immaturity of BIM software and data exchange difficulties</li> <li>- External environmental (lack of professional BIM skills and motivation)</li> <li>- High cost and time in training</li> <li>- Age and generation gap</li> <li>- Facilitating conditions like ease of use</li> </ul>                                                                              | Civil Engineering | (Taib et al., 2023)          |
| 2   | Modifying the UTAUT Model for the Digital Transformation of the Construction Industry from the User Perspective                                            | UTAUT                                                      | <ul style="list-style-type: none"> <li>- The important factors, such as accuracy, time, quality, effort to use, satisfaction level, flexibility, dependence on manual processes, error recovery, peer pressure, regulations, top management perspective, social network configuration, productivity, performance level, level of goal achievement, and job security, influence technology acceptance and use.</li> </ul>                                            | All Sector        | (Hewavitharana et al., 2021) |
| 3   | A Relevance-based Technology-Organization-Environment Model of Critical Success Factors for Digital Procurement Adoption in Chinese Construction Companies | TOE + CSF (Critical Success Factor)                        | <ul style="list-style-type: none"> <li>- Organizational factors (management support, employee commitment, training, collaboration, communication)</li> <li>- Environmental factors (government support, industry consensus on the value of digital procurement, and market dynamics)</li> <li>- Technology factors (the selection and implementation of digital tools, system stability, reliability, and availability of advanced digital technologies)</li> </ul> | All Sector        | (Luo et al., 2023)           |
| 4   | Predicting behavioral resistance                                                                                                                           | TAM (Technology                                            | <ul style="list-style-type: none"> <li>- Perceived ease of use (individuals believe using BIM)</li> </ul>                                                                                                                                                                                                                                                                                                                                                           | Civil             | (Wang, 2020)                 |

|   |                                                                                                                                                                                   |                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                          |                        |
|---|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|------------------------|
|   | to BIM implementation in construction projects: An empirical study integrating technology acceptance model and equity theory                                                      | Acceptance Model) + Equity Theory | <ul style="list-style-type: none"> <li>- Perceived usefulness (individuals believe BIM will improve their job performance)</li> <li>- Perceived Distributive Equity (fairness in the distribution of outcomes related to BIM implementation)</li> <li>- Personal innovativeness (willingness to try out new technology)</li> </ul>                                                                                                                                                                                                                                                                                                                                           | Engineering Sector       |                        |
| 5 | BIM adoption among contractors: A longitudinal study in Peru                                                                                                                      | TAM                               | <ul style="list-style-type: none"> <li>- Perceived Usefulness to Project (perception of how useful the technology is to construction projects)</li> <li>- Perceived Ease of Implementation (how easy or difficult it is for contractors to implement technology)</li> <li>- Attitude toward technology (Positive or negative attitude toward the technology implementation)</li> <li>- Use of technology (users' intention to use technology)</li> </ul>                                                                                                                                                                                                                     | Civil Engineering Sector | (Murguia et al., 2023) |
| 6 | Acceptance model of precast concrete components in Building construction based on Technology Acceptance Model (TAM) and Technology, Organization, and Environment (TOE) framework | TAM + TOE                         | <ul style="list-style-type: none"> <li>- Perceived Ease of Use (Easy to work with)</li> <li>- Perceived Usefulness (See the benefits and advantages of technology)</li> <li>- Technological Characteristics (Specific characteristics of the technology)</li> <li>- Organizational Readiness (Availability of resources, management support)</li> <li>- Environmental Context (External factors such as government support, market demand, competitive pressure)</li> <li>- Cost (Provide long-term savings)</li> <li>- Perceived Risk (construction delay due to the adaptation of new technology)</li> <li>- Competitive Advantage (Using technology gives more</li> </ul> | All Sector               | (Katebi et al., 2022)  |

|   |                                                                                                                                                                                                                   |           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                         |                     |  |
|---|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------|---------------------|--|
|   |                                                                                                                                                                                                                   |           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | advantages than the traditional method) |                     |  |
| 7 | Using a TAM-TOE Model to explore factors of Building Information Modelling (BIM) adoption in the construction industry                                                                                            | TAM + TOE | <ul style="list-style-type: none"><li>- Technical factors (localization, standardization, compatibility)</li><li>- Economic factors (cost, return on investment)</li><li>- Organizational factors (organizational mode and workflow, traditional thinking mode, support from senior management)</li><li>- Environmental factors (National policy requirements, popularity of BIM in the industry, competition from other companies)</li></ul>                                                                                               | All Sector                              | (Qin et al., 2020)  |  |
| 8 | Understanding the Determinants of Blockchain Technology Adoption in the Construction Industry                                                                                                                     | TAM + TOE | <ul style="list-style-type: none"><li>- Perceived usefulness (individuals believe that using blockchain technology will enhance their job performance)</li><li>- Perceived ease of use (how easy individuals believe it is to use blockchain technology)</li><li>- Technological dimension (relative advantage, compatibility, technological maturity)</li><li>- Organizational dimension (organizational readiness)</li><li>- Environmental dimension (competitive pressure, policy)</li></ul>                                             | All Sector                              | (Wang et al., 2022) |  |
| 9 | Acceptance Model of Artificial Intelligence (AI)-Based Technologies in Construction Firms: Applying the Technology Acceptance Model (TAM) in Combination with Technology-Organisation-Environment (TOE) Framework | TAM + TOE | <ul style="list-style-type: none"><li>- Technological context (suitability and ease of use, compatibility issues)</li><li>- Organizational context (organizational structure and culture, impact on PU and PEOU)</li><li>- Environmental context (external social and technological support, conservatism in adoption)</li><li>- Personality (individual reactions, influence on Pu and PEOU)</li><li>- Perceived Usefulness (impact on attitude and intention)</li><li>- Attitude towards utilization (Users' attitude to make a</li></ul> | All Sector                              | (Na et al., 2022)   |  |

|    |                                |         |     |           |                          |             |                     |
|----|--------------------------------|---------|-----|-----------|--------------------------|-------------|---------------------|
|    |                                |         |     |           | decision)                |             |                     |
| 10 | Promoting                      | Owners' | BIM | TAM + TOE | - Behavioral intention   | Civil       | (Yuan et al., 2019) |
|    | Adoption behaviors to achieve  |         |     |           | - Attitude               | Engineering |                     |
|    | sustainable project management |         |     |           | - Perceived Usefulness   |             |                     |
|    |                                |         |     |           | - Perceived Ease of Use  |             |                     |
|    |                                |         |     |           | - Social Influence       |             |                     |
|    |                                |         |     |           | - Organizational Support |             |                     |
|    |                                |         |     |           | - Technical Features     |             |                     |
|    |                                |         |     |           | - Government Policies    |             |                     |

Note: Summarization of articles that the author made based on related articles.

The studies reviewed in Table 2.1 show that technology adoption in the construction industry has been explored using various theoretical frameworks, particularly the Unified Theory of Acceptance and Use of Technology (UTAUT), the Technology Acceptance Model (TAM), and the Technology-Organization-Environment (TOE) framework. While UTAUT-based studies, such as Taib et al. (2023) and Hewavitharana et al. (2021), emphasize factors including awareness, user perceptions, training costs, and external influences, TAM-based studies by Guangbin et al. (2020) and Murguia et al. (2023) primarily focus on individual-level determinants, particularly perceived usefulness, perceived ease of use, attitudes, and actual use. Although these frameworks provide valuable insights into technology acceptance, they tend to focus on either individual or organizational perspectives.

To address this limitation, recent studies have increasingly integrated multiple theoretical frameworks to capture the complexity of technology adoption within the construction industry. It is proven by previous studies, which were Katebi et al. (2022), Wang et al. (2022), Na et al. (2022), Qin et al. (2020), and Yuan et al. (2019), where the studies combined the TOE and TAM frameworks to examine both behavioural and contextual factors influencing adoption. The increased use of integrated frameworks suggests that technology adoption is influenced by multiple interconnected factors rather than a single dimension. Furthermore, a study by Luo et al. (2023) expanded these frameworks by adapting additional variables, including cost, risk, and competitive advantage, indicating that technology adoption is evolving beyond the traditional constructs proposed by the TAM and TOE frameworks.

However, several gaps remain in the existing literature despite the integration of multiple theoretical frameworks. First, most studies integrating the TAM and TOE frameworks have been conducted in countries such as China, Iran, and South Korea, which limits the generalizability of their findings to the Malaysian construction industry. As highlighted by Na et al. (2022), future research should investigate technology adoption across diverse geographical and industrial contexts to address contextual differences and improve the generalizability of findings. Furthermore, although previous studies have extensively investigated technological, organizational, environmental, and behavioural factors, limited attention has been given to the influence of government support and regulatory involvement. This limitation is relevant in the Malaysian construction industry, where government agencies such as CIDB play an active role in promoting digital transformation through the implementation of policies,

incentives, strategic roadmaps, and industry development programmes.

Among the reviewed studies, Katebi et al. (2022) is identified as the anchor study because it successfully integrated TAM and TOE variables to explain the adoption of precast concrete components. The framework provides a comprehensive perspective by considering technological, organizational, and environmental dimensions simultaneously. However, the model mainly focuses on the adoption of a specific construction product and gives more attention to organizational and technical factors than to people's attitudes and perceptions toward adopting the technology. In contrast, Na et al. (2022) integrated personality and attitude variables into the integrated TAM and TOE framework, offering a more human-centred perspective that better reflects the challenges of digital transformation in the view of the construction industry. Therefore, while Katebi et al. (2022) offer a strong structural foundation for understanding adoption readiness, Na et al. (2022) provide a more holistic and adaptive model for studying disruptive technology adoption in the modern construction context.

Building upon these insights, this study aims to examine the factors influencing the adoption of disruptive technology in the construction industry by adopting selected variables from both the TAM and TOE frameworks, with the addition of a government context. The inclusion of TAM variables, perceived usefulness, and actual use allows the study to explore individual attitudes and actual use toward disruptive technology adoption. Meanwhile, TOE variables, such as organizational support, technological features, and environmental pressure, capture the structural and contextual factors that influence adoption in the construction industry.

To further strengthen the framework, this research introduces the government dimension as an additional construct, acknowledging the critical roles of policymakers and institutional support in driving digital transformation adoption in Malaysia's construction sector. Given the government's significant role in setting regulations, providing incentives, and developing digital transformative initiatives such as PCDS 2030 and the Construction 4.0 Strategic Plan, government involvement can influence the extent of disruptive technology adoption and actual use. By integrating the government dimension with variables from the TAM and TOE frameworks, this research seeks to develop a more holistic model that captures the multi-level factors influencing disruptive technology adoption in the Malaysian construction industry. The proposed framework contributes to a more comprehensive understanding of adoption behaviour by combining individual, organizational, technological, environmental, and

government-related factors within a unified model.

## 2.6 Theoretical Framework

To examine the factors influencing the adoption of disruptive technology in the construction industry, it is essential to establish a comprehensive theoretical foundation. Various theoretical frameworks have been widely applied in previous studies on technology adoption. Among the most frequently used are the Technology Acceptance Model (TAM), the Unified Theory of Acceptance and Use of Technology (UTAUT), and the Technology-Organization-Environment (TOE) framework. A detailed discussion of each framework is presented in the following subsections.

### 2.6.1 Technology Acceptance Model (TAM) Framework

Figure 2.1 shows the Technology Acceptance Model (TAM) framework by Davis (1989). It is a powerful tool that examines the factors that influence users who adopt new technologies.

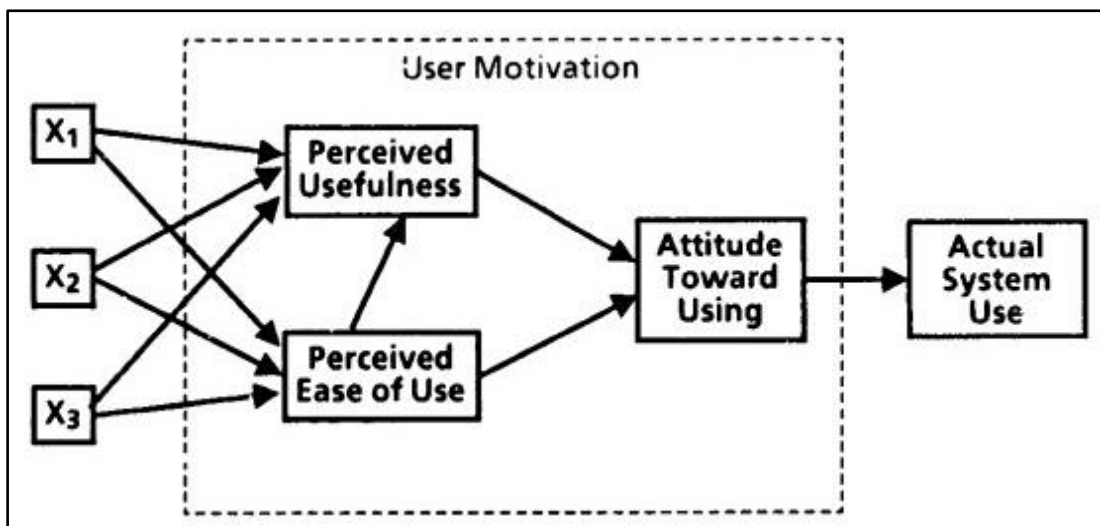


Figure 2.1 Technology Acceptance Model (TAM) Framework by Davis (1989)

The TAM model has been widely used until recently, even though it was introduced a long time ago. Some researchers developed an extension of the TAM

framework. The framework was formed based on the theory of planned behavior (TPB) and the theory of reasoned action (TRA). The framework appeared simpler, but it had a significant impact on examiners' acceptance of the new technology (Na et al., 2022). There are two primary variables in this model, which are perceived ease of use and perceived usefulness, that will determine an individual's adoption of the new technology (Davis, 1989).

## 2.6.2 Technology-Organization-Environment (TOE)

Figure 2.2 illustrates the Technology-Organization-Environment (TOE) model, developed by Tornatzky and Fleischer in 1990. The TOE framework has a solid theoretical basis and potential application to information system innovation domains through three specific factors that have been identified (Oliveira et al., 2011).

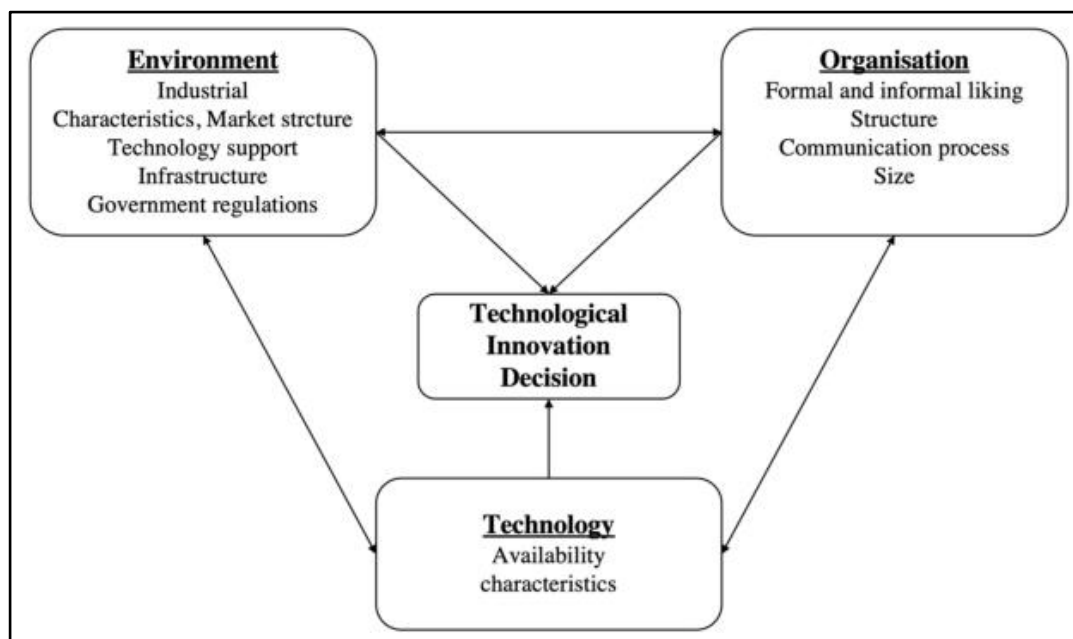


Figure 2.2 Technology-Organization-Environment (TOE) Model by Tornatzky & Fleischer (1990)

As shown in Figure 2.2, the TOE framework identifies three factors that influence the implementation of technological innovation: technological, organizational, and environmental context. The technological context explains both the external and internal relevance of technology to the organization. The organizational

context refers to the organization's existing characteristics and resources. Meanwhile, the environmental context includes the organization's industry, competitors, governmental regulations, and business partners (Na et al., 2022).

### 2.6.3 Unified Theory of Acceptance and Use of Technology (UTAUT)

Figure 2.3 shows the Unified Theory of Acceptance and Use of Technology (UTAUT) by Venkatesh, Morris, and Davis (2003). The UTAUT model integrates four core determinants of technology adoption and provides a comprehensive view of factors influencing the users' adoption behavior. Performance expectancy shows the degree to which an individual believes that using the system will help them to achieve better job performance. Effort expectancy refers to the degree to which a person believes using technology is easy. Meanwhile, social influence refers to the degree to which an individual feels social pressure from others to use technology, and facilitating conditions refer to how much a person believes their organization provides sufficient support, resources, and infrastructure for their use of technology (Khechine et al., 2016).

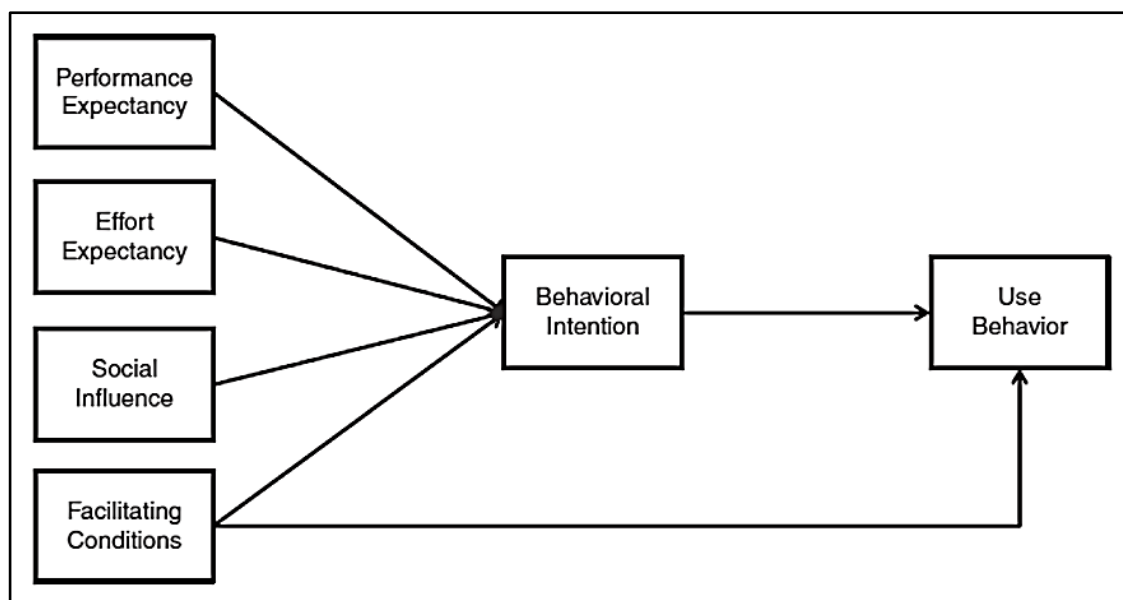


Figure 2.3 Unified Theory of Acceptance and Use of Technology by Venkatesh, Morris, & Davis (2003)

Following the discussion of each theoretical framework, Table 2.2 summarizes the main strengths and weaknesses of the models reviewed.

Table 2.2  
The Strengths and Weaknesses of Each Model Framework

| No | Type of Framework                                          | Strengths of the Framework                                                                                                               | Weaknesses of the Framework                                                                      |
|----|------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|
| 1  | Technology Acceptance Model (TAM)                          | Focuses on individual factors related to perceived usefulness and perceived ease of use that explain users' attitudes toward technology. | Does not include external or organizational factors that also influence technology adoption.     |
| 2  | Technology-Organization-Environment (TOE) Framework        | Explores the organizational and external environmental factors that influence technology adoption.                                       | There is less focus on individual perceptions and attitudes.                                     |
| 3  | Unified Theory of Acceptance and Use of Technology (UTAUT) | Provides a comprehensive view of technology acceptance by integrating individual, social, and organizational factors.                    | Gives less focus on the personal attitudes and perception factors compared to the TAM framework. |

Note: Comparison of frameworks that the author made based on the reviewed frameworks.

#### 2.6.4 Comparison and Justification of the Selected Framework

Although the TAM framework has been widely applied in technology adoption studies, researchers have criticized the framework for its limited consideration of organizational and environmental influences, which are particularly important in complex industries such as construction (Na et al., 2022b; Or, 2024). On the other hand, the TOE framework provides a broader perspective by including technological, organizational, and environmental contexts, but it pays less attention to individual perceptions towards technology adoption (Oliveira et al., 2011). Meanwhile, the UTAUT framework extends the understanding of technology acceptance through social influence and facilitating conditions. However, it was primarily developed to explain individual user behavior rather than organizational decisions (Venkatesh et al., 2003). Therefore, no single framework fully explains the complex nature of technology adoption in the construction industry.

The TOE framework is selected as the primary framework for this study because technology adoption in the construction industry is influenced by organizational, technological, and environmental characteristics, all of which are explicitly addressed

by the TOE framework (Tornatzky & Fleischer, 1990; Oliveira et al., 2011). Previous studies on technology adoption in the construction industry have predominantly focused on Building Information Modelling (BIM), commonly using the TAM, the TOE, or the UTAUT frameworks (Hewavitharana et al., 2021; Taib et al., 2023). However, findings regarding the influence of government support remain inconsistent across these studies (Lee et al., 2022; Zaini et al., 2020). Moreover, the existing literature has largely concentrated on BIM, with limited attention given to the adoption of a broader range of disruptive technologies. Therefore, this study extends the TOE framework by incorporating government support and examining disruptive technologies beyond BIM within the construction industry.

## **2.7 Conclusion of the Chapter**

This chapter reviewed the main theoretical frameworks related to technology adoption in the construction industry, namely the Technology Acceptance Model (TAM), the Technology–Organization–Environment (TOE) framework, and the Unified Theory of Acceptance and Use of Technology (UTAUT). TAM emphasizes individual perceptions, particularly perceived usefulness and perceived ease of use, while TOE explains technology adoption from technological, organizational, and environmental perspectives. UTAUT provides a more comprehensive perspective by incorporating social influence and facilitating conditions. However, each framework has limitations in fully explaining disruptive technology adoption. TAM pays limited attention to external contextual factors, TOE places less emphasis on individual perceptions, and UTAUT gives less consideration to attitude-based acceptance. These limitations highlight the need for a more comprehensive framework to better understand disruptive technology adoption in the construction industry. The next chapter presents the research methodology, providing a detailed explanation of the research design, data collection procedures, and data analysis techniques employed to achieve the research objectives.

## **CHAPTER 3**

### **RESEARCH METHODOLOGY**

#### **3.1 Introduction of the Chapter**

This chapter describes the research methodology employed to achieve the objectives of this study. It outlines the research design and the methodological procedures used to examine the influence of technological, organizational, environmental, and government factors on the adoption of disruptive technologies in the construction industry, as well as the mediating role of perceived usefulness in these relationships. This chapter presents the conceptual framework and research hypotheses, followed by the population and sampling procedures, data collection method, survey instrument, and data analysis techniques. These methodological components provide a systematic approach for collecting and analysing data to ensure that the research objectives are addressed effectively and that the findings are reliable and valid.

#### **3.2 Research Design**

This study adopts a quantitative research design to examine the factors influencing the adoption of disruptive technologies in the construction industry. A quantitative approach is appropriate as it allows the systematic measurement of relationships among variables and allows the proposed hypotheses to be tested objectively through statistical analysis. Furthermore, prior studies such as Al-Ashmori et al. (2020) indicate that there is limited comprehensive understanding of technology adoption among construction practitioners in Malaysia. Therefore, a quantitative approach is suitable for providing a broader understanding of the factors influencing disruptive technology adoption within the construction industry.

This study is designed as applied research, as it aims to determine and examine the factors that influence the adoption of disruptive technologies in the construction industry. To achieve these objectives, the study integrates variables from the

Technology-Organization-Environment (TOE) and the Technology Acceptance Model (TAM) frameworks. The integration of these frameworks enables a more comprehensive understanding of technology adoption, as the result can be both contextual and individual factors that influence adoption behaviours. Specifically, the TOE framework focuses on technological, organizational, and environmental perspectives, while the TAM focuses on individual perception of technology, particularly perceived usefulness.

In addition, this study extends the original TOE framework by incorporating government factors as an additional dimension. This extension recognizes the important role of government support, regulatory policies, and institutional pressure in influencing technology adoption within the construction industry. This extension is relevant in the Malaysian context, where construction practices are highly influenced by policy direction and industry regulations. Based on the integrated framework, this study examines technological, organizational, environmental, and government factors as independent variables, perceived usefulness as a mediating variable, and actual use of disruptive technologies as the dependent variable. The framework enables the study to investigate both the direct influence of external factors on technology adoption and the indirect influence through perceived usefulness.

Furthermore, this study adopts a descriptive and cross-sectional research design, with an explanatory approach to examine the relationship between variables. The descriptive design allows the researcher to describe the current adoption level of disruptive technology in the construction industry. A cross-sectional design allows data collection at a single point in time. Data collection was conducted using a structured questionnaire developed based on an extensive review of previous literature and adapted according to the research context. The questions were designed to measure the study variables and ensure the relevance and reliability of the collected data. The survey was distributed through an online platform and during seminars involving construction practitioners to obtain responses from relevant industry stakeholders.

The overall research process is presented in a flowchart to provide a clear overview of the systematic procedures undertaken in this study. The flowchart illustrates the key stages of the research, including problem identification, literature review, development of the conceptual framework, formulation of hypotheses, data collection, data analysis, and interpretation of findings.

