



**Model for Improving the Level of Labourers' Productivity
Through the Use of BIM and Cloud Technology in UAE
Building Construction Projects**

نموذج لتحسين مستوى إنتاجية العمال من خلال استخدام برنامج نمذجة
معلومات البناء والتكنولوجيا السحابية في مشاريع تشييد المباني في الامارات
العربية المتحدة.

by

MUNEER MOHAMMAD ISMAIL SHAHATIT

**A thesis submitted in partial fulfilment
of the requirements for the degree of
DOCTOR OF PHILOSOPHY IN PROJECT MANAGEMENT
at**

The British University in Dubai

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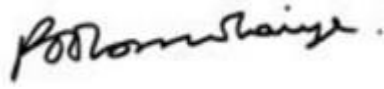
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Abstract

Importance of the research

This study examined the capabilities of building information modelling (BIM) and cloud technologies and their impact on improving labourers' productivity in building construction projects in the United Arab Emirates (UAE). Thus, there was a need for this research to identify the key factors affecting labourers' productivity in construction projects in the UAE and their impact magnitude.

Problem and aim

The research aimed to examine how advanced technologies such as BIM and cloud could be used to improve labourers' productivity during the delivery of building construction projects in the UAE. The research proposed a model that comprises of Building Information Modelling (BIM) and cloud technology determinants that could be used to improve labourers' productivity in the UAE building construction sector.

Method

The study adopted a quantitative method approach to achieve the intended research objectives. The population of the study comprised construction contractors and consultants working on building construction projects in the UAE. The key targeted participants who provided the data required for this study were project managers, supervisors, foremen, inspectors, project engineers, and consultant resident engineers. Analysis was performed using IBM-SPSS and Hayes process.

Findings

The research proposed and validated a model that comprises BIM, cloud technology and labourers' productivity determinants that can be used to improve labourers' productivity in the UAE building construction sector. As shown in this study, the advancement of BIM and

cloud technologies can democratize access to vital information, tools, and techniques, which can be used to create a collaborative team environment. Within the context of the UAE, this research has also shown how these technologies have emerged as a means of improving productivity in the construction sector.

Conclusion

The research identified several factors affecting construction labourers' productivity. Among the 42 factors identified from the reviewed literature. From the findings of the study, it was found that the UAE construction sector is still facing labourers' productivity challenges, and the industry has one of the lowest productivity rates. As a result, it was revealed that implementing BIM and cloud technologies facilitates the successful delivery of building construction projects. In addition, the study further established that BIM and cloud technologies can be used to facilitate integrated project delivery.

Future research

The study achieved its main aim of proposing a model that comprises BIM and labourers' productivity determinants'. Although the findings and the conclusion of the study have added value to the existing knowledge on the use of BIM to improve labourers' productivity in the UAE, it is important that further research is carried out in the form of a case study to evaluate the impact of the model's proposed context.

Keywords: construction labourers' productivity, UAE construction sector, digital construction technology, Building Information Modelling (BIM), cloud technology.

خلاصة

أهمية البحث

تناولت هذه الدراسة إمكانيات نمذجة معلومات البناء (BIM) والتقنيات السحابية وأثرها على تحسين إنتاجية العمال في مشاريع البناء في دولة الإمارات العربية المتحدة. وبالتالي، كانت هناك حاجة لهذا البحث لتحديد العوامل الرئيسية التي تؤثر على إنتاجية العمال في مشاريع البناء في دولة الإمارات العربية المتحدة وحجم تأثيرها.

المشكلة والهدف

ويهدف البحث إلى دراسة كيفية استخدام التقنيات المتقدمة مثل BIM والسحابة لتحسين إنتاجية العمال أثناء تسليم مشاريع تشييد المباني في دولة الإمارات العربية المتحدة. واقترح البحث نموذجًا يتكون من نمذجة معلومات البناء (BIM) ومحددات التكنولوجيا السحابية التي يمكن استخدامها لتحسين إنتاجية العمال في قطاع تشييد المباني في دولة الإمارات العربية المتحدة.

الطريقة

واعتمدت الدراسة المنهج الكمي لتحقيق أهداف البحث المنشودة. يتألف مجتمع الدراسة من مقاولي البناء والاستشاريين الذين يعملون في مشاريع تشييد المباني في دولة الإمارات العربية المتحدة. وكان المشاركون الرئيسيون المستهدفون الذين قدموا البيانات المطلوبة لهذه الدراسة هم مديري المشاريع والمشرفين ورؤساء العمال والمفتشين ومهندسي المشروع والمهندسين المقيمين الاستشاريين. تم إجراء التحليل باستخدام عملية IBM-SPSS و Hayes

الموجودات

اقترح البحث وتحقق من صحة نموذج يتضمن BIM والتكنولوجيا السحابية ومحددات إنتاجية العمال التي يمكن استخدامها لتحسين إنتاجية العمال في قطاع تشييد المباني في دولة الإمارات العربية المتحدة. كما هو موضح في هذه الدراسة، فإن تقدم تقنيات BIM والتقنيات السحابية يمكن أن يضيف طابعًا ديمقراطيًا على الوصول إلى المعلومات والأدوات والتقنيات الحيوية، والتي يمكن استخدامها لإنشاء بيئة فريق تعاونية. وفي سياق دولة الإمارات العربية المتحدة، أظهر هذا البحث أيضًا كيف ظهرت هذه التقنيات كوسيلة لتحسين الإنتاجية في قطاع البناء.

الخاتمة

حدد البحث عدة عوامل تؤثر على إنتاجية عمال البناء. من بين العوامل الـ 42 التي تم تحديدها من الأدبيات التي تمت مراجعتها. ومن نتائج الدراسة، تبين أن قطاع البناء في دولة الإمارات العربية المتحدة لا يزال يواجه تحديات إنتاجية العمال، وتتمتع الصناعة بأحد أدنى معدلات الإنتاجية. ونتيجة لذلك، تم الكشف عن أن تطبيق تقنيات BIM والسحابة يسهل

التنفيذ الناجح لمشاريع تشييد المباني. بالإضافة إلى ذلك، أثبتت الدراسة أيضاً أنه يمكن استخدام تقنيات BIM والتقنيات السحابية لتسهيل التسليم المتكامل للمشروع.

البحث مستقبلي

حققت الدراسة هدفها الرئيسي وهو اقتراح نموذج يشتمل على BIM ومحددات إنتاجية العمال. على الرغم من أن النتائج واستنتاجات الدراسة قد أضافت قيمة إلى المعرفة الحالية حول استخدام BIM لتحسين إنتاجية العمال في دولة الإمارات العربية المتحدة، فمن المهم إجراء المزيد من الأبحاث في شكل دراسة حالة لتقييم التأثير. للسياق المقترح للنموذج. الكلمات المفتاحية: إنتاجية عمال البناء، قطاع البناء في دولة الإمارات العربية المتحدة، تكنولوجيا البناء الرقمي، نمذجة معلومات البناء (BIM)، التكنولوجيا السحابية.

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Chapter 1 : Introduction

1.1 Background of the Study

Productivity in the construction industry has a direct impact on a nation's economic growth globally. The construction industry has only witnessed an increase in productivity for the last two decades, slightly above four percent. However, the manufacturing sector had the highest percentage of an increase in productivity, which stands at above 59 percent (Barbosa et al., 2017). Therefore, the construction industry's low labourers' productivity phenomenon has ignited the need for research by various scholars on improving the issues and the innovations that can be carried out to ensure this percentage increases to meet the level of other industries (Antunes & Gonzalez 2015). Productivity enables and increases the competitive advantages of an organization. It empowers the organization to achieve its intended goals, satisfy stakeholder value propositions, and conserve strategic and financial health. At the sector level, productivity allows the industry to achieve client satisfaction, attract investment and maintain profitability. Despite the numerous difficulties experienced by the construction sector, the most significant challenges are related to labourers' productivity (Hamza et al., 2022). Labourers' productivity is considerably impacting the performance of construction projects; it demonstrates the most considerable variability amongst other project resources, and it is a tremendous source of uncertainty (Hamza et al., 2022). The complexity and range of diversity in construction projects makes productivity a crucial factor for project success (Choudhry 2015). Labourers' productivity is a significant contributor to any construction development; it accounts for approximately 30 to 50 percent of the entire project cost (Kaming et al., 1998). Improving labourers' productivity can significantly reduce project cost and dramatically optimize the time taken for completion (Kazaz & Ulubeyli 2004; Caldas et al., 2015 & Momade & Hainin 2019).

There is no doubt that construction labourers' productivity is one of the fundamental pillars in the construction project, although the level of labourers' productivity is dynamic and often varies (Moselhi & El-Rayes 2002). The construction project is a complicated endeavour that involves several risks. The labourers' productivity rate is a significant risk in construction projects; hence, research on improving labourers' productivity is continuously needed, both now and in the future (Tsehayae & Fayek 2016). Moreover, the construction sector is a labourers'-intensive environment; therefore, construction companies' profit depends mainly on the workers' performance (Doloi 2007). Hence, enhancement of construction labourers' productivity could be a primary subject of concern in the future as it is today (Attar et al., 2012). Though advanced technologies have been newly introduced in the construction project management process, the industry remains one of the world's most labourers'-intensive industries (Jarkas et al., 2015). Research carried out by Ansah and Sorooshian (2018) showed that the construction industry has been criticized for an extended period over its inability to both meet and raise current technology rates rapidly and efficiently. Since Roman times, construction has witnessed minimal changes in the techniques and methods used. Nowadays, the construction industry must cope rapidly with technological change and the highly interconnected world and complex problems that require interdisciplinary solutions. Advanced digital technologies, such as Building Information Modelling (BIM), 3D printing, Artificial Intelligence (AI), Virtual Reality and Augmented Reality (VR and AR), Blockchain technology, Cloud technology, LiDAR and Robot, could have a significant impact on improving construction labourers' productivity and, indeed, enhancing the entire industry performance (Ansah & Sorooshian 2018).

Mocerino (2018) referred to digital construction technology as the assemblage of creative implements, machines, software, and modifications used to create a specific construction project. Mocerino (2018) further suggested that technological advancement in the construction industry includes semi-automated and automated construction tools and equipment. Moreover, this definition has been expanded to include other pre-construction technology such as bid management applications, online bid boards and digital take-off solutions. Modern technology is developing faster than what was envisioned 10 to 20 years ago. Things such as drones, telematics mobile apps, robots, autonomous heavy equipment, and three-dimensional printed buildings are now present and still being advanced. Research has indicated that most construction companies are not yet investing much in these technological advancements in their field (Mocerino 2018). Venture capitalists have taken the responsibility head-on and are seeing the construction industry's future as technologically advanced. Bilal et al. (2016) further defined the term advanced technology in the construction industry as a comprehensive range of modern methods, techniques and activities that entail the newest developments in material technology, facility management, structural analysis, quantity surveying, design processes and services. In their studies, Bilal et al. (2016) explained that integrating advanced technology in the construction industry ensures high-quality work, safety and sustainability. Advanced technology also enhances the value for money and increases the rate of efficiency at work.

Nevertheless, building information modelling (BIM) has emerged as a vital technology. BIM empowers better governance of the construction procedure and improves team coordination, cross-functional collaboration, problem-solving, assists leaders in making proper and faster decision-making, provides better risk management, and enhances productivity

(Sacks, et al., 2018 & Volk et al., 2014). BIM in the construction industry brings a diverse collaboration process and a method of functioning, transforming existing architecture engineering and construction industry organizations and practices to enhance efficiency and environmental purposes (Jung & Joo 2011). BIM applications in construction projects offer several advantages to construction practitioners, such as enhancing coordination between construction stakeholders and promoting faster design resolution (Kang et al., 2016). Moreover, BIM has minimized the time spent on design, avoids cost overrun and optimizes project delivery (JKR 2015). BIM application could be used throughout the pre-construction, construction, and post-construction phases of the building project (Sarvari et al., 2020). BIM can improve cooperation between project stakeholders and enhance the design process's decision (Azhar et al., 2015). Additionally, BIM can ensure the successful completion of construction projects within budget, time, and quality because it helps establish activities relationship and phasing throughout the planning stage and project lifecycle processes (Azhar et al., 2015). BIM tools assist construction practitioners in all phases during the project lifecycle and increase communication reliability, accuracy, usability and data exchange reliability (JKR 2015).

1.1.1 The Need to Build Construction Projects in the UAE

Knowing and comprehensively understanding the productivity level of various trades and factors affecting it in the construction industry is critical for accurate project estimation, proper planning and effective execution, and successful project completion. A maximum productivity rate helps the contractor be more efficient and profitable during project execution and allows them to be more competitive during the project bidding and awarding stage (Presley & Meade 2010).

Most UAE contractors face almost the same challenges since construction contracts have similar conditions and specifications. Moreover, contractors' performance outcome is affected by how efficient and properly planned the construction methodology and execution techniques are, and if the construction workers performed at an acceptable level of productivity or not (Zahmak et al., 2020). Accomplishing value and amount of work while managing the inputs is consequently a vital challenge for those contractors. Thus, this research is crucial for construction practitioners to understand the essential factors affecting the level of labourers' productivity. As established from the reviewed literature, the labourers' supervisor can implement the right digital construction technology model to ensure optimum activity conditions on site and, therefore, achieve the maximum productivity rate to complete the project on time and within the allocated budget. This achievement helps to boost the morale of workers and other project staff. Altogether, indeed, it is in the project's best interests to ensure successful completion as planned and within budget, and hence enable construction companies to easily manage their business to ensure that it is profitable.

1.1.2 Why Labourers' Productivity in the UAE Construction Sector?

The construction industry is the largest and the most problematic sector (Barbosa et al., 2017). This is evidenced by the numerous constructions works, such as roads, bridges, buildings and railway lines. Every year, the world is spending around 13 percent of its GDP, approximately 10 trillion USD on construction-related projects (Barbosa et al., 2017). The UAE's contribution to the construction sector is outperforming that of other countries in the region. According to the Cherian (2020) the United Arab Emirates construction industry's share is 11 percent of GDP annually. There are five main factors used in determining whether a construction project is successful or not. A project is considered successful if completed

within budget and on time, and if it adheres to all safety precautions and policies and meets all the required quality standards (Shenhar et al., 2001). The successful completion of a construction project is feasible if appropriate productivity standards are maintained (Presley & Meade 2010).