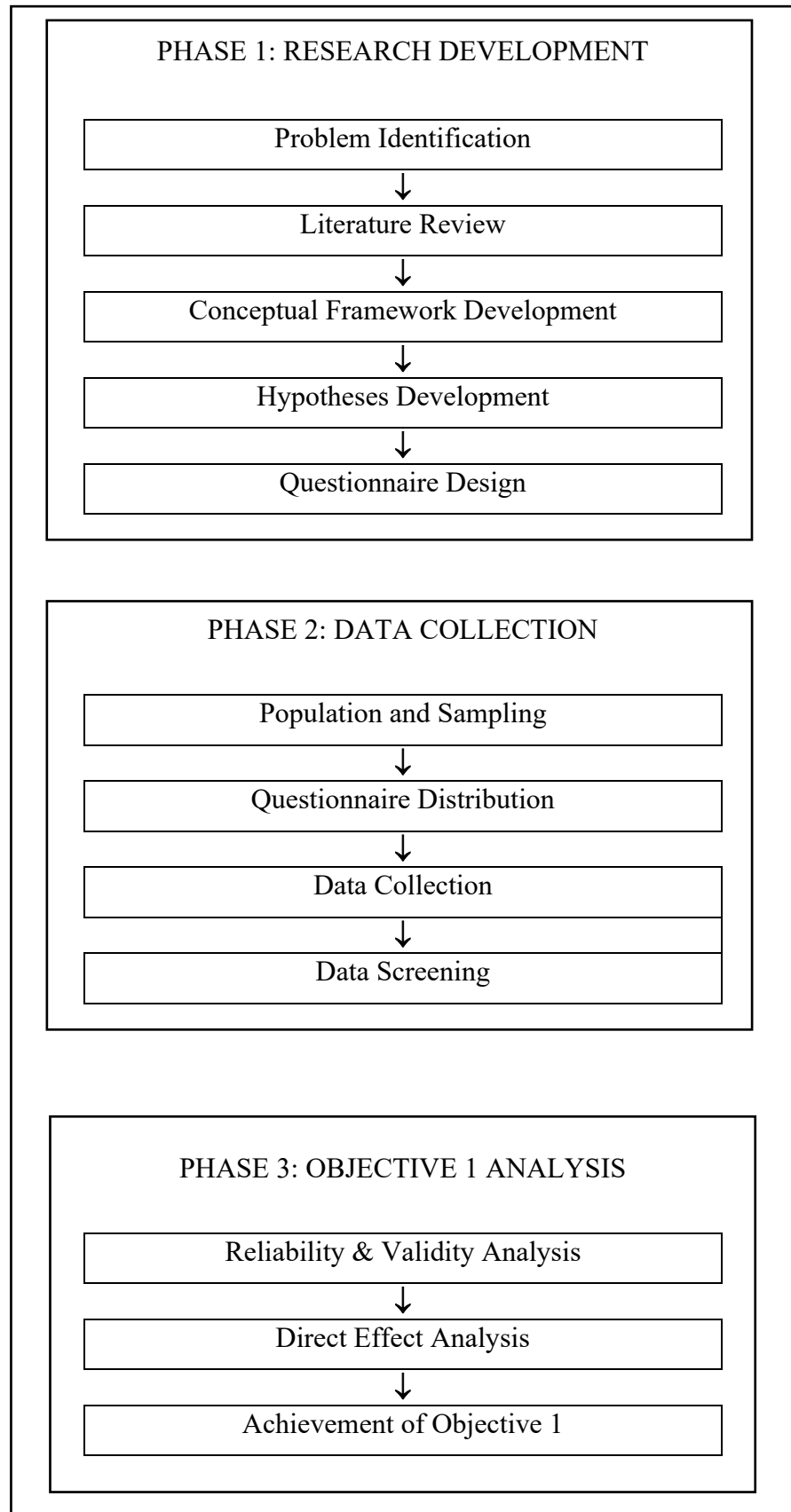


Figure 3.1 Research Process Flowchart

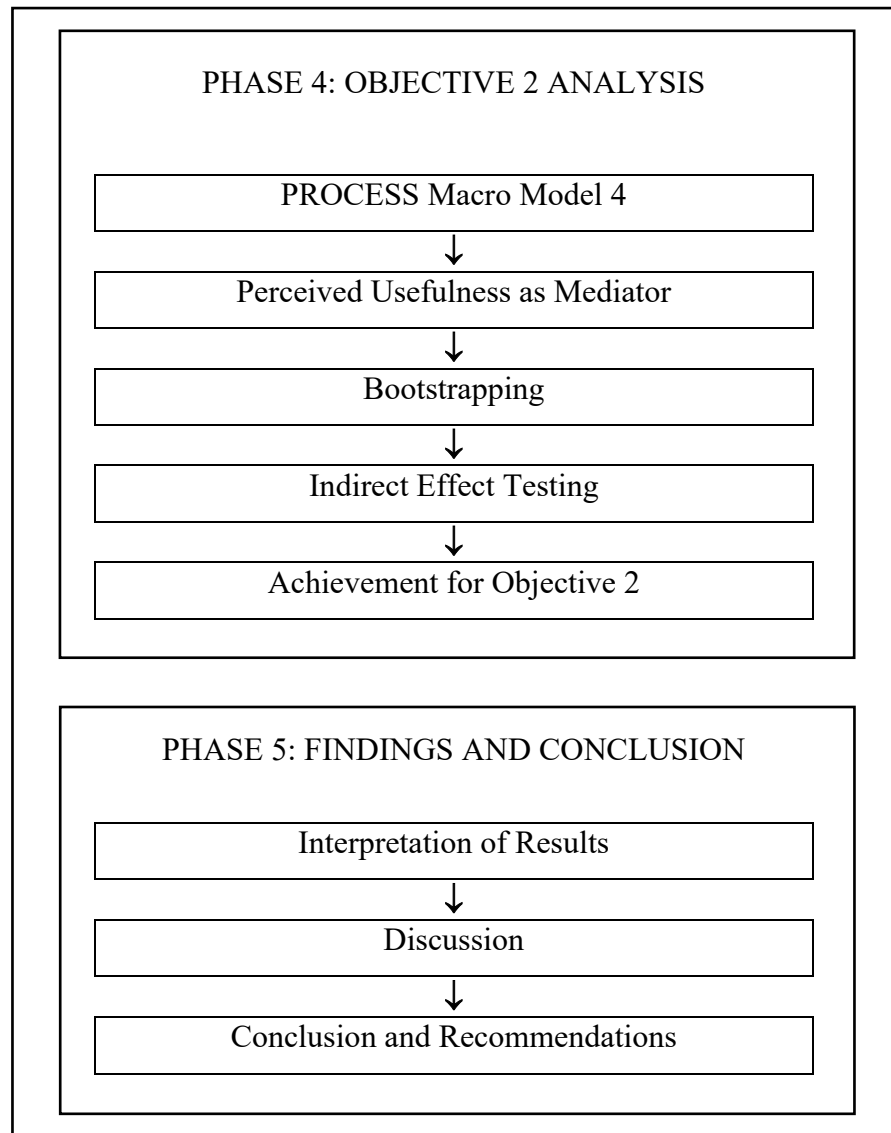


Figure 3.1 (continued) Research Process Flowchart

Figure 3.1 illustrates the overall research process undertaken in this study. The research process begins with the identification of the research problem, followed by a comprehensive literature review and the development of the conceptual framework. Subsequently, data collection and data analysis procedures are conducted to examine the proposed relationships among the variables. The final stage involves hypothesis testing and interpretation of the findings in relation to the research objectives. Each stage of the research process is systematically structured to ensure alignment with the objectives of the study.

### **3.3 Conceptual Framework**

Various theoretical frameworks have been used to investigate and identify factors influencing the adoption of technology, including the UTAUT framework, TAM framework, and other frameworks. The UTAUT framework can predict up to 70% of technology acceptance, whereas other models can predict up to 40% only (Hewavitharana et al., 2021). Nevertheless, although the UTAUT framework considers social and facilitating conditions, it primarily emphasizes individual behavioral factors and provides limited coverage of broad organizational and environmental contexts relevant to this study.

Therefore, this research selects variables from both the TOE and TAM frameworks to provide a broader perspective on the factors influencing the adoption of disruptive technology in the construction industry. The TOE and TAM frameworks complement each other in studying the adoption of technology to provide insight into users' attitudes, the benefits of technology use, and organizational and environmental influences (Katebi et al., 2022). Integrating variables from both frameworks enables the development of a comprehensive model that aligns with the study's objectives and the construction industry context. In addition, Legris et al. (2003) suggested that the TAM framework has valuable variables, but it should be integrated into a broader model that emphasizes both human and social factors.

This research examines the factors influencing the adoption of disruptive technology in the construction industry. Figure 3.2 is developed to achieve the research objectives, based on the literature discussion that determines the factors influencing the adoption of disruptive technology in the construction industry. The research framework for this study combines variables from two frameworks that are TOE and TAM framework. The TOE framework focuses on external factors (technology, organization, environment), whereas the TAM framework focuses only on individual factors (perceived usefulness). It shows that both integrated variable frameworks can complement each other by providing a holistic view of how both individual perception and external factors contribute to technology adoption. Chatterjee et al. (2021) mentioned that both frameworks have highly correlated variables, as the TOE framework can explain the factors adopted by using technological, organizational, and environmental dimensions. Meanwhile, the TAM framework can explain the individual

perceptions of technology acceptance.

The TOE framework consists of technological, organizational, and environmental context. This study also includes the government and its agencies' context to identify the government's role in adapting to disruptive technology, given the inconsistency in its adoption. Kong & Jie (2024) found that government involvement is crucial for successful digital transformation, as the government has the power to enact laws and rules to ensure the usage of technology, but Wang et al. (2022) found that the government has an insignificant impact on the adoption, as the construction industry personnel feel that technology is useful to them. Still, the government's role is not strong enough.

The TAM framework that is proposed in this study consists of Perceived Usefulness (PU) as the core variable, which explains at least 40% of the reasons for using the technology (Chatterjee et al., 2021). This study does not use the attitude of utilization variable as the influence of the variable was not significant, according to Davis (1989). Moreover, this study excludes the attitude of utilization because it primarily focuses on real-world implementation rather than planned intention. The previous study, which also removed the attitude of utilization in TAM, includes Chatterjee et al. (2021), Wang et al. (2022), Katebi et al. (2022), Sulaiman et al. (2023), Mujalli et al. (2024), and Legesse et al. (2024). Next, this study did not use the Perceived Ease of Use (PEOU) variable, as many studies confirm that PEOU influences the intention to use a technology, not directly on actual use (Na et al., 2022; Hamza et al., 2023; Wei et al., 2025).

This study also excludes variables intended for use and focuses directly on the actual use of disruptive technology in the construction industry. This is due to several disruptive technologies in the Malaysian construction industry that are policy-driven and mandatory. The government has introduced mandatory policies requiring the use of disruptive technology in construction projects (Bernama, 2023; CIDB Malaysia, 2025; Ramlin, 2025). When adoption is compulsory, organizations do not decide based on their intention; instead, they must comply. Therefore, including intention to use becomes irrelevant, and examining actual use is more appropriate for this study.

Based on this integration, the proposed conceptual framework, namely the Construction Technology Adoption Framework (ConTech-AF), was developed. The framework comprises four independent variables (technology, organization, environment, and government), one mediating variable (perceived usefulness), and one

dependent variable (actual use of disruptive technology). Perceived usefulness mediates the relationship between the independent variables and actual use by explaining how external factors influence the adoption of disruptive technology. Figure 3.2 illustrates the proposed ConTech-AF and the relationships among the study variables.

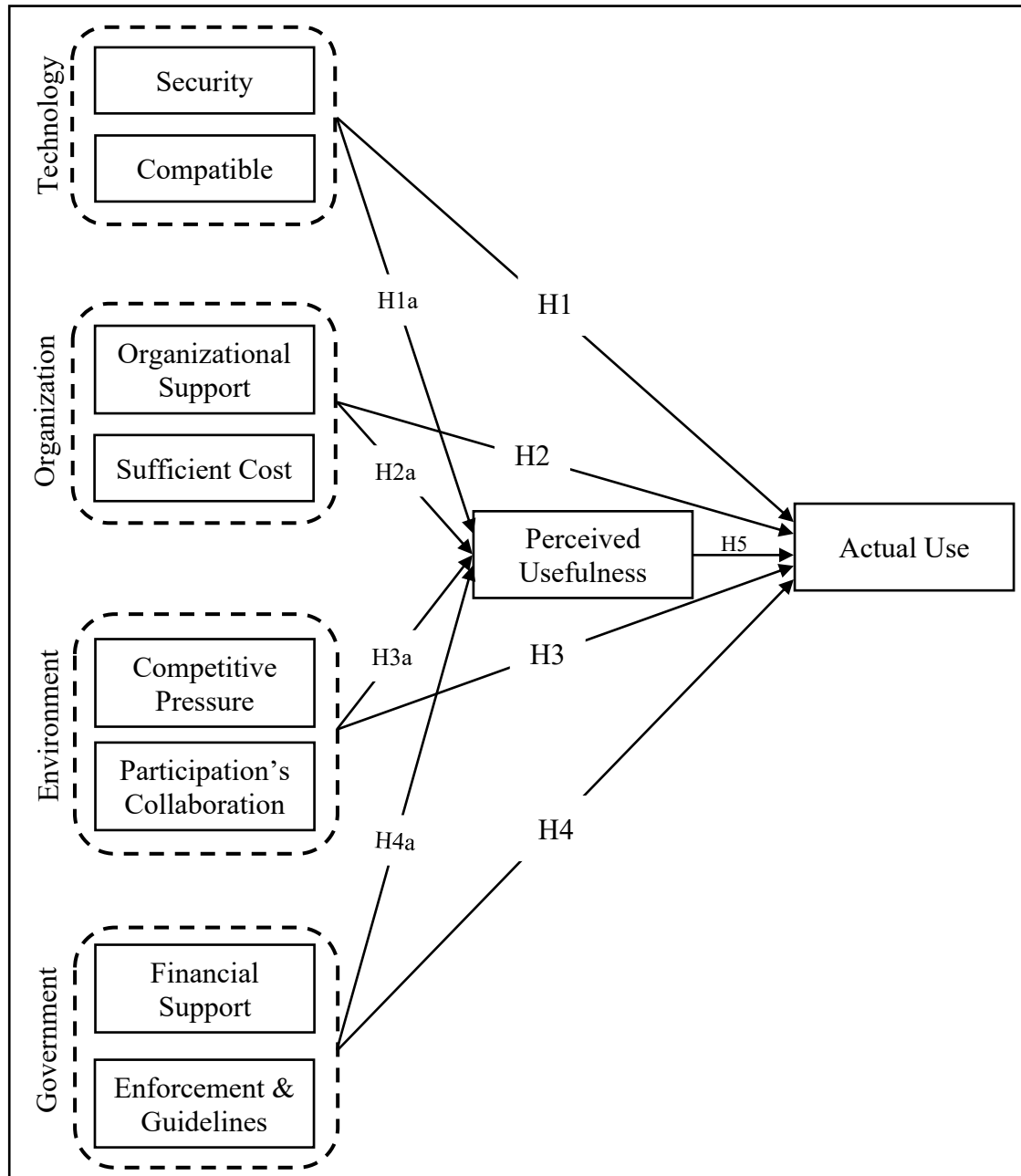


Figure 3.2 Construction Technology Adoption Framework (ConTech-AF)

### **3.4 Research Hypotheses**

Based on the literature and theoretical frameworks, this study proposes hypotheses to examine how technological, organizational, environmental, and governmental factors influence the actual use of disruptive technologies in the construction industry, with perceived usefulness acting as a mediator.

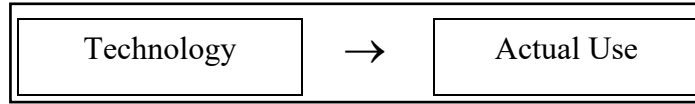
#### **3.4.1 Technological Context**

There is a positive influence of technological context in adopting new technology, as selecting the technology that offers strong user benefits and strong performance will encourage users to use the technology (Na et al., 2022). When it comes to adopting a new technology, companies usually compare it with the existing technology and consider the difference between the characteristics of the new and existing technology (Yuan et al., 2019).

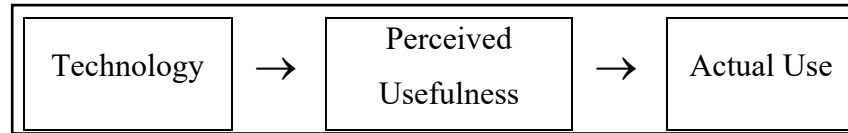
In this study, the technological context evaluates the disruptive technology's security and its system's compatibility. Wilson & Mergel (2022) mentioned that security concerns are one of the barriers experienced by individuals to implement digital technologies. Chomistrian et al. (2024) study mentions that there is a significant direct effect on the user's trust and ability (which includes compatible content), along with perceived usefulness, that will lead to the use of the system. Na et al. (2022) study mentioned that there is a positive effect on the technical feature (compatibility) in adopting the new technology to enhance the end-user's work performance.

To conclude, this technological context will examine how the technical features in terms of its function and performance (compatibility) and security of disruptive technology will influence the actual use of disruptive technology. In addition, a study from Nguyen et al. (2024) shows that the technological factors influence perceived usefulness, which is important for end-user acceptance in the construction industry. This study suggests that perceived usefulness can directly influence actual use, especially when the government mandates adoption.

Hypothesis 1: The technological context has a significant effect on the actual use of disruptive technology.



Hypothesis 1a: The technological context has a significant indirect effect on the actual use of disruptive technology through perceived usefulness.



### 3.4.2 Organizational Context

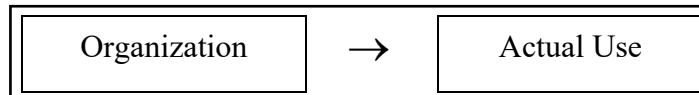
According to Na et al. (2022), the organizational factors should be considered to disrupt new technology. The research also found that the organization's cultures and structures are influenced by users' acceptance of the new technology. Top management plays an important role in the adoption of new technology within the organization. Moreover, Jaafar et al. (2024) found that the adoption of new technologies depends strongly on the top management's decision. For instance, the organization did not implement new technologies due to its limited financial resources and limited knowledge. Even when technology has been adopted, weak management often fails to implement the necessary changes.

Additionally, organizational culture shows the most stand-out results of barriers to implementing digital technologies (Wilson & Mergel, 2022). The potentially high cost appears to be a hindrance to adopting new technologies in the construction industry, given the low profit margins of the sector (Wilson & Mergel, 2022). The high cost of implementing disruptive technologies is the top barrier to their widespread adoption in the construction industry (Van et al., 2024). A study by Katebi et al. (2022) shows that cost had a positive and significant effect on perceived usefulness but no effect on the intention to adopt technology, Precast Concrete Component (PCC).

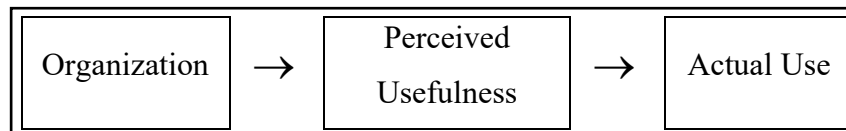
In this study, the organizational context refers to the management support and the cost of adoption in the organization. This organizational context will examine the organizational support and costs required for disruptive technology in the construction industry. Moreover, a study by Na et al. (2023) found that AI-based technologies in the construction industry show that organizational factors positively influence perceived

usefulness, which in turn mediates the relationship with usage. Therefore, the following hypothesis can be assumed.

Hypothesis 2: The organizational context has a significant effect on the actual use of disruptive technology.



Hypothesis 2a: The organizational context has a significant indirect effect on the actual use of disruptive technology through perceived usefulness.



### 3.4.3 Environmental Context

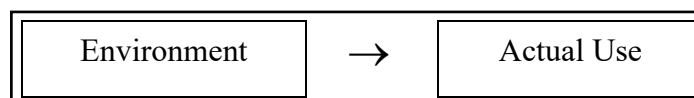
The environmental context here refers to the external social competitors that influence the actual use of new technology. According to Na et al. (2022), there has been little research that examines the impact of the social environment on the user's perceived usefulness. A study by Wang et al. (2022) found that companies feel the pressure of competition when the leading companies in the industry first apply disruptive technology successfully. Katebi et al. (2022) study mentions that there is a significant effect on the competitive pressure to adopt, as many barriers will be removed by organizations after looking at their competitors in the market using new technology. In addition, a study by Chatterjee et al. (2021) found that competitive pressure has a significant effect on the perceived usefulness, which, in turn, influences the intention to use Artificial Intelligence.

A study conducted by Tjandra et al. (2022) shows that limited information about drone technology appears to be the main barrier to construction actors' perception of its use. A study conducted by Othman et al. (2021) mentioned that the implementation of BIM technology has a significant effect on collaboration among stakeholders in the construction industry. A finding from Jaafar et al. (2024) found that small and medium-sized projects hesitate to use new technologies due to concerns about risk and

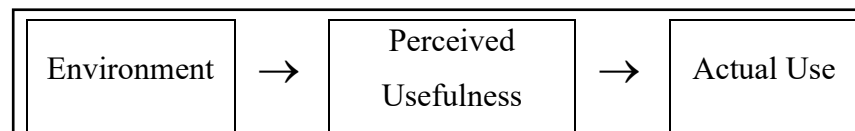
inadequate policies, and this behavior demotivates ambitious employees. Small and Medium Enterprises (SMEs) face challenges allocating funds to implement new technologies, as they often operate with low profit margins.

Therefore, previous studies indicate that organizations are more likely to adopt disruptive technology when competitors in the industry have already adopted it to avoid being left behind. However, several studies highlight that environmental challenges may weaken the relationship between the environment and actual use, such as limited financial resources and limited information on disruptive technology. Therefore, this study examines how competitive pressure and stakeholder collaboration will influence the adoption of disruptive technology.

Hypothesis 3: The environmental context has a significant effect on the actual use of disruptive technology.



Hypothesis 3a: The environmental context has a significant indirect effect on the actual use of disruptive technology through perceived usefulness.



#### 3.4.4 Government Context

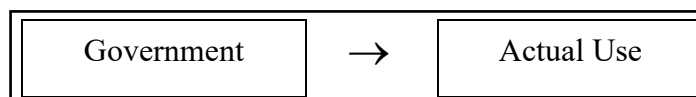
The government plays a crucial role in the construction industry. To increase the use of technology, government policy should favor construction initiatives. Government support through encouraging policies and incentives is an effective way to promote digitalization in the industry (Katebi et al., 2022). Governmental regulations and policies can significantly influence the acceptance level of new technology (Na et al., 2022). Musharavati (2023) mentions that the lack of government incentives significantly influences the adoption of one of the disruptive technologies, BIM technology. The study by Taib et al. (2023) found that government enforcement has an

insignificant effect on companies' adoption of BIM technology unless it directly addresses their needs.

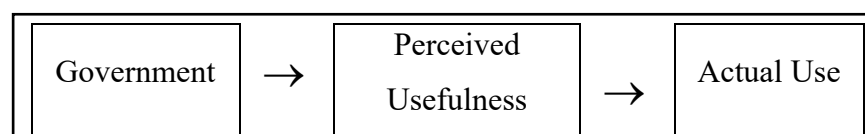
Although the Malaysian government has made efforts to improve the construction industry, it still relies heavily on low-cost foreign labor, which hinders the adoption of modern technologies such as machinery and advanced equipment due to their high costs and the lack of trained personnel (Jaafar et al., 2024). Government efforts to increase knowledge and awareness of disruptive technologies through seminars and programs remain successful, as only 2% of respondents are confident in their knowledge (Lee et al., 2022). Meanwhile, 96% of respondents agree that the government should enforce adoption in the future for the Sarawak construction industry, as they have no choice (Lee et al., 2022).

The government context is a new context that has been adapted in the conceptual framework by the author of this study. The findings from Jaafar et al. (2024) mention that there is a critical need for the government to plan actions to help increase the transformative agenda in Malaysia's construction industry. Moreover, studies from Tran Pham (2023) and Qiu et al. (2023) show that the government rules and regulations mediate the relationship of technology adoption through perceived usefulness. In this study, the government context involves the Malaysian government and its construction agencies. Through financial support, regulatory enforcement, and established guidelines, the government and its agencies can influence how users adopt disruptive technologies within the industry.

Hypothesis 4: The government context has a significant effect on the actual use of disruptive technology.



Hypothesis 4a: The government context has a significant indirect effect on the actual use of disruptive technology through perceived usefulness.

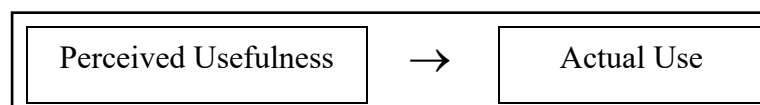


### 3.4.5 Perceived Usefulness (PU)

According to Katebi et al. (2022), perceived usefulness refers to the extent to which an individual perceives improvements in performance and efficiency resulting from the use of new technology. It can be seen that perceived usefulness plays a crucial role as a mediating variable in technology adoption, as the use of a mediator (perceived usefulness) has an impact on triggering the adoption of technology (Chatterjee et al., 2021). There is a strong impact of perceived usefulness in the context of the adoption of Artificial Intelligence in an organization (Chatterjee et al., 2021). A study from Vietnam found that perceived usefulness is a critical factor influencing end-user ICT acceptance in the construction industry (Nguyen et al., 2024). In addition, the government requirement to mandate the use of technology can directly influence the role of perceived usefulness, which can increase the actual use (Nguyen et al., 2024; Wong et al., 2025).

In this study, perceived usefulness refers to the extent to which respondents understand the benefits of using disruptive technologies in the construction industry. This variable indicates how much an individual, especially users of disruptive technology, understands that using disruptive technology would enhance their job performance in construction processes. Based on this understanding, the following hypothesis is proposed.

Hypothesis 5: The perceived usefulness has a significant effect on the actual use of disruptive technology.



### 3.4.6 Actual Use (Adoption of Disruptive Technology)

The adoption of technology is defined by Davis as an “individual’s actual direct usage of a given system in the context of his or her job” (Davis, 1989). The adoption of disruptive technologies in the context of this study refers to the user’s actual use of disruptive technology.

### 3.5 Population and Sampling

This section explains the population and sampling strategy used in this study to provide relevant data for examining the factors influencing the adoption of disruptive technologies in the construction industry.

#### 3.5.1 Population of the Study

The population of this study consists of construction practitioners in the construction industry who are directly engaged in construction activities and the adoption of disruptive technologies. According to the Malaysia Contractors Portal (2024), there were 5,372 companies registered with CIDB in Sarawak as of April 2024. Table 3.1 shows the total number of companies that have been registered with CIDB in the Sarawak District.

Table 3.1  
The Total Number of Companies That Have Been Registered Under CIDB Sarawak

| District     | Total Company |
|--------------|---------------|
| Kuching      | 2817          |
| Miri         | 1093          |
| Sibu         | 813           |
| Bintulu      | 649           |
| <b>Total</b> | <b>5 372</b>  |

Source: Malaysia Contractors Portal (2024)

The target population for this research is in Sarawak, specifically in the Bintulu Division. Bintulu plays a significant role in attracting investors due to the flourishing business (New Sarawak Tribune, 2021). In addition, Bintulu is a contributor to Sarawak's government revenue, as it is mainly involved in oil and gas production (Dayak Daily, 2023). The oil and gas production and construction sectors have a significant impact on each other. For instance, the demand for construction projects will increase when the oil and gas industry requires specialized infrastructure, such as pipelines.

The population for this study comprises construction companies registered with

the Construction Industry Development Board (CIDB) in Bintulu, Sarawak. As shown in Table 3.1, a total of 649 construction companies are registered with CIDB in Bintulu. Each company is represented by at least one construction practitioner, such as a manager, engineer, or construction player who is knowledgeable about the company's technology adoption practices and, therefore, suitable to respond to the survey.

Although the number of registered construction companies in Bintulu is relatively limited, the high number of customers visiting the CIDB Bintulu Branch indicates active participation and engagement among these companies in CIDB-related activities, such as registration, renewal, and compliance matters. This demonstrates that the registered construction companies are accessible through the CIDB Bintulu Branch, making it a practical and appropriate channel for data collection. In addition, Bintulu is selected as the study location due to its relatively active construction sector compared to other areas, which supports its suitability for obtaining data on technology adoption in the industry.