Over the past four decades, productivity has been an attractive subject for researchers. A substantial body of writing has been dedicated to research studies on productivity and labourers' productivity problems (Yi & Chan 2014). Scholars have examined the factors influencing productivity in the construction industry, and they have also studied different approaches and models to enhance productivity and labourers' productivity in construction projects (Yi & Chan 2014). However, it was found that, in the context of UAE, there was a shortage of research in this area. This conclusion has been supported by (AbuMoeilak et al. 2023). Thus, there was a need for this research to identify the key factors affecting labourers' productivity in construction projects in the UAE and their impact magnitude.

A study conducted by Zahmak et al. (2020) demonstrated contractors and consultants' evaluation of the root cause of cost overruns in building construction projects in the UAE. In this study, low productivity has been reported as the second most important factor causing cost overruns in building construction projects in the UAE. Johnson and Babu (2018), in their study concerning time and cost overruns in the UAE construction industry, performed a critical analysis using a quantitative research method approach. According to their research, low productivity is one of the top 10 factors that causes cost overruns in UAE construction projects. Faridi and El-Sayegh (2006) conducted a study on factors that are significant in triggering delay in the UAE construction industry. A total of 93 construction experts from the UAE construction business participated in this study. The study provided expert opinion in the

form of responses to a questionnaire survey. Their research showed that 50 percent of the UAE's construction projects face cost overrun and are not completed on time. The study also concluded that workforce productivity plays a crucial role in construction delays; low workforce productivity was reported by the authors as one of the top three causes of delays to construction projects in the UAE. The above recent studies showed that low labourers' productivity in construction projects in the UAE was one of the most significant factors behind the current problem of project delay and cost overrun in the UAE construction sector.

1.2 Justification of the Research Problem

In the past four decades, substantial research has been carried out to define the factors influencing construction labourers' productivity (Yi & Chan 2014). The labourers' productivity problem has always been a vital research subject. Scientists have examined the factors influencing productivity in construction projects, and they have also studied different approaches and models to enhance productivity and labourers' productivity in construction projects. An assessment of recent literature on labourers' productivity and other relevant subsequent topics revealed that the studies that have been performed generally involved productivity trade problems, such as masonry, framework and concrete. Thus, there was a need for this study to examine the role of digital technology, mainly BIM and cloud technology, in improving construction labourers' productivity.

Other studies have examined the factors affecting labourers' productivity in different countries in a separate form as one variable at a time (Kazaz et al., 2016). Though there has been an improvement in developing methods and techniques for measuring productivity, numerous literatures highlighted the need for the construction sector to invest in innovation and technology to enhance productivity in construction projects (Chowdhury, Adafin &

Wilkinson 2019). However, the development of a useful construction labourers' productivity model remains a challenge. The combined effect of various dependent and independent factors affecting labourers' productivity must be studied in different project environments (Tsehayae & Fayek 2018 & Golnaraghi et al., 2019).

Some recent studies on labourers' productivity subject, such as Dixit et al. (2019), studied significant factors affecting construction productivity using the relative importance index in the Indian Construction Industry. Castro (2009) looked at productivity improvement in the construction industry using automation techniques, whilst Karthik and Rao (2019) studied significant factors affecting masonry labourers' productivity in building construction projects in India. Additionally, there are several other studies on factors affecting labourers' productivity, for example, in Jordan (Hiyassat et al., 2016), in Bahrain (Jarkas 2015), in Oman (Jarkas et al., 2015), in Pakistan (Tahir et al., 2015), in Egypt (Hafez et al., 2014), in Zimbabwe (Chigara & Moyo 2014), in India (Thomas & Sudhakumar 2014), in Saudi Arabia (Mahamid et al., 2013), and in Kuwait (Jarkas & Bitar 2012). However, from the reviewed literature, the alignment of labourers' productivity factors and the use of advanced digital construction technologies abilities has not been extensively examined. Consequently, this research proposes a model that comprises labourers' productivity key determinants and the most significant advanced digital construction technologies abilities that can be used to improve the labourers' productivity level and optimize the delivery of building construction projects in the UAE construction sector.

Studies such as Almamlook et al. (2020) focused on identifying factors affecting labourers' productivity in the Libya contracting market. However, the study neither addresses the relationship with other factors nor proposes any method to improve those significant

factors. It could be concluded that research on improving labourers' productivity is still needed at present and in the future. Halder (2020) conducted a study on the workers' opinion on which factors affect their productivity the most and concluded that labourers' is the most vital resource to complete the project successfully.

Various studies have been conducted on the improvement of labourers' productivity. However, there is a gap in the existing studies as they did not focus on an improvement model related to labourers' productivity in the UAE's construction sector. For example, Mlybari (2020) studied the application of soft computing strategies to identify the issues relating to low labourers' productivity in the construction sector in Saudi Arabia. Hamouda and Abu-Shaaban (2015) focused on the labourers' productivity within the construction section of the Gaza Strip, using the analytical hierarchy process method. However, these studies did not focus on the UAE construction sector labourers' productivity. Also, they did not identify any model for improving labourers' productivity. On the other hand, Mahamid, Al-Ghonamy and Aichouni (2013) focused on Saudi Arabia and indicated factors that impact employee productivity.

Omoregie, Khairy and Farrell (2017) identified the technologies that could be used to improve labourers' productivity in the UAE construction and housing sectors. However, their study lacked integration with a specific model to enhance labourers' productivity in the UAE construction sector. Yousaf (2022) provided an overview of an EFQM model for improving labourers' productivity, but he used Czech companies to determine the model's performance, not UAE companies. Hence, the current study aims to fill the gap by focusing on the UAE specifically and identifying a model to improve labourers' productivity in the UAE construction sector.

Nasirzadeh et al. (2022) conducted a study on labourers' productivity in Australia's building construction projects. They adopted different techniques in analysing significant factors affecting labourers' productivity in multi-story buildings in Australia. They used the cause-and-effect response circle scheme of factors influencing labourers' productivity to illustrate and reflect their complex relationships. The authors focused on defining the relationship between the factors themselves, without considering external variables such as technology that could positively impact either one of those factors or a group of them together. The authors recommended that project managers make reasonable efforts to minimize the effect of those influential factors. For instance, they suggested that project managers adopt an effective plan to increase the labourers' level of skills and knowledge. There is no doubt that the researchers performed an extensive analysis and used an innovative approach to identify the most significant factors affecting labourers' productivity in building construction projects. However, this study neither proposed a model to improve the significant factors affecting labourers' productivity nor provided any recommendations to project managers to use the technology to minimize the impact of those factors. Thus, this study bridges the above by examining the impact of using advanced digital construction technology on construction labourers' productivity.

According to Froese (2010), a broad range of digital technology applications can positively affect both construction organizations' operations and affordability and productivity. These comprise the application of digital technologies in design and construction stages to enhance stakeholder communication, progress monitoring and controlling, visualization, comfortable and comprehensive access to on-site and off-site information, and safety and security management (Vlist et al., 2014 & Arditi & Zhang 2013). The positive

impact of digital technology was also supported by Miettinen and Paavola (2014): that integration between digital technology applications creates a unified automated scheme that can make information available on time to all project parties. For instance, Wang et al. (2014), in their study, indicated that integrating augmented reality technology in building information modelling for on-site information and data management could significantly improve productivity. Moreover, various digital technologies have been shown to improve construction productivity to approximately 40 percent on off-site construction activities, fulfilling the significant improvement needed in productivity (Zhou et al., 2012). Advanced digital technology can result in substantial productivity enhancement; however, these effects are inadequately recognized (Chowdhury et al., 2019). Therefore, this study examines the critical capabilities of advanced digital construction technologies that have an impact on the level of labourers' productivity.

Unlike other sectors, the construction industry uses many unskilled labourers' and lags in implementing and utilizing advanced technologies (Goodrum et al., 2011). Productivity in the construction sector mostly relies on personal work and performance (Jarkas 2010). Due to reduced production rates, most construction projects struggle because of cost overruns and time delays (Sun & Meng 2009). However, there is not much research has been conducted in the UAE context, and there is a shortage of research in this area. Moreover, it could be suggested that advanced digital construction technologies impact labourers' productivity performance in UAE construction projects. Thus, there was a need for this research to assess how construction practitioners could improve the level of labourers' productivity in the building construction sector.

1.3 Research Aim

The research aimed to examine how advanced technologies such as BIM and cloud could be used to improve labourers' productivity during the delivery of building construction projects in the UAE. The research proposes a model that comprises of Building Information Modelling (BIM) and cloud technology determinants that could be used to improve labourers' productivity in the UAE building construction sector.

1.4 Research Objectives

The research objectives were to:

1. Ascertain the main factors affecting construction labourers' productivity in building construction projects in the UAE.
2. Identify advanced digital construction technologies that could be used to improve labourers' productivity in the UAE building construction sector.
3. Identify main group of factors improving labour productivity and establish how advanced technologies (BIM and cloud) could be used to improve labourers' productivity and optimize project performance in the UAE construction sector.
4. Propose and validate a model that comprises of building Information Modelling (BIM) and cloud technology determinants that can be used to improve labourers' productivity in the UAE building construction sector.

1.5 Research Questions

Four research questions were addressed in this study:

5. What factors affect the construction labourers' productivity while building construction projects in the UAE?

6. Which advanced digital construction technologies could improve labourers' productivity in the building construction sector in the UAE?
7. How can advanced digital construction technologies integrate with building construction projects in the UAE to achieve optimal productivity?
8. How would Building Information Modelling (BIM) and cloud technology improve the construction labourers' productivity in the UAE building construction sector as a model?

1.6 Scope of the Research

The study was based on an extensive exploratory literature review, which included themes involving the UAE construction sector and labourers' productivity. Diverse secondary sources such as books, journal articles and reports were used to include all themes related to the topic. The theoretical background of this study is described in detail in the literature review section. Different theories were included in the study related to the topic. For instance, the fundamental approaches included in the study were Thomas and Završki's (1999) factor model of construction labourers' productivity and Thomas and Yiakoumis's (1987) factors model of construction labour productivity. In addition, the study adopted a quantitative research method to achieve the intended objectives. Accordingly, the study population comprised the construction contractors and consultants currently working in the UAE building construction projects. The key targeted personnel who provided the data for this study were project managers, supervisors, foremen, inspectors, project engineers and consultant resident engineers. The study covered the UAE, but the focus was specifically on Abu Dhabi and Dubai.

The research instrument used in the study was a survey questionnaire. The purpose was to identify the most significant factors affecting labourers' productivity in the construction industry in the UAE. Also, the questions in the questionnaire covered the relationship between building information modelling (BIM) abilities, cloud technology, and the significant factors affecting labourers' productivity. After getting the informed consent, the questionnaires were distributed to the participants. The collected data were organized and analysed to develop a model for improving construction labourers' productivity. In addition, interviews were conducted with construction industry experts to validate the proposed model. The evaluated data were presented in terms of findings with an appropriate discussion. In the end, a comprehensive conclusion was provided. Nevertheless, the study also had limitations. For example, the study only covered building construction projects in the UAE. The study did not cover all construction projects such as road and infrastructure, wastewater projects, etc. Also, the study investigated advanced digital construction technologies. Other types of technologies, such as material technology, were not evaluated.

1.7 The Novelty of the Study

This research will be most significant to contractors and construction practitioners within the building construction sector in the UAE. Low productivity is the second most important factor causing cost overruns in building construction projects in the UAE (Zahmak et al., 2020). Several studies have been carried out on factors affecting construction labourers' productivity. However, the construction industry's low labourers' productivity phenomenon has ignited the need for research by various researchers to improve the issues and the innovations that can be made to ensure construction productivity increases and meets the level of other industries (Antunes & Gonzalez 2015). It has been concluded from the reviewed

pieces of literature that not much has been done in the UAE context, and there is a shortage of research in this area.

It was observed from the reviewed pieces of literature that the alignment of labourers' productivity factors and the use of advanced digital construction technology abilities had not been extensively examined. Very few studies discussed the method for improving construction labourers' productivity. Even studies that tackled this subject merely mentioned some suggestions and recommendations without proposing a specific model for improving construction labourers' productivity. It was also noticed that most of the previous studies dealt with construction labourers' productivity as a separate variable without considering other variables that could have a positive impact on improving the construction labourers' productivity rate, such as using advanced digital technologies during execution. The review of previous literature on advanced digital construction technologies illustrated a wide range of digital technologies available in the construction market with very high capabilities in different construction disciplines. However, these studies neither address a particular framework of these technologies together so construction projects can benefit from all their capabilities in one application form nor discuss a model of using some of these technologies to enhance construction labourers' productivity. Thus, the novelty of this study materialized from the vital role it will play in contributing to the existing knowledge on using building information modelling (BIM) and cloud technology to improve construction labourers' productivity in building construction projects. Therefore, the novelty of this study is significant from both perspectives, theory and practice, because of the following reasons:

The study adds value to the existing theories related to personal construct theory and factors affecting construction labourers' productivity (Nurhendi, Khoiry & Hamzah 2019) by classifying 42 factors and grouping them into main categories based on their significance.

The proposed model in this study is intended to provide building construction project practitioners in the UAE with an improved collaborative way of working underpinned by building information modelling (BIM) and cloud technologies.

1.8 Abridged Research Method

The researcher adopted a quantitative method approach to achieve the intended research objectives. The research methodology structure is divided into several stages. In stage one, the researcher provided a list of general factors affecting construction labourers' productivity and the most significant construction digital technologies in the construction industry from the previous literature and studies. In stage two, the researcher used the collected data and developed a questionnaire survey to identify the most significant factors affecting the level of labourers' productivity in the building construction industry in the UAE and the relationship between advanced digital construction technology abilities and the significant factors affecting labourers' productivity. The population of the study comprised of construction contractors and consultants working on UAE building construction projects. The key targeted participants who provided the data required for this study were project managers, supervisors, foremen, inspectors, project engineers and consultant resident engineers. The study covered the UAE; however, the focus was on Abu Dhabi and Dubai. In stage three, the questionnaire was distributed to the population of the study. In stage four, the researcher used the collected data to develop a model for improving the level of construction labourers' productivity by using

BIM and cloud technology. In the last stage, the researcher conducted interviews with construction industry experts to validate the proposed model.

1.9 Structure of the Thesis

The thesis is comprised of eight chapters:

Chapter one: focuses on the study background. This chapter comprises the following: research background, research justification, research questions, aims and objectives, research novelty, and a chapter summary.

Chapter two: provides an overview of the UAE and the construction industry in the UAE. Moreover, the chapter offers a review of previous literature on factors affecting labourers' productivity and advanced digital construction technologies.

Chapter three: provides a description of how the study's conceptual framework was developed. The relationship of variables and theoretical coherence is provided in this chapter. In addition, justification of theories adopted, and hypotheses, are presented in this chapter.

Chapter four: provides the overall study methodology used to collect the primary data. The overall process, which entailed pilot study, philosophical stance, justification of quantitative method, data collection, data analysis, sampling strategy and ethics protocols, is described in this chapter.

Chapter five: primary data collected are presented, and an analysis of the study is also presented in this chapter. "

Chapter six: the findings of the study are described in this chapter. The discussion of the study findings is aligned with the study objectives.

Chapter seven: offers the study framework, as well the validation process, which was achieved through focus groups with experts from the construction industry.

Chapter eight: the study statement is restated, and key findings of the study are summarised in this chapter.

1.10 Chapter Summary

As shown in this chapter, productivity is one of the most critical aspects of labourers' in any organization. It is linked to the performance of the labourers' in achieving organizational goals, financial and non-financial. The existing literature provides an overview of the use of technologies in the construction sector. From the reviewed literature, it was established that previous research studies have not focused on the use of technologies in the UAE's construction sector to increase labourers' productivity. Instead, they examined factors that influence labourers' productivity in general. Hence, the current study aimed to fill this gap. The main objective was to identify the role of BIM and cloud technology in enhancing labourers' productivity in the UAE's construction sector.

Chapter 2 : Literature Review

2.1 Introduction

The construction industry has been suffering for decades from traditional project management approaches, old techniques and repeating the same mistakes. Among all sectors, the construction sector remains the last industry to implement digital technologies in its construction project management lifecycle. According to Barima (2017) construction, unlike other sectors, uses a significant number of unskilled labourers' and is lagging in the implementation and the utilization of advanced technologies. Li et al. (2014) linked the key challenges in building construction identified by Schoenborn (2012) productivity, time delays and cost overruns with the advanced technologies' slow uptake. Moreover, a study performed by Mackenize (2016) concluded that the construction industry has not yet incorporated innovative digital technologies which need up-front investment. Mackenize (2016) also shows that less than one percent of the construction industry's revenues was spent on research and development compared to three to four percent for the other industries. Hence, this chapter was designed to review factors affecting construction labourers' productivity and advanced digital construction technologies which can be implemented in the construction industry to improve labourers' productivity in building construction projects and optimize project delivery in the UAE.

2.2 An Overview of the United Arab Emirates

2.2.1 Society

Arab communities share many characteristics, incorporating a typical physical and geographic world and a collective mind regarding their role and place in history (Goldberg 1998). The Arab world is greatly transitional, balancing contemporary phenomena, including

petroleum exploration, with traditional buildings (Goldberg 1998). Their material and human resources are used for the benefit of only a tiny part of the public. (Goldberg 1998). Arab communities frequently include complementary patterns of family structures, expressiveness, spontaneity, primary group relations and patriarchy. They have a slower speed of social shift and a much better sense of social stability (Goldberg 1998 & Al-Krenawi & Graham 2000). Consequently, the family members are crucial to the homologous interrelationship between the person and team and their economic and social status (Goldberg 1998).

The United Arab Emirates (UAE) is a geographically small nation, of 83,600 sq. km. Based on the research done by the global media insight (GMI) in 2023, the population of the United Arab Emirates is 10.17 million people, with 69 percent males and 31 percent females. It is ethnically diffuse: just 19 percent of the public are Emirati, the balance comprising various other Iranian and Arab peoples (twenty-three percent), South Asian (50 percent), and other expatriates, including Westerners and East Asians (eight percent). Since 1973, oil has converted the Emirates from an impoverished area of tiny desert principalities to an oil-rich country – the UAE's per capita GDP is not much below those of the major West European nations. The Gross Domestic Product (GDP) per capita is 22,800 and region. Its generosity with oil revenues and its affordable foreign policy stance has allowed it to play an essential role in the region (Goldberg 1998).

2.2.2 Economic Outlook

The UAE has an open economic climate with a very high per capita income and a sizable yearly industry surplus. Successful financial diversification efforts have lowered the GDP percentage out of the engine oil and gas market to 30 percent. Since the discovery of oil in the UAE almost 60 years ago, the nation has undergone a profound transformation from an

impoverished region of small desert principalities to a modern state with an impressive living standard. The UAE government has increased spending on job creation as well as infrastructure development. Moreover, it is opening services to better private sector contribution. The country's free trade zones – offering one hundred percent overseas ownership – are helping entice international investors. In recent years, the UAE's strategy has concentrated on financial diversification, advertising the UAE as a worldwide industry and tourism hub, building business, and producing employment opportunities for many nationals via enhanced training and improved private sector work. According to Fulton (2020), the UAE's financial leaders are optimistic about economic recovery post-COVID-19. Nearly 70 percent of the participants believed that the economy would strengthen within the next three months and that is what is happening now.

The UAE was positioned 17th from 137 nations by the Global Competitiveness Index in 2017 and 2018, one spot lower than the prior year. The improved diversification makes the economy much more adaptable and able to overcome the two-fold shock of reducing oil and global trade and gas prices while keeping a healthy macroeconomic setting. The Global Competitiveness Report (2018) predicted that the UAE would improve its financial flexibility in the future. It had been among the first to follow the brand-new Gulf Cooperation Council value-added tax created in the nation in early January 2018 following the deceleration in 2017 (Schwab (2018)). To boost its competitiveness, based on the Global Competitiveness Report, the UAE has to accelerate the process in deploying the most recent digital technology (in which it ranks 36th globally) and in higher education (also 36th). Within the previous 10 years, the UAE has witnessed a great deal of enhancement in all dimensions of competitiveness. Generally, innovation, financial industry growth, and industry size are areas

for improvement, though the nation has advantages in terms of adequate health rates, good infrastructure, and the relative progress of primary education (Schwab 2018).

2.2.3 The Political Context

The United Arab Emirates is a federation of seven emirates founded in 1971 – Abu Dhabi, Dubai, Sharjah, Ajman, Fujairah, Umm Al Quwain and Ras Al Khaimah – with Abu Dhabi being the capital of the nation. Each emirate has its local government that manages/controls economic and financial matters. From the time of its formation in 1971, the UAE has experienced political stability. The current political framework seems to suit the tribal society of the UAE. Also, the distribution of enormous oil revenues in economic and social infrastructure, high wages, a superior standard of social facilities, like education and health, have all improved the standard of living for UAE people and significantly decreased the chance of internal politics and community unrest. It is worth mentioning that the UAE government has maintained a somewhat excellent human rights record since the country's development. This achievement, in turn, has encouraged social and political stability. The UAE is an influential member in numerous local and global associations like the Arab League, the United Nation, the Non-Aligned Movement, the Arab Gulf Cooperation Council, and the Islamic Conference Organization. Relations with several countries around the world, especially the Western democratic nations, have been usually warm. The social and political balance went hand by hand, liberal trade strategies, and this has smoothed the way for domestic and overseas investment in the manufacturing sector (Abed & Hellyer 2001).

2.2.4 The Socio-Economic Development

Before discovering oil in the 1950s, the region's economic climate was driven primarily by nomadic farming, date palm cultivation, fishing, maritime activities and pearling. Since the discovery of oil, the economy has been affected mainly by various sectors such as extraction of natural gas and crude oil, construction, manufacturing, real estate, business services, retail and wholesale trade, and repair services. According to the UAE's Ministry of Economy (2018), the estimated GDP for 2017 rose by one percent at actual (constant) costs, amounting to AED 1422.2 billion compared with the state's rate of AED 1411.1 billion in 2016. Based on economic diversification and the relative value of financial pursuits in the GDP, existing costs of the non-oil fields amounted to about AED 1092 billion, with three percent growth in 2017 compared to the end of 2016.

2.2.5 Long-Term and Short-Term Goals of the UAE

As a short-term plan, the UAE government announced the following goals to be achieved from 2021 to 2030. The UAE would have to meet the Abu Dhabi Economic Vision 2030, Environment Vision 2030 (Abu Dhabi), Plan Abu Dhabi 2030, Abu Dhabi Transportation Mobility Management Strategy, Surface Transport Master Plan (Abu Dhabi), Dubai Autonomous Transportation Strategy, Dubai Industrial Strategy 2030, Dubai 3D Printing Strategy and UN's 2030 Agenda. For instance, sustainable development goals (SDGs) as part of the UN's 2030 Agenda, also referred to as Global Goals, are a group of 17 objectives that offer many people better living conditions. The SDGs are based upon the United Nations' Millennium Development Goals. The SDGs are a part of the 2030 Agenda for Sustainable Development.

As a long-term plan from 2030 to 2117, the UAE government announced several goals to be achieved, such as uninhabitable human settlement on Mars by 2117. The UAE Centennial Plan 2071 is a long-term, full-vision strategy that covers the five decades after 2021. It shapes a well-defined plan for the long-term government effort to reinforce its reputation and soft power. As a part of this plan, the UAE would have accomplished the Dubai Clean Energy Plan under which seventy-five percent of Dubai's power will be created using clean energy resources. The UAE will also have completed the Fujairah 2040 Plan and UAE Strategy for Artificial Intelligence and UAE Energy Strategy 2050.

2.3 The Construction Sector in the UAE

2.3.1 Recent Developments in The UAE Construction Sector

UAE is the second leading construction market in the GCC with over 785 billion USD worth of scheduled and current projects. The UAE is further the most effective in the urban construction industry, contributing approximately 60 percent to the total value of projects in the nation, followed by 13 percent in transportation and 12 percent in the services sector (Asif 2016). The construction industry is realized as one of the most critical pillars of the UAE economy's progression. It is the fourth leading industry and has contributed 8.40 percent of United Arab Emirates GDP for 2022. According to Meed project tracker report (2023) seventeen billion USD worth of construction projects awarded in 2023. This is 21.5 percent of all construction developments in the GCC region (Meed 2023). However, the construction industry faces enormous challenges: project financing, cost overrun and time delays. According to Umar, Rizeiqi and Badr (2020), 44 percent of construction project problems are associated with time delay and cost overruns. Several mega-projects are currently under the development stage in the UAE; some of the current major projects are mentioned below.

Khalifa Industrial Zone Expansion comprises a viable three-phase 15-year plan for developing 7.6 square kilometres of land in the Khalifa Industrial Zone (KIZAD). The project includes expanding Khalifa Industrial Zone Abu Dhabi (KIZAD) directly into probably the largest Free Trade Zone (FTZ) located in Abu Dhabi. The expansion project has an additional 100 square kilometres of space to accommodate many more industries and a brand-new business park. “KIZAD Business Park in Area ‘A’ offers two different property opportunities and also welcomes curious vendors to serve the needs of more than 50,000 clients, both visitors and employees. KIZAD Business Park in Area ‘B’, using a complete area of 84 square kilometres, will feature weighty light: logistics industries, industrial complexes, big-box retail shops, mixed-use developments and town center and non-commercial developments” (Fulton 2020). The brand-new free trade zone will be linked to the future rail system to transport goods (Fulton 2020).

ADNOC Integrated Refining and Petrochemicals Complex – Ruwais: this mega project consists of building and advancing the world's largest integrated refining and petrochemicals complex at Ruwais manufacturing town of Abu Dhabi. Al Maktoum International Airport – Dubai South (DWC): Al Maktoum International Airport (AMIA) will probably be the largest cargo and passenger hub worldwide after completion. It will consist of five parallel (Code F) runways of 4.5 km each in length spaced large enough apart to offer simultaneous operation. Dubai South (DWC) – Jebel Ali: the project comprises a development of Dubai South (DWC) which contains eight incorporated spans and districts roughly 145 square kilometres. The districts are logistics district, aviation district, Al Maktoum International Airport, commercial district, residential neighbourhoods, a humanitarian community, golf district, and exhibition district. Al Reem Island (Pearl of the Emirates): the project consists of the construction of a

mixed-use development with definite residential, business, and business districts. The development is spread across 6.5 million square metres of a natural island, merely 600 metres of the coastline of Abu Dhabi mainland; the project includes facilities, shopping malls, golf courses, art galleries, and four hospitals. The island is anticipated to accommodate a population of more than 200,000 people (Asif, 2016).

2.3.2 Performance of the UAE Construction Sector

According to Puspasari (2005), construction projects' inefficient performance is a global phenomenon. Cost overruns and time delays are the key components of concern because failure to accomplish the project on time and within the allocated budget could impact employers, contractors, and stakeholders (Assaf & Al-Hejji 2006). A study conducted by Motaleb and Kishk (2010) showed that the construction sector was contributing approximately 14 percent of the UAE's GDP. The construction market was classified as the fifth largest sector contributing to the Dubai economy, with about an 8.3 percent share of the entire GDP in 2014 (Emirates NBD 2014). Nevertheless, cost overruns and time delays are often experienced in construction projects regardless of project type, size, and complexity (Faridi & El-Sayegh 2006). According to a study published in 2006, approximately 50 percent of UAE construction projects have been reported with cost overruns and time delays due to delay in client decision making, delay in design and construction drawing approval, and insufficient early planning (Faridi & El-Sayegh 2006). The Dubai metro has been classified as the third most challenging project with a five-year delay and 85 percent increase in cost from the anticipated budget primarily due to the extensive number of debates from variation and design changes (Arjmand 2016).