However, this study does not assume that Bintulu represents the whole Sarawak construction industry. Instead, it is selected as a focused study area based on its higher level of construction activity and accessibility of respondents. Therefore, the findings should be interpreted within the context of Bintulu rather than generalized to the entire Sarawak construction industry.

Table 3.2 shows the total number of customers coming to CIDB Sarawak Branches in 2023, based on the CIDB Customer Service Report.

Table 3.2  
The Total Number of Customers Who Come to CIDB's Sarawak Branches for Customer Services

| CIDB's Branches | The Total Number of Customers Comes to the Office (persons) |
|-----------------|-------------------------------------------------------------|
| Bintulu         | 9109                                                        |
| Kuching         | 3849                                                        |
| Sibu            | 2478                                                        |
| Miri            | 1840                                                        |

Source: CIDB Customer Service Report (*Bahagian & Korporat, 2023*)

### 3.5.2 Sample Size of the Study

This research used a questionnaire survey that was designed based on the literature review. To obtain holistic, accurate data on the factors influencing the adoption of disruptive technology, a purposive sampling technique will be used. Purposive sampling is an effective method to ensure that every player in the population has a chance of being selected (Ahmed, 2024). This sampling is flexible and allows researchers to select respondents who best fit the study's needs (Ahmad & Wilkins, 2025). As the purpose of this research is to examine the overall adoption of disruptive technology in the construction industry, purposive sampling ensures that only qualified and knowledgeable respondents are included.

The sample size is determined using the GPOWER program. GPOWER is a software tool to determine the minimum required sample size, especially in behavioral research, for common statistical tests (Erdfelder et al., 1996). As this study focuses on multiple regression analysis, the test family used is the F test, with the statistical test being linear multiple regression: fixed model, R-squared deviation from zero.

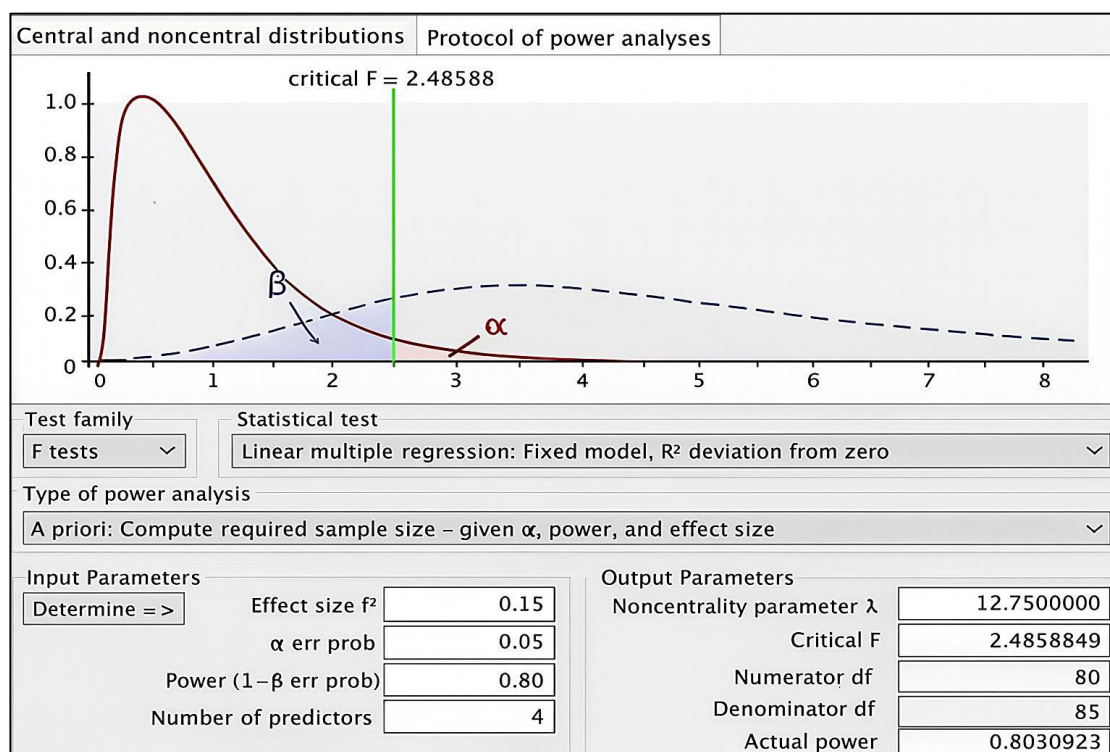


Figure 3.3 GPOWER Output for Sample Size Calculation in Linear Multiple Regression

Based on the recommendation of Cohen (1988), 0.80 power is standard and adequate in behavioral science studies (Buchberger et al., 2024). Thus, this study uses a statistical power of 0.80 and an alpha level of 0.05. Next, a medium effect size of 0.15 was selected to balance the realistic expectations of effect magnitude and adequate statistical power, as commonly recommended in behavioral and social sciences (Erdfelder et al., 1996; Faul & Lang, 2009). This study includes four predictors, namely technological, organizational, environmental, and government factors, which are examined as independent variables influencing disruptive technology adoption. Based on the G\*Power calculation, the minimum required sample size for this study is 85 construction companies.

### **3.6 Data Collection Methods**

This study collects primary data using a structured questionnaire as a single-method data collection approach. The questionnaire refers to a set of research instruments that aim to collect information from construction practitioners. The purpose is to collect data on technological, organizational, environmental, and governmental factors that influence the actual use of disruptive technologies in the construction industry. The questionnaire consists of structured, closed-ended questions, allowing responses to be collected systematically and measured quantitatively for statistical analysis. The questionnaire was distributed to construction practitioners from CIDB-registered construction companies through an electronic platform, the WhatsApp mobile application. The contact information of registered companies was obtained from the official CIDB directory to facilitate the distribution process. In addition, the questionnaire was distributed during seminars and industry-related events attended by potential respondents. This approach enabled direct engagement with relevant construction practitioners and increased the accessibility of the survey, thereby obtaining responses from the targeted population.

### 3.7 Survey Instrumentation

In this study, closed-ended questionnaires are being used to collect data. The questionnaire items are adapted from established instruments in previous studies to ensure that the constructs are measured accurately and consistently. This approach supports the construct validity of the instrument, as the measurement items are derived from validated literature and aligned with the study variables.

There are three sections in this set of questionnaires. Section 1 comprises the respondent's demographic data; Section 2 assesses the current level of disruptive technology in the construction industry; Section 3 examines the relationships of independent variables (technological, organizational, environmental, and government), and the mediator variable (perceived usefulness), on the use of disruptive technologies. Thus, the structure of the questionnaire design is illustrated in Table 3.3.

For section 3, a 5-point Likert scale is used to measure the independent variables, ranging from strongly disagree to strongly agree (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree). Meanwhile, the dependent variable is measured using a 7-point Likert scale, ranging from strongly disagree to strongly agree (1 = strongly disagree, 2 = disagree, 3 = somewhat disagree, 4 = neutral, 5 = somewhat agree, 6 = agree, 7 = strongly agree). Different Likert-scale formats are used for independent and dependent variables in this study to reduce the likelihood that respondents use the same response pattern across all items, thereby minimizing potential response bias.

Table 3.3  
Structure of Question

| Section | Items                                 | No. of Questions |
|---------|---------------------------------------|------------------|
| 1       | Demographic Respondent                | 10               |
| 2       | Assess the current level of adoption: |                  |
|         | - Technology adoption metric          | 3                |
| 3       | Factors influencing the adoption:     |                  |
|         | - Technology                          | 4                |
|         | - Organization                        | 4                |
|         | - Environment                         | 4                |
|         | - Government                          | 4                |
|         | - Perceived Usefulness                | 3                |
|         | - Adoption of Disruptive Technology   | 4                |

### 3.7.1 Section One

Section One consists of the respondents' demographic data, including gender, age range, race, education level, work location, company name, project management roles, company specialization, profession, and work experience.

Table 3.4  
Questionnaires for Demographic Respondents

| No of Question | Code | Question                             | Category                                                                                                       | Source               |
|----------------|------|--------------------------------------|----------------------------------------------------------------------------------------------------------------|----------------------|
| 1              | R1   | What is your gender?                 | - Male<br>- Female                                                                                             | (Na et al., 2022)    |
| 2              | R2   | How old are you?                     | - 20 – 30 Years Old<br>- 31 – 40 Years Old<br>- 41- 50 Years Old<br>- 51 – 60 Years Old                        | (Lekan et al., 2021) |
| 3              | R3   | What is your race?                   | - Malay<br>- Iban<br>- Chinese<br>- Other                                                                      |                      |
| 4              | R4   | What is your highest education level | - Certificate<br>- Diploma<br>- Bachelor's Degree<br>- Bachelor's Master<br>- Doctor of Philosophy<br>- Others | (Na et al., 2022)    |

|   |    |                                                                             |   |                                           |                          |
|---|----|-----------------------------------------------------------------------------|---|-------------------------------------------|--------------------------|
| 5 | R5 | What is your company name?                                                  | - | Open-ended question                       |                          |
| 6 | R6 | What is the project management role of your current company?                | - | Main Contractor                           |                          |
|   |    |                                                                             | - | Sub-contractor                            |                          |
|   |    |                                                                             | - | Others                                    |                          |
| 7 | R7 | What is your company's specialization sector?                               | - | Civil Engineering                         | (Obidallah et al., 2024) |
|   |    |                                                                             | - | Non-Residential Building                  |                          |
|   |    |                                                                             | - | Residential Building                      |                          |
|   |    |                                                                             | - | Special Trade Activities                  |                          |
|   |    |                                                                             | - | Others                                    |                          |
| 8 | R8 | What is the profession or job title of your current company?                | - | Project Manager/Assistant Project Manager | (Van et al., 2021)       |
|   |    |                                                                             | - | Architect                                 |                          |
|   |    |                                                                             | - | Engineer                                  | (Lekan et al., 2021)     |
|   |    |                                                                             | - | Contractor                                | (Vitente et al., 2024)   |
|   |    |                                                                             | - | Administrative Staffs                     | (Gong et al., 2024)      |
|   |    |                                                                             | - | Finance Officers                          |                          |
|   |    |                                                                             | - | Project Coordinator                       |                          |
|   |    |                                                                             | - | Human Resources Officer                   |                          |
|   |    |                                                                             | - | Others (Specify)                          |                          |
| 9 | R9 | How many years of work experience do you have in the construction industry? | - | 3 Years or Less                           | (Na et al., 2022)        |
|   |    |                                                                             | - | 3 – 5 Years                               |                          |
|   |    |                                                                             | - | 6 – 10 Years                              |                          |
|   |    |                                                                             | - | 11 – 15 Years                             |                          |
|   |    |                                                                             | - | 16 Years and Above                        |                          |

### 3.7.2 Section Two

Section Two will focus on the questionnaire that assesses the current level of disruptive technology adoption in the construction industry. The questionnaire is based on the literature review of articles by Al-Ashmori et al. (2020) and Jaafar et al. (2024). There are three main questions, each with 12 sub-questions.

Table 3.5  
Questionnaires to Assess the Current Level of Disruptive Technology

| No of Question | Code | Dimension                                                                | Classification       | Source                    |
|----------------|------|--------------------------------------------------------------------------|----------------------|---------------------------|
| 1              | M1   | Are you aware of the disruptive technologies that have been implemented? | 1 = Not at all       | (Al-Ashmori et al., 2020) |
|                | DT1  | - Building Information Modelling                                         | 2 = Slightly aware   |                           |
|                | DT2  | - Pre-fabrication and modular construction                               | 3 = Moderately Aware |                           |
|                | DT3  | - Autonomous construction                                                | 4 = Somewhat Aware   |                           |
|                | DT4  | - Augmented Reality & Virtualization                                     | 5 = Extremely Aware  |                           |
|                | DT5  | - Cloud & Realtime Collaboration                                         |                      |                           |
|                | DT6  | - 3D Scanning & Photogrammetry                                           |                      |                           |
|                | DT7  | - Big Data & Predictive Analytics                                        |                      |                           |
|                | DT8  | - Internet of Things (IoT)                                               |                      |                           |
|                | DT9  | - 3D Printing & Additive Manufacturing                                   |                      |                           |
|                | DT10 | - Advanced Building Materials                                            |                      |                           |
|                | DT11 | - Blockchain Technology                                                  |                      |                           |
|                | DT12 | - Artificial Intelligence                                                |                      |                           |

|   |    |                                                                                   |                                                                                                                            |                       |
|---|----|-----------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------|-----------------------|
| 2 | M2 | How do you rate your understanding of each disruptive technology?                 | 1 = No Knowledge<br>2 = Limited Knowledge<br>3 = Having Basic Knowledge<br>4 = Proficient<br>5 = Expert                    | (Jaafar et al., 2024) |
| 3 | M3 | How would you rate the level of usage of disruptive technologies in your company? | 1 = Not in use<br>2 = Considering using<br>3 = Early Adoption<br>4 = Having been used for some time<br>5 = Frequently used | (Jaafar et al., 2024) |

### 3.7.3 Section Three

Section 3 focuses on the questionnaire developed to achieve the study objectives, namely to determine the influence of technological, organizational, environmental, and government factors on the adoption of disruptive technology in the construction industry and to examine the mediating role of perceived usefulness in these relationships. This study will use a 5-point Likert scale for the independent variables, which range from strongly disagree to strongly agree (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree). Meanwhile, for the dependent variable, there is a 7-point Likert scale, which ranges from strongly disagree to strongly agree (1 = strongly disagree, 2 = disagree, 3 = somewhat disagree, 4 = neutral, 5 = somewhat agree, 6 = agree, 7 = strongly agree). Different Likert-scale formats are used for independent and dependent variables in this study to reduce the likelihood that respondents use the same response pattern across all items, thereby minimizing potential response bias. The Likert scale, developed by Rensis Likert in 1932, was originally designed to measure individuals' attitudes, opinions,

and perceptions, and it is still widely used to this day (Susan, 2024).

In addition, this questionnaire includes a variable marker, but it is not included in the model being tested. The marker variable is an unrelated variable that is included in research to assess the extent of common method bias (CMB) (Podsakoff et al., 2003). When both independent and dependent variables were collected at the same time and by the same respondents, CMB might exist (Avolio et al., 1991). To avoid it, the researcher used one of the recommendations from Kock et al. (2021) to control the CMB, which is achieved by adding a directly measured latent model variable. In this research, the researcher uses the social desirability variable from Fischer & Fick (1993), as it is theoretically unrelated to the main constructs of the conceptual frameworks. Yet, it captures potential response tendencies of respondents to present themselves favorably. Social desirability refers to the tendency of participants to try to act in a way that makes them appear acceptable to others (Fur, 2010).

Table 3.6  
Questionnaires for Technological Context

| No of Question | Code | Original Version                                                                                              | Adapted Version                                                                                                           | Classification                                       | Source              |
|----------------|------|---------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------|---------------------|
| 1              | T1   | Security and authentication are relevant to the D-Procurement adoption success.                               | The disruptive technology must have security and be validated before being used.                                          | 1 = Strongly Disagree<br>2 = Disagree<br>3 = Neutral | (Luo et al., 2023)  |
| 2              | T2   | Blockchain technical features are well compatible with the current working mode of the construction industry. | The disruptive technology's technical features/specifications are fully aligned with your company's current working mode. | 4 = Agree<br>5 = Strongly Agree                      | (Wang et al., 2022) |
| 3              | T3   | Blockchain technology itself has been developed and improved, and the blockchain system is very stable.       | The disruptive technology should be stable and should keep improving.                                                     |                                                      | (Wang et al., 2022) |

|   |    |                                                                                                                                     |                                                                                                                                  |                    |
|---|----|-------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------|--------------------|
| 4 | T4 | Our digital platform (disruptive innovation) is scalable to support open connections between our partners' systems and our systems. | The disruptive technology is scalable to support open connections between my company partners' systems and my company's systems. | (Jin & Wang, 2024) |
|---|----|-------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------|--------------------|

Table 3.7  
Questionnaires for Organizational Context

| No of Question | Code | Original Version                                                                                               | Adapted Version                                                                                             | Classification                                       | Source                   |
|----------------|------|----------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------|------------------------------------------------------|--------------------------|
| 1              | O1   | Do you think that a supportive organizational culture will encourage the adoption of BIM in your organization? | My organization encourages the adoption of disruptive technology for daily use.                             | 1 = Strongly Disagree<br>2 = Disagree<br>3 = Neutral | (Muthusamy et al., 2023) |
| 2              | O2   | The organization provides staff guidance on how to change to the new way of working with new technology.       | My organization guides me on how to adapt new ways of working with disruptive technology.                   | 4 = Agree<br>5 = Strongly Agree                      | (Jackson & Allen, 2024)  |
| 3              | O3   | The company provides sufficient resources (such as manpower and funding) to enhance employee safety education. | My company provides sufficient resources (such as manpower and funding) to implement disruptive technology. |                                                      | (Liu et al., 2024)       |
| 4              | O4   | My organization allocates sufficient funds for BIM facilities.                                                 | The cost of investment in disruptive technology is sufficient for my organization.                          |                                                      | (Yang et al., 2018)      |

Table 3.8  
Questionnaires for Environmental Context

| No of Question | Code | Original Version                                                                                                                                  | Adapted Version                                                                                                                            | Classification                                       | Source                  |
|----------------|------|---------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------|-------------------------|
| 1              | N1   | The organization thinks that new technology has an influence on competition in their industry.                                                    | Industry competition influences the company's decision to adopt disruptive technology.                                                     | 1 = Strongly Disagree<br>2 = Disagree<br>3 = Neutral | (Jackson & Allen, 2024) |
| 2              | N2   | With fierce competition in the industry, the enterprise must adopt blockchain technology to ensure that it will not be eliminated by competition. | With high competition in the industry, companies must adopt disruptive technology to ensure that it will not be eliminated by competition. | 4 = Agree<br>5 = Strongly Agree                      | (Wang et al., 2022)     |
| 3              | N3   | The growth of small-scale enterprises (SMEs) should be supported by technological advancement.                                                    | Small and Medium Enterprises (SME) should be supported in the context of technological advancement.                                        |                                                      | (Lekan et al., 2021)    |
| 4              | N4   | The development of smart construction systems can bring economic benefits.                                                                        | The implementation of disruptive technology can bring economic benefits to the construction industry.                                      |                                                      | (Yang et al., 2018)     |

Table 3.9  
Questionnaires for Government Context

| No of Question | Code | Original Version                                                                                                | Adapted Version                                                                                                     | Classification                        | Source                   |
|----------------|------|-----------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|---------------------------------------|--------------------------|
| 1              | GA1  | Do you think the lack of support and enforcement by the government is a factor that impedes the adoption of BIM | The government and its agencies' support and enforcement play an important role in the implementation of disruptive | 1 = Strongly Disagree<br>2 = Disagree | (Muthusamy & Chew, 2023) |

|   |     |                                                                                                                                                                    |                                                                                                                                                                               |                                 |                       |
|---|-----|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|-----------------------|
|   |     | in your organization?                                                                                                                                              | technologies.                                                                                                                                                                 | 3 = Neutral                     |                       |
| 2 | GA2 | Government departments have formulated relevant guidelines and application standards for the implementation of blockchain technology in the construction industry. | The government and its agencies have formulated relevant guidelines and application standards for the implementation of disruptive technologies in the construction industry. | 4 = Agree<br>5 = Strongly Agree | (Wang et al., 2022)   |
| 3 | GA3 | Precast Concrete Components (PCC) usage and development receive financial support from the government or relevant authorities.                                     | The government and its agencies should give financial support to construction companies that implement disruptive technologies.                                               |                                 | (Katebi et al., 2022) |
| 4 | GA4 | It is in favor of reducing the cost of BIM use if the government exerts the subsidy policy for our BIM implementation.                                             | The cost of implementing disruptive technology can be reduced if the government provides subsidies to the company.                                                            |                                 | (Yuan et al., 2019)   |

Table 3.10  
Questionnaires for Perceived Usefulness

| No of Question | Code | Original Version                                                | Adapted Version                                                                        | Classification                                 | Source              |
|----------------|------|-----------------------------------------------------------------|----------------------------------------------------------------------------------------|------------------------------------------------|---------------------|
| 1              | PU1  | Using blockchain technology can improve my productivity.        | Using disruptive technology will increase the speed of my task completion.             | 1 = Strongly Disagree<br>2 = Disagree          | (Wang et al., 2022) |
| 2              | PU2  | Using blockchain technology can improve the quality of my work. | Using disruptive technology can improve the quality of construction plans and designs. | 3 = Neutral<br>4 = Agree<br>5 = Strongly Agree | (Wang et al., 2022) |
| 3              | PU3  | Using smart construction technology helps                       | Using disruptive technology helps me                                                   |                                                | (Liu et al., 2024)  |

|                                   |                                |
|-----------------------------------|--------------------------------|
| me better manage my work content. | better manage my work content. |
|-----------------------------------|--------------------------------|

Table 3.11  
Questionnaires for Actual Use (Adoption of Disruptive Technology)

| No of Question | Code | Original Version                                                                     | Adapted Version                                                      | Classification                                             | Source                    |
|----------------|------|--------------------------------------------------------------------------------------|----------------------------------------------------------------------|------------------------------------------------------------|---------------------------|
| 1              | AU1  | I use BIM at work.                                                                   | I personally have used disruptive technology in my work.             | 1 = Strongly Disagree<br>2 = Disagree                      | (Yuan et al., 2019)       |
| 2              | AU2  | I prefer green building technologies (GBTS) to traditional architectural technology. | I use disruptive technology rather than traditional working methods. | 3 = Somewhat Disagree<br>4 = Neutral<br>5 = Somewhat Agree | (Wang et al., 2019)       |
| 3              | AU3  | My firm adopts new technologies                                                      | My company had implemented disruptive technology.                    | 6 = Agree<br>7 = Strongly Agree                            | (Badghish & Soomro, 2024) |
| 4              | AU4  | My organization uses BIM                                                             | My organization already used disruptive technology.                  |                                                            | (Murguia et al., 2023)    |

Table 3.12  
Questionnaires for Marker Variables

| No of Question | Code | Question                                                      | Classification                                 | Source                 |
|----------------|------|---------------------------------------------------------------|------------------------------------------------|------------------------|
| 1              | PU1  | I am always willing to admit it when I make a mistake.        | 1 = Strongly Disagree                          | (Fischer & Fick, 1993) |
| 2              | PU2  | There have been occasions where I took advantage of someone.  | 2 = Disagree                                   |                        |
| 3              | PU3  | At times, I have really insisted on having things my own way. | 3 = Neutral<br>4 = Agree<br>5 = Strongly Agree |                        |
|                |      |                                                               |                                                |                        |

### **3.8 Data Analysis Procedures**

This section describes the procedures used to analyze the data collected for this study. The procedures include checking data reliability and validity, data screening, organizing quantitative data for analysis, managing the data process, the software tools used for analysis, and the ethical considerations applied throughout the data analysis. These steps are essential to ensure that the findings are trustworthy, accurate, and consistent with the study's objectives.

#### **3.8.1 Data Management and Software**

The collected data handled effectively to ensure it is accurate, secure, accessible, and organized for current and future reference throughout the research process. Two software applications, namely Microsoft Excel and Statistical Package for Social Sciences (SPSS) Statistics software, are used for data management and analysis.

Microsoft Excel is used during the initial stage of data management, including data entry and data checking. Meanwhile, the SPSS software is used for data entry and analysis, which can handle large amounts of data (Nagaiah et al., 2016). In this study, SPSS software is used for data screening, descriptive analysis, reliability analysis, and mediation analysis through the PROCESS Macro.

#### **3.8.2 Data Screening**

In this study, several data screening procedures are being conducted, including checking for missing data, measuring normality, and detecting the common method bias. These procedures ensure that the dataset is clean, reliable, and suitable for further statistical analysis, thereby enhancing the accuracy, validity, and credibility of the research findings.

### 3.8.3 Data Reliability and Validity

Before conducting the main survey, the questionnaires are evaluated through a pre-test and a pilot test to ensure their validity and reliability. The pre-test is conducted to assess the clarity, relevance, and suitability of the questionnaire items. In this study, the pre-test involves three experts from the Construction Industry Development Board (CIDB). Their feedback is used to identify ambiguous wording, unclear instructions, and potential issues related to the questionnaire content. Stockemer (2018) said that it is important to conduct a pre-test, as it can ensure respondents understand the survey questions and that the wording is not problematic.

Following the pre-test, a pilot test is conducted to evaluate the reliability and feasibility of the questionnaire before the main data collection. Lowe (2019) said that a pilot test is a small feasibility study designed to test various aspects of the methods planned for a confirmatory investigation. In this study, the pilot test involves 30 construction industry practitioners from different construction companies. The pilot test enables the researcher to identify potential issues related to questionnaire administration and item interpretation.

The data collected from the pilot test are analysed using the Statistical Package for the Social Sciences (SPSS) software. Reliability will be assessed using Cronbach's Alpha coefficient to determine the internal consistency of the measurement items. A higher Cronbach's Alpha value indicates greater reliability of the instrument. Table 3.13 presents the interpretation guidelines for Cronbach's Alpha.

Next, the Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy and Bartlett's test are used to assess the validity of this study's instrument. A KMO value closer to 1 suggests that the data are highly suitable for factor analysis, while a value below 0.5 indicates that the data are not suitable for factor analysis. Meanwhile, Bartlett's test indicates a significant relationship among variables when the p-value is less than 0.05 ( $p < 0.05$ ) (Ekyalimpa et al., 2023).

Table 3.13  
The Cronbach's Alpha Value Interpretation

| Cronbach's Alpha ( $\alpha$ ) | Description |
|-------------------------------|-------------|
| $\alpha > 0.9$                | Excellent   |
| $\alpha > 0.8$                | Good        |

|                |              |
|----------------|--------------|
| $\alpha > 0.7$ | Acceptable   |
| $\alpha > 0.6$ | Questionable |
| $\alpha > 0.5$ | Poor         |
| $\alpha < 0.5$ | Unacceptable |

Source: Gliem & Gliem (2003)

### 3.8.4 Quantitative Data Analysis

Quantitative data analysis is a systematic and precise method for studying numerical data, including data collected from questionnaires, allowing researchers and decision-makers to discover insights, test hypotheses, and make well-informed judgments (Ghanad, 2023). By analyzing data using various statistical methods, quantitative analysis can reveal relationships among variables, providing insight into the research. After the data have been collected, the questionnaire will be checked and cleaned to ensure it has been fully answered. If a response is incomplete, the questionnaire will be removed.

#### 3.8.4.1 Descriptive Analysis Procedure

Demographic respondents' data, such as gender, age range, education level, and company information, are analyzed using descriptive statistics. To summarize the respondents' demographic profiles, frequencies and percentages are used. Next is the data analysis for the current level of disruptive technology adoption. Descriptive analysis is a statistical method used to summarize and provide a comprehensive understanding of data. It helps to organize and evaluate the data in an easy-to-understand way. Nassaji (2015) mentioned that descriptive analysis is a research method used to describe existing phenomena and their characteristics systematically and accurately. Descriptive statistics clearly and understandably represent data using measures such as the mean, median, mode, and standard deviation (Vetter, 2017).

The research uses descriptive analysis to examine the use of disruptive technology, calculating frequency (how often each technology is used) and percentages (what percentage of respondents use each technology) for each technology. This analysis can help identify which disruptive technologies are commonly used by

construction companies. It also analyzes the central tendency (the central point of the data distribution) using three main measures: mean, median, and mode. The mean can provide the average usage frequency, and the mode can provide the most used technology among the respondents. Meanwhile, the median is the middle value and can be effective when the data includes extreme scores (Croucher & Cronn-Mills, 2024).

#### **3.8.4.2 Multiple Regression Analysis Procedure**

For objective one (to determine the influence of technological, organizational, environmental, and government factors on the adoption of disruptive technology in the construction industry), a multiple regression analysis is used to support the findings of this research. Aryel et al. (2006) noted that multiple regression is a statistical technique used to predict a dependent variable from two or more independent variables. In this study, multiple regression analysis is used to determine how four factors influence the actual use of disruptive technology adoption in the construction industry.

The multiple regression analysis is conducted to test the direct effect hypotheses of this study. This study will determine how the independent variables (technology, organization, environment, government) might significantly influence the dependent variable (actual use) of disruptive technology in the construction industry. The equation used for multiple regression analysis in this study is shown as Equation (3.1):

$$AU = \beta_0 + \beta_1 (\text{TECH}) + \beta_2 (\text{ORG}) + \beta_3 (\text{ENV}) + \beta_4 (\text{GOV}) + \varepsilon \quad (3.1)$$

Where:

AU = Actual Use of disruptive technology adoption (dependent variable)

$\beta_0$  = Constant/intercept of the regression model

$\beta_1$  = Regression coefficient for technological factors

$\beta_2$  = Regression coefficient for organizational factors

$\beta_3$  = Regression coefficient for environmental factors

$\beta_4$  = Regression coefficient for government factors

TECH = Technological factors (independent variable)

ORG = Organizational factors (independent variable)

ENV = Environmental factors (independent variable)

GOV = Government factors (independent variable)

$\varepsilon$  = Error term

The beta value ( $\beta$ ) is a coefficient in regression analysis that is used to measure how strong the relationship between independent variables and the dependent variable is. It helps determine the direction and strength of the relationship. If  $\beta$  is positive, it indicates a positive relationship between the independent and dependent variables. Vice versa, if  $\beta$  is negative, there is a negative relationship between the independent and dependent variables. Table 3.14 shows the interpretation of  $\beta$ .

Table 3.14  
The Interpretation of Beta Value ( $\beta$ )

| Beta Value ( $\beta$ ) | Description           |
|------------------------|-----------------------|
| $\beta < 0$            | Negative Relationship |
| $\beta = 0$            | No Relationship       |
| $\beta > 0$            | Positive Relationship |

Next is analyzing the R-squared ( $R^2$ ) value, as it complements  $\beta$  in regression analysis. The  $R^2$  is a coefficient of determination that provides an overall measure of how well the relationship between the predictors (independent variables) and the outcome (dependent variable) of the analysis results. The higher the  $R^2$  value, the better the model explains the variability in the dependent variable. Table 3.15 shows the interpretation of R-squared range values after analysis in SPSS.

Table 3.15  
The R-squared value in regression

| R-Squared Value | Description           |
|-----------------|-----------------------|
| 0 – 0.30        | Weak Relationship     |
| 0.31 – 0.69     | Moderate Relationship |
| 0.70 – 1.00     | Strong Relationship   |

### 3.8.4.3 Mediation Analysis Procedure

For the second objective (to examine the mediating role of perceived usefulness in the relationship between technological, organizational, environmental, and government factors and the adoption of disruptive technology in the construction industry), the mediator examined in the mediation analysis is Perceived Usefulness (PU), which was analyzed using the PROCESS Macro (Model 4) developed by Andrew F. Hayes and run in SPSS. The model examines the indirect paths to determine whether PU significantly mediates and explains how independent variables influence the actual use of disruptive technologies (IV  $\rightarrow$  PU  $\rightarrow$  Actual Use). The mediation model is presented using two equations. Equation (3.2) represents the effect of independent variables on Perceived Usefulness (PU).

$$PU = \beta_0 + \beta_1 (TECH) + \beta_2 (ORG) + \beta_3 (ENV) + \beta_4 (GOV) + \varepsilon \quad (3.2)$$

Equation (3.3) represents the effect of Perceived Usefulness (PU) and independent variables on actual use.

$$AU = \beta_0 + \beta_1 (TECH) + \beta_2 (ORG) + \beta_3 (ENV) + \beta_4 (GOV) + \beta_5 (PU) + \varepsilon \quad (3.3)$$

Where:

AU = Actual Use of disruptive technology adoption (dependent variable)

$\beta_0$  = Constant/intercept of the regression model

$\beta_1$  = Regression coefficient for technological factors

$\beta_2$  = Regression coefficient for organizational factors

$\beta_3$  = Regression coefficient for environmental factors

$\beta_4$  = Regression coefficient for government factors

$\beta_5$  = Regression coefficient for perceived usefulness

TECH = Technological factors (independent variable)

ORG = Organizational factors (independent variable)

ENV = Environmental factors (independent variable)

GOV = Government factors (independent variable)

PU = Perceived Usefulness (mediator)

$\varepsilon$  = Error term

The significance of the mediation effect is determined via bootstrapping, in which PROCESS generates bias-corrected confidence intervals for the indirect effect. Bootstrapping with 5,000 resamples was applied to generate a 95% confidence interval for the indirect effect. When the confidence interval does not include zero (0), it indicates that the indirect effect is statistically significant (Hayes, 2013). The mediation analysis can produce three possible outcomes: full mediation, partial mediation, and no mediation. Full mediation interprets that the independent variable influences the dependent variable only through the mediator. Partial mediation interprets that the independent variable influences the dependent variable, both directly and indirectly through the mediator. No mediation interprets that the independent variables do not influence the dependent variable through the mediator. Table 3.16 shows the interpretation results of the mediation analysis (Ledermann et al., 2025).

Table 3.16  
Mediation's Interpretation Result

| Mediation         | Result          |                 |
|-------------------|-----------------|-----------------|
|                   | Direct Effect   | Indirect Effect |
| Full Mediation    | Not Significant | Significant     |
| Partial Mediation | Significant     | Significant     |
| No Mediation      | Any             | Not Significant |

Source: Ledermann et al. (2025)

Next, Table 3.17 shows the summary of data analysis for this study for simpler reference.

Table 3.17  
Summary of Data Analysis

| Analysis Technique          | Purpose                                            | SPSS Procedure                                  |
|-----------------------------|----------------------------------------------------|-------------------------------------------------|
| Frequency and Percentage    | Analyze respondent demographic profiles.           | Analyze → Descriptive Statistics → Frequencies  |
| Mean and Standard Deviation | Measure the level of agreement for each construct. | Analyze → Descriptive Statistics → Descriptives |

|                              |                                                                                    |                                        |
|------------------------------|------------------------------------------------------------------------------------|----------------------------------------|
| Cronbach's Alpha             | Assess the reliability of questionnaire items.                                     | Analyze → Scale → Reliability Analysis |
| Pearson Correlation          | Examine relationships among variables.                                             | Analyze → Correlate → Bivariate        |
| Multiple Regression Analysis | Test the effect of independent variables on the adoption of disruptive technology. | Analyze → Regression → Linear          |
| Mediation Analysis           | Test the mediating role of Perceived Usefulness.                                   | PROCESS Macro Model 4                  |

Note: Compiled and summarized by the author based on the data analysis procedures used in this study.

### 3.8.5 Ethical Considerations in Data Analysis

Ethical considerations in data analysis are critical to ensure that data is used ethically, politely, and respectfully. Ethical considerations are important for protecting individuals' rights, maintaining integrity in data handling, and promoting transparency. For this study, the demographic part of the survey instrument will be anonymized. Before distributing the set of questionnaires to the respondents, a researcher will request Ethical approval from UiTM. This is because research ethics approval is mandatory for all research that involves humans conducted by UiTM staff/students.

### 3.9 Conclusion of the Chapter

In conclusion, this section described the statistical techniques used for data analysis. The pre-test involved three experts from the Construction Industry Development Board (CIDB), while the pilot test involved 30 construction industry practitioners from various construction companies to ensure the validity and reliability of the research instrument. To achieve the objectives of this study, questionnaires were distributed to construction companies through construction-related seminars and an online platform, specifically the WhatsApp application. After data collection, the data were sorted, cleaned, and entered into SPSS for analysis. The collected data were then analyzed using descriptive statistics, multiple regression analysis, and mediation analysis. The methodology outlined in this chapter provides a systematic approach to achieving the research objectives and addressing the research questions. The findings and results of the analyses are presented in the following chapter.

## **CHAPTER 4**

### **RESULTS AND DISCUSSION**

#### **4.1 Introduction of the Chapter**

This chapter analyzes the study's findings based on data collected from respondents in the construction industry. The data are analyzed using SPSS software to examine the factors influencing the adoption of disruptive technology in the construction industry. The chapter begins with the reliability and validity analysis of the measurement survey, followed by an outline of the total number of respondents and data screening. The findings from the hypothesis testing are then presented based on the proposed conceptual framework.

#### **4.2 Data Reliability and Validity Analysis**

The pre-test was conducted with three staff members from CIDB Bintulu Management on 07<sup>th</sup> November 2024, in the morning session at the CIDB Bintulu office. During the session, the draft of the questionnaire was presented, and valuable feedback was received. Based on the feedback, it is recommended to use simpler, easier-to-understand language and avoid technical or research-specific terms. For example, “Perceived Usefulness” was rephrased as “Perception of Being Useful” to ensure clarity. In addition, it is suggested to include brief explanations for certain terms, such as “disruptive,” to avoid confusion. It is also requested that the questionnaire be presented in bilingual formats (English and Malay) to make it more suitable and easier to understand for many people.

Next, a pilot test was conducted with 30 respondents. Overall, Cronbach’s Alpha value for the instrument is 0.829, which is considered good. The data were run separately for each category. The results for the reliability test showed that all items indicate that Cronbach’s Alpha values are above 0.90, as shown in Table 3.13 in Chapter 3 (page 62). Based on these findings, the instruments were considered reliable and

suitable for the actual data collection phase. Table 4.1 shows the reliability test results for each category in the conceptual framework.

Table 4.1  
Results of Cronbach's Alpha for Pilot Test

| Category                             | No of Items | Cronbach's Alpha | Interpretation |
|--------------------------------------|-------------|------------------|----------------|
| Awareness of Disruptive Technology   | 12          | 0.969            | Excellent      |
| Understand the Disruptive Technology | 12          | 0.976            | Excellent      |
| Usage of Disruptive Technology       | 12          | 0.936            | Excellent      |
| Technology Factors                   | 4           | 0.910            | Excellent      |
| Organization Factors                 | 4           | 0.938            | Excellent      |
| Environment Factors                  | 4           | 0.958            | Excellent      |
| Government Factors                   | 4           | 0.963            | Excellent      |
| Perceived Usefulness                 | 3           | 0.967            | Excellent      |
| Actual Use                           | 4           | 0.974            | Excellent      |

Meanwhile, for the validity test, the Kaiser-Meyer-Olkin (KMO) test yielded a value of 0.775, indicating good suitability for factor analysis, as it exceeds the minimum threshold of 0.5. Bartlett's test results are statistically significant ( $p < 0.001$ ), confirming that the instrument is suitable for factor analysis and valid for further analysis.

### 4.3 Response Rate

Table 4.2 presents the response rate of the questionnaires distributed, received, and retained for data analysis in this study.

Table 4.2  
Response Rate

| Description                           | Number | Percentage (%) |
|---------------------------------------|--------|----------------|
| Questionnaires distributed            | 250    | 100            |
| Questionnaires returned               | 142    | 56.8           |
| Invalid/incomplete responses excluded | 1      | 0.4            |
| Valid responses used for analysis     | 141    | 56.4           |

At the end of data collection, a total of 142 responses were received. One response was excluded due to the respondent's disagreement with the questionnaire

consent statement. After the exclusions, 141 valid responses remained for data analysis, representing 91 construction companies. This number exceeded the minimum sample size requirement determined by G\*Power. Overall, 250 questionnaires were distributed to the targeted respondents, and 141 valid responses were obtained, resulting in a response rate of 56.4%.

#### 4.4 Data Screening

Before conducting the analysis, data must be cleaned and checked to ensure the reliability of the results. The first step is handling the missing data. Missing data refers to data that researchers were unable to collect from respondents for some reason (Pham et al., 2024). This study has no missing data because all questions in the Google Form were set as "required," ensuring that respondents answered every question before submitting.

The second screening is normality. The study from Isiyaku et al. (2015) used the data range from Kline (2011), where the normal distribution of data should have skewness within -3 to +3, and kurtosis within -10 to 10. Table 4.3 shows the skewness and kurtosis results for each variable in this study. The results show that the data are normally distributed. As recommended by Field (2024), normality testing is conducted only for continuous construct variables measured through Likert scales, so demographic respondents and descriptive technology items are not tested for normality. Therefore, the result in Table 4.3 shows that the data in this study are normally distributed.

Table 4.3  
Skewness and Kurtosis Results

| Category             | Skewness  |            | Kurtosis  |            |
|----------------------|-----------|------------|-----------|------------|
|                      | Statistic | Std. Error | Statistic | Std. Error |
| Technology Factors   | -0.681    | 0.204      | 0.549     | 0.406      |
| Organization Factors | -0.076    | 0.204      | -0.180    | 0.406      |
| Environment Factors  | -0.360    | 0.204      | 0.008     | 0.406      |
| Government Factors   | -0.136    | 0.204      | -0.765    | 0.406      |
| Perceived Usefulness | -0.091    | 0.204      | -0.466    | 0.406      |
| Actual Use           | -0.391    | 0.204      | -0.126    | 0.406      |

The last step for data screening is common method bias (CMB). The CMB is a potential problem in behavioral research and can threaten the validity of the findings (Podsakoff et al., 2003). For this study, two techniques were used. First, the researchers conducted Harman's single-factor test. According to Podsakoff et al. (2003), CMB is not present if the variance accounted for by the first single-factor variable is less than 50%. Table 4.4 shows the result of Harman's Single Factor Test analysis from SPSS. For this study, the total variance is 20.825%, which is less than 50%, showing the dataset has no CMV.

Table 4.4  
Results of Harman's Single Factor Test Analysis

| Category           | Variable Name                        | Initial Eigenvalues |               |                | Extraction Sums of Squared Loadings |               |                |
|--------------------|--------------------------------------|---------------------|---------------|----------------|-------------------------------------|---------------|----------------|
|                    |                                      | Total               | % of Variance | Cumulative (%) | Total                               | % of Variance | Cumulative (%) |
| <b>Demographic</b> | <b>Gender</b>                        | <b>3.748</b>        | <b>20.825</b> | <b>20.825</b>  | <b>3.748</b>                        | <b>20.825</b> | <b>20.825</b>  |
| <b>Respondents</b> | Age                                  | 2.864               | 15.908        | 36.733         |                                     |               |                |
|                    | Race                                 | 1.687               | 9.371         | 46.105         |                                     |               |                |
|                    | Education                            | 1.367               | 7.592         | 53.697         |                                     |               |                |
|                    | Role                                 | 1.253               | 6.963         | 60.660         |                                     |               |                |
|                    | Sector                               | 1.051               | 5.839         | 66.499         |                                     |               |                |
|                    | Profession                           | 0.874               | 4.855         | 71.354         |                                     |               |                |
|                    | Experience                           | 0.823               | 4.570         | 75.924         |                                     |               |                |
|                    | Company Grade                        | 0.755               | 4.192         | 80.116         |                                     |               |                |
|                    | Awareness of Disruptive Technology   | 0.622               | 3.455         | 83.572         |                                     |               |                |
|                    | Understand the Disruptive Technology | 0.586               | 3.258         | 86.830         |                                     |               |                |
|                    | Usage of Disruptive Technology       | 0.512               | 2.847         | 89.676         |                                     |               |                |
|                    | Technology Factors                   | 0.486               | 2.701         | 92.377         |                                     |               |                |
|                    | Organization Factors                 | 0.362               | 2.013         | 94.391         |                                     |               |                |
|                    | Environment Factors                  | 0.301               | 1.672         | 96.063         |                                     |               |                |
|                    | Government Factors                   | 0.268               | 1.490         | 97.553         |                                     |               |                |
|                    | Perceived Usefulness                 | 0.242               | 1.345         | 98.898         |                                     |               |                |
|                    | Actual Use                           | 0.198               | 1.102         | 100.000        |                                     |               |                |

The study from Podsakoff et al. (2003) argues that Harman's single-factor test is a basic tool and not sufficient to detect CMB. Thus, researchers in this study applied the marker variable technique, as recommended by Podsakoff et al. (2003) and Kock et

al. (2021), to determine whether this dataset exhibits CMB. The CMB is not a serious concern when the correlation between the marker variable and other variables is less than 0.30, and the significance is more than 0.05 (Lindell & Whitney, 2001). Table 4.5 shows the results of the marker-variable analysis used to detect the presence of CMB. Based on the criteria proposed by Lindell and Whitney (2001), common method bias is considered a concern when the correlation between the marker variable and the study variables exceeds 0.30. The results indicate that most variables demonstrated weak correlations with the marker variable, with correlation coefficients below 0.30. However, Actual Use showed a relatively higher correlation with the marker variable ( $r = 0.422$ ,  $p < 0.001$ ), suggesting a potential influence of common method bias for this construct. Therefore, an additional assessment was conducted by comparing regression coefficients before and after including the marker variable.

Table 4.5  
Results of the Marker Variables Analysis

| Category                             | Variable Name | Marker Variable       |                           | Common Method Bias? |
|--------------------------------------|---------------|-----------------------|---------------------------|---------------------|
|                                      |               | Pearson Correlation ® | Significance (Two-tailed) |                     |
| Demographic Respondents              | Gender        | 0.037                 | 0.662                     | No                  |
|                                      | Age           | -0.021                | 0.805                     | No                  |
|                                      | Race          | -0.145                | 0.086                     | No                  |
|                                      | Education     | -0.004                | 0.967                     | No                  |
|                                      | Role          | 0.148                 | 0.079                     | No                  |
|                                      | Sector        | 0.099                 | 0.242                     | No                  |
|                                      | Profession    | 0.000                 | 0.996                     | No                  |
|                                      | Experience    | 0.036                 | 0.668                     | No                  |
|                                      | Company Grade | -0.096                | 0.257                     | No                  |
| Awareness of Disruptive Technology   |               | 0.095                 | 0.261                     | No                  |
| Understand the Disruptive Technology |               | 0.165                 | 0.050                     | No                  |
| Usage of Disruptive Technology       |               | 0.188                 | 0.026                     | No                  |
| Technology Factors                   |               | 0.181                 | 0.032                     | No                  |
| Organization Factors                 |               | 0.272                 | 0.001                     | No                  |
| Environment Factors                  |               | 0.233                 | 0.005                     | No                  |
| Government Factors                   |               | 0.270                 | 0.001                     | No                  |
| Perceived Usefulness                 |               | 0.219                 | 0.009                     | No                  |
| Actual Use                           |               | 0.422                 | <0.001                    | Yes                 |

Next, further analysis is conducted using the marker-variable approach to assess the extent to which the CMB influences the regression results. The analysis compared the results of standardized regression coefficients ( $\beta$ ) in regression analysis, before and after the inclusion of marker variables. It is used to determine how CMB influences the relationship between the independent variables and the dependent variable. As recommended by Podsakoff et al. (2003), CMB may influence the relationship between the variables if the comparison of  $\beta$  is more than 0.10.

Based on the comparison presented in Table 4.6, all changes in  $\beta$  values were below the recommended threshold, with the largest change being 0.041. Furthermore, the significance levels and direction of the relationships remained consistent before and after including the marker variable. Although slight reductions in  $\beta$  values were observed for Organization and Perceived Usefulness, both relationships remained statistically significant. Therefore, the marker variable was excluded as it did not significantly affect the result, indicating that common method bias is not a major concern in this study.

Table 4.6  
Effect of Marker Variable on Regression Coefficients

| Effect of Marker Variable on Regression Coefficients |                      |        |                     |       |        |                        |
|------------------------------------------------------|----------------------|--------|---------------------|-------|--------|------------------------|
| Variables<br>(Average)                               | Result before Marker |        | Result after Marker |       | Change | Common<br>Method Bias? |
|                                                      | Variable             |        | Variable            |       |        |                        |
|                                                      | $\beta$              | Sig.   | $\beta$             | Sig.  |        |                        |
| Aware                                                | 0.181                | 0.042  | 0.199               | 0.019 | 0.018  | No                     |
| Understand                                           | -0.098               | 0.334  | -0.128              | 0.186 | 0.030  | No                     |
| Usage                                                | 0.291                | 0.001  | 0.273               | 0.001 | 0.018  | No                     |
| Technology                                           | -0.268               | 0.004  | -0.259              | 0.003 | 0.009  | No                     |
| Organization                                         | 0.310                | <0.001 | 0.272               | 0.001 | 0.038  | No                     |
| Environment                                          | 0.144                | 0.154  | 0.140               | 0.144 | 0.004  | No                     |
| Government                                           | 0.013                | 0.886  | -0.028              | 0.744 | 0.041  | No                     |
| Perceived                                            | 0.266                | 0.006  | 0.237               | 0.011 | 0.029  | No                     |
| Usefulness                                           |                      |        |                     |       |        |                        |

#### 4.5 Demographic Respondent Analysis

As mentioned in the survey instruments, respondents must be aged 20 or above and work in the construction industry in Sarawak. Table 4.7 shows that the dataset has a relatively diverse sample, with respondents showing various characteristics. In detail,

the majority of respondents are male (67.4%), while the remaining 32.6% are female. Most of the respondents are between 31 and 40 years old (41.8%), followed by those between 20 and 30 years (27.7%), and 41 to 50 years (24.8%). Only a small proportion are above 50 years old (5.7%). In terms of race, there is a balanced distribution between Iban (31.2%) and Malay (30.5%), while Chinese (19.1%), and others (19.1%). Most of the respondents held a bachelor's degree (46.1%), followed by those with a diploma (31.2%), and a bachelor's master (13.5%).

Next, the largest group of respondents by work experience is those with 3 years or less (23.4%), followed by 3 to 5 years (22.7%) and 6 to 10 years (22.0%). For project management roles, the majority of respondents worked as main contractors (66.0%), followed by sub-contractors (32.6%). More than half of the respondents are involved in special trade activities (55.3%), while others worked in civil engineering (23.4%) and non-residential building projects (17.7%). In terms of company grade, the largest proportion is from G7 companies (66.0%), followed by G5 (12.1%); the rest are distributed across G1 to G6.

Table 4.7  
Demographic Respondents Analysis

|                         |                          | Frequency | Percentage (%) |
|-------------------------|--------------------------|-----------|----------------|
| Gender                  | Male                     | 95        | 67.4           |
|                         | Female                   | 46        | 32.6           |
| Age Range               | 20 to 30                 | 39        | 27.7           |
|                         | 31 to 40                 | 59        | 41.8           |
|                         | 41 to 50                 | 35        | 24.8           |
|                         | 51 to 60                 | 6         | 4.3            |
|                         | 61 and above             | 2         | 1.4            |
| Race                    | Malay                    | 43        | 30.5           |
|                         | Iban                     | 44        | 31.2           |
|                         | Chinese                  | 27        | 19.1           |
|                         | Others                   | 27        | 19.1           |
| Highest Education       | Certificate              | 11        | 7.8            |
|                         | Diploma                  | 44        | 31.2           |
|                         | Bachelor's Degree        | 65        | 46.1           |
|                         | Bachelor's Master        | 19        | 13.5           |
|                         | Doctor of Philosophy     | 2         | 1.4            |
| Work Experience         | 3 Years or Less          | 33        | 23.4           |
|                         | 3 to 5 Years             | 32        | 22.7           |
|                         | 6 to 10 Years            | 31        | 22.0           |
|                         | 11 to 15 Years           | 24        | 17.0           |
|                         | 16 Years and Above       | 21        | 14.9           |
| Project Management Role | Main Contractor          | 93        | 66.0           |
|                         | Sub-Contractor           | 46        | 32.6           |
|                         | Others                   | 2         | 1.4            |
| Company Sector          | Civil Engineering        | 33        | 23.4           |
|                         | Non-Residential Building | 25        | 17.7           |
|                         | Residential Building     | 3         | 2.1            |
|                         | Special Trade Activities | 78        | 55.3           |
|                         | Others                   | 2         | 1.4            |
| Company Grade           | No Grade                 | 2         | 1.4            |

|    |    |      |
|----|----|------|
| G1 | 6  | 4.3  |
| G2 | 5  | 3.5  |
| G3 | 11 | 7.8  |
| G4 | 2  | 1.4  |
| G5 | 17 | 12.1 |
| G6 | 5  | 3.5  |
| G7 | 93 | 66.0 |

## 4.6 Descriptive Analysis

The descriptive analysis for this study is assessed using SPSS software. The results of the descriptive analysis are described below.

### 4.6.1 The Awareness Level of Disruptive Technology

This section shows the respondents' awareness of the existence of disruptive technology in the construction industry. There are 12 disruptive technologies, measured using the DT1-DT12 code on a 5-point Likert scale (not at all, slightly aware, moderately aware, aware, and extremely aware). DT1 represents BIM, DT2 represents pre-fabrication and modular construction, DT3 represents autonomous construction, DT4 represents augmented reality and virtualization, DT5 represents cloud and real-time collaboration, DT6 represents 3D scanning and photogrammetry, DT7 represents big data and predictive analysis, DT8 represents internet of things (IoT), DT9 represents 3D printing and additive manufacturing, DT10 represent advanced building materials, DT11 represents blockchain technology, and DT12 represents artificial intelligence (AI).