2.3.3 Types of Projects Delivered in the UAE

The UAE is one of the most developed countries in the region and the second major country in the construction sector after the Kingdom of Saudi Arabia (KSA). Thus, diverse projects are delivered every year, such as mega infrastructure projects (NES Fircroft 2022), port and airport projects (MeTenders 2022), mega building projects (Oxborrow 2022), power and energy projects (NES Fircroft 2022), and oil and gas projects (NES Fircroft 2021). According to Construction Week (2022), there have been several mega projects delivered in recent years as follows: Al Maktoum International Airport Expansion (Airport-Technology 2017), Deira Islands Boulevard Towers (AE7.com. 2022), The Heart of Europe (Dobson 2020), Expo 2020 Infrastructure Works (Coates 2020), Corniche Towers (Bayut 2022), Wasl district 1 (Phase 5) (Wasl Properties 2022), Al Dhafra Independent Power Plant (Masdar 2022), Dubai Eye project (Mace 2022), Le Meridien Mina Seyahi Hotel Expansion (TPM Williams 2022) and Shah Gas Development Gas Gathering Facility (Hydrocarbons-Technology 2021).

2.3.4 Key Challenges of the UAE Construction Sector

According to the MEED White Paper and Think Tank report (2019), the UAE construction industry's key challenges are the absence of long-term planning and inadequate financing. These challenges have hindered investment in advanced digital technologies and talents and kept the construction sector struggling behind almost every other industry. A sustainable and productive construction sector is essential to accomplishing the UAE's long-term plans (MEED 2019). MEED director Mr Richard Thompson stated that, “Unfortunately, the construction sector nowadays is characterized by short-term thinking as an outcome of persistent behaviours like lowest-price-wins tendering” (MEED 2019). The construction sector

has continued to be one of the fundamental parts of the UAE's economy and a crucial factor of its diversification plan. “As we enter a new phase of economic and technological growth in the UAE, it is imperative for the construction sector to progress in parallel and be able to adapt and thrive in a digital-led era” (Mr Mohammad Khader al-Should, managing director, head of contracting finance at Mashreq Bank) (MEED 2019).

Nevertheless, the most common factors that influence construction project delivery include the availability of materials, workforce (labourers’), stakeholder collaboration, management of construction sites, and construction equipment availability. Those factors considerably influence the successful completion of construction projects (Attar et al., 2012). Five main factors determine whether a construction project is successful or not. The project is considered successful if it is completed within budget, on time, adheres to all safety precautions and policies, and meets all the required quality standards. Successful completion is feasible if effective collaboration and appropriate productivity standards are maintained (Choudhry & Zafar 2017). Moreover, the construction project comprises labourers’ and project teams from different social, cultural, mental, and objective characteristics joining a temporary organization for one common objective (Dubois & Gadde 2002).

2.4 An Overview of the UAE’s Building Construction Projects

2.4.1 Building Construction Project in the UAE

The United Arab Emirates (UAE) building construction sector has achieved a superior position in the last 20 years. After the discovery of oil in the late 1960s, the building sector began to grow to fill the need for housing, offices, and shopping malls. However, the actual boom started in the mid-1990s, moving the country from an oil-dependent nation to a far more industrial, business, and tourist centre – the transformation led by the public sector and the

private sector's effective involvement. The downtown of the Emirate of Dubai was acknowledged as the most expensive square kilometre of building activity globally (Faridi & El-Sayegh 2006). Dubai plays a vital role in the latest development of the building sector in the Gulf: of the \$50billion appraised region-building construction projects spend, 60 percent of that, approximately \$30billion, is in the UAE alone; and the bulk of that is in Dubai (Abdulmaksoud & Beheiry 2023).

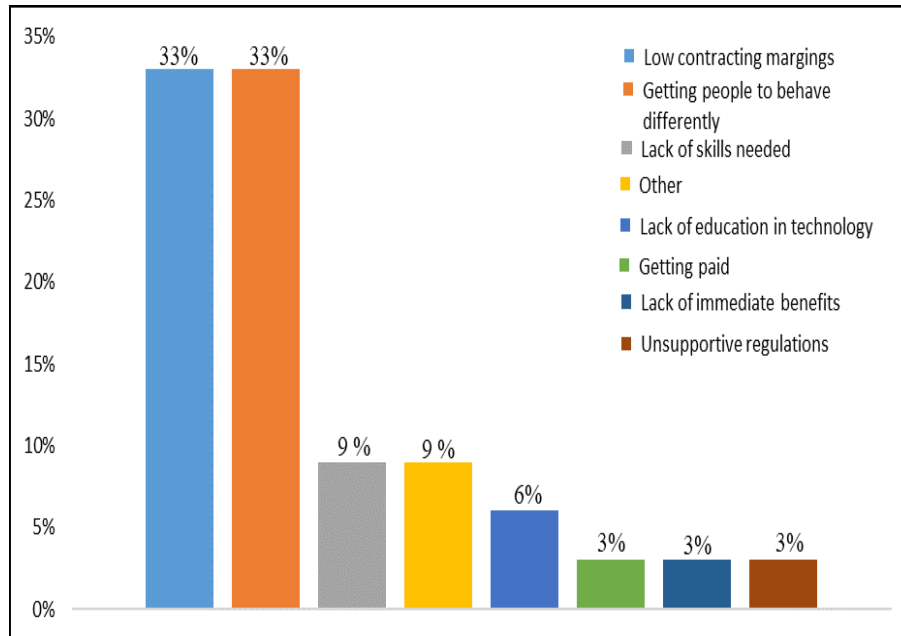
The UAE's construction sector is anticipated to reach AED 278.7 billion by 2024 with a Compound Annual Growth Rate of six percent. According to Kerr et al. (2013), they anticipate progress among residential, commercial, industrial, and institutional sectors in the United Arab Emirates to remain affected by economic decline caused by the Covid-19 outbreak. However, despite these short-term challenges, the intermediate and long-term outlook remains positive. The residential construction sector was boosted at a compound annual growth rate of seven percent during 2015-2019. Furthermore, the commercial building construction sector is expected to reach a compound annual growth rate of nine percent a forecasted plan (Kerr et al., 2013).

2.4.2 Building Construction Project Performance in the UAE

According to Umar, Rizeiqi and Badr (2020), the construction industry senior managers surveyed in the UAE are optimistic about progression prospects. They are confident that technology and governance will play a significant role in enhancing construction project performance and optimizing project delivery in the coming five years (Mack 2020). However, the survey also showed that construction practitioners still have different opinions about whether companies in the UAE are accomplishing projects on time and within budget. The results showed that 44 percent of cost overruns and 44 percent of time delays in the

construction projects were classified as the top obstacles facing the building construction sector in the UAE (Rizeiqi & Badr 2020). Nevertheless, the performance of construction projects in the UAE is affected by many factors. The four main issues faced by the UAE construction sector are: lack of collaboration in the industry, attracting and retaining talent, poor innovation culture, and lack of industry representation. As per the survey of MEED construction, the companies identified low contracting margins and people's attitudes as central challenges to innovation (e-Zigurat 2019).

In addition, the key recommendation to construction companies is to invest in the latest technologies to face the identified challenges. Survey conducted by e-Zigurat 2019 showed that about 55 percent of the respondents to one survey stated that the companies must build information modelling. Other respondents indicated the use of cloud-based project management, robotics, and smart contracts (e-Zigurat 2019). It was corroborated that implementing new technologies would increase the efficiencies that facilitate the speed of project delivery. Also, costs will be reduced, the collaboration between end-user contractors and designers will be improved, and accurate as-built asset data will be achieved to assist lifecycle operations (e-Zigurat 2019). However, there are many challenges to innovation in construction in the UAE as shown in Figure 2.1 below.

Figure 2. 1*Main Challenges to Innovation in Construction in UAE*

Note. eZigurat (2019)

2.4.3 Rules and Regulations Related to the Adoption of Technology in the Construction

Sector

Generally, the UAE has comprehensive rules and regulations relative to the construction industry, including Abu Dhabi Law No. 2 of 2019 related to the Regulating Partnership that facilitated the new Public-Private Partnership Law. It regulates private involvement in government development projects. It also sets the essential requirements for private participation in the projects (ICLG 2021). Dubai Law No. 12 of 2020 related to Contracts and Warehouse Management identifies the fundamental requirements for procurement, bid bonds, performance bonds, and other construction-based policies (ICLG 2021).

Nevertheless, there is a lack of laws and compliance regulations in the UAE construction sector to implement innovation and technology. For example, recently, the Prime Minister of

the UAE issued a new decree, Decree No. 24 of 2021. It regulates the utilization of 3D printing in the construction sector. The new law aims to assist Dubai's strategic target. It ensures that 25 percent of the buildings must be developed using 3D printing technology by 2030. In addition, the decree also promotes Dubai as a hub for the implementation of 3D technologies at local and international levels (Government of Dubai 2021). Also, recently, Dubai International Financial Centre (DIFC) Courts introduced a new Technology and Construction Division (TCD). Establishing the TCD aims to focus on complex technology and construction disputes. The division should resolve the issues more speedily and efficiently based on judicial expertise (Simmons-Simmons 2017). But there is a need to develop and implement more rules and regulations to promote the use of technologies in the construction sector.

2.5 International Comparison of Building Construction Project Performance

2.5.1 Lessons the UAE Can Learn from Different Countries that Use Advanced Technologies in the Construction Sector to Improve Productivity

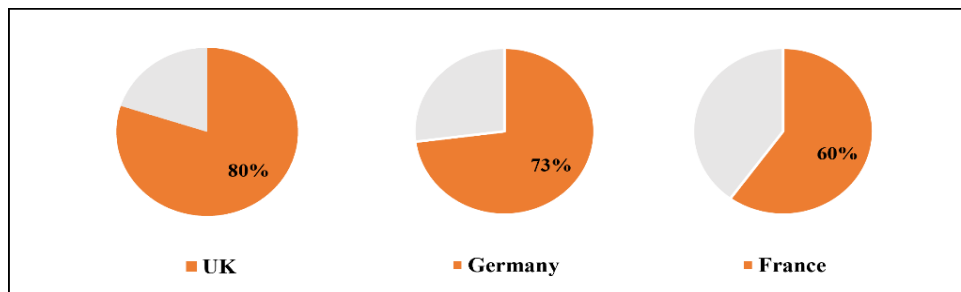
Various countries in the world are implementing the latest technologies in the construction sector to increase labourers' productivity and efficiency. One of these is the UK as of 2021, the UK has been the leader in using technologies like BIM in the construction sector compared to other European countries (Steers 2021). Figure 2.2 below shows that 80 percent of the developers in the UK, 73 percent in the Germany, and 60 percent in France implement BIM in their projects. The primary purpose is to improve the projects' performance and labourers' productivity to get optimal output for the economies. Germany's government is investing in BIM standardization, BIM skills training, and support for BIM projects. They are doing this to align with its vision for the future digitalization of the construction sector in

Germany. In the UK, since 2016, all public projects must implement at least level two BIM (Steers 2021).

On the other side, in the private sector, the use of BIM is appreciated but not mandatory. Additionally, approximately 62 percent of the small businesses in the UK utilize BIM compared to 80 percent of larger companies. In Russia, BIM technology is used by major developers in larger cities like Mosco, Yekaterinburg, and Kazan. Relative to law and compliance, Russia has more than 15 national standards (GOSTs) and eight sets of rules related to information modelling. From March 2022, all government-level projects have been required to utilize BIM technology (Steers 2021).

Figure 2. 2

Developers Using BIM in the UK, Germany and France



Note. Steers (2021)

Another example is China, whose growing construction sector has optimally used diversified digital technologies, such as the Internet of Things (IoT) and majorly BIM. These solutions enable construction companies to plan, design, construct, and manage new buildings and infrastructure more efficiently (Zhang 2019). Technologies like BIM also allow companies to collect all sorts of data in a building, ranging from environmental data to resident usage habits, to evaluate and implement to increase efficiencies and enhance

operations. As a result, the companies now have more control over resources. It has been specified that China is among the five fastest-growing BIM territories. The construction companies in China grew by 108 percent in 2015, and almost 30 percent of their construction projects were based on BIM (Zhang 2019).

2.6 Productivity in the Construction Industry

2.6.1 Definition of Productivity in the Construction Industry

Productivity is a fundamental factor in any industry. It is an essential component of project management in the construction industry (Taifa & Vhora 2019). The productivity rate in construction projects varies from one project to another and from one country to another, depending on the environmental and administrative conditions. According to Park and Kim (2013), labourers' productivity is essential to a project due to its significant impact on project success. Improving productivity eventually means a decrease in construction cost and better value for money. Productivity is defined in multiple ways; for the purposes of this study the definition of productivity as stated in Merriam-Webster (2002) is used. According to Merriam-Webster (2002), productivity is defined as the quality of being productive. Productivity in the construction industry is measured in terms of output per every labourers' hour (Durdyev & Mbachu 2011). Two conditions indicate increased productivity: the first condition is a reduction in input, as a result the quality or quantity of output remains constant; the second condition is whereby input remains constant while the quality or quantity of output is enhanced (Attar et al., 2017).

Productivity can be viewed from either the contractor or the client's perspective. From the client's perspective, high productivity shortens project schedule, reduces costs, and provides value for money. On the contractor's front, high productivity results in satisfied

clients. Satisfied customers result in customer loyalty and sustained business performance (Attar et al., 2017 & Durdyev & Mbachu 2011). Despite the numerous advantages linked to high productivity in the construction industry, contractors should consider seven significant aspects to realize increased productivity. These are: the management of construction equipment and tools, management skills, safety concerns, quality control, scheduling, employee training and skills, and employee motivation (Pheng & Meng 2018). Construction labourers' productivity is one of the most researched subjects in the construction domain. However, the development of a useful construction labourers' productivity model remains a challenge. A combination of dependent and independent variables affecting labourers' productivity has to be studied in different project environments while working with inadequate data accessibility (Tsehayae & Fayek 2018 & Golnaraghi et al., 2019).

2.6.2 Construction Productivity Measurement

Measuring construction productivity in a precise, consistent, and repeatable approach is a major problem in building construction projects. Productivity is affected by several direct and indirect factors. Those factors could be associated with the work site quality and convenience, the quality and volume of work equipment, the commitment and number of employees, the climatic circumstances, and the level of difficulty related to the process used. In the construction industry, there are various perceptions regarding how productivity is measured. For example, the method used by Langston (2013) links productivity to the price paid for building on a particular task. However, resource usage hours per day are probably easier to acquire than confidential financial project data. Rivera et al. (2016) identified three techniques to measure productivity in the construction sector: macroeconomic rate, industry rate, and project rate. Theoretically, these methods are all interrelated, as they explicitly or

implicitly supply estimates of a production procedure. The main differences between these techniques are the supply of information, the rate of its aggregation, the boundary of the operation process, and the comprehensiveness with which it has been defined (Walker & Chau 1988).