Table 4.8  
Results for Awareness of the Existence of Disruptive Technology

| Code | Items           | Descriptive Statistics |             | Central Tendency |        |      |
|------|-----------------|------------------------|-------------|------------------|--------|------|
|      |                 | Frequency              | Percent (%) | Mean             | Median | Mode |
| DT1  | Not At All      | 7                      | 5.0         | 3.09             | 3.00   | 3    |
|      | Slightly Aware  | 39                     | 27.7        |                  |        |      |
|      | Moderate Aware  | 42                     | 29.8        |                  |        |      |
|      | Aware           | 41                     | 29.1        |                  |        |      |
|      | Extremely Aware | 12                     | 8.5         |                  |        |      |
| DT2  | Not At All      | 10                     | 7.1         | 3.20             | 3.00   | 4    |
|      | Slightly Aware  | 35                     | 24.8        |                  |        |      |

|      |                 |    |      |      |      |   |
|------|-----------------|----|------|------|------|---|
|      | Moderate Aware  | 28 | 19.9 |      |      |   |
|      | Aware           | 53 | 37.6 |      |      |   |
|      | Extremely Aware | 15 | 10.6 |      |      |   |
| DT3  | Not At All      | 12 | 8.5  | 3.18 | 3.00 | 4 |
|      | Slightly Aware  | 33 | 23.4 |      |      |   |
|      | Moderate Aware  | 33 | 23.4 |      |      |   |
|      | Aware           | 44 | 31.2 |      |      |   |
|      | Extremely Aware | 19 | 13.5 |      |      |   |
| DT4  | Not At All      | 6  | 4.3  | 3.17 | 3.00 | 4 |
|      | Slightly Aware  | 40 | 28.4 |      |      |   |
|      | Moderate Aware  | 34 | 24.1 |      |      |   |
|      | Aware           | 46 | 32.6 |      |      |   |
|      | Extremely Aware | 15 | 10.6 |      |      |   |
| DT5  | Not At All      | 4  | 2.8  | 3.56 | 4.00 | 4 |
|      | Slightly Aware  | 25 | 17.7 |      |      |   |
|      | Moderate Aware  | 34 | 24.1 |      |      |   |
|      | Aware           | 44 | 31.2 |      |      |   |
|      | Extremely Aware | 34 | 24.1 |      |      |   |
| DT6  | Not At All      | 7  | 5.0  | 3.26 | 3.00 | 4 |
|      | Slightly Aware  | 34 | 24.1 |      |      |   |
|      | Moderate Aware  | 37 | 26.2 |      |      |   |
|      | Aware           | 41 | 29.1 |      |      |   |
|      | Extremely Aware | 22 | 15.6 |      |      |   |
| DT7  | Not At All      | 12 | 8.5  | 3.08 | 3.00 | 4 |
|      | Slightly Aware  | 37 | 26.2 |      |      |   |
|      | Moderate Aware  | 36 | 25.5 |      |      |   |
|      | Aware           | 40 | 28.4 |      |      |   |
|      | Extremely Aware | 16 | 11.3 |      |      |   |
| DT8  | Not At All      | 8  | 5.7  | 3.18 | 3.00 | 4 |
|      | Slightly Aware  | 36 | 25.5 |      |      |   |
|      | Moderate Aware  | 36 | 25.5 |      |      |   |
|      | Aware           | 45 | 31.9 |      |      |   |
|      | Extremely Aware | 16 | 11.3 |      |      |   |
| DT9  | Not At All      | 6  | 4.3  | 3.22 | 3.00 | 4 |
|      | Slightly Aware  | 36 | 25.5 |      |      |   |
|      | Moderate Aware  | 39 | 27.7 |      |      |   |
|      | Aware           | 41 | 29.1 |      |      |   |
|      | Extremely Aware | 19 | 13.5 |      |      |   |
| DT10 | Not At All      | 13 | 9.2  | 3.09 | 3.00 | 4 |
|      | Slightly Aware  | 31 | 22.0 |      |      |   |
|      | Moderate Aware  | 41 | 29.1 |      |      |   |
|      | Aware           | 42 | 29.8 |      |      |   |
|      | Extremely Aware | 14 | 9.9  |      |      |   |
| DT11 | Not At All      | 15 | 10.6 | 2.96 | 3.00 | 3 |

|      |                 |    |      |      |      |   |
|------|-----------------|----|------|------|------|---|
|      | Slightly Aware  | 37 | 26.2 |      |      |   |
|      | Moderate Aware  | 40 | 28.4 |      |      |   |
|      | Aware           | 37 | 26.2 |      |      |   |
|      | Extremely Aware | 12 | 8.5  |      |      |   |
| DT12 | Not At All      | 3  | 2.1  | 3.45 | 4.00 | 4 |
|      | Slightly Aware  | 35 | 24.8 |      |      |   |
|      | Moderate Aware  | 29 | 20.6 |      |      |   |
|      | Aware           | 44 | 31.2 |      |      |   |
|      | Extremely Aware | 30 | 21.3 |      |      |   |

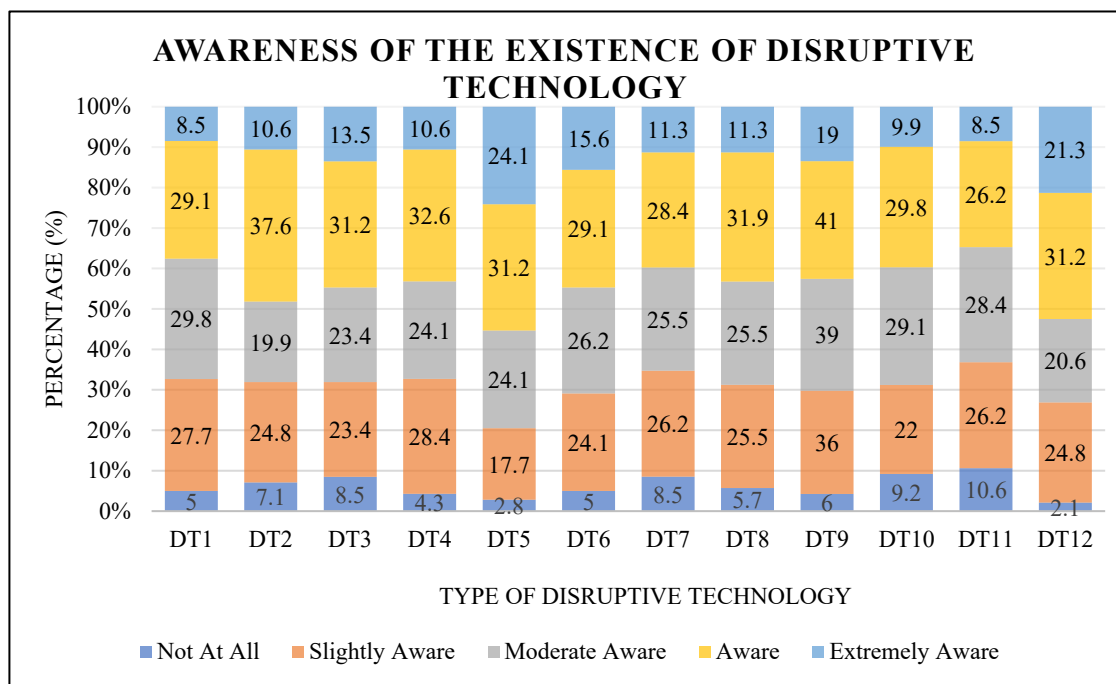


Figure 4.1 Awareness of the Existence of Disruptive Technologies by Respondents

Based on the results in Figure 4.1 and Table 4.8, the majority of the respondents are moderately aware, aware, and extremely aware across all 12 types of disruptive technologies. The mean values range from 2.96 to 3.56, indicating a moderate to high level of awareness of disruptive technology in the construction industry. This shows that respondents are aware of disruptive technologies and that they are not new to them. DT5 (cloud and real-time collaboration) and DT12 (AI) recorded the highest awareness levels, with 24.1% and 21.3%, respectively, indicating extremely high awareness. Both DT5 and DT12 also show the lowest percentages for the not at all categories at 2.8% for DT5 and 2.1% for DT12. This indicates that respondents are aware of and recognize these technologies. Meanwhile, DT11 (blockchain technology) shows the lowest awareness among respondents, with the highest percentage in the not at all category

(10.6%) and the lowest in the extremely aware category (8.5%). This indicates a gap in exposure to disruptive technology within the construction industry. Overall, the results suggest that respondents are aware of the existence of disruptive technologies, but the depth of awareness varies by type.

A comparison with Al-Ashmori et al. (2020), conducted five years earlier, shows that the awareness of BIM in Sarawak has improved over time. In Al-Ashmori et al. (2020) study, 22% of respondents are not aware at all, 42% are slightly aware, 19% are moderately aware, 12% are somewhat aware, and only 5% are extremely aware. In contrast, the current study shows a more positive trend: only 5% of respondents are not at all aware, 27.7% are slightly aware, 29.8% are moderately aware, 29.1% are aware, and 8.5% are extremely aware. This increase shows a clear upward trend in BIM awareness, specifically in Sarawak, with fewer respondents reporting low levels of awareness.

Further comparison with Lee et al. (2022) study, which examined BIM implementation specifically in Sarawak, also supports this upward trend in awareness. Lee et al. (2022) reported that 63% of respondents are aware of BIM, while 37% had never heard of it. In the current study, only 5.0% of respondents reported not being aware of BIM, indicating a significant improvement in BIM awareness in the Sarawak construction industry. These findings show that industry players are currently better informed and more exposed to BIM-related issues due to the government mandate to use BIM technology. Overall, the comparisons with past studies show a positive development in awareness levels of disruptive technologies in the Sarawak construction industry.

#### **4.6.2 The Understanding Level of Disruptive Technology**

This section presents an analysis of respondents' understanding level of disruptive technology, based on 12 specific disruptive technologies. The understanding level was categorized into five levels: Not Understand, Limited, Basic, Proficient, and Expert. DT1 represents BIM, DT2 represents pre-fabrication and modular construction, DT3 represents autonomous construction, DT4 represents augmented reality and virtualization, DT5 represents cloud and real-time collaboration, DT6 represents 3D scanning and photogrammetry, DT7 represents big data and predictive analysis, DT8

represents internet of things (IoT), DT9 represents 3D printing and additive manufacturing, DT10 represent advanced building materials, DT11 represents blockchain technology, and DT12 represents artificial intelligence (AI).

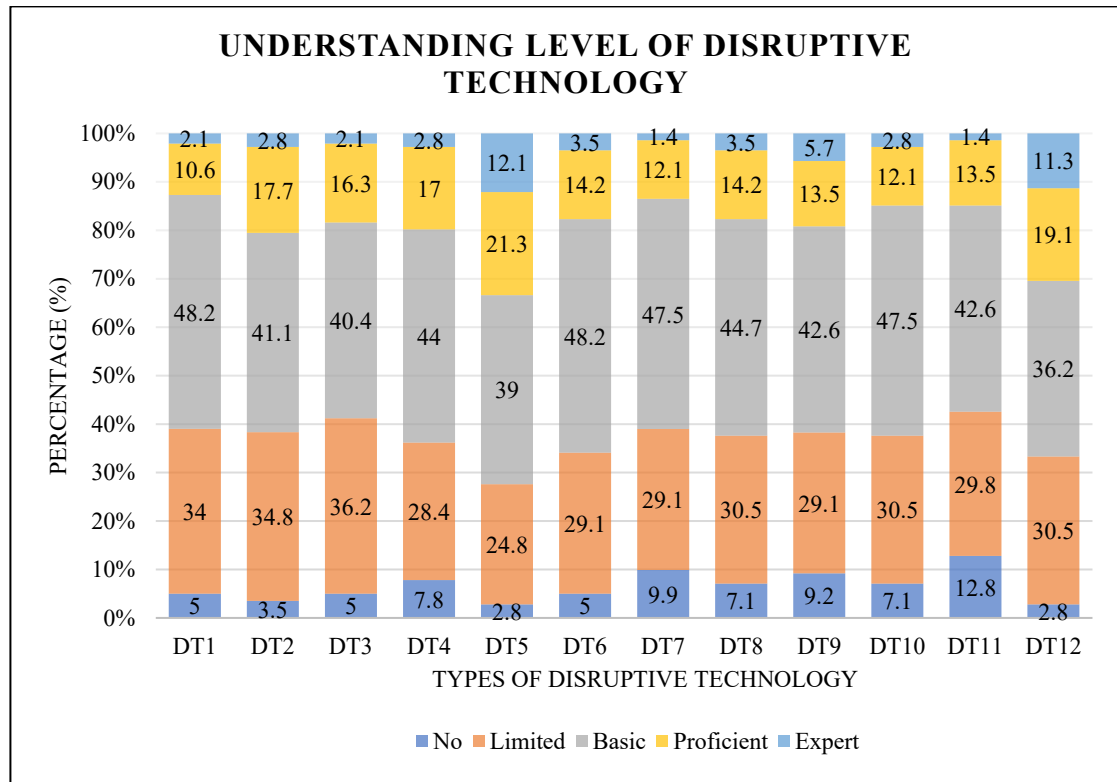


Figure 4.2 Level of Understanding of Disruptive Technology by Respondents

Table 4.9  
Results for Understanding of Disruptive Technology

| Code | Items      | Descriptive Statistics |         | Central Tendency |        |      |
|------|------------|------------------------|---------|------------------|--------|------|
|      |            | Frequency              | Percent | Mean             | Median | Mode |
| DT1  | No         | 7                      | 5.0     | 2.71             | 3.00   | 3    |
|      | Limited    | 48                     | 34.0    |                  |        |      |
|      | Basic      | 68                     | 48.2    |                  |        |      |
|      | Proficient | 25                     | 10.6    |                  |        |      |
|      | Expert     | 3                      | 2.1     |                  |        |      |
| DT2  | No         | 5                      | 3.5     | 2.82             | 3.00   | 3    |
|      | Limited    | 49                     | 34.8    |                  |        |      |
|      | Basic      | 58                     | 41.1    |                  |        |      |
|      | Proficient | 25                     | 17.7    |                  |        |      |
|      | Expert     | 4                      | 2.8     |                  |        |      |
| DT3  | No         | 7                      | 5.0     | 2.74             | 3.00   | 3    |
|      | Limited    | 51                     | 36.2    |                  |        |      |
|      | Basic      | 57                     | 40.4    |                  |        |      |

|      |            |    |      |      |      |   |
|------|------------|----|------|------|------|---|
|      | Proficient | 23 | 16.3 |      |      |   |
|      | Expert     | 3  | 2.1  |      |      |   |
| DT4  | No         | 11 | 7.8  | 2.79 | 3.00 | 3 |
|      | Limited    | 40 | 28.4 |      |      |   |
|      | Basic      | 62 | 44.0 |      |      |   |
|      | Proficient | 24 | 17.0 |      |      |   |
|      | Expert     | 4  | 2.8  |      |      |   |
| DT5  | No         | 4  | 2.8  | 3.15 | 3.00 | 3 |
|      | Limited    | 35 | 24.8 |      |      |   |
|      | Basic      | 55 | 39.0 |      |      |   |
|      | Proficient | 30 | 21.3 |      |      |   |
|      | Expert     | 17 | 12.1 |      |      |   |
| DT6  | No         | 7  | 5.0  | 2.82 | 3.00 | 3 |
|      | Limited    | 41 | 29.1 |      |      |   |
|      | Basic      | 68 | 48.2 |      |      |   |
|      | Proficient | 20 | 14.2 |      |      |   |
|      | Expert     | 5  | 3.5  |      |      |   |
| DT7  | No         | 14 | 9.9  | 2.66 | 3.00 | 3 |
|      | Limited    | 41 | 29.1 |      |      |   |
|      | Basic      | 67 | 47.5 |      |      |   |
|      | Proficient | 17 | 12.1 |      |      |   |
|      | Expert     | 2  | 1.4  |      |      |   |
| DT8  | No         | 10 | 7.1  | 2.77 | 3.00 | 3 |
|      | Limited    | 43 | 30.5 |      |      |   |
|      | Basic      | 63 | 44.7 |      |      |   |
|      | Proficient | 20 | 14.2 |      |      |   |
|      | Expert     | 5  | 3.5  |      |      |   |
| DT9  | No         | 13 | 9.2  | 2.77 | 3.00 | 3 |
|      | Limited    | 41 | 29.1 |      |      |   |
|      | Basic      | 60 | 42.6 |      |      |   |
|      | Proficient | 19 | 13.5 |      |      |   |
|      | Expert     | 8  | 5.7  |      |      |   |
| DT10 | No         | 10 | 7.1  | 2.73 | 3.00 | 3 |
|      | Limited    | 43 | 30.5 |      |      |   |
|      | Basic      | 67 | 47.5 |      |      |   |
|      | Proficient | 17 | 12.1 |      |      |   |
|      | Expert     | 4  | 2.8  |      |      |   |
| DT11 | No         | 18 | 12.8 | 2.61 | 3.00 | 3 |
|      | Limited    | 42 | 29.8 |      |      |   |
|      | Basic      | 60 | 42.6 |      |      |   |
|      | Proficient | 19 | 13.5 |      |      |   |
|      | Expert     | 2  | 1.4  |      |      |   |
| DT12 | No         | 4  | 2.8  | 3.06 | 3.00 | 3 |
|      | Limited    | 43 | 30.5 |      |      |   |

|            |    |      |
|------------|----|------|
| Basic      | 51 | 36.2 |
| Proficient | 27 | 19.1 |
| Expert     | 16 | 11.3 |

Based on Figure 4.2 and Table 4.9, most respondents have a basic understanding of disruptive technology, as the mean values range from 2.60 to 3.15, and the median and mode are consistently 3 across all items. DT5 (cloud and real-time collaboration) shows the highest level of understanding, as it recorded the highest percentage of expert respondents (12.1%) and the lowest percentage of respondents with no understanding (2.8%). This indicates that more respondents are moving from basic to proficient or expert levels compared to the other 11 technologies. Vice versa, DT11 (blockchain technology) shows the lowest level of understanding, with most respondents (12.8%) not understanding the technology and the lowest percentage of expert understanding (1.4%), indicating that it is the least familiar and least adopted technology among the respondents. Thus, the findings suggest that the respondents have a basic understanding of disruptive technology, but a proficient or expert level of understanding remains limited.

A comparison finding with Jaafar et al. (2024), whose data were collected in 2022, shows that the understanding levels have improved, although only slightly, within three (3) years. In Jaafar et al. (2024) findings, the mean values for understanding ranged between 2.31 and 2.84, indicating a limited knowledge category. In contrast, the current study reported that the mean range is wider, suggesting that the understanding of disruptive technologies among Malaysian construction stakeholders has increased, but the improvement is not substantial.

Moreover, current findings indicate that there is a notable lack of expert-level knowledge of disruptive technology among construction industry stakeholders. This is due to insufficient information from the government and policymakers about disruptive technology. This interpretation is supported by Zaini et al. (2020) and Tjandra et al. (2022), who emphasize that insufficient information contributes to a low level of understanding among industry players. Overall, these results suggest that the construction industry continues to face challenges in improving the understanding of disruptive technology without more comprehensive information.

### 4.6.3 Level of Usage of Disruptive Technology

This section analyzes the current level of disruptive technology adoption in the construction industry. The usage levels are categorized as follows: not in use, considering use, early adoption, used sometimes, and frequently used. DT1 represents BIM, DT2 represents pre-fabrication and modular construction, DT3 represents autonomous construction, DT4 represents augmented reality and virtualization, DT5 represents cloud and real-time collaboration, DT6 represents 3D scanning and photogrammetry, DT7 represents big data and predictive analysis, DT8 represents internet of things (IoT), DT9 represents 3D printing and additive manufacturing, DT10 represent advanced building materials, DT11 represents blockchain technology, and DT12 represents artificial intelligence (AI).

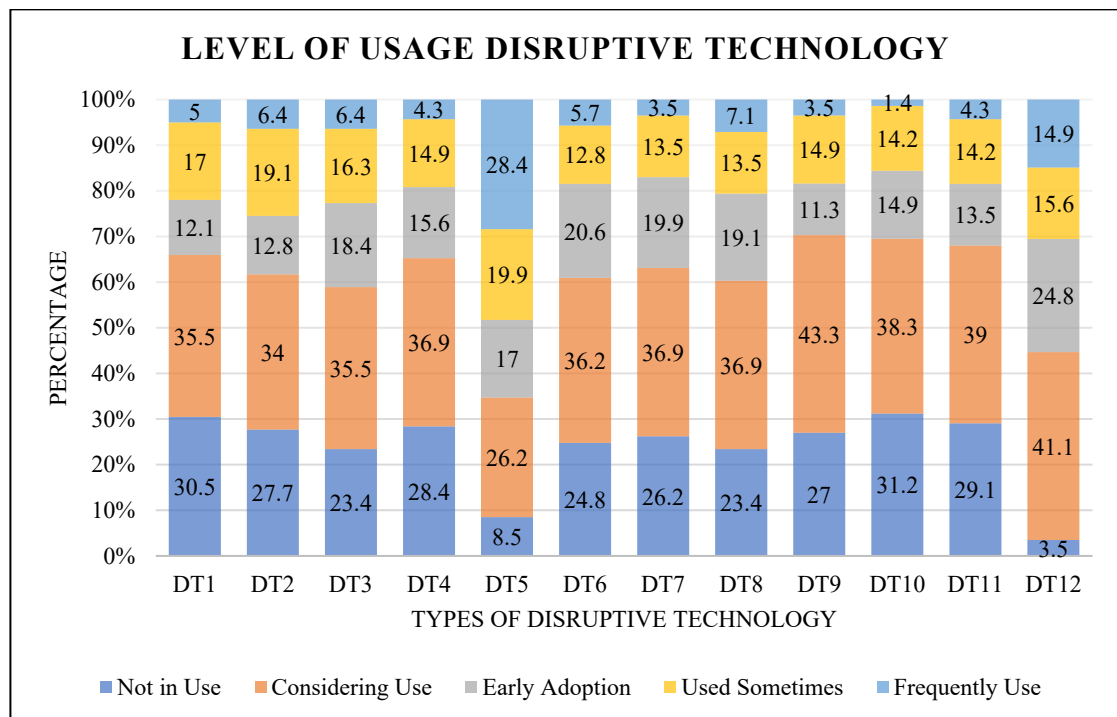


Figure 4.3 Current Level of Disruptive Technology's Usage among the Respondents

Table 4.10  
Current Level of Disruptive Technology's Usage

| Code | Items           | Descriptive Statistics |         | Central Tendency |        |      |
|------|-----------------|------------------------|---------|------------------|--------|------|
|      |                 | Frequency              | Percent | Mean             | Median | Mode |
| DT1  | Not in Use      | 43                     | 30.5    | 2.30             | 2.00   | 2    |
|      | Considering Use | 50                     | 35.5    |                  |        |      |

|      |                    |    |      |      |      |   |
|------|--------------------|----|------|------|------|---|
|      | Early Adoption     | 17 | 12.1 |      |      |   |
|      | Used for Sometimes | 24 | 17.0 |      |      |   |
|      | Frequently Use     | 7  | 5.0  |      |      |   |
| DT2  | Not in Use         | 39 | 27.7 | 2.43 | 2.00 | 2 |
|      | Considering Use    | 48 | 34.0 |      |      |   |
|      | Early Adoption     | 18 | 12.8 |      |      |   |
|      | Used for Sometimes | 27 | 19.1 |      |      |   |
|      | Frequently Use     | 9  | 6.4  |      |      |   |
| DT3  | Not in Use         | 33 | 23.4 | 2.47 | 2.00 | 2 |
|      | Considering Use    | 50 | 35.5 |      |      |   |
|      | Early Adoption     | 26 | 18.4 |      |      |   |
|      | Used for Sometimes | 23 | 16.3 |      |      |   |
|      | Frequently Use     | 9  | 6.4  |      |      |   |
| DT4  | Not in Use         | 40 | 28.4 | 2.30 | 2.00 | 2 |
|      | Considering Use    | 52 | 36.9 |      |      |   |
|      | Early Adoption     | 22 | 15.6 |      |      |   |
|      | Used for Sometimes | 21 | 14.9 |      |      |   |
|      | Frequently Use     | 6  | 4.3  |      |      |   |
| DT5  | Not in Use         | 12 | 8.5  | 3.33 | 3.00 | 5 |
|      | Considering Use    | 37 | 26.2 |      |      |   |
|      | Early Adoption     | 24 | 17.0 |      |      |   |
|      | Used for Sometimes | 28 | 19.9 |      |      |   |
|      | Frequently Use     | 40 | 28.4 |      |      |   |
| DT6  | Not in Use         | 35 | 24.8 | 2.38 | 2.00 | 2 |
|      | Considering Use    | 51 | 36.2 |      |      |   |
|      | Early Adoption     | 29 | 20.6 |      |      |   |
|      | Used for Sometimes | 18 | 12.8 |      |      |   |
|      | Frequently Use     | 8  | 5.7  |      |      |   |
| DT7  | Not in Use         | 37 | 26.2 | 2.31 | 2.00 | 2 |
|      | Considering Use    | 52 | 36.9 |      |      |   |
|      | Early Adoption     | 28 | 19.9 |      |      |   |
|      | Used for Sometimes | 19 | 13.5 |      |      |   |
|      | Frequently Use     | 5  | 3.5  |      |      |   |
| DT8  | Not in Use         | 33 | 23.4 | 2.44 | 2.00 | 2 |
|      | Considering Use    | 52 | 36.9 |      |      |   |
|      | Early Adoption     | 27 | 19.1 |      |      |   |
|      | Used for Sometimes | 19 | 13.5 |      |      |   |
|      | Frequently Use     | 10 | 7.1  |      |      |   |
| DT9  | Not in Use         | 38 | 27.0 | 2.25 | 2.00 | 2 |
|      | Considering Use    | 61 | 43.3 |      |      |   |
|      | Early Adoption     | 16 | 11.3 |      |      |   |
|      | Used for Sometimes | 21 | 14.9 |      |      |   |
|      | Frequently Use     | 5  | 3.5  |      |      |   |
| DT10 | Not in Use         | 44 | 31.2 | 2.16 | 2.00 | 2 |

|      |                    |    |      |      |      |   |
|------|--------------------|----|------|------|------|---|
|      | Considering Use    | 54 | 38.3 |      |      |   |
|      | Early Adoption     | 21 | 14.9 |      |      |   |
|      | Used for Sometimes | 20 | 14.2 |      |      |   |
|      | Frequently Use     | 2  | 1.4  |      |      |   |
| DT11 | Not in Use         | 41 | 29.1 | 2.26 | 2.00 | 2 |
|      | Considering Use    | 55 | 39.0 |      |      |   |
|      | Early Adoption     | 19 | 13.5 |      |      |   |
|      | Used for Sometimes | 20 | 14.2 |      |      |   |
|      | Frequently Use     | 6  | 4.3  |      |      |   |
| DT12 | Not in Use         | 5  | 3.5  | 2.97 | 3.00 | 2 |
|      | Considering Use    | 58 | 41.1 |      |      |   |
|      | Early Adoption     | 35 | 24.8 |      |      |   |
|      | Used for Sometimes | 22 | 15.6 |      |      |   |
|      | Frequently Use     | 21 | 14.9 |      |      |   |

Based on Figure 4.3 and Table 4.10, most respondents are still in the early stage of adoption, as most technologies recorded median and mode values of 2 (considering use). DT1 to DT4 (BIM, pre-fabrication and modular construction, autonomous construction, augmented reality and virtualization), DT6 to DT11 (3D scanning and photogrammetry, big data and predictive analysis, IoT, 3D printing and additive manufacturing, advanced building materials, blockchain technology) show mean values between 2.16 and 2.47, which is close to the use category. Moreover, the considered use category recorded the highest percentage, with around 34% to 43% for each disruptive technology.

The respondents have the lowest percentage of frequently used categories, with 1.4% to 7.1% only, indicating that the respondents have low adoption of these disruptive technologies. In contrast, DT5 (cloud and real-time collaboration) demonstrates the highest usage level among the 12 disruptive technologies, with the highest percentage of respondents reporting frequent use (28.4%) and one of the lowest percentages reporting that it is not in use (8.5%). Next, this is followed by DT12 (AI), which shows the second-highest level of usage with 14.8% of respondents frequently using the technology, and only 3.5% of respondents not using AI technology. Thus, these results show an early stage of adoption for disruptive technologies, with DT5 (cloud real-time collaboration) showing the highest adoption among respondents. In contrast, other technologies are mostly considered but not fully used.

A comparison with previous studies further supports this study's finding. Jaafar et al. (2024), whose data were collected in 2022, also reported similarly low levels of

usage of disruptive technologies. Their study found that the mean values ranged from 1.98 to 2.57, with median and mode values consistently at two (2), which also fall under the considering use category. This suggests that usage levels in the current study have increased slightly, although the improvement remains minimal over the past three years.

Similarly, a study on BIM implementation within the Sarawak construction industry from Lee et al. (2022) found that only 14% of respondents had experience using BIM. In comparison, 86% reported having no experience using the technology. In the current study, 36% of the respondents have used BIM technology, while 66% have no experience with it. This finding indicates that the adoption and actual use of disruptive technology in the Sarawak construction industry remain low, despite the government having a mandate to adopt and use technology.

The current results show an early-stage adoption trend among disruptive technologies, with cloud and real-time collaboration showing the highest levels of adoption among respondents. In contrast, other technologies are mostly considered but not fully adopted. This is due to the high cost of adopting technologies, especially advanced ones such as BIM, prefabrication, modular technology, and advanced building materials. This statement is supported by Satyir et al. (2024), where the main barrier to adopting technology is the high initial cost of investment in projects. A study from Raslim et al. (2024) stated that the adoption rate in Malaysia's construction industry is comparatively low compared to that in foreign countries, due to the high cost of implementation and a lack of awareness and understanding.

#### **4.6.4 The Comparison between Awareness, Understanding, and Level of Usage of Disruptive Technology**

The findings on awareness, understanding, and the level of use of disruptive technologies reveal a consistent pattern in adopting new technologies. The results suggest that the transition from awareness to understanding and to actual use remains slow, although awareness levels have improved over recent years. Firstly, the level of awareness among respondents is moderate to high, but it shows a noticeable improvement compared to previous studies. Despite this improvement in awareness, the level of understanding remains limited due to insufficient information and limited training, as highlighted by Zaini et al. (2020) and Tjandra et al. (2022). Consequently,

the level of usage remains the lowest among the three items as the respondents are still in the “considering use” category. The results of current usage levels remain consistent with the past studies by Jaafar et al. (2024) and Lee et al. (2022), which also reported low-level usage, although the current study indicates a slight improvement. This indicates the adoption remains slow due to the high implementation cost and limited expert workers, as supported by Satyir et al. (2024) and Raslim et al. (2024).

The current results show a clear transition gap: awareness is increasing, but understanding is not developing at the same pace, and usage lags significantly behind both awareness and understanding. The findings also suggest that a higher level of awareness alone is not sufficient to drive disruptive technology adoption in the construction industry. This is because the respondents are skeptical. Although they are aware of the existence of disruptive technology, their understanding is limited, resulting in usage that remains at the considering stage rather than transitioning towards actual adoption. In other words, the respondents are resistant to change due to their comfort with existing systems, as supported by Sarvari et al. (2024) and Musarat et al. (2025).

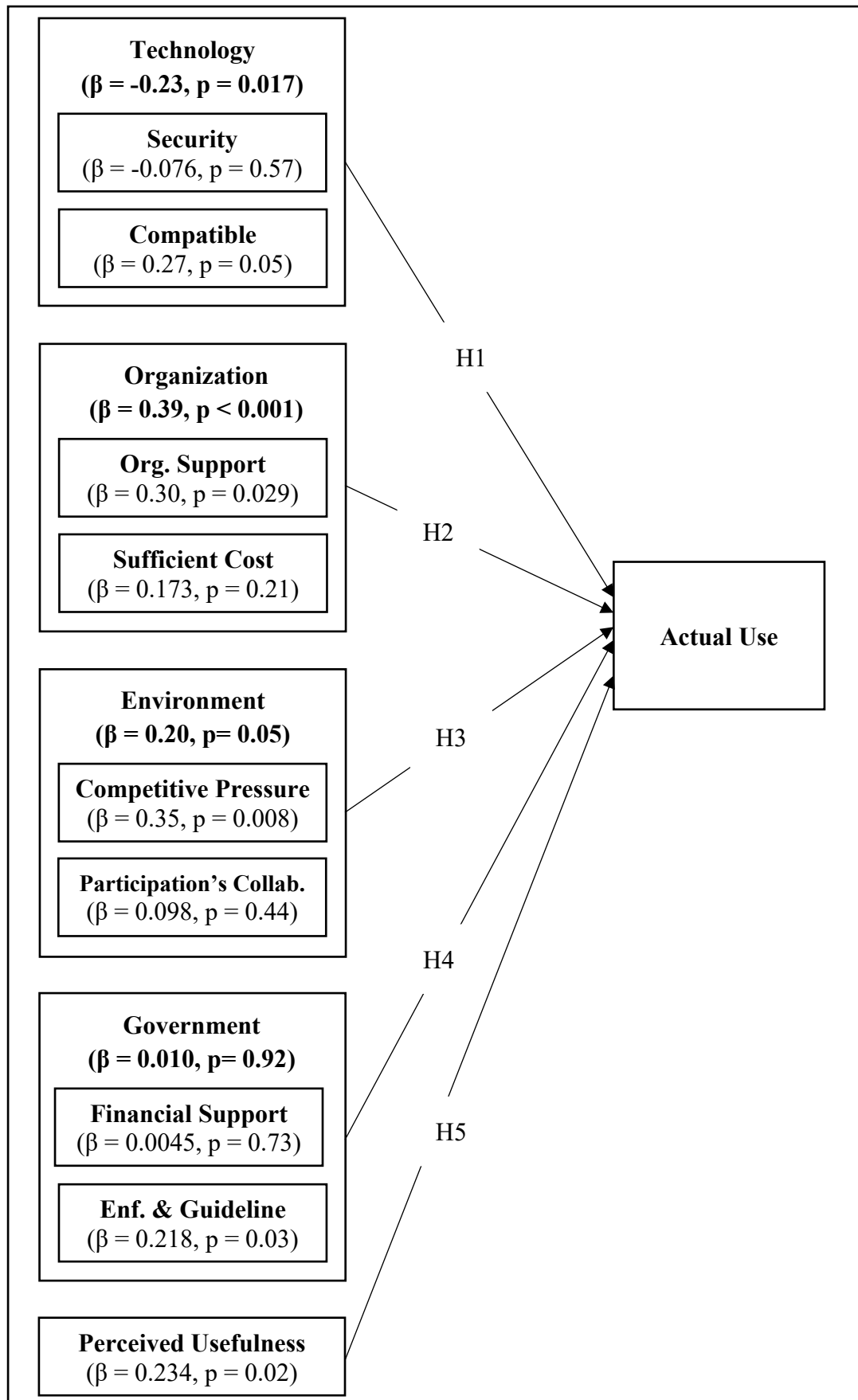


Figure 4.4 Construction Technology Adoption Framework (ConTech-AF) - Multiple Regression Analysis

## 4.7 Multiple Regression Analysis

This section provides the multiple regression analysis conducted before adding the mediator (perceived usefulness). A multiple regression analysis was conducted to examine the relationships among four independent variables (technology, organization, environment, and government), perceived usefulness, and actual use of disruptive technology in the construction industry. The results provide the baseline findings that researchers compared with the model that includes the mediator. Figure 4.4 shows the diagram of hypothesis testing for a clearer understanding. Table 4.11 shows the regression coefficients, t-values, and significance value (p-value) for each variable.

Unstandardized coefficient (B) shows how much the dependent variable changes if one of the independent variables increases by one unit, while the other independent variables stay the same (Field, 2024). Standard error (SE) refers to the precision of coefficient estimates. A smaller SE indicates a more precise and reliable coefficient. The standardized coefficient (Beta) is used to compare the relationship between independent and dependent variables. Table 3.14 in Chapter 3 shows the interpretation of the beta value. The t-value (t) tests whether the coefficient is significantly different from zero. A higher t-value indicates a stronger relationship between the independent and dependent variables. The p-value indicates whether the result is statistically significant, where a value below 0.05 indicates that the result is significant.(Field, 2024).

Table 4.11  
Results of Multiple Regression Analysis

| Code | Independent Variable | Unstandardized Coefficient (B) | Standard Error (SE) | Standardized Coefficient ( $\beta$ ) | t-value (t) | p-value (p) | Support? |
|------|----------------------|--------------------------------|---------------------|--------------------------------------|-------------|-------------|----------|
| H1   | Technology           | -0.431                         | 0.179               | -0.230                               | -2.410      | 0.017       | Yes      |
| H2   | Organization         | 0.720                          | 0.160               | 0.392                                | 4.500       | <0.001      | Yes      |
| H3   | Environment          | 0.382                          | 0.199               | 0.201                                | 1.917       | 0.05        | Yes      |
| H4   | Government           | 0.018                          | 0.169               | 0.010                                | 0.106       | 0.92        | No       |
| H5   | Perceived Usefulness | 0.488                          | 0.211               | 0.234                                | 2.315       | 0.02        | Yes      |

Based on the results in Table 4.11, organization, technology, and environment factors with perceived usefulness have significant positive effects on the actual use of

disruptive technology ( $p < 0.05$ ), indicating that stronger organizational support, financial support, advanced technical features, competitive pressure, and collaboration among construction companies can increase the adoption levels. In contrast, government factors do not have a significant effect on actual use ( $p > 0.05$ ). The insignificance indicates that government support does not strongly influence actual use in this context. Thus, the R-squared ( $R^2$ ) value for this model is 0.31, indicating that the model explains 30.5% of the variance in the dependent variable and reflecting a moderate relationship, as recommended in Chapter 3, Table 3.15. Thus, the findings offer a clear understanding of the key determinants of factors influencing the adoption of disruptive technology in the construction industry within the proposed model.

#### 4.7.1 Analysis for Hypothesis 1

Hypothesis 1 (H1): The technological context has a significant effect on the actual use of disruptive technology.

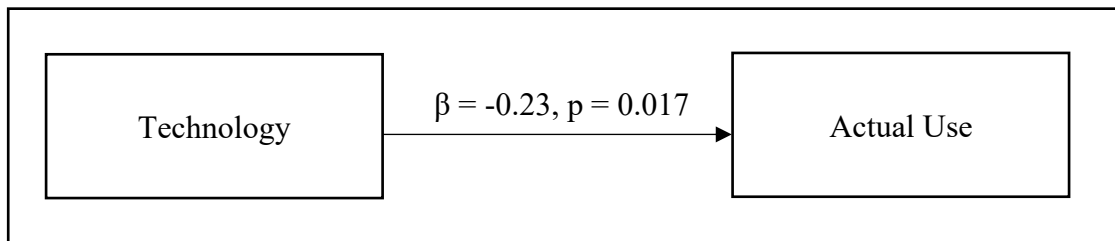


Figure 4.5 Relationship between Technology and Actual Use

Figure 4.5 shows the relationship between technology and the actual adoption of disruptive technologies in this study. The result shows that technology has a significant ( $p = 0.017$ ) but negative relationship ( $\beta = -0.23$ ) with actual use. Hence, Hypothesis H1 (the technological context has a significant effect on the actual use of disruptive technology) is accepted, indicating that the technology significantly influences the actual use of disruptive technologies.

Technology factors have a significant negative relationship with the actual adoption of disruptive technology. The results indicate that current technological features, in terms of system compatibility and security, remain insufficient to encourage

actual use, despite the technologies' advanced capabilities. The technologies are too advanced and complex, making it difficult for users to understand and use them. This complexity discourages users from adopting and using technologies. The statement is supported by Benbya et al. (2020), highlighting that the complexity of technology influences user experience, as it makes technology difficult to manage. Similarly, Bucaioni et al. (2025) stated that the absence of clear references hinders users' understanding, which slows down technology use.

The negative result shows that if the users do not trust the technology to perform securely, they are not likely to use the technology, as trust plays a critical role in this context. This statement is supported by Bahram (2025) and Wilson & Mergel (2022) studies, where it is stated that a lack of trust hinders the adoption and application of disruptive technology in the construction industry. In contrast, Botrugno et al. (2022) found that technology in terms of security-related issues has received less attention due to users not considering it as a decisive role in shaping the actual use of disruptive technology. Thus, this study shows that the technological context, in terms of security, remains a crucial factor in disruptive technology adoption. However, past studies report mixed evidence on the importance of security-related issues.

In addition, a study by Na et al. (2022) reported a positive relationship between the technological context, in terms of technical features (compatibility), and technology adoption, suggesting that adoption enhances users' work performance when new technologies align with their functionality and characteristics. Similarly, Zhao et al. (2025) found that system compatibility has a direct and positive relationship with technology adoption behavior in the construction industry. However, the negative relationship between technological factors and actual use in the current study suggests that although users recognize the potential benefits of disruptive technologies, technological features that are not compatible with existing systems may limit their practical application. As a result, users may be less likely to adopt and use these technologies.

#### 4.7.2 Analysis for Hypothesis 2

Hypothesis 2 (H2): The organizational context has a significant effect on the actual use of disruptive technology.

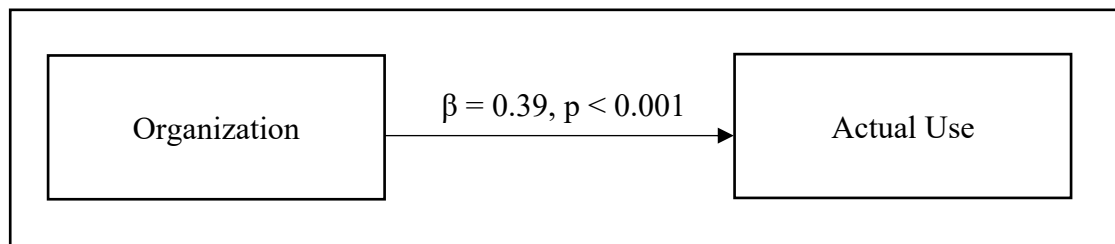


Figure 4.6 Relationship between Organization and Actual Use

Figure 4.6 shows the relationship between organizational factors and the actual use of disruptive technology adoption in this study. The result shows that the organization has a significant ( $p < 0.001$ ) positive relationship ( $\beta = 0.39$ ) with actual use. Hence, Hypothesis H2 (the organizational context has a significant effect on the actual use of disruptive technology) is accepted, indicating that the organizational context significantly influences the actual use of disruptive technologies.

The results of this study reveal that organizational factors are the strongest and most significant predictors of disruptive technology adoption. This indicates that organizational support, such as providing clear guidance and encouraging the daily use of disruptive technology, plays a decisive role in driving the adoption. This finding aligns with Na et al. (2022), which emphasizes that organizational culture and structure strongly influence users' acceptance of new technologies. The other two studies on technology adoption in the construction industry also emphasized that top management support has a significant positive effect on technology adoption (Mabad et al., 2021; Tavallaei et al., 2022). Similarly, Jaafar et al. (2024) reported that top management's decisions depend highly on adopting or hindering the adoption of technology.

In addition, the organizational context, particularly financial capacity, plays a significant role in technology adoption. When an organization has sufficient budget, it has a greater chance of investing in and adopting disruptive technology. The findings from Wilson & Mergel (2022) and Van et al. (2021) also support the current findings that insufficient implementation costs remain a barrier to adopting disruptive

technology, especially for Small and Medium Enterprises (SMEs). Similarly, Addy et al. (2024) found that the financial capacity of the companies is influenced by the size of the construction companies. In addition, a study by Wilson & Mergel (2022) further supports the idea that the lack of incentives and fears of changing traditional norms to digital transformation hinder the adoption within the organization.

The relationships among organizational support, budgetary sufficiency, and disruptive technology adoption are closely interconnected. Top management support plays an important role in encouraging technology adoption, while sufficient organizational budget provides the necessary resources to facilitate implementation decisions. For example, organizations should develop a systematic roadmap for technology implementation, including clear adoption strategies, timelines, and the resources required for successful implementation. Taken together, these findings suggest that the organizational context, particularly management commitment and financial readiness, plays a dominant role in shaping and enabling the adoption of disruptive technologies in the construction industry.

### 4.7.3 Analysis for Hypothesis 3

Hypothesis 3 (H3): The environmental context has a significant effect on the actual use of disruptive technology.

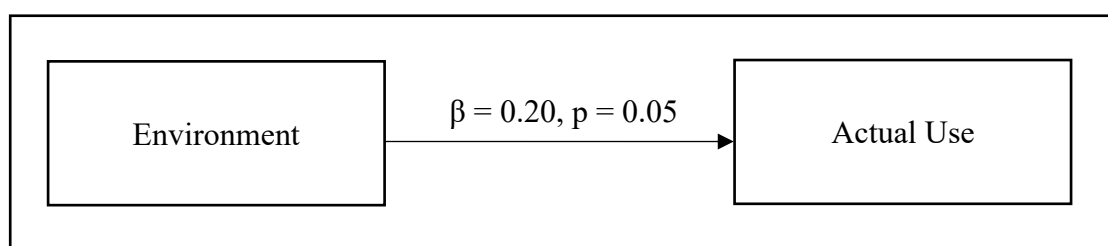


Figure 4.7 Relationship between Environment and Actual Use

Figure 4.7 shows the relationship between environmental factors and the actual use of disruptive technology adoption in this study. The result shows that technology has a significant ( $p = 0.05$ ) positive relationship ( $\beta = 0.20$ ) with actual use. Hence, Hypothesis H3 (the environmental context has a significant effect on the actual use of

disruptive technology) is accepted, indicating that the environment significantly influences the actual use of disruptive technologies.

The findings of the current study indicate that the environmental factors have a significant effect on the actual use of disruptive technology in the construction industry. This suggests that external factors, such as competitive pressure and stakeholder collaboration, play an important role in encouraging users to actually use technology. The findings are supported by Wang et al. (2022) and Chatterjee et al. (2021), who emphasized that competitive pressure leads to the usage of disruptive technology. Similarly, Katebi et al. (2022) reported that the organization tends to remove internal barriers once it observes competitors successfully implementing the new technology. However, a study by Ahmed et al. (2024) reported that competitive pressure did not significantly influence BIM adoption in this industry. The difference between those findings suggests that competitive pressure alone is not enough to encourage actual technology use, without support from other external factors.

Despite this, participation and collaboration within the construction industry have consistently been found to play an important role in the success of technology adoption. Ahmed et al. (2024) findings show that strong collaboration among stakeholders positively supports the adoption of new technology. Similarly, Othman et al. (2021) reported that BIM adoption positively influences stakeholder collaboration, suggesting that external collaboration can drive the adoption of disruptive technology. These findings suggest that environmental factors can encourage adoption through competitive pressure and stakeholder participation in construction. Taken together, the significant results indicate that organizations need to remain competitive by embracing new technologies and strengthening collaboration with industry stakeholders to support digital transformation in the construction industry.

#### 4.7.4 Analysis for Hypothesis 4

Hypothesis 4 (H4): The government context has a significant effect on the actual use of disruptive technology.

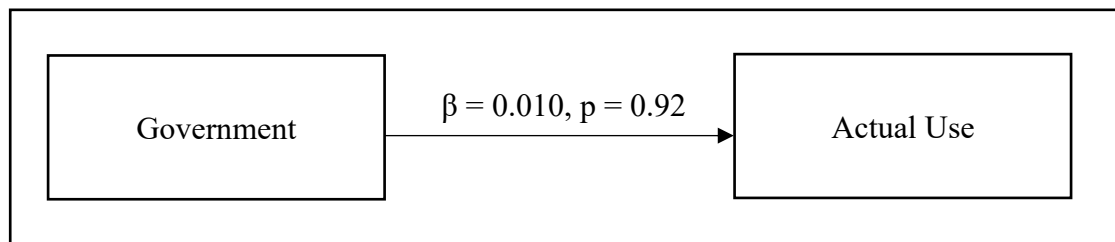


Figure 4.8 Relationship between Government and Actual Use

Figure 4.8 shows the relationship between governments and the actual adoption of disruptive technology in this study. The result shows that the government has an insignificant ( $p = 0.92$ ) positive relationship ( $\beta = 0.010$ ) with actual use. Hence, Hypothesis H4 (the government context has a significant effect on the actual use of disruptive technology) is rejected, indicating that the government did not significantly influence the actual use of disruptive technologies.

Government factors do not have a significant effect on the actual use of disruptive technology. The results suggest that the government's current financial support, enforcement, and guidelines are not sufficient to encourage the actual use of disruptive technology in the construction industry. While government factors can significantly influence the adoption of disruptive technology, there are cases where the impact is insignificant. The studies by Taib et al. (2023), Wang et al. (2022), and Zaini et al. (2020) also show an insignificant effect of the government factor, indicating that the government's role is not strong enough to encourage actual use of adoption.

Surprisingly, the current result contradicts the findings of previous studies, which highlight that government involvement plays a significant role in technology adoption. A study by Luo et al. (2023) stated that government support has a significant effect on one of the disruptive technologies, known as D-procurement adoption success. Next, Kong & Jie (2024) study stated that the government and the developers play a pivotal role in the success of technology transformation in the Malaysian Construction Industry. The findings from Katebi et al. (2022) study also revealed that government

support had a positive and significant impact on the intention to adopt Precast Concrete Components (prefabrication technology).

The adoption rate of technologies in the current study remains low, suggesting that financial support from the government and its agencies may be insufficient to encourage actual use of disruptive technology. Despite budget allocations through the Construction Industry Transformation Plan (CITP) (Mamter et al., 2019), the impact on technology adoption in the construction sector remains limited. A study from Jaafar et al. (2024) indicates that the enforcement by the government is not fully effective in increasing the adoption of technology. In addition, Jaafar et al. (2024) highlighted that the guidelines provided in the Construction Strategy Plan 4.0 remain insufficient, as actual technology adoption continues to be low.

Thus, the government factors do not have a significant effect on the actual use of disruptive technology in the construction industry. Although the government has provided financial support, enforcement, and guidelines, these strategies are not strong enough to encourage actual use. This study identifies a gap between the government's roles and their actual implementation, indicating that government initiatives need to be better planned and more user-centric to improve the government's role.

#### 4.7.5 Analysis for Hypothesis 5

Hypothesis 5 (H5): The perceived usefulness has a significant effect on the actual use of disruptive technology.

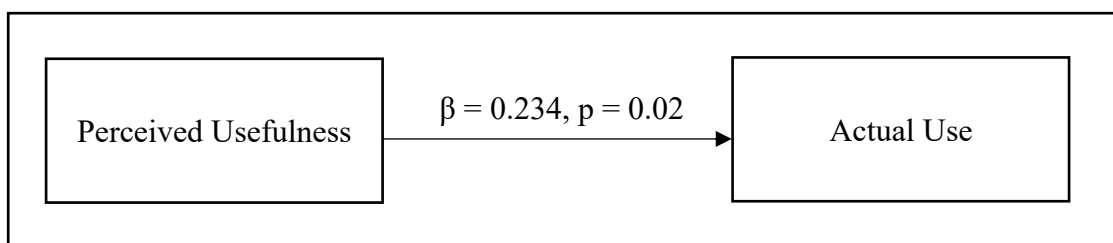


Figure 4.9 Relationship between Perceived Usefulness and Actual Use

Figure 4.9 shows the relationship between perceived usefulness and the actual use of disruptive technology adoption in this study. The result shows that perceived

usefulness has a significant ( $p = 0.02$ ) positive relationship ( $\beta = 0.234$ ) with actual use. Hence, Hypothesis H5 (the perceived usefulness has a significant effect on the actual use of disruptive technology) is accepted, indicating that perceived usefulness significantly influences the actual use of disruptive technologies.

Perceived usefulness in this study has a significant effect on the actual use of disruptive technologies. This finding indicates that users are more likely to use disruptive technologies when they believe that the technology can enhance their work performance and efficiency. In addition to government mandates to adopt disruptive technology, it can enhance perceived usefulness, leading to increased actual use, even in the absence of an intention to use. This statement is supported by Zaid et al. (2025), who show that actual use of BIM positively influences perceived usefulness, suggesting that the more people use BIM, the more they see its benefits, which encourages them to use it even more. Similarly, studies by Nguyen et al. (2024) and Wong et al. (2025) also supported the role of perceived usefulness in increasing the actual use of disruptive technology, without the intention to use. Therefore, users are more willing to adopt disruptive technologies in their daily work practices when they recognise clear benefits. The benefits include enhancing their job performance in the construction processes.

#### **4.8 Mediation Analysis**

This section presents the mediation analysis conducted to examine the mediating role of perceived usefulness (PU) in the relationships between the independent variables (technology, organization, environment, and government) and the dependent variable (actual use). The analysis was tested using the PROCESS Macro (Model 4) in SPSS. Four separate mediation models were conducted because PROCESS only allows one independent variable per run. The results allow the researchers to determine whether the relationship's significance has changed or not. The mediation analysis results are reported using the unstandardized coefficient (B), standard error (SE), t-value, p-value, lower-level confidence interval (LLCI), and upper-level confidence interval (ULCI) for each variable. When the confidence interval does not include zero (0), it indicates that the indirect effect is statistically significant (Hayes, 2013). Figure 4.10 shows the final diagram for hypothesis testing, mediation analysis.

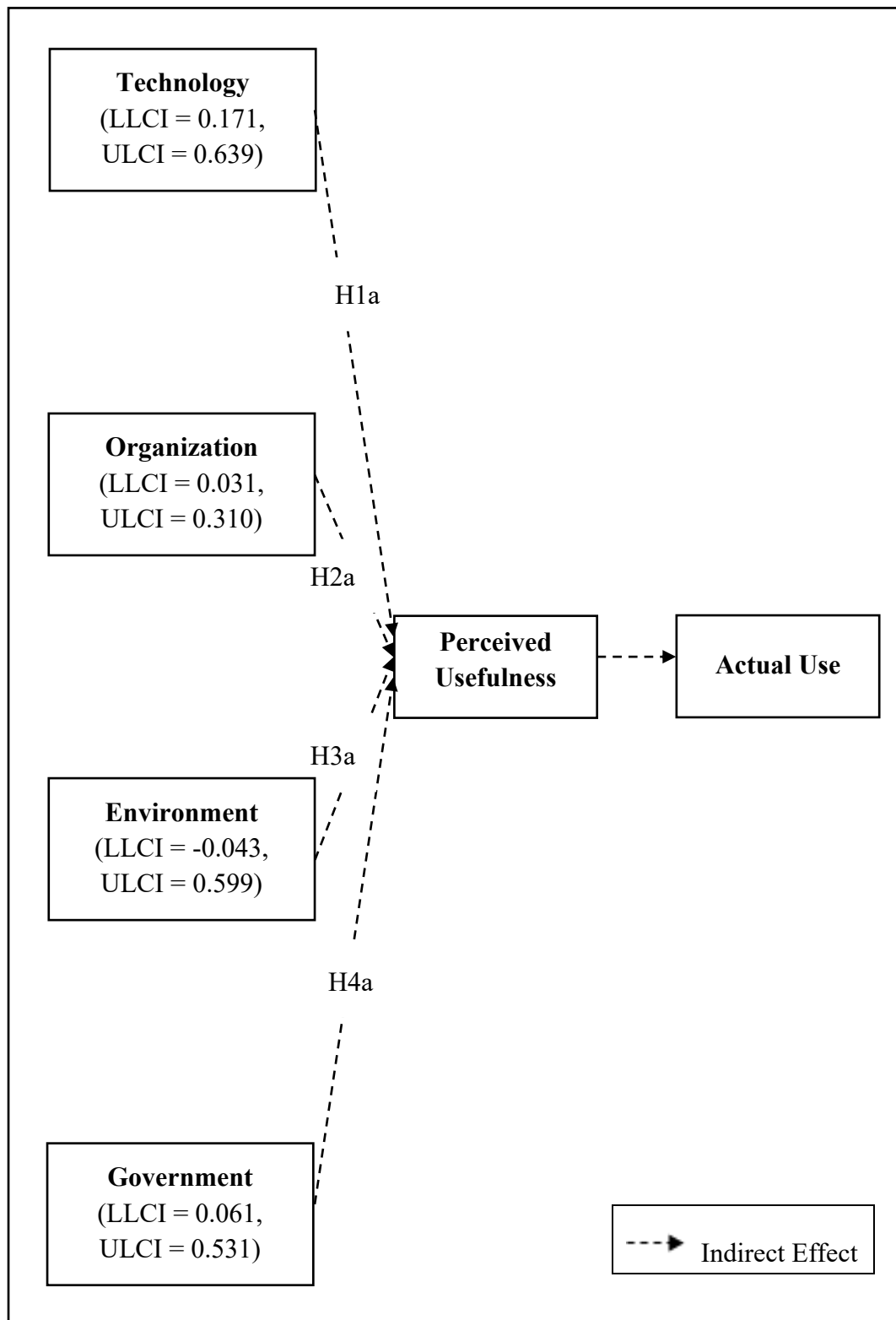


Figure 4.10 Construction Technology Adoption Framework (ConTech-AF) - Mediation Analysis

### 4.8.1 Analysis for Hypothesis 1a

Hypothesis 1a: The technological context has a significant indirect effect on the actual use of disruptive technology through perceived usefulness.