The measurement problem is even more intensified by measurement discrepancies between macroeconomic, microeconomic, project, and task rate methods of measurement (Chan & Yi 2013). Variances occur in information sources, amounts of data aggregation, procedure limitations, and complete method definition (Walker & Chau 1988). For instance, Goodrum et al. (2009) identified considerable inconsistencies between combined macroeconomic information and business task data, consequently causing anomalies that create unclear variances between them. This gap arises when the macroeconomic rate is attempting to organize massive data into general trends (Abdel-Wahab & Vogl 2011). In specific ways, concentrating on the project level provides a mid-point that offers the right unit of measure as keeping the specialized complexities of trade tasks, including inter-dependencies involving different tasks and still offering extrapolation to business level (Thomas & Završki 1999). However, dealing with productivity measurement at the project level always involves uncertainties as each project is unique. Each project comprises different activities from various trades, which would create substantial inconsistency in both the inputs and the outputs used in the measurement approach (Pilat & Schreyer 2002).

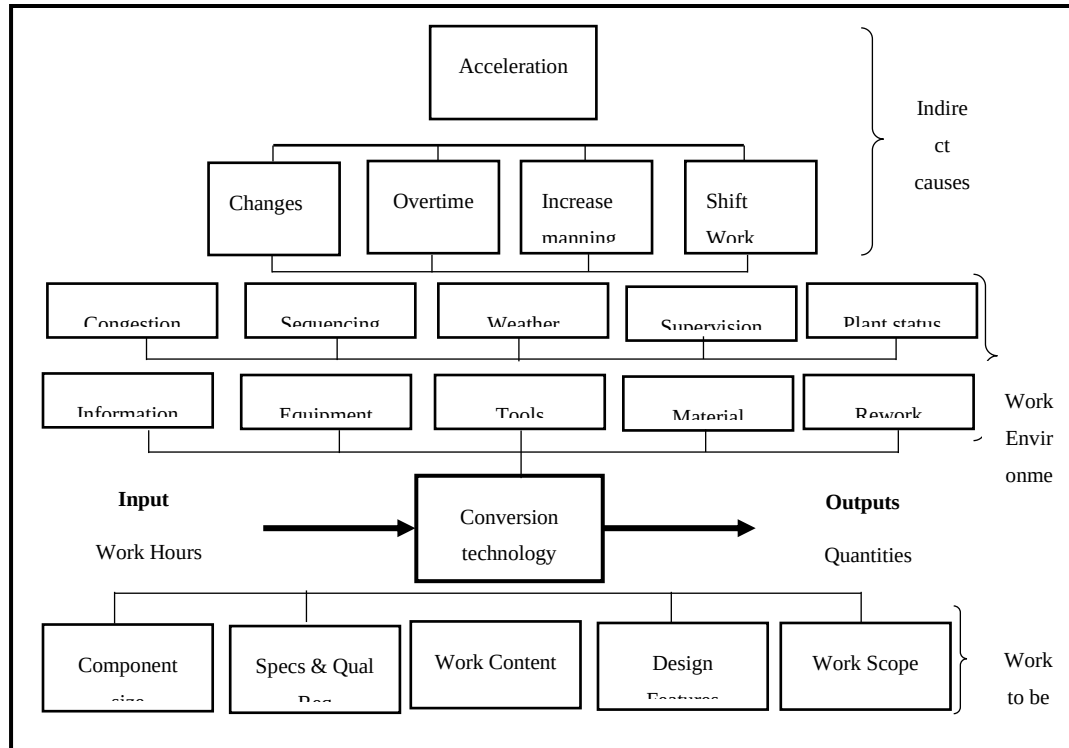
Research carried out by Crawford and Vogl (2006) defined a framework for measuring productivity in the construction industry by the potential output of a production procedure provisional upon its inputs. The research explained that there are different methods for measuring productivity in the construction industry. Individual component element

productivity measures depend on the effect of single resource's input (labourers'). On the other hand, total (multi-factor) productivity measures (TFP) consider the impact of multi-resources input on the output. The authors further identified the advantages and disadvantages of both productivity measurement methods. For instance, the individual component element productivity method (labourers' productivity) is implemented as an indicator for primary administration strategy purposes and is quite simple to measure and commonly used. However, total productivity measures are preferred by economists in their estimations for more detailed productivity analysis where there is a requirement to independently find the contribution of the fundamental factors to the growth of the industry. As per the study, total productivity measures exercises involve intangible inputs such as administration, skills, and technological advancement, and quantifiable physical efforts such as workers and capital. The study pointed out that the total factor measurement approach is much more challenging than the single factor productivity measurement approach. It also emphasized that TFP cannot yet be demanded due to the unavailability of appropriate methodology to guarantee precise results.

Research conducted by Forsythe (2018) adopted systematic literature reviews and occasionally quantitative data methods described by the author. The study presented a productivity measurement framework in building construction projects based on resource usage rather than the amount paid for construction projects or activities. As claimed by Forsythe (2018), this framework balances primary data collection and descriptive capability. The study recommended measuring productivity at the project level rather than measuring it at the economy, macroeconomic, or industrial level. Forsythe (2018) concluded that, by following this approach to productivity measures, researchers could produce a comprehensive

framework offering a more cohesive and targeted method. In this study, the researcher concluded that, for construction practitioners to manage and control the different work packages, they must use a resource-based productivity measurement, i.e., labourers' productivity rate.

Based on the above review, it could be concluded that measuring construction productivity is a complex task in the construction industry. Several pieces of research have tackled this problem and reported different methods and highlighted each method's advantages and disadvantages. It is noticeable that all studies agree on the vital role of labourers'/resource productivity and measuring it in the construction industry. Thus, for this study, the researcher defines construction productivity as construction labourers' productivity, and the method of measurement used for this study is the output per every labourer's hour. For the purpose of demonstrating the theoretical background of the construction labourers' productivity measurement in this study, the researcher used the factor model of construction labourers' productivity theory developed by Thomas and Završki 1999, as shown in Figure 2.3 below as one of the main references for this study. The authors demonstrated the process of converting the input into an output by using conversion technology.

Figure 2. 3*Factor Model of Construction Labourers' Productivity*

Note. Thomas & Završki (1999)

2.7 Factors Affecting Construction Labourers' Productivity

2.7.1 Introduction

Extensive studies have been performed on the subject of construction labourers' productivity. In the past four decades, construction labourers' productivity has been one of the most investigated subjects. Big efforts have been made to identify factors influencing construction labourers' productivity by several researchers across the world. In the past four decades, much research has been conducted in various countries to define the factors influencing construction labourers' productivity (Yi & Chan 2014). As a result of these studies, a large number of factors influencing construction labourers' productivity have been

identified. These factors cover a broad range of labourers' productivity challenges in different geographical areas and in various types of construction projects. Identification of the key factors influencing labourers' productivity is essential for any effort to improve labourers' productivity in the construction sector (Ghoddousi & Hosseini 2012). Nevertheless, despite the enormous efforts, labourers' productivity enhancement remains an area in which more studies are required to investigate significant factors affecting labourers' productivity and suggest methods for improvement (Hamza et al., 2022).

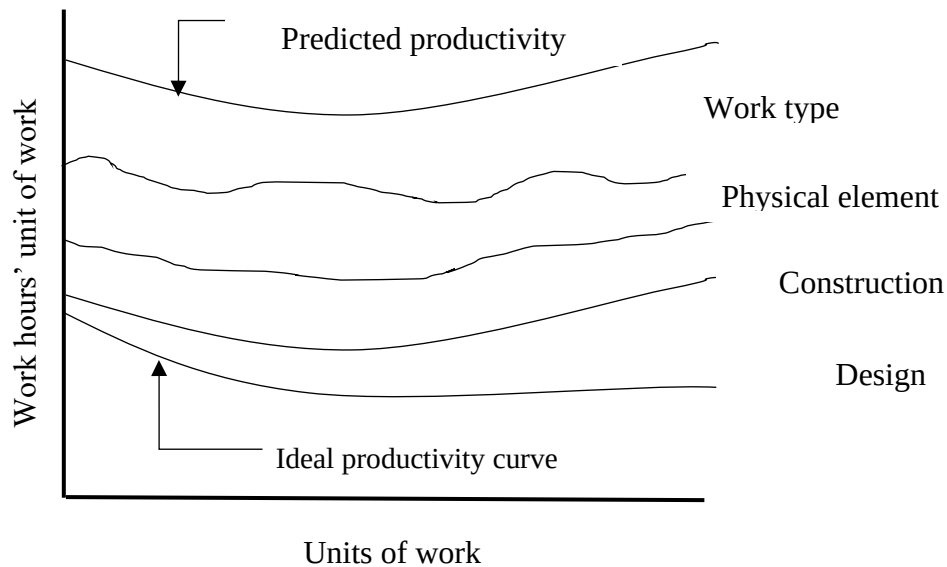
2.7.2 Difference Between Factors Influencing Labourers' Productivity and Factors Affecting Construction Productivity

There is a significant difference between factors influencing labourers' productivity and factors affecting construction productivity, as both are not accumulated simultaneously. Labourers' productivity is one component of construction productivity (Herbsman & Ellis, 1990). For improving labourers' productivity, research into the factors influencing it, whether negatively or positively, is essential. Considering the use of the factors that positively influence labourers' productivity and ensuring the proper set up of a model to control the factors that negatively affect labourers' productivity will result in improving the productivity rate. Moreover, identifying the fundamental factors affecting labourers' productivity will ultimately help project estimators to produce an accurate project estimation avoiding unforeseen productivity problems. The subject of labourers' productivity is decades old, as researchers' interest in this subject started in early 1987. Thomas and Yiakoumis (1987) conducted a study on factors model affecting labourers' productivity on construction crew rate. In their findings, they stated that several factors adversely affected labourers' productivity and, if those factors were quantified and discounted from the crew rate

productivity curve, the remaining productivity value would be the ideal productivity curve. Thomas and Yiakoumis' theory presented in Figure 2.4 below is the basic theory for this study. Their study was based on data collected from three commercial building projects in central Pennsylvania, USA; the authors collected crew productivity daily. Thomas and Yiakoumis' theory has been confirmed by many successive studies that have highlighted several factors that cause low labourers' productivity. Moreover, the United Nations report (1995) revealed that two leading sets of variables impact the labourers' productivity requirements: administrative stability and execution continuity in normal circumstances. Administrative stability involves physical elements of work, design particulars, and specification constraints. Execution continuity pertains to the work atmosphere and how efficiently a task is planned and supervised. Management features include weather, out-of-sequence work and congestion, and equipment and material availability. Despite the extensive studies performed for more than four decades, researchers have not concurred on a standard set of factors with a substantial impact on labourers' productivity; no agreement has been reached on a universal grouping of these factors. This section presents a literature review from various studies on factors affecting construction labourers' productivity. The undertaken literature review addressed the construction labourers' productivity subject from past, present and very recent journals.

Figure 2. 4

Graphical Representation of Factors Model of Construction Labourers' Productivity



Note. Thomas and Yiakoumis (1987)

Abdul Kadir et al. (2005) conducted a study on factors affecting construction labourers' productivity in Malaysian residential projects. The research asserts the most significant project delay factors and most frequent delay factors that impacted construction productivity. The authors used a questionnaire survey to fulfil their study's objective, and 100 questionnaires were completed by the participants, 70 contractors, 11 developers, and 19 consultants. The study showed that the most significant and the most frequent factors affecting construction labourers' productivity were the shortage of material, non-payment to suppliers, payment delay to the main contractor, lack of skilled labourers'ers, lack of proper coordination at the project site, change orders, site management problems, unrealistic working schedule, design errors in the construction drawings, and late issuing of construction drawings by consultants. Attar et al. (2012), in their study on various factors affecting labourers' productivity and

methods to improve them, segregated factors affecting labourers' productivity in small and medium companies and factors affecting labourers' productivity in large companies. This study attempted to agree with Abdul Kadir et al. (2005) on the 10 factors most affecting labourers' productivity; however, it added poor communication and supervision delays as part of its top 10 factors affecting construction labourers' productivity. The study further recommended a set of guidelines to enhance labourers' productivity in building construction projects as follows: a suitable training programme for the labourers' an incentive scheme for the labourers' proper procurement management, on-time payments, on-time supervision, proper site layout, maintain work discipline, provide the labourers' with necessary facilities, obtain all permissions required from the relevant authorities before work starts, efficient fund planning in advance, proper work plan, maximum use of machinery, and proper equipment planning. However, the study neither provides the alignment between those guidelines and the factors affecting labourers' productivity nor proposes a model or framework for using technology to achieve those guidelines and therefore enhance labourers' productivity in construction projects.

Enshassi et al. (2007) conducted a study on factors affecting labourers' productivity in building projects in the Gaza Strip which showed that 45 factors affect labourers' productivity. Ten factors were identified as the most significant factors that negatively impacted construction labourers' productivity. Those factors are the shortage of material, inadequate labourers' experience, lack of labourers' monitoring, lack of effective communication between labourers' and supervisors, design changes during execution, payment deferment, inspection delay, labourers' disloyalty, long working hours, and shortage of tools and equipment. Enshassi et al.'s (2007) study surveyed more than 76 contracting companies within the Gaza

Strip, and most of their respondents were construction experts with a higher rate of employment, such as directors and general managers. The study further illustrated the 45 factors in 10 groups and ranked the groups according to their relevant importance. The factor groups are tools and material group, supervision group, management group, quality group, time group, labourers' factors group, project group, external group, motivation group and safety group. However, due to this study's longitudinal nature, only the three most significant factors in each group are captured in this review, under tools and material group, shortage of material, shortage of equipment and tools, and store locations. For the supervision group, the factors were design changes during execution factor, inspection deferment and rework factor. Under the management group, they lacked labourers' monitoring, lack of effective communication between labourers and supervisor, and lack of regular meetings with labourers. Under the quality group, were factors such as shortage of equipment, inadequate material quality, and high quality specified in the contract. Under time group were long working hours, inappropriate schedule, and unsuitable labourers' distribution. Under the labourers' group were factors such as inadequate labourers' experience, labourers' disloyalty, and labourers' disappointment. Under the project group were factors such as working in a restricted area, disturbances, and construction technique. Under the external group were weather conditions and an increase in government requirements. Under the motivation group were factors such as payment delays, lack of incentive scheme, and lack of labourers' appreciation plans. Lastly, the safety group included factors such as incidents, violation of safety measures, and inadequate lighting when working at night (Enshassi et al., 2007).

Kazaz et al. (2008) showed that the organizational group of factors are the most significant factors affecting construction labourers' productivity. The study indicated that quality of site management, management of material, planning and workflow, supervision, and project site layout are also significant factors affecting labourers' productivity. Kazaz et al. (2008), further described each factor in more detail; for instance, quality of management such as accurate time and cost estimation of the project during the planning stage, proper labourers' distribution and well-defined activity allocation, effective site communication, comfortable flow of information and feedback, on-time decision making, lean management style, and simple organizational structure. Management of material refers to the shortage of material, inappropriate material handling, inadequate material storage, low-quality material, and material delivery. For the planning and workflow factor, it is common in project management that a project is considered successful if it is completed within time, to the budget, to a high quality, and adheres to all safety requirements. Proper resources planning is the leading agent in achieving these constraints. However, poor planning could negatively impact labourers' productivity as it introduces rework and results in workers' time being taken up (Kazaz et al., 2008). Supervision is a crucial factor because the project supervision team must inspect any completed work to certify that work has been completed as per the contract specifications (Kazaz et al., 2008). If work done is rejected by the supervisor or the supervisor is delayed in making their work inspection, this means the workers will need to remove such work and redo it or they have to stay idle until the work has been inspected and accepted before they can start successive activities; thus, supervision is a vital factor in improving labourers' productivity. The project site layout is an essential element in the project construction

management; proper site layout means smooth logistical arrangement and easy labourers' and equipment movements, and appropriate handling of material storage and material distribution.

In a longitudinal study conducted by Durdyev and Mbachu (2011) on the key Constraints and Improvement Measures of on-site Labourers' Productivity of New Zealand's Construction Industry, the authors used a quantitative method research approach: nine interviews with construction industry experts were conducted to confirm constructs derived from the literature review and 150 questionnaires were completed by consultants, contractors and subcontractors. Their study classified factors affecting labourers' productivity into two main groups, internal factors group and external factors group. These were further divided into subgroups; for instance, internal factors consist of task finance, workforce, technology development, project characters, and project management. For the external group, constitutional compliance, unexpected events, and others are three subgroups identified. Durdyev and Mbachu (2011) further revealed factors affecting labourers' productivity under each subgroup; for instance, under task finance, the factors are payment delay, low estimation, expenses of disputes, interest charges, high insurance payments, insufficient supply, or high cost of required labourers'ers. Factors under the workforce subgroup include responsibility, authorization, labourers' skills and experience, labourers' involvement from external subcontractors, labourers' absenteeism, employee turnover, and labourers' health situation. For the technology development subgroup, factors included availability and sustainability of tools and equipment, construction method, the technology used, lack of training on advanced technology, resistance to accepting advanced technology, and insufficient setup and application in the construction sector. For the project characteristics subgroup, they identified factors such as site situation, project complexity, buildability problem, and procurement

methods. Pertaining to the project management subgroup, factors were identified as follows: inadequate planning and risk management practice, poor coordination and progress monitoring and controlling, project organizational culture, management relationship, project team competencies, and design variations frequency. This research identified 56 factors affecting labourers' productivity, and, unlike other studies, classified them from different perspectives. However, nothing was mentioned about methods or framework for improving those factors.

Thorpe and Huges (2014) conducted a study on determining and analysing factors influencing construction labourers' productivity. The research concentrated on building construction projects in the state of Queensland, Australia. The study concluded that the three most significant factors influencing the Australian construction sector's labourers' productivity were rework, incomplete drawings, and inadequate supervision. Moreover, the most significant secondary factors impacting the Australian construction sector's labourers' productivity were the design details offered by architects, low evaluation of the approved drawings, and unfeasible design. The authors recommended that construction labourers' productivity can be enhanced by efficient monitoring and controlling of the above-mentioned six factors. Loosemore (2014) studied enhancing construction labourers' productivity from the subcontractors' viewpoint. The results of this study showed that the main factors impacting labourers' productivity from the subcontractors' perspective were timely design envelopment, coordination, scheduling, risk management, rational tender process, project management skills, and document control. Moreover, El-Gohary and Aziz (2014) conducted a study on factors affecting labourers' productivity across 10 countries; the availability of material and method of handling material procurement and distribution was ranked as the second most significant factor affecting labourers' productivity. In addition to material management,

labourers' productivity is positively affected by equipment and tools management, and the methods and policy in managing the equipment fleet.

According to Naoum (2016), the most significant factors affecting labourers' productivity were associated with the pre-construction tasks such as project management experience, design mistakes, design buildability, project planning, communication problems, management style, and procurement processes. The study surveyed 36 main contractors to examine 46 factors affecting labourers' productivity identified by the literature review. The study further revealed that, despite developing methods and tools and enhancing construction, labourers' productivity still requires investments in advancement and technology. Hughes and Thorpe (2014) concluded that non-traditional contracts, specifically design and build, management contracting, and partnering, would offer good advantages, including effectively managed activities, enhanced coordination, logistic, effective communications, and good relationships between construction parties, teamwork and ethics. Earlier in the project planning stage, the project manager with the project planning team made several assumptions such as resource readiness, construction suitability, and necessary predecessor activities. However, few of those assumptions were explicitly acknowledged and confirmed before the execution stage started. Decisions made according to such unconfirmed assumptions could adversely affect the progress and the outcome of a project. This kind of problem could result in rework being required, extra material being required, or incur additional cost (Gao et al., 2014). This concept supports Doloi's (2008) conclusion, who revealed that inadequate project planning and design mistakes are probably the essential factors influencing labourers' productivity. This research also recommended that workers' attitude about advanced

productivity might not be restricted to solely monetary incentives, but characteristically connected to several other hidden factors, such as planning and scheduling.

Kazaz et al. (2016), identified 37 factors affecting labourers' productivity and classified them into four different clusters as follows: economic, organizational, socio-physiological, and physical characteristics. They analyzed the distribution and the effectiveness of each element within the group. Moreover, the outcomes showed that the corporate factors group has a maximum weighted average and the smallest standard deviation. Therefore, aspects under the corporate group are observed as equally significant by craft workers. The authors also found physical and economic factors to be equally crucial for craft workers. Only elements classified under the socio-psychological group had different significant rates according to craft workers' appraisal. Saravanan et al. (2016) identified 11 factors affecting labourers' productivity: quality, safety, time, labourers' skills, organizational factors, misunderstanding, project type, motivation, material/tools, natural elements, and external factors.

Nasirzadeh et al. (2022) conducted a study on labourers' productivity in Australian building construction projects. They performed a literature review and then interviewed some experts who had extensive building construction project experience in Australia. As a result of the literature review and the interviews, they identified 26 factors affecting labourers' productivity in Australia's building construction projects. Next, they used a cause-and-effect response circle scheme of factors influencing labourers' productivity to illustrate and reflect their complex relationships. They then used their cause-and-effect structure to analyse the influencing factors using the decision-making trial and evaluation laboratory technique. Their results illustrated that the five most significant factors impacting labourers' productivity in Australian multi-story building projects were skills and experience, fatigue, inadequate

supervision (planning and workflow), award rates, and communication problems with foreign workers. Their conclusion was the project's scope, rate of skill and knowledge, and communication issues with foreign workers are the most significant factors that impact labourers' productivity in Australian multi-storey building construction projects. The authors recommended that project managers make reasonable efforts to minimize the effect of those influential factors. For instance, they suggested that project managers adopt an effective plan to increase the workers' rate of skills and knowledge. There is no doubt that the researchers conducted an interesting study and used an innovative approach to analyse and determine the most significant factors affecting labourers' productivity in building construction projects. They successfully identified a group of influential factors. However, this study neither proposed a model to improve the identified significant factors affecting labourers' productivity nor provided any recommendations to the project managers to use the technology to minimize the impact of those factors. The study did provide a subjective conclusion identifying 26 elements and three out of them have the most significant effect on labourers' productivity in building construction projects in Australia. Moreover, it is also suggested that project managers should make an effective plan to increase the workers' skills and experience.

A study conducted by Almamlook et al. (2020), on the factors affecting labourers' productivity in the construction industry in Libya, classified the factors into three groups: management group, human group, and technological. The study surveyed more than 90 contractors; a questionnaire consisting of 30 factors examined by a construction expert was distributed to the contractors to rank them based on their significant impact on labourers' productivity. According to their findings, inadequate supervision, workload, poor leadership, poor site management, incentive programme, financial problems, shortage of material,

construction method, logistic problems, and health and safety are the most significant factors affecting labourers' productivity under the management group. However, factors such as motivation, lack of labourers' skills and experience, and physical labourers' condition were the most significant factors identified under the human group. Moreover, factors such as design coordination, design mistakes, sharing information, rework, delay in work inspection, construction technology, variation orders, quality of working drawings, unclear specifications, and project planning were the most significant factors affecting labourers' productivity identified under the technological group.

2.8 Conceptual Underpinnings Related to Labourers' Productivity in the Construction Sector

2.8.1 General Factors Affecting Construction Labourers' Productivity

Table 2.1 below presents the findings from the reviewed literature on the general factors affecting construction labourers' productivity. The table illustrates factors, context, authors, and the number of times a particular author(s) has mentioned individual factors.

Table 2. 1*General Factors Affecting Construction Laborer's Productivity*

		Enshassi <i>et al.</i> ,(2007)	M. Hafez (2014)	(Dai <i>et al.</i> ,2009)	Naoum (2016)	Ailabouni <i>et al.</i> ,(2007)	(Thomas & Sudhakumar, 2013)	Nasirzadeh <i>et al.</i> ,(2022)	Kazaz <i>et al.</i> ,(2008)	Bekr (2016)	Jarkas <i>et al.</i> ,(2015)	Durdyev & Mbachu (2017)	Jarkas (2015)	Jarkas & Bitar (2012)	
1	Lack of labourers' supervision	x	X	X	x	X	X	X	x		x	X	x	x	12
2	Unavailability of material on time at the site	x	X	X	x	X	X	X		X			X	x	10
3	Inadequate labourers'	x	X	X	x	X		X		X		X	X	x	10

	skills and experience														
4	Change orders during execution	x	X		x		X	X		X		X	X	x	9
5	Payment delay	x	X				X		x	X	x	X	X	x	9
6	Shortage of tools and equipment	x		X	x		X	X		X		X	X	x	9
7	Poor construction method	x	X		x	x		X			x	X	X	x	9
8	Work overtime		x	X		x			x	x	x	X	X	x	9
9	Ineffective communication	x		X	x		X	x				X	X	x	8
10	Delay of response to			X	x	x				x	x	X	X	x	8

	the request for information from the engineer														
11	Rework	x	x		x	X	x		x		X	x	8		
12	Management of material delivery and storage	x	x		x	X	x	x		X		x	8		
13	Site congestion	x			x	X	x	x		X	X	x	8		
14	Lack of incentive scheme	x		X		x	X		x	x		X	x	8	
15	Unrealistic schedule	x	x					x	x		x		X	x	7
16	Lack of health and safety	x		X		x	X	x	x		x				7

	planning													
17	Weather condition	x	x				x	x			X	X	x	7
18	Lack of training and development for labourers'ers		x	X	x		x	x			X		x	7
19	Lack of design coordination		x	X	x			x		x		X	x	7
20	Size of the crew		x	X		x		x		x		X	x	7
21	Design buildability		x		x	x		x		x		x	x	7
22	Inappropriate site layout		x				x	x			X	X	x	6
23	Lack of leadership		x	X	x	x					X		x	6
24	Accidents		x			x				x	X	X	x	6

34	Subcontractor involvement	x						X	x	3
35	Work sequencing problems		X					X	x	3
36	Lack of appropriate temporary facilities		X		x		x			3
37	Slow decision-making process		X		x				x	3
38	Delay in authority approvals		X		x			X	x	3
39	Lack of supervisor experience		X		x		x			3

40	Lack of on-time equipment repair	X	x	x					3
41	Lack of appreciation for useful labourers'ers		x	x				x	3
42	Design errors					x	X	X	3

2.8.2 Top 10 Significant Factors Affecting Construction Labourers' Productivity

Table 2.2 below presents the top 10 significant factors and the number of times each factor was mentioned in the literature and the reference. Moreover, since these factors were found to be key for this study, the researcher has provided an explanation about each factor in the next section.