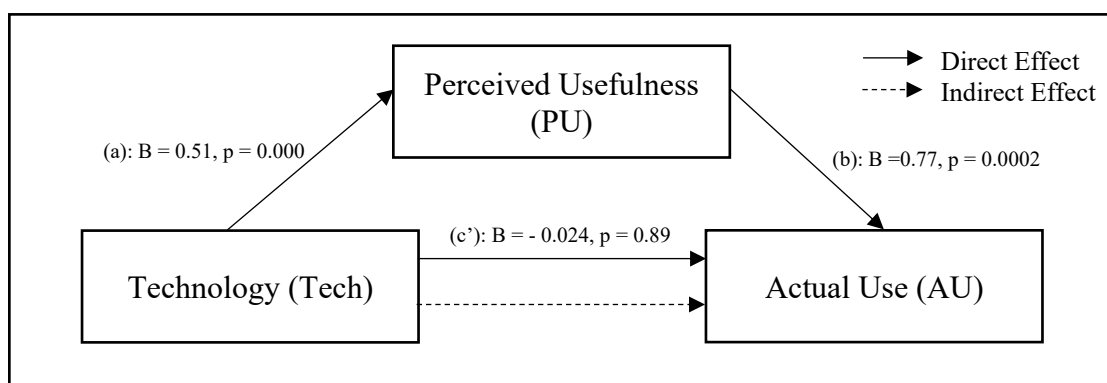


Figure 4.11 Relationship between Technology and Actual Use through Perceived Usefulness

Table 4.12  
Mediation Analysis Results for Hypothesis 1a

| Effect                  | B       | SE     | t       | p      | LLCI    | ULCI   | Significant? |
|-------------------------|---------|--------|---------|--------|---------|--------|--------------|
| Tech → PU (a)           | 0.5106  | 0.0630 | 8.1080  | 0.0000 | 0.3861  | 0.6351 | Yes          |
| PU → AU (b)             | 0.7727  | 0.2002 | 3.8598  | 0.0002 | 0.3769  | 1.1686 | Yes          |
| Tech → AU (direct, c')  | -0.0247 | 0.1804 | -0.1372 | 0.8911 | -0.3814 | 0.3320 | No           |
| Indirect effect (a × b) | 0.3946  | 0.1186 | -       | -      | 0.1713  | 0.6393 | Yes          |

Figure 4.11 and Table 4.12 present the results of the mediation analysis, examining whether the technology factor (tech) has a significant indirect effect on the actual use (AU) of disruptive technology through perceived usefulness (PU). The first path revealed that technology has a significant impact on perceived usefulness ( $B = 0.51, p = 0.000$ ), indicating that people are more likely to believe that disruptive technology is helpful and useful for their task as the technology context becomes more advanced. When perceived usefulness is included as an independent variable in the relationship with actual use, it has a significant effect on actual use ( $B = 0.77, p = 0.002$ ).

The direct effect of technology on actual use is not significant ( $LLCI = -0.38, ULCI = 0.33$ ). However, the indirect effect of technology and actual use through perceived usefulness is significant ( $LLCI = 0.17, ULCI = 0.64$ ). These results indicate

that perceived usefulness has fully mediated the relationship between technology and actual use. Thus, Hypothesis H1a (the technological context has a significant indirect effect on the actual use of disruptive technology through perceived usefulness) is accepted.

The results for the technological context indicate that perceived usefulness significantly mediates the relationship between the technological context and actual use, presenting a full mediation effect. The findings suggest that compatibility and security do not directly influence actual adoption unless users perceive the technology as beneficial to their work. These results are consistent with the Technology Acceptance Model (TAM) framework, which suggests that technology characteristics shape adoption through perception-based beliefs (Chomistrian et al., 2024).

Furthermore, the current findings are also consistent with previous studies by Chomistrian et al. (2024) and Nguyen et al. (2024), who reported that technological factors positively influence perceived usefulness, which, in turn, enhances end-user acceptance and improves work performance. This indicates that the technological features do not directly encourage users to use disruptive technology. Instead, these features have an indirect effect on the actual use by making the technology appear more useful.

## 4.8.2 Analysis for Hypothesis 2a

Hypothesis 2a: The organizational context has a significant indirect effect on the actual use of disruptive technology through perceived usefulness.

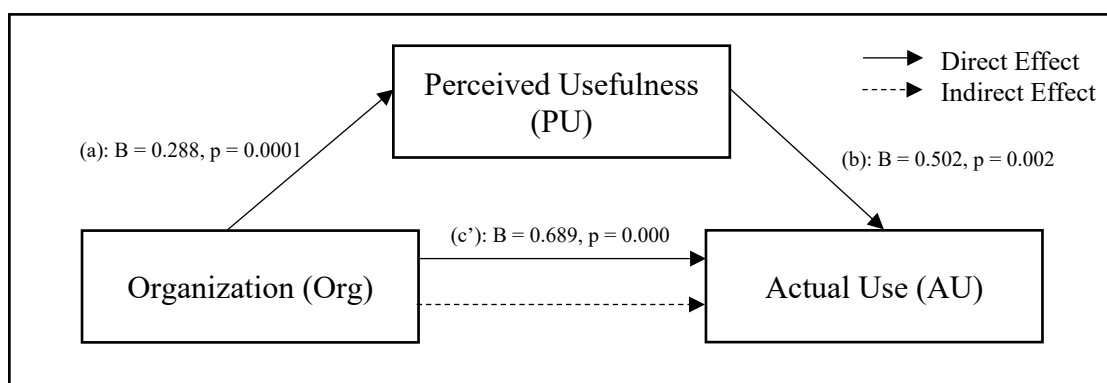


Figure 4.12 Relationship between Organization and Actual Use through Perceived Usefulness

Table 4.13  
Mediation Analysis Results for Hypothesis 2a

| Effect                  | B      | SE     | t      | p      | LLCI   | ULCI   | Significant? |
|-------------------------|--------|--------|--------|--------|--------|--------|--------------|
| Org → PU (a)            | 0.2884 | 0.0708 | 4.0720 | 0.0001 | 0.1484 | 0.4285 | Yes          |
| PU → AU (b)             | 0.5025 | 0.1614 | 3.1132 | 0.0023 | 0.1833 | 0.8216 | Yes          |
| Org → AU (direct, c')   | 0.6893 | 0.1426 | 4.8339 | 0.0000 | 0.4073 | 0.9712 | Yes          |
| Indirect effect (a × b) | 0.1449 | 0.0727 | -      | -      | 0.0319 | 0.3108 | Yes          |

Figure 4.12 and Table 4.13 present the mediation results for the organization (Org) to actual use (AU) via perceived usefulness (PU). The organization has a significant effect on perceived usefulness, as B is 0.28 and  $p = 0.001$ . This shows that the more the organization plays its role in adoption, the more users believe the technology is useful. Next, perceived usefulness has a significant effect on actual use ( $B = 0.50$ ,  $p = 0.0023$ ), indicating that users are more likely to use disruptive technology when they find it useful. The direct effect of the organization on actual use is significant ( $p = 0.000$ ), with no zero included in the confidence interval ( $LLCI = 0.40$ ,  $ULCI = 0.97$ ). There is a significant indirect effect of organization on actual use through perceived usefulness, as the confidence interval does not include zero ( $LLCI = 0.03$ ,  $ULCI = 0.31$ ). Overall, both direct and indirect effects of the organization on actual use

through perceived usefulness are significant, suggesting partial mediation. Thus, Hypothesis 2a (the organizational context has a significant indirect effect on the actual use of disruptive technology through perceived usefulness) is accepted.

The mediation results of organizational context indicate that perceived usefulness partially mediates the influence of organizational context on actual use. These findings suggest that management support and cost sufficiency influence the adoption both directly and indirectly through perceived usefulness. The finding indicates that organizational factors, such as management support and cost sufficiency, can help users see the technology as useful, which can encourage them to use it, even if these factors do not directly influence adoption.

A finding from Katebi et al. (2022) supports the statement, as the study stated that cost sufficiency in the companies significantly influences perceived usefulness, but not with the intention to adopt. A study by Wong et al. (2025) also found that perceived usefulness mediates the relationship between organizational factors and the actual use of Building Information Modelling (BIM). Thus, the current result and past studies consistently support the mediation effect of perceived usefulness on the relationship between organizational factors and actual use in the construction industry.

#### 4.8.3 Analysis for Hypothesis 3a

Hypothesis 3a: The environmental context has a significant indirect effect on the actual use of disruptive technology through perceived usefulness.

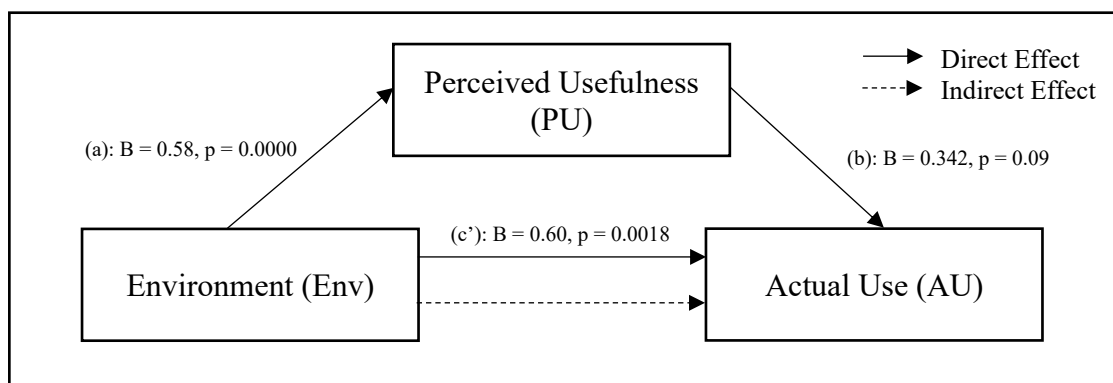


Figure 4.13 Relationship between Environment and Actual Use through Perceived Usefulness

Table 4.14  
Mediation Analysis Results for Hypothesis 3a

| Effect                  | B      | SE     | t      | p      | LLCI    | ULCI   | Support? |
|-------------------------|--------|--------|--------|--------|---------|--------|----------|
| Env → PU (a)            | 0.5801 | 0.0602 | 9.6398 | 0.0000 | 0.4611  | 0.6991 | Yes      |
| PU → AU (b)             | 0.3427 | 0.2057 | 1.6662 | 0.0979 | -0.0640 | 0.7494 | No       |
| Env → AU (direct, c')   | 0.6001 | 0.1885 | 3.1838 | 0.0018 | 0.2274  | 0.9729 | Yes      |
| Indirect effect (a × b) | 0.1988 | 0.1626 | -      | -      | -0.0433 | 0.5990 | No       |

In order to understand the indirect relationship of perceived usefulness (PU) between environment (env) and actual use (AU), a mediation analysis was performed, and the results are presented in Figure 4.13 and Table 4.14. The environmental factor has a significant effect on perceived usefulness, with  $B = 0.58$  and  $p = 0.000$ , indicating that users are more likely to perceive technology as useful when environmental pressure on construction companies increases. The path from perceived usefulness to actual use is not significant ( $p = 0.05$ ), which is greater than 0.05, suggesting a positive relationship, but the effect is not significant.

Next is the direct effect of the environment on actual use. The result shows that there is a significant effect ( $LLCI = 0.23$ ,  $ULCI = 0.97$ ). This indicates that environmental factors alone have a direct effect on the actual use. However, the indirect effect of the environment on actual use via perceived usefulness is not significant ( $LLCI = -0.04$ ,  $ULCI = 0.60$ ), indicating that users' perception of the technology's usefulness does not influence their actual use. Overall, environmental factors do not significantly influence actual use via perceived usefulness of the technology, indicating no mediation of the relationship. Thus, Hypothesis 3a (the environmental context has a significant indirect effect on the actual use of disruptive technology through perceived usefulness) is rejected.

This indicates that the competitive pressure and participation in collaboration do not have an indirect effect on actual use through perceived usefulness. However, the environmental context has a significant direct effect on the actual use. This means that while users may directly feel pressured by competitors or collaboration to adopt disruptive technology, this pressure does not change their perception of whether the technology is useful or easy to use.

In other words, the environment directly drives adoption, but not through perceived usefulness. One possible reason is that many construction companies, especially Small and Medium Enterprises (SMEs), remain cautious about new

technologies, even though they recognize their usefulness. They often hesitate to adopt despite competitive pressure due to cost concerns, fear of risks, and limited resources. This statement is supported by previous findings by Jaafar et al. (2024) and Tjandra et al. (2022).

#### 4.8.4 Analysis for Hypothesis 4a

Hypothesis 4a: The government context has a significant indirect effect on the actual use of disruptive technology through perceived usefulness.

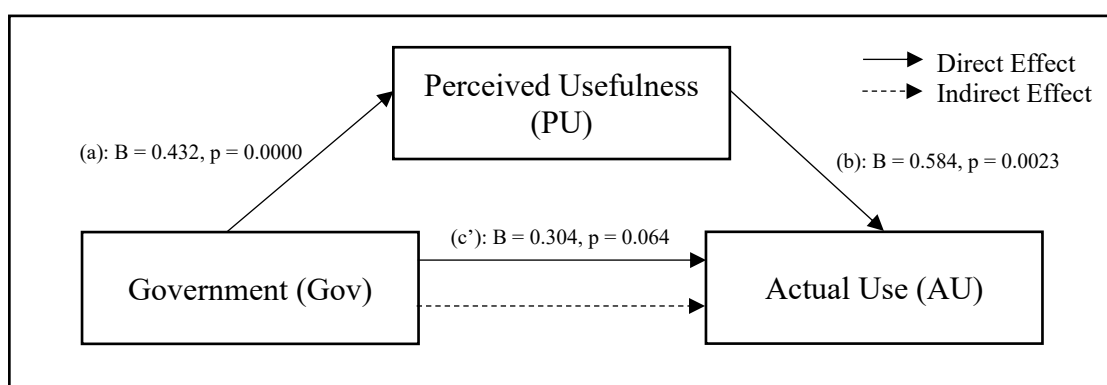


Figure 4.14 Relationship between Government and Actual Use through Perceived Usefulness

Table 4.15  
Mediation Analysis Results for Hypothesis 4a

| Effect                  | B      | SE     | t      | p      | LLCI    | ULCI   | Support? |
|-------------------------|--------|--------|--------|--------|---------|--------|----------|
| G → PU (a)              | 0.4328 | 0.0643 | 6.7297 | 0.0000 | 0.3057  | 0.5600 | Yes      |
| PU → AU (b)             | 0.5841 | 0.1876 | 3.1132 | 0.0023 | 0.2131  | 0.9551 | Yes      |
| G → AU (direct, c')     | 0.3049 | 0.1638 | 1.8612 | 0.0648 | -0.0190 | 0.6288 | No       |
| Indirect effect (a × b) | 0.2528 | 0.1208 | -      | -      | 0.0619  | 0.5319 | Yes      |

Next, the mediation analysis aims to determine whether the effect of government (G) on actual use (AU) is mediated by perceived usefulness (PU). The results are presented in Figure 4.14 and Table 4.15. The government has a positive and significant effect on perceived usefulness, with  $B = 0.43$  and  $p = 0.000$ . Perceived usefulness has a positive, significant effect on actual use ( $B = 0.58$ ,  $p = 0.0002$ ). This indicates that when

the government is involved, users are more likely to see disruptive technology as useful and are more likely to use it.

There is no direct effect of the government on actual use (LLCI = -0.02, ULCI = 0.63). Still, there is a significant indirect effect of the government on actual use through perceived usefulness, with LLCI = 0.06 and ULCI = 0.53, indicating that the government's role indirectly increases actual use. Overall, government factors significantly influence actual use through perceived usefulness of the technology, which indicates full mediation of the relationship. Thus, Hypothesis 4a (the government context has a significant indirect effect on the actual use of disruptive technology through perceived usefulness) is accepted.

The findings of current research show that perceived usefulness significantly mediates the effect of government context on actual use, presenting a full mediation effect. However, the government has no significant effect on the direct effect of actual use. This suggests that government policies, financial support, and enforcement do not directly influence the adoption of disruptive technologies, but instead create conditions that make them more useful. These results align with Na et al. (2022) and Katebi et al. (2022) findings, where they emphasize the important role of government incentives in enhancing adoption perceptions.

A study by Lee et al. (2022) mentioned that clear and firm enforcement, together with clear guidance, can significantly enhance users' belief that technology is useful. Moreover, the findings are also supported by Tran Pham (2023) and Qiu et al. (2023), where the government rules and regulations significantly mediate the relationship of technology adoption through perceived usefulness. Thus, this highlights that the government context plays an important role in shaping the users' perception of its usefulness.

#### **4.9 Summary of Hypotheses**

This section presents a summary of the hypothesis-testing results from the multiple regression and mediation analyses. The purpose of the analysis was to examine the relationships between the independent and the dependent variables of disruptive technology adoption in the construction industry. A total of nine hypotheses were tested.

Table 4.16 outlines the outcomes for each hypothesis, indicating whether they were supported, not supported, or mediated (partially or fully).

**Table 4.16**  
**Summary Results of the Hypothesis Testing**

| <b>Code</b> | <b>Hypothesis</b>                                                                                                                     | <b>Accepted?</b>        |
|-------------|---------------------------------------------------------------------------------------------------------------------------------------|-------------------------|
| 1           | The technological context has a significant effect on the actual use of disruptive technology.                                        | Yes                     |
| 1a          | The technological context has a significant indirect effect on the actual use of disruptive technology through perceived usefulness.  | Yes (Full Mediation)    |
| 2           | The organizational context has a significant effect on the actual use of disruptive technology.                                       | Yes                     |
| 2a          | The organizational context has a significant indirect effect on the actual use of disruptive technology through perceived usefulness. | Yes (Partial Mediation) |
| 3           | The environmental context has a significant effect on the actual use of disruptive technology.                                        | Yes                     |
| 3a          | The environmental context has a significant indirect effect on the actual use of disruptive technology through perceived usefulness.  | No                      |
| 4           | The government context has a significant effect on the actual use of disruptive technology.                                           | No                      |
| 4a          | The government context has a significant indirect effect on the actual use of disruptive technology through perceived usefulness.     | Yes (Full Mediation)    |
| 5           | The perceived usefulness context has a significant effect on the actual use of disruptive technology.                                 | Yes                     |

#### **4.10 Conclusion of the Chapter**

In summary, this chapter presented the findings of the data analysis, including the respondents' demographic profiles, the current level of disruptive technology adoption, hypothesis testing, and mediation analysis. The descriptive analysis indicated that awareness is increasing, but understanding is not developing at the same pace, and usage lags significantly behind both awareness and understanding. The hypothesis testing revealed that organizational, technological, environmental, and perceived usefulness factors have significant direct effects on the actual use of disruptive technologies, whereas government factors do not have a significant direct effect. The mediation analysis further demonstrated that perceived usefulness significantly mediates the relationships between technology, organization, and government factors and actual use, but does not mediate the relationship between environmental factors and actual use. Overall, these findings provide empirical support for the proposed Construction Technology Adoption Framework (ConTech-AF) and offer insights into the factors influencing disruptive technology adoption in the construction industry. The next chapter will provide the study's overall conclusions.

## **CHAPTER 5**

### **CONCLUSIONS AND RECOMMENDATIONS**

#### **5.1 Introduction of the Chapter**

This chapter presents the conclusions of the study on the adoption of disruptive technologies in the construction industry. It summarises the key findings in relation to the research objectives and discusses the main results derived from the data analysis. In addition, the chapter highlights the research contributions of the study and provides recommendations for relevant stakeholders. Finally, it concludes by presenting suggestions for future research to further advance the understanding of disruptive technology adoption in the construction industry.

#### **5.2 Research Summary**

The objectives of this study are to determine the influence of technological, organizational, environmental, and government factors on the adoption of disruptive technology and to examine the mediating role of perceived usefulness in the relationships between these factors and disruptive technology adoption in the construction industry. This study integrates variables from the TOE and TAM frameworks to investigate disruptive technology adoption in the construction industry, resulting in the development of the Construction Technology Adoption Framework (ConTech-AF). This study determined the relationships between the independent variables, namely technology, organization, environment, and government factors, and the dependent variable, actual use of disruptive technology. In addition, this study examined the mediating role of perceived usefulness (PU) in explaining the relationship between these factors and actual use.

There are 141 total respondents from 91 construction companies who participated in this study. The number of responses collected in this study exceeds the minimum sample size required (85 construction companies), as calculated by using

G\*Power in Chapter 3. By using purposive sampling techniques, the respondents represent various characteristics in the demographic profile. The majority of respondents are male (67.4%), mostly aged 31 to 40 (41.8%), and most hold a bachelor's degree (46.1%). In terms of experience, 23.4% of respondents have 3 years or less (23.4%) working experience in the construction industry, and many respondents are main contractors (44.0%). Additionally, more than half are involved in special trade activities (53.2%), with a large proportion coming from the G7-grade companies (41.8%).

The respondents' awareness levels are moderate to high, as the mean values range from 2.96 to 3.56. This shows that the respondents are aware of disruptive technologies and recognize them. Next, the level of understanding of disruptive technology shows basic understanding only, as both the median and mode for all 12 disruptive technologies are consistently recorded at three (3). The findings suggest that respondents have a basic understanding of disruptive technology but remain at proficient or expert levels. Most of the respondents are still in the early stage of adopting disruptive technology, as most of the results recorded the values of the median and mode consistently at two (2), considering the use category. This finding suggests that the adoption trend is still in its early stages, and they are mostly considered used rather than fully used.

Four factors have been examined to determine the factors influencing the adoption of disruptive technologies, which are technology, organization, environment, and government, with perceived usefulness as a mediating effect. Overall, the findings indicate that the organization, technology, and environment have a significant effect on the actual use of adoption; the government, meanwhile, has an insignificant effect. As for the mediating effect of perceived usefulness, technology and government factors fully mediate the effect on actual use, organizational factors partially mediate the effect on actual use, and environmental factors do not mediate the effect on actual use.

The findings of this study showed that all independent variables are significantly related to the actual use of disruptive technologies, except the governmental factor. The independent variables that have a significant relationship with actual adoption use are organizational, technological, and environmental factors. With perceived usefulness acting as a mediator, the relationship between governmental, technological, and organizational factors and actual use is indirect and significant.

The adoption of disruptive technologies in the construction industry, particularly in Sarawak, remains slow due to several challenges, including resistance to change, skill-related barriers, limited information and understanding of these technologies, as well as insufficient political commitment, legislation, and enforcement by the government and relevant agencies. Therefore, it is important to study the factors that influence the adoption of disruptive technologies, as identifying these key factors helps industry players understand the main barriers and drivers of actual use.

By understanding how organizational supports, budgetary sufficiency, technical features in terms of security and compatibility, competitive pressure, and participation and collaboration among the construction industry, government financial support and enforcement, and guidelines can be developed to address these challenges, thereby supporting higher adoption rates and more effective use of disruptive technologies in the construction industry.

In addition, perceived usefulness is important as a mediator because it explains how and why those factors influence the actual use of disruptive technology. Even when the government mandates the use of disruptive technology, adoption will occur only when users believe the technology is useful and can improve their job performance. This result highlights that increasing adoption is not only about providing technology or policies, but also about ensuring that the users clearly see the practical benefits of disruptive technologies in their daily construction tasks.

Overall, these findings provide valuable insight into advancing the implementation of the Construction 4.0 Strategic Plan, as the key adoption factors have been comprehensively examined. Despite the ongoing initiatives, the Sarawak construction industry remains at an early to moderate stage of adoption. Bridging the gap between current adoption levels and the strategic goals of Construction 4.0, therefore, requires stronger collaboration among industry practitioners and government agencies.

### **5.3 Research Contribution**

This study contributes to the existing body of knowledge on disruptive technology adoption in the construction industry by integrating the Technology-Organization-Environment (TOE) and Technology Acceptance Model (TAM) framework into a single research model. While previous studies have commonly examined technology adoption using either TOE or TAM independently, this study combines both frameworks, together with government-related factors, to develop the Construction Technology Adoption Framework (ConTech-AF), which provides a more comprehensive understanding of the factors influencing the actual use of disruptive technologies in the Sarawak construction industry. Furthermore, the inclusion of perceived usefulness as a mediating variable extends the theoretical understanding of how technological, organizational, environmental, and governmental factors influence actual adoption behaviour. In addition, the study offers a structured assessment of awareness, understanding, and actual use levels across various disruptive technologies, enabling a clearer distinction between technology awareness and actual adoption.

Practically, the findings provide valuable insights for construction industry stakeholders, including contractors, consultants, developers, policymakers, and government agencies. The study identifies organizational, technological, and environmental factors as key determinants of disruptive technology adoption, while highlighting the important role of perceived usefulness in influencing actual use. These findings can assist industry practitioners and policymakers in formulating targeted strategies, training initiatives, financial support mechanisms, and regulatory frameworks to accelerate digital transformation and improve the implementation of Construction 4.0 initiatives. Ultimately, the study supports efforts to enhance productivity, competitiveness, and technological innovation within the construction industry.

## **5.4 Recommendations**

Based on the findings of this study, several recommendations are proposed for relevant stakeholders, including government ministries, departments, agencies, and industry practitioners, to support the adoption of disruptive technologies in the construction industry.

### **5.4.1 Government Ministries, Departments, and Agencies**

The findings highlight that government factors do not have a direct significant effect on actual use; however, they remain important in shaping adoption indirectly through perceived usefulness. Therefore, government agencies such as CIDB and relevant ministries should strengthen their role in promoting awareness and demonstrating the practical benefits of disruptive technologies in the construction industry. This can be achieved through continuous awareness programmes, industry seminars, and demonstration projects that showcase successful implementation cases. In particular, CIDB can play a more active role by developing structured technology adoption guidelines and assessment frameworks to evaluate contractors' readiness, knowledge, and capability in adopting disruptive technologies.

In addition, policymakers should adopt a more user-centric approach when designing policies and initiatives related to disruptive technology adoption, as the findings on the government role become significant through the perception of the user. Rather than focusing solely on regulatory requirements, government agencies should actively engage with industry practitioners to understand their needs, challenges, and expectations regarding technology implementation. Feedback from contractors, consultants, and other industry stakeholders should be incorporated into the development of support programmes, guidelines, and digital transformation initiatives to ensure that they are practical, relevant, and beneficial to end users.

Furthermore, policymakers should enhance financial incentives, subsidies, and grants to reduce the cost burden associated with technology adoption, particularly for small and medium-sized contractors. Clearer policies, guidelines, and enforcement mechanisms should also be developed to ensure alignment with the Construction 4.0 Strategic Plan. CIDB may also strengthen collaboration with technology providers,

academic institutions, and industry associations to promote the exchange of knowledge, conduct hands-on technology demonstrations, and assist contractors in addressing technical and implementation challenges associated with disruptive technology adoption. Strengthening collaboration between government bodies and industry players is essential to improve understanding, increase trust, and indirectly enhance perceived usefulness among users, thereby encouraging wider adoption of disruptive technologies in the construction industry.

#### **5.4.2 Industry Practitioners**

For industry practitioners, particularly construction companies, the findings indicate that organizational, technological, and environmental factors significantly influence actual adoption of disruptive technologies. Therefore, construction companies should prioritize strengthening internal organizational readiness by allocating sufficient budgets for digital transformation, providing continuous training and skills development, and creating a workplace culture that embraces innovation and technological change.

In addition, companies should conduct careful evaluations of the suitability, compatibility, usability, security, and expected benefits of disruptive technologies before implementation. Selecting technologies that align with organizational needs and project requirements can enhance employees' perceptions of their usefulness and encourage greater acceptance and actual usage. This is particularly important as perceived usefulness plays a significant mediating role in influencing technology adoption behaviour.

Furthermore, industry practitioners are encouraged to actively participate in collaboration and knowledge-sharing activities among the construction industry to improve awareness, understanding, and exposure to emerging technologies. Companies should also view competitive pressure as an opportunity to enhance innovation and operational performance rather than merely as an external challenge. By engaging with industry networks, technology providers, and other construction stakeholders, practitioners can gain valuable insights and develop strategies to improve productivity, efficiency, and competitiveness through disruptive technology adoption.

## **5.5 Limitations of the Study**

The limitations of this study can be categorized into two main areas. Firstly, this study is limited by the use of IBM SPSS Statistics for mediation analysis. The mediation effect was examined using regression-based procedures, which involve testing the relationships through separate analytical steps rather than estimating all relationships simultaneously within a single model. Unlike SmartPLS, which applies Partial Least Squares Structural Equation Modeling (PLS-SEM) to assess direct, indirect, and total effects simultaneously, SPSS does not provide a comprehensive structural model that integrates all relationships in one analysis. Therefore, future studies may consider using SEM-based approaches, such as SmartPLS, to provide a more comprehensive assessment of the proposed framework.

Secondly, this study is limited by the distribution of contractor grades among the respondents. The majority of respondents were Grade G7 contractors, which may limit the generalizability of the findings across contractors with different resource capacities and operational scales. Although G7 contractors generally possess greater financial and organizational capabilities to adopt disruptive technologies, the findings indicate that the overall level of technology adoption remains relatively low. Therefore, the findings may not fully represent the adoption challenges experienced by lower-grade contractors, who may face greater financial, technical, and organizational constraints.

## **5.6 Recommendations for Future Research**

Given the limited understanding and availability of information regarding disruptive technologies, future studies should further investigate the role of government support in facilitating technology adoption. Researchers may explore government-related factors beyond financial support, enforcement mechanisms, and policy guidelines, including the effectiveness of national standards, implementation frameworks, and industry support initiatives in influencing actual technology use. This is particularly important as the current study identified inconsistent findings regarding the direct influence of government factors on disruptive technology adoption, while their indirect influence through perceived usefulness remained significant.

Furthermore, future studies may employ Structural Equation Modeling (SEM)-based techniques, such as SmartPLS, to simultaneously estimate structural relationships and provide a more comprehensive evaluation of direct, indirect, and mediating effects within an integrated model. This approach may offer deeper insights into the complex relationships among technology, organizational, environmental, and government factors, perceived usefulness, and actual use.

In addition, future research may consider a more balanced representation of contractors across different grades to provide a broader understanding of technology adoption differences based on organizational capacity, resources, and readiness. Expanding the geographical scope beyond Sarawak may also improve the generalizability of findings and provide a more comprehensive view of disruptive technology adoption within the construction industry.

## **5.7 Summary of the Chapter**

In summary, this chapter presented the key findings, contributions, limitations, and recommendations of the study on disruptive technology adoption in the construction industry based on the proposed ConTech-AF framework. The findings revealed that while respondents demonstrated moderate levels of awareness and understanding of disruptive technologies, actual use remains at an early stage of adoption. The results further indicated that organizational, technological, and environmental factors significantly influence actual use, whereas government factors do not have a direct significant effect. However, perceived usefulness plays an important mediating role in explaining how these factors influence actual technology adoption. Based on these findings, the chapter proposes recommendations for government agencies and industry practitioners, highlighting the importance of strengthening organizational support, enhancing technological readiness, improving knowledge and skills development, and fostering collaboration among stakeholders. Overall, the study concludes that despite ongoing initiatives such as the Construction 4.0 Strategic Plan, disruptive technology adoption in the construction industry remains at an early stage. Therefore, government bodies, industry practitioners, and other stakeholders need to work more closely together to overcome existing barriers and speed up digital transformation and wider technology adoption.

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## **APPENDICES**

## APPENDIX A

### Letter of Request for Collaboration with CIDB Bintulu Branch

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Cawangan Sarawak  
Kampus Samarahan

Rujukan kami: UITMKS/(FBM-BA770/08112023(1))  
Tarikh: 08 November 2023

**Ts. Kamarul Azman Bin A. Razak**  
Pengurus Cawangan  
Construction Industry Development Board (CIDB)  
Lot 4372, Phase 7, Parkcity Commercial Area,  
97000 Bintulu,  
Sarawak.

Tuan,

#### **JEMPUTAN KERJASAMA UNTUK MENJALANKAN PROJEK PENYELIDIKAN - NUR SYAMILAH BUJANG HASSIM**

Dengan segala hormatnya perkara di atas adalah dirujuk.

2. Sebagai makluman, Cik Nur Syamilah Binti Bujang Hassim merupakan pelajar semester pertama Ijazah Sarjana Pengurusan Perniagaan di Fakulti Pengurusan dan Perniagaan Universiti Teknologi MARA Kampus Samarahan. Beliau sedang menjalani projek penyelidikan yang bertajuk "*A study of disruptive technology adoption in Construction Industry Development Board (CIDB) Malaysia*" selama empat semester atau dua tahun tempoh pengajian.

3. Sehubungan itu, sukacitanya pihak kami ingin menjemput pihak Tuan untuk bekerjasama di dalam menjayakan penyelidikan ini. Pihak kami berharap agar pihak Tuan memberi keizinan kepada beliau untuk mendapatkan sebarang maklumat berkaitan dengan CIDB untuk menjayakan penyelidikan ini.

4. Hasil dapatan dari penyelidikan ini juga akan turut akan dikongsikan kepada pihak Tuan setelah penyelidikan ini telah selesai dijalankan. Bersama surat ini, dilampirkan kertas cadangan penyelidikan sebagai rujukan pihak Tuan. Semoga kerjasama ini dapat memberi manfaat dan kesudian dari pihak Tuan untuk menerima jemputan ini didahului dengan ucapan terima kasih.

Sekian,

Yang benar,

**Ts. Dr. Mohd Norhisham Razali**

Penyelia Utama Pelajar/ Pensyarah Kanan  
Program Pengurusan Teknologi Perniagaan  
Fakulti Pengurusan dan Perniagaan  
Universiti Teknologi MARA  
Cawangan Sarawak

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Faks: (+6082) 677 300  
Laman Web: <http://sarawak.uitm.edu.my>



## APPENDIX B

### Letter of Acceptance of Collaboration with CIDB Bintulu Branch



Lembaga Pembangunan Industri Pembinaan Malaysia  
Ibu Pejabat  
Tingkat 10, Menara Dato Onn,  
Pusat Dagangan Dunia Kuala Lumpur,  
No 45, Jalan Tun Ismail, 50480 Kuala Lumpur  
Tel : 603-4047 7000 Fax : 603-4047 7070  
E : [www.cidb.gov.my](http://www.cidb.gov.my)

Ruj. Kami : LPIPM: SM/PSM/01/1/1 Klt. 19 ( 61 )  
Tarikh : 02 Januari 2024

Penyelia Utama Pelajar/ Pensyarah Kanan,  
Program Pengurusan Teknologi Perniagaan,  
Fakulti Pengurusan dan Perniagaan,  
Universiti Teknologi MARA,  
Cawangan Sarawak.  
(u/p : Ts. Dr. Mohd Norhisham Razali)

Tuan,

#### JEMPUTAN KERJASAMA UNTUK MENJALANKAN PROSES PENYELIDIKAN – NUR SYAMILAH BUJANG HASSIM

Dengan segala hormatnya merujuk kepada perkara di atas dan surat rujukan UITMKS/(FBM-BA770/08112023(1) bertarikh 8 November 2023 adalah berkaitan.

- Dimaklumkan bahawa pihak pengurusan Lembaga Pembangunan Industri Pembinaan Malaysia (CIDB) telah menerima surat jemputan kerjasama untuk menjalankan proses penyelidikan – Nur Syamilah Bujang Hassim pada 30 November 2023 yang lalu.
- Untuk makluman YBrs. Ts. Dr, pihak CIDB tiada halangan untuk bekerjasama bagi menjalankan projek penyelidikan oleh pelajar seliaan YBrs. Ts. Dr iaitu Cik Nur Syamilah binti Bujang Hassim.
- Pengurusan CIDB bersetuju bekerjasama dalam kajian ini tanpa melibatkan sebarang implikasi kewangan CIDB. Hasil dapatan penyelidikan ini juga perlu dimaklumkan dan dikongsi bersama-sama dengan CIDB. Sebarang pertanyaan berkaitan penyelidikan boleh berhubung dengan pejabat CIDB Sarawak Cawangan Bintulu.

Sekian, terima kasih.

“MALAYSIA MADANI”  
“BINA SEMPURNA”

(MARINA PUTEH)  
Pengurus Besar  
Bahagian Sumber Manusia  
b.p Ketua Eksekutif  
Lembaga Pembangunan Industri Pembinaan Malaysia

☎ 603 – 4047 7000  
☎ 603 – 4047 7070  
✉ [marina@cidb.gov.my](mailto:marina@cidb.gov.my)

s.k. Pengurus CIDB Sarawak Cawangan Bintulu

## APPENDIX C

### Letter of Permission

www.uitm.edu.my



Cawangan Sarawak  
Kampus Samarahan

Rujukan kami: UITMKS/(FBM-BA770/08112023(3))  
Tarikh: 08 Januari 2025

**Ts. Kamarul Azman Bin A. Razak**  
Pengurus Cawangan  
Construction Industry Development Board (CIDB)  
Lot 4372, Phase 7, Parkcity Commercial Area,  
97000 Bintulu,  
Sarawak.

Tuan,

#### PERMOHONAN KEBENARAN UNTUK MENJALANKAN KAJI SELIDIK DI PEJABAT CIDB CAWANGAN BINTULU

Dengan segala hormatnya perkara di atas adalah dirujuk.

2. Sebagai makluman, Cik Nur Syamilah Binti Bujang Hassim sedang menjalankan kajian yang bertajuk "*Factors Affecting the Adoption of Disruptive Technology in the Construction Industry*" untuk memenuhi keperluan di dalam pengajian Ijazah Sarjana Sains (Pengurusan Perniagaan). Kajian ini juga turut melibatkan kerjasama dari organisasi Tuan.

3. Sehubungan itu, saya ingin memohon kebenaran untuk menjalankan kaji selidik di Pejabat CIDB Cawangan Bintulu. Kaji selidik ini bertujuan untuk mendapatkan maklum balas daripada pegawai dan kakitangan berkaitan penggunaan teknologi digital dalam pengurusan projek pembinaan. Maklum balas ini akan digunakan semata-mata untuk tujuan akademik dan semua maklumat yang diperolehi akan dirahsiakan sepenuhnya. Soalan kaji selidik ini telah mendapat kelulusan daripada Jawatankuasa Etika Penyelidikan UiTM (Nombor rujukan kelulusan etika: REC/12/2024 (PG/MR/617)).

4. Terima kasih atas sokongan dan kerjasama yang diberikan oleh pihak Tuan dalam membantu melancarkan proses penyelidikan ini. Dilampirkan bersama adalah surat kelulusan etika UiTM, poster beserta kod QR untuk soalan kaji selidik sebagai rujukan Tuan. Saya berharap, dengan kerjasama pihak Tuan projek penyelidikan ini akan berjalan lancar dan berjaya.

Sekian,

Yang benar,

**Ts. Dr. Mohd Norhisham Razali**

Penyelia Utama Pelajar/ Pensyarah Kanan  
Program Pengurusan Teknologi Perniagaan  
Fakulti Pengurusan dan Perniagaan  
Universiti Teknologi MARA  
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## APPENDIX D

### Research's Ethics Approval

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UNIVERSITI  
TEKNOLOGI  
MARA

Pejabat  
Timbalan Naib Canselor  
(Penyelidikan dan Inovasi)

Reference : 600-TNCPI (5/1/6)  
Our reference : REC/12/2024 (PG/MR/617)  
Date : 14 جمادي الآخر 1446H  
16 December 2024

**Ms Nur Syamilah Bujang Hassim - 2023297556**  
(Supervisor: Ts. Dr Mohd Norhisham Razali @ Ghazali)  
Faculty of Business and Management  
UiTM Sarawak Branch  
Jalan Meranek  
94300 Kota Samarahan  
SARAWAK

and Greetings سلام عليكم ورحمة الله وبركاته

Ms

#### APPROVAL LETTER - UiTM RESEARCH ETHICS COMMITTEE

Thank you for submitting your research proposal to the Research Ethics Committee (REC). After considering your application, the Committee approved your proposal titled "Factors Affecting the Adoption of Disruptive Technology in the Construction Industry" at the office of the Construction Industry Development Board (CIDB) Bintulu Branch. Details of the approval are as follows:

|                       |                                                                                                   |
|-----------------------|---------------------------------------------------------------------------------------------------|
| Ref. number:          | REC/12/2024 (PG/MR/617)                                                                           |
| Approval Period:      | 16 December 2024 until 26 September 2025                                                          |
| Authorised personnel: | 1. Nur Syamilah Bujang Hassim<br>2. Ts. Dr Mohd Norhisham Razali @ Ghazali<br>3. Dr Lee Wen Chiat |

The UiTM Research Ethics Committee operates in accordance with ICH Good Clinical Practice Guidelines, Malaysian Good Clinical Practice Guidelines and the Declaration of Helsinki. The approval of this project is conditional upon your continuing compliance with these guidelines and declaration.

We draw to your attention the requirement that a report on this research, must be submitted every 12 months from the date of the approval or on the completion of the project, whichever occurs first. Failure to submit reports will result in withdrawal of consent for the project to proceed. Amendments, if any, to the study documents are to be submitted to the REC for approval.

If you require further information, please contact the REC Secretariat at 03-55442846/03-55442737 or email at [recsecretariat@uitm.edu.my](mailto:recsecretariat@uitm.edu.my).

اوسهيا، تقوى، موليا

"MALAYSIA MADANI"

"BERKHIDMAT UNTUK NEGARA"

Yours sincerely,

(EMERITUS PROFESSOR DATO' DR RAYMOND AZMAN ALI)

Chairman  
UiTM Research Ethics Committee

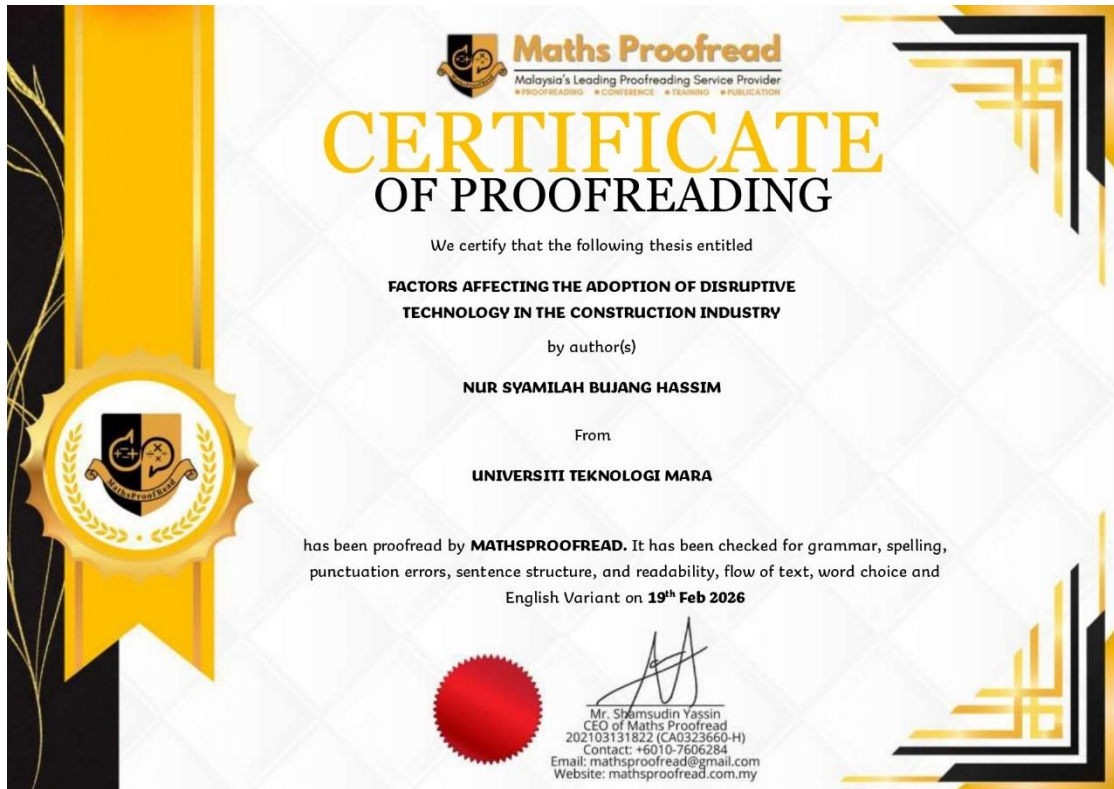
c.c.: Deputy Rector (PJIM&A), UiTM Sarawak Branch

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## APPENDIX E

### Proof of Proofreading Services



**APPENDIX F**  
**Certificate of Participation (Presenter)**



## APPENDIX G

### Definition of Disruptive Technologies Adoption

Definition of Types of Disruptive Technology Adoption according to Related Sources.

| No. | Disruptive Technology                           | Definition                                                                                                                                                                                                                                                                                  | Source                    |
|-----|-------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------|
| 1   | Building Information Modelling (BIM)            | BIM is used to design and manage the structural and functional components of a building or infrastructure project as digital representations.                                                                                                                                               | (Vitente et al., 2024)    |
|     |                                                 | BIM is a centralized digital storage system that contains data about a building, helping to make informed decisions throughout the building's lifecycle, from planning and construction to maintenance & demolition.                                                                        | (Zulkifli & Roslan, 2024) |
| 2   | Pre-fabrication and Modular Construction        | Prefabrication involves assembling construction components in a factory and transporting them to the construction site for final installation. Modular construction involves creating entire sections of a building in a factory and then transporting them to the site for final assembly. | Palcis (2023)             |
| 3   | Autonomous Construction                         | Autonomous construction refers to the use of advanced technology. For example, robotics and advanced automation can reduce problems encountered in construction, such as labor-related issues.                                                                                              | (Akinradewo et al., 2021) |
|     |                                                 | In other scenarios, it is a method where the construction tasks are done by robots that are being controlled by using computer processes and mechanization.                                                                                                                                 | (CIDB Malaysia, 2020a)    |
| 4   | Augmented Reality (AR) and Virtual Reality (VR) | AR is an interaction between humans and computers, where it enables an individual to differentiate between virtual and real-world objects. VR is a simulated experience that can be like or completely different from the real world.                                                       | (CIDB Malaysia, 2020a)    |

|   |                                  |                                                                                                                                                                                                                                                                                                                          |                        |
|---|----------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|
|   |                                  | AR and VR are complementary technologies. AR is a live, direct, or indirect view of a physical, real-world environment; meanwhile, the view is made by computer graphics using VR technology.                                                                                                                            | (Chai et al., 2019)    |
| 5 | Cloud and Realtime Collaboration | Cloud computing refers to the distribution of computer services through the Internet. It also provides real-time collaboration, high availability, and access to scalable resources.                                                                                                                                     | (Arthur et al., 2017)  |
|   |                                  | In the context of construction, it is also internet-centric, providing a free flow of information among construction professionals and offering a vast amount of storage resources.                                                                                                                                      | (CIDB Malaysia, 2020a) |
|   |                                  | The construction industry has increasingly adopted cloud-based collaboration tools, and these tools are becoming increasingly familiar in the industry and significantly improving project implementation when adopted. The example of this includes the Google Drive, Microsoft OneDrive, and Microsoft Project Online. | (Fateh et al., 2024)   |
| 6 | 3D Scanning and Photogrammetry   | 3D Scanning is one of the latest emerging technologies, which helps design, assess the minor features of any products, and provide precise points for complicated geometry and curved surfaces.                                                                                                                          | (Haleem et al., 2022)  |
|   |                                  | Photogrammetry, along with 3D Scanning, can capture the real surface of an object, which is accurate to one thousandth of a millimeter.                                                                                                                                                                                  | (Kudela et al., 2020)  |
|   |                                  | It is a process of data collection in the form of a point cloud (a collection of data in a three-dimensional coordinate system) and mapping tools with the ability to insert images to become a 3D model for monitoring changes.                                                                                         | (CIDB Malaysia, 2020a) |
| 7 | Big Data Predictive Analysis     | It is used to handle a large amount of project data efficiently with advanced analytical techniques by using a commodity server to predict future trends and enhance decision-making within the construction industry.                                                                                                   | (CIDB Malaysia, 2020a) |
|   |                                  | Big data analysis helps in decision-making and operational efficiency in the construction industry to mitigate risks and lead to better project outcomes.                                                                                                                                                                | (Maaz et al., 2025)    |

|    |                                        |                                                                                                                                                                                                                                                                                                                                       |                           |
|----|----------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------|
| 8  | Internet of Things (IoT)               | IoT is created by human technology based on intelligent virtual objects that can know everything and allow the devices around them to communicate automatically without human intervention.                                                                                                                                           | (Mahmud et al., 2018)     |
|    |                                        | IoT is a system that connects computing devices and sensors that provide extensive data sharing capability for safety management, especially in the construction industry.                                                                                                                                                            | (Waqar et al., 2023)      |
| 9  | 3D Printing and Additive Manufacturing | 3D printing is a process of creating three-dimensional components; meanwhile, additive manufacturing is a technique that creates objects by adding material layer by layer.<br><br>It can be concluded as a process of creating or recreating a physical object that is modeled in the digital version by adding layers of materials. | (CIDB Malaysia, 2020a)    |
|    |                                        | Additive manufacturing, also known as 3D printing, refers to the technology that creates real objects by building them layer by layer from a computer design.                                                                                                                                                                         | (Srivastava et al., 2025) |
| 10 | Advanced Building Materials            | The development of innovative materials that integrate new technology and processes to create new or improved products so that the construction industry can enhance the efficiency, durability, and environmental impact of construction projects.                                                                                   | (CIDB Malaysia, 2020a)    |
|    |                                        | The examples of advanced building materials include high-performance concrete and self-healing concrete. The characteristics of these materials are flexible design, durability, and high strength, which can be used to build structures that are capable of withstanding dynamic loads and harsh environmental conditions.          | (Shukla & Kaul, 2024)     |
| 11 | Blockchain Technology                  | Blockchain is a decentralized, distributed ledger that enables secure and transparent record-keeping and transactions without the need for intermediaries. It is also an open, digital database that maintains the integrity and authenticity of the ledger, which can prevent data breaches.                                         | (Singh et al., 2023)      |
|    |                                        | Blockchain technology applied in the construction context can enable comprehensive traceability and oversight, which can improve the transparency and reliability of all transactions. It also supports rapid information sharing and verifications, which can help to                                                                | (Zhou et al., 2023)       |

|    |                              |                                                                                                                                                                                                                                                                                                               |                     |
|----|------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|
|    |                              | reduce transaction costs and increase operational efficiency.                                                                                                                                                                                                                                                 |                     |
| 12 | Artificial Intelligence (AI) | AI enables computers to perceive and learn inputs like humans. AI can encompass capabilities such as perception, knowledge representation, reasoning, problem-solving, and planning for a construction project.                                                                                               | (Li et al., 2024)   |
|    |                              | AI technology in the construction industry is often used to improve construction efficiency, improve building management, optimize building design, and monitor real-time progress. Examples of AI applications include intelligent cameras, sensors, smart helmets, and the prediction of safety conditions. | (Min & Huang, 2024) |

## AUTHOR'S PROFILE



Nur Syamilah Binti Bujang Hassim is currently pursuing her MSc. in Business Management at the Faculty of Business and Management, Universiti Teknologi MARA. She received her BSc. in Office System Management from the same faculty. Her expertise lies in the adoption of disruptive technologies in the construction industry, with a focus on technology acceptance, organizational and environmental factors, and the use of frameworks to study technology adoption processes. Her research has been presented at the 9<sup>th</sup> International Conference on Recent Advances and Innovations in Engineering (ICRAIE) 2025. She has also published a research article in the Journal of Engineering Education and Innovative Research (JEEIR), a MyCITE-indexed journal.

## LIST OF PUBLICATIONS

- Hassim, N. S. B., Razali, M. N., Razak, K. A. B. A., Chiat, L. W., Hanapi, R., & Arabi, A. (2025). A conceptual framework for disruptive technology adoption in the construction industry. *2025 9th International Conference on Recent Advances and Innovations in Engineering (ICRAIE)*, 69–74. <https://doi.org/10.1109/ICRAIE65839.2025.11239284>.
- Hassim, N. S. B., Razali, M. N., Lee, W. C., Bennie, N., Hanapi, R., & Yong, S. W. (2026). An analysis of awareness, understanding, and usage of disruptive technologies in the construction economy. *Journal of Emerging Economies and Islamic Research*, 14(1), Article 9141. <https://doi.org/10.24191/jeeir.v14i1.9141>.