Table 2. 2*Top 10 Significant Factors Affecting Construction Laborer's Productivity*

Serial number	Factors	No of references	References
1	Inadequate supervision	20	Dai & Goodrum (2011), Abdul Kadir <i>et al.</i> (2005), Ohueri <i>et al.</i> (2018), Hickson and Elli (2014), Enshassi <i>et al.</i> (2007), Ailabouni <i>et al.</i> (2007), Singh (2010), Odesola & Idoro (2014), (Thomas & Sudhakumar, 2013), Dixit & Saurabh (2019), Jarkas <i>et al.</i> (2012), Hughes & Thorpe (2014), Kazaz <i>et al.</i> (2008), Bekr (2016), Palikhe <i>et al.</i> (2018), M. Hafez (2014), Jarkas <i>et al.</i> (2015), Durdyev & Mbachu (2017), Jarkas (2015) & Jarkas & Bitar (2012).
2	Lack of labourers' skills and experience	18	Alaghbari <i>et al.</i> (2017), Bekr (2016), Choudhry (2015), Dixit & Saurabh (2019), Enshassi <i>et al.</i> (2007), Hickson & Elli (2014), Jarkas <i>et al.</i> (2012), M. Hafez (2014), Mahamid (2013), Naoum (2016), Nasirzadeh <i>et al.</i> (2022), Odesola & Idoro (2014), Palikhe <i>et al.</i> (2019), Yi & Chan (2014), Porntepkasemsant & Charoenpornpattana (2014) & Singh (2010).
3	Poor planning and scheduling	17	Thomas & Sudhakumar (2013), Abdul Kadir <i>et al.</i> (2005), Bekr (2016), Dai and Goodrum (2011), Dai <i>et al.</i> (2007), Dixit & Saurabh (2019), Durdyev & Mbachu (2017), Hiyassat <i>et al.</i> (2016), Jarkas <i>et al.</i> (2015), Kazaz <i>et al.</i> (2008), M. Hafez (2014), Mahamid (2013), Naoum (2016), Yi & Chan (2014), Pambhar <i>et al.</i> (2020), Shoar & Banaitis (2019), Singh (2010) & Yi & Chan (2014).
4	Poor site management	17	Abdul Kadir <i>et al.</i> (2005), Alaghbari <i>et al.</i> (2017), Bekr (2016), Dai & Goodrum (2011), Dai <i>et al.</i> (2007), Hickson & Elli (2014), Jarkas (2015), Jarkas <i>et al.</i> (2012), Kazaz <i>et al.</i> (2008), M. Hafez (2014),

			Mahamid (2013), Naoum (2016), Ohueri <i>et al.</i> (2018), Yi & Chan (2014), Porntepkasemsant & Charoenpornpattana (2014), Shoar & Banaitis (2019) & Yi & Chan (2014).
5	Shortage/management of material	17	Thomas & Sudhakumar (2013), Ailabouni <i>et al.</i> (2007), Alaghbari <i>et al.</i> (2017), Bekr (2016), Dai <i>et al.</i> (2007), El-Batreek <i>et al.</i> (2013), Enshassi <i>et al.</i> (2007), Hughes & Thorpe (2014), Jarkas (2015), Jarkas <i>et al.</i> (2012), M. Hafez (2014), Mahamid (2013), Nasirzadeh <i>et al.</i> (2022), Yi & Chan (2014), Porntepkasemsant & Charoenpornpattana (2014) & Singh (2010).
6	Payment delay	15	Thomas & Sudhakumar (2013), Abdul Kadir <i>et al.</i> (2005), Ailabouni <i>et al.</i> (2007), Bekr (2016), Dixit & Saurabh (2019), Enshassi <i>et al.</i> (2007), Hickson & Elli (2014), Kazaz <i>et al.</i> (2008), M. Hafez (2014), Mahamid (2013), Palikhe <i>et al.</i> (2019), Yi & Chan (2014), Porntepkasemsant & Charoenpornpattana (2014), Shoar & Banaitis (2019) & Singh (2010).
7	Ineffective communication		Thomas & Sudhakumar (2013), Alaghbari <i>et al.</i> (2017), Choudhry (2015), Dai <i>et al.</i> (2007), Durdyev & Mbachu (2017), El-Batreek <i>et al.</i> (2013), Enshassi <i>et al.</i> (2007), Hickson & Elli (2014), Hiyassat <i>et al.</i> (2016), Jarkas & Bitar (2012), Mahamid (2013), Naoum (2016), Nasirzadeh <i>et al.</i> (2022), Ohueri <i>et al.</i> (2018) & Yi & Chan (2014).
8	Shortage of tools and equipment	11	Thomas & Sudhakumar (2013), Bekr (2016), Dai & Goodrum (2011), Durdyev & Mbachu (2017), El-Batreek <i>et al.</i> (2013), Enshassi <i>et al.</i> (2007), Mahamid (2013), Nasirzadeh <i>et al.</i> (2022), Ohueri <i>et al.</i> (2018), Palikhe <i>et al.</i> (2019) & Yi & Chan (2014).
9	Rework	11	Abdul Kadir <i>et al.</i> (2005), Bekr (2016), Dai <i>et al.</i> (2007), Hickson & Elli (2014), Hughes & Thorpe (2014), Jarkas (2015), Jarkas <i>et al.</i> (2015), Odesola & Idoro (2014), Palikhe <i>et al.</i> (2019), Porntepkasemsant & Charoenpornpattana (2014) & Shoar & Banaitis (2019).

10	Lack of design coordination	8	Abdul Kadir <i>et al.</i> (2005), Dixit & Saurabh (2019), Enshassi <i>et al.</i> (2007), Jarkas (2015), Jarkas & Bitar (2012), Jarkas <i>et al.</i> (2015), M. Hafez (2014) & Yi & Chan (2014).
10	Variations	8	Abdul Kadir <i>et al.</i> (2005), Alaghbari <i>et al.</i> (2017), Bekr (2016), Durdyev & Mbachu (2017), Hughes & Thorpe (2014), Jarkas & Bitar (2012), Jarkas <i>et al.</i> (2015), Nasirzadeh <i>et al.</i> (2022).

As shown in Table 2.2 above, the following are the top 10 factors affecting construction labourers' productivity.

2.8.2.1 Inadequate Supervision. Construction development is a collective effort comprising a group of specialists from various companies. A practical management approach to manage work packages from inception to execution and employees' welfare is crucial to reach higher productivity (Ailabouni et al., 2009). Effective management can make significant time and cost savings (Zayed & Shahata 2011).

2.8.2.2 Lack of Labourers' Skills and Experience. According to Abdel-Wahab et al. (2008), the effective use of skills rather than merely increasing the number of skilled workers is key for improving construction projects' productivity.

Poor planning and scheduling are among the most significant factors affecting labourers' productivity. Among the 42 factors identified from 34 pieces of literature covering 21 countries, poor planning and scheduling were ranked the third most significant factor causing low labourers' productivity in the construction industry globally.

2.8.2.3 Poor Site Management. Poor site management is one of the 10 most significant factors affecting labourers' productivity. Among the 42 factors identified from 34 pieces of literature covering 21 countries, poor site management was ranked the fourth most significant factor causing low labourers' productivity in the construction industry globally.

2.8.2.4 Material Management. Material management is a global concern and has been cited as a significant cause of low productivity in the construction industry. Material procurement, material storage, nature of material process which involves several parties, material distribution method, and material delivery schedule are just a few examples of material mismanagement situations that have been stated by previous scholars such as Thomas et al. (1989), Abdul Kadir et al. (2005), Singh (2010) and El-Gohary and Aziz (2014). A previous study by Ferguson et al. (1995) discovered that, in the UK, 50 percent of the surplus materials transferred to a dumping location is construction waste. Just-in-time material delivery was employed on construction projects by the early 1990s to decrease waste and enhance productivity. Pheng and Tan (1998) presented strong proof to boost that conception's advantages. Furthermore, Faniran and Caban (1998) suggested that design changes must be reduced or avoided during construction execution to reduce construction site waste and improve overall productivity.

2.8.2.5 Payment Delay. As noted from the reviewed literature, payment delay is one of the 10 most significant factors affecting labourers' productivity. Among the 42 factors identified from 34 pieces of literature covering 21 countries, payment delay was ranked the sixth most significant factor causing low labourers' productivity in the construction industry globally. Payment delay could have a severe negative impact on project cash flow, and hence this may result in workers' salary delay, shortage of material or a labourers' strike, which will harm the labourers' productivity level.

2.8.2.6 Ineffective Communication. As established from the reviewed literature, ineffective communication was found to be among the most significant factors affecting labourers' productivity. Among the 42 factors identified from 34 pieces of literature covering 21 countries, ineffective communication was ranked the seventh most significant factor causing low labourers' productivity in the construction industry globally. Communication is a vital factor in project construction; it plays a significant role in project success. With an effective communication plan, all project parties involved in construction would be able to receive on-time project information, and they would be able to know their responsibility to take the necessary decision without delay. It is also vital for site people to understand what is required from them and when. It facilitates site work activities by raising a request for information to the consultant to clarify specific design issues or provide them with a construction method statement to perform work without delay. Indeed, effective communication is an essential tool for supervisors to ensure higher worker productivity.

2.8.2.7 Shortage of Tools and Equipment. From the reviewed literature it was noted that the shortage of tools and equipment is another one of the 10 most significant factors affecting labourers' productivity. Among the 42 factors identified from 34 pieces of literature covering 21 countries, shortage of tools and equipment was ranked the eighth significant factor causing low labourers' productivity in the construction industry globally. Tools and equipment are considered the backbone of any construction project; most construction activities depend heavily on the availability of tools and equipment. Non-availability of on-time tools and equipment could result in workers being idle, which results in low productivity. Moreover, equipment breakdown or improper maintenance could also result in significant idle time for the workers and a low productivity rate.

2.8.2.8 Rework. Many studies have been performed to determine the productivity rate of different construction techniques, including evaluating the productivity rate of concrete compared with productivity on the steel structure of various forms of frameworks utilized in building projects. For instance, Jarkas (2012) studied the effect of main buildability components on concrete labourers' productivity. His results demonstrated that three significant factors could affect the concreting process's effectiveness: steel reinforcement obstructions, the quantity of concrete pouring, and activity height. Moreover, precast concrete and other offsite construction activities show a much higher labourers' productivity level than similar on-site activities. A study conducted by Eastman and Sacks (2008) showed that offsite labourers' reported higher productivity levels and their productivity rate growth is much higher than on-site sectors.

2.8.2.9 Lack of Design Coordination. As suggested from the reviewed literature, lack of design coordination is one of the 10 most significant factors affecting labourers' productivity. Among the 42 factors identified from 34 pieces of literature covering 21 countries, lack of design coordination was ranked the 10th most significant factor causing low labourers' productivity in the construction industry globally. Lack of design coordination could result in rework or variations, and both are a significant cause of low labourers' productivity in construction projects.

2.8.2.10 Variations. As found from the reviewed literature, variations are one of the 10 most significant factors affecting labourers' productivity. Among the 42 factors identified from 34 pieces of literature covering 21 countries, variations were ranked the tenth most significant factor causing low labourers' productivity in the construction industry globally. Several studies have been performed that examine the impact of change orders on labourers' productivity; for instance, Thomas and Napolitan (1995), Leonard (1987) and Zink (1990) in their findings stated that 10 to 30 percent is the average labourers' productivity loss due to change orders during execution. Interestingly, they argued that variations themselves do not directly affect labourers' productivity; rather, it is the humans' involvement in the change orders procedure. Several reasons cause variations in construction projects; for instance, the variation could be due to design errors, lack of design coordination between project stakeholders, and the client expected a different final product.

2.9 Digital Construction Technologies in the Construction Industry

2.9.1 Introduction

Mocerino (2018) referred to digital construction technology as the assemblage of creative implements, machines, software and modification used to create a specific construction project. He added that technological advancement in the construction industry includes the use of semi-automated and automated construction tools and equipment. Moreover, this definition has been expanded to include other pre-construction technology such as bid management applications, online bids, and digital take-off solutions. Modern technology is developing faster than what was envisioned between 10 and 20 years ago. Things such as drones, telematics mobile apps, robots, autonomous heavy equipment, and three-dimensional printed buildings are now present and still being advanced. Research indicated that most of the construction companies are not yet investing much in these technological advancements in their field. Venture capitalists have taken the responsibility head-on and are seeing the construction industry's future as technologically advanced. This literature analyses different scholars' works on advanced digital technology in the construction industry, and advanced digital technology capabilities, and explores the impact of advanced digital construction technologies on labourers' productivity.

2.9.2 Advanced Digital Technologies in the Construction Industry

Research carried out by Ansah and Sorooshian (2018) showed that the construction industry has been criticized for an extended period over its inability to meet and raise current technology rates quickly and efficiently. Since Roman times, construction has witnessed minimal changes in the techniques and methods used. However, the application of advanced

technologies in this industry is not direct and may quickly go unnoticed. The projects involved in construction are usually varied, and each site has its unique requirements. The construction industry consists of frequent relocation of both the workers and machinery, which interferes with the application of advanced technologies since different weather types and other environmental factors may hinder previous methods. Bilal et al. (2016) further defined the term advanced technology in the construction industry as a comprehensive range of modern methods, techniques, and activities that entail the newest development in material technology, facility management, structural analysis, quantity surveying, and design processes and services. In their study, Bilal et al. (2016) explained that integrating advanced technology into the construction industry ensures high-quality work, safety, and sustainability. Advanced technology also enhances the value for money and increases the rate of efficiency at work. The study also indicates that there are different types of technology which have found their space in the construction industry. These technologies include LiDAR, material advancements, BIM software, mobile technologies and drones, building information technology, virtual reality, wearable AR, artificial intelligence, three-dimensional printing, and other equipment discussed in this review.

A study done on 3D printing by Tay et al. (2017) asserted that it is a computer-controlled sequencing layering of materials to create shapes in a three-dimensional order. This technology is commonly used in the construction of complex buildings that require geometrically complex elements. The research further revealed that this method, though considered advanced, was discovered in the 1980s but was not put into regular use since it was considered very expensive, and its operation was quite complicated. In the year 2000, this

technique became cheaper and applicable to many construction sites. It is applied in different stages of the construction process, including tool production, product design, and components, which has led to the wide use of AM machines or what is known as 3D machines that have been commonly used even in the home since 2005. The 3D devices specifically developed for the construction industry are known as 3D construction printers. The items are usually created by a Computer-Aided Design (CAD) or through the 3D scanner. The printer can read and lay down the required layers of printing, which can be in a solid, liquid or powder state depending on the specifications. The layers are joined to create the required object.

Tay et al. (2017) further explored the disadvantages of 3D printing and showed that some materials may be expensive to print; for example, metal. In such cases, a mould can be used, which is easier to create and can be painted in the desired colour. This research has further shown that 3D printing produces different colours and varied components depending on the client's need. The modern world has created some giant 3D printers in various countries such as China and the Netherlands. Tay et al. (2017) also showed that Computer-Aided Design (CAD), also referred to as Computer-Aided Manufacturing (CAM), has also been used as an advanced technology in this industry. According to the study, CAM technology allows total numerical control by the computer, known as Computer Numerical Control (CNC). It involves the production of commands by design to operate various machines singularly or collectively to carry out tasks set in building components. This advanced technology can function in multiple ways, including bringing together different tools to a single cell to work on an already set program. CAM is used in the production of mechanical components that closely match the original design.

A longitudinal study by Jiang et al. (2019) argued that, in modern times, the essential resource in the construction industry is data. It is within this basis that big data was founded. Advanced technology has enhanced the storage of enormous amounts of data that can be used to uncover trends and patterns that were previously unknown. Data resources also help construction businesses to make better-informed decisions and act as the foundation from which automation is carried out. The research further shows that this type of data is usually collected from internet searches, social media, digital photographs, phones and other types of media that enhance data storage and transfer. This research further sought to find out how big data is being used in the construction industry in modern times, and it discovered various sorts of information. First, big data is used to give out historical information on the patterns and procedures used in particular construction sites to develop the best knowledge on carrying out a specific task without repeating the same mistakes, in order to achieve better outcomes. Other big data from sources that explore the weather also help constructors to determine the phasing of a construction site to avoid damage due to weather issues.

Bilal et al. (2016), in their study about the significance of big data in the construction industry, stated that it is essential to understand the functioning of equipment and analyse how its geo-location affects its functional properties. Such information is vital in the production of spare parts and the improvement of logistics. Big data can also be kept in the Building Information Modelling (BIM), which helps when information on maintenance is required. The construction industry was also set to benefit from the innovation of artificial intelligence (AI) and machine learning (ML), where Artificial Intelligence (AI) entails creating machines and programming them to function similar to human beings. On the other hand, machine learning

(ML) is a section of AI where statistical strategies are used to provide data and enable it to synthesize this data to work as a human with minimal control. Construction sites worldwide are already using robots and machine control equipment in the construction of different buildings (Bilal et al. 2016). A parallel study aimed at expounding on the importance of AI in the construction industry asserts that it helps in the reduction of operation costs and enhances efficiency (Regona et al. 2022). However, this study warns that it leads to loss of jobs and income-earning opportunities for those supposed to work as builders.

Advanced technology such as AI enables the manipulation of different types of data such that the user can come up with different designs and solutions for various issues. Moreover, the use of AI for repetitive tasks enhances high productivity and saves time. The research further shows that construction companies that rely on AI for different tasks have better financial management strategies due to predictability of the available labourers' and the highly reliable nature of this labourers. AI can analyse historical information and predict the unusual costs and achievable timelines, which helps a company to only focus on what is beneficial to it and its client. Ghosh, Edwards and Hosseini (2021) explored the construction industry's use of the Internet of Things (IoT), which refers to technological devices that can transmit data to one another and can easily be controlled from one central location. According to Ghosh et al. (2021), this method ensures there is a high rate of efficiency and safety. IoT is also known for its enhancement of worker management; for instance, footfall can be tracked on site, and the applications can be used in the checking in and out of workers and inducting them.

Ghosh et al. (2021) contributed to the study of advanced technologies in the construction industry by looking into drones and robots. As noted in their study, the construction industry is among the least technologically developed industries, and it heavily relies on intense manual labourers as its primary resource for productivity. The authors suggested that robots have not yet found a place in this industry. The authors explained that the main problem that has hindered the use of robots is the construction site itself, as robots are good at carrying out repetitive work under a controlled environment. According to Ghosh et al. (2021), drones are useful in enhancing site security when they are fixed with a camera; they can guide the site manager to identify threats to safety without the manager being present on site. Drones are also an essential tool of delivery such that they can be used to bring different materials to the site, thus reducing the number of vehicles in use, which is cost-efficient. Most construction sites that have applied robots usually give them tasks such as bricklaying and masonry work. Ghosh et al. (2021) mentioned the term demolition robots, which are used to destroy structural components at the end of a project; they are said to be slower but are safe and efficient.

The study further revealed that the evolution of advanced technology in the construction industry is an implication that a reliable network connection is required which is supposed to support significant data transfer and enhance speed (Ghosh et al., 2021). Currently, 5G and Wi-Fi 6 are the fastest internet connectivity technology. 5G refers to the fifth-generation wireless technology, which enhances digital cellular networks. It boasts fast speed, enhanced mode of data management, and less traffic. Wi-Fi 6 is also the latest rate of Wi-Fi technology, which is an improvement from the previous networks. The presence of fast speed network connectivity on a construction site enhances the quality of work done by other machinery

(Oughton et al., 2021). A separate study by Chan, Olawumi and Ho (2019) on BIM indicated that fields such as architecture, engineering, and other construction professionals can quickly design, plan, and change building structures to fit their needs. BIM also enhances proper site management among these professionals such that each activity is well taken care of at the right time. Moreover, there is improved and well-organized collaboration among the different professionals to contribute to the construction process's various stages. Equal contributions enable a review of the project progress and the functional outcomes in real time (Chan, Olawumi & Ho 2019).

Virtual Reality and Augmented Reality (VR and AR) technologies have also been studied by different scholars, and their meanings and contributions towards the construction industry have been analyzed. Virtual reality technology is no longer for the gaming industry alone. VR refers to a completely different environment where the real world is shut out while AR adds digital components to a live view. VR can be used as a site mode, once a particular building project has been completed. All these technologies are used before the actual building is entirely constructed or even started (Li et al., 2018). A study by Ahmed (2019) alludes that the work that VR can do is enormous and may not be precisely quantified with relation to the construction industry. VR helps the construction professionals as well as the client to have a view of the final product even before it is commenced. Like BIM, VR further enhances collaboration among the different professionals as they can analyse a finished product and know what needs to be improved, by whom, and in which way. Since the viewing is in real time, these corrections are also made with immediate effect, so the system is reliable. VR is

also useful in ensuring there are no potential risks during the building and after the full process has been completed.

Blockchain technology has also been linked to the construction industry in different ways. Turk and Klinc's (2017) study acknowledge that blockchain technology has widely affected the activities of the construction industry. This advanced technology was founded in 2008, when digital currency was first created. The study defined blockchain technology as digital data stored in a transactional public database, referred to as a block in this context. The stored information is verified by a network of computers working at a similar rate. Blockchain does not require any form of central control since all information moves from peer to peer without any form of mediation or any types of intermediaries. In every part of the chain, there are different types of information: the proof of bank physical transaction, originality statement, contract, and certificates of ownership (Turk & Klinc, 2017). Every section of the chain is responsible for ensuring that data remains private, and there is no access by any third parties. Blockchain helps the construction industry in establishing smart contracts since it helps in the implementation of the error-free procedure of contract generation. Every node is fully aware of the terms of the agreement involved and does not allow for its destruction. This helps the contractors to engage in truthful relations with their clients (Wang, Wu, Wang & Shou, 2017).

Bilal et al. (2016) conducted studies on cloud technology as an advanced technology in the construction industry. The study described this form of technology as one that enables people to get access to data that is stored on remote servers by using various software applications. The user is also allowed to make changes, manage, administer or exchange this information. The authorization is usually issued to anyone with a mobile service, which will

enable them to access information that has been stored in the cloud services. The study analyzed the importance of cloud technology to the construction industry and discovered that more than 15 percent of the contractors viewed cloud services as important to their work in 2005. The figure rose by 70 percent when similar research was conducted by Kumar, et al. (2010). Cloud technology allows for data sharing from one site to other entities related to the construction work going on at the exact same time, allowing for a real-time response from the respective sections. An example of data that can be shared in this manner is reviewing tools for engineers and architects or the tools used in the project management. Business efficiency, as well as real-time information, has been enhanced by cloud technologies.

Another advanced technological tool that has been put to use is LiDAR. LiDAR is a tool that has sensors which are mounted on construction equipment used in light detection and ranging and can scan the surrounding work areas and produce 3D images of high resolution (Bilal et al., 2016). As a result, site work can be performed from a long distance away, reducing the chances of any of the workers getting hurt. The study revealed the disadvantages of LiDAR are that it is a too-fragile tool, and the capacity of the sensor is minimal. Factors such as heavy dust, fog, rain or snow can ruin the sensors. Tanie (2019) conducted a study seeking to find out how the lack of adequate labourers' in the construction industry in countries such as Japan has been solved, and discovered the use of humanoid labourers'. The study was only conducted in Japan, and it asserted that Japanese researchers created the HRP-5P, which is a human-like robot that can perform tasks such as installing drywalls without the help of real humans. Moreover, other humanoid robots such as Tybot have been tasked with

responsibilities like tying rebars on bridges. They have proven to be more efficient than humans by taking half the time humans take to carry out the same activity.

Research by Ansah and Sorooshian (2018) on robot swarms has shown that advanced technology is present in the construction industry. A robot swarm is a collection of many tiny robots working together like insects. This has been observed at Harvard by a self-organizing research group where these robots have been tasked with laying bricks (Ansah & Sorooshian 2018). Robot swarms are highly advantageous as they can reach places that the constructors may not be able to access, and construct features that human would not be able to do with their own hands. Structures such as those built deep in the sea are usually enhanced using robot swarms. The same research investigated the use of connected hardhats, which are a wearable safety device. Japanese researchers created the Shimbun-equipped hardhat, which monitors the location, movement, and temperature of the worker. It provides a warning that a particular worker may be lightheaded or overheated. The tool can also warn that a specific worker has fallen and call for emergency services to attend such cases.

2.9.3 Advanced Digital Construction Technology Capabilities

The presence of advanced technology in the construction industry has enabled various activities to take place successfully. Some of these activities were previously seen as impossible while others were regarded as extremely difficult. One of the things that has been enhanced is labourers' productivity. A study by García De Soto et al. (2018) on the capabilities of advanced digital technologies in the construction industry asserted that productivity has had a flat curve for many decades. The use of traditional building methods and following through different processes has made it hard for the industry to progress.

Moreover, the research states that each construction is unique and needs unique problem-solving ideas. The varied needs of various projects make it hard for productivity to improve in this industry quickly. Advanced technology thus comes in handy in ensuring that productivity has been achieved. For instance, the use of software and mobile applications has been useful in this activity. Mobile solutions have been developed to manage every aspect of the construction process. Information in the cloud software enables the restoration of data as well as necessary changes and modifications. This helps different professionals within the construction industry to collect important data that helps them to avoid past mistakes and produce high-quality work.

Furthermore, Pillai and Matus (2019) explained that productivity is experienced when professionals decide to apply the use of digital technologies such as AI and machine learning. In their argument, Pillai and Matus (2019) pointed out that AI helps workers to make well-informed decisions, which is an important element in increasing the rate of productivity. Data collected over the years can now be synthesized and used in the production of valuable information which is used in the invention of new ideas. A study by Zhou, Goh and Li (2015) also supported the idea that AI reduces the amount of time wasted by workers and improves productivity. The time that would be used moving around the construction premises in search of tools, equipment, and various materials is used more productively by letting this work be done by machines. Furthermore, advanced technology enhances the safety of the workers by tracking them down and giving warnings whenever something is wrong. When workers are safe, they are highly likely to be more productive. The study further elaborated that, when different tools and pieces of equipment are fitted with tracking machines, it is easy to tell how

each task is carried out and stop the activities whenever something seems wrong. Other tools such as LiDAR take clear photos of the site and pinpoint where any correction type is needed, thus creating enough room for improvement. This study, therefore, elaborates on the capability of advanced technology as a tool for maximum productivity compared to traditional methods of construction.

In a longitudinal study by Hickman et al. (2018), the capability of advanced technologies to enhance safety was studied. This study only focused on the fact that the use of modern digitized materials enhances the workers' safety within the construction site. The review was a result of a survey that was conducted in 2016 which showed that, out of the total number of workers who died that year (4963), 991 were construction workers. The study insisted that workers' safety is the essential factor at every construction site as they ensure that work occurs as planned. Injuries or deaths are an implication that work must stop for a particular period to find suitable replacements. The availability of advanced technology helps in ensuring that workers are adequately trained and monitored to reduce the risks of the consequences which occur because of both minor and major accidents. Virtual Reality (VR) is believed to be one of the tools that enhance safety on a site. Workers working at dangerous sites should be allowed to use VR to carry out tasks using controllable machines. Similar to the way in which VR has been used in the training of soldiers, surgeons, and pilots, the construction industry should adopt the same methods for training workers on the operation of cranes.

Noghabaei et al. (2020) also supported the use of Augmented Reality on the construction site to promote workers' safety. The authors explained that AR can be applied at different rates in different construction processes to improve security. AR allows for the creation of

plans to enhance security within the site and provide training on the handling of various technological machinery. The use of other wearables, as studied by Awolusi et al. (2018), is also a mode of enhancing safety on the construction site. Wearables provide information on workers while they continue with their jobs. The most common wearables already present in the industry are hard hats, gloves, and safety vests. Wearables are fitted with different sensors such as biometrics, environmental sensors, location finders, and voltage detectors. It is also possible to find others equipped with Wi-Fi and other sensors that monitor locomotive activities of the workers, falls or slips, posture, and other repetitive movements. Moreover, this study states that safety within the construction site can be enhanced through geo-fencing. The workers can be alerted when they enter dangerous zones within the area using alarms or lights to avoid accidents that would lead to severe injuries. The use of smart clothing which keeps the workers' temperature and other body factors in shape is also considered a way of enhancing safety on site, since people carrying out tasks while under the influence of various substances can be identified and controlled appropriately.

Karimi and Walter (2015) carried out a study on the capability of advanced technology in correcting the problem of labourers' shortage. The research states that, during the housing crash and the great recession, more than 19 million workers left the construction industry due to different reasons such as layoffs, the pursuit of jobs in other sectors, and early retirement. Over the years, job growth has been tremendous in the industry. However, some countries are still facing the problem of inadequately skilled labourers. A study by Chen et al. (2017) showed that the demand for workers in the construction sector was expected to rise significantly in the following 10 years. The technology being deployed at construction sites

today is set to benefit the younger workers who lack experience compared to their veteran counterparts. Some of the tools used to ensure that jobs run smoothly despite the lack of workers include drones. According to the authors, drones can quickly inspect a construction site and identify any threats to the site on a specific day. Drones are also useful in monitoring workers during the day and ensuring that each of them is carrying out their task as expected, and they are all working in a safe environment. Moreover, they are used to taking photos as the work continues to keep everyone posted on the different activities throughout the construction period.

A cross-sectional study by Sang et al. (2021) on the capability of advanced technology in influencing labourers' shortage also shows that robots have been used to provide labourers' in different construction industry sections. The study further elucidates that, to date, robots are only best at carrying out repetitive tasks such as bricklaying. The advantage of robots is that, once they are set, they can complete tasks at a higher speed than that of the average human. Robots do not need rest, and neither do they go home to sleep, as is the case with people. The study further explains that, even though robots can be more efficient and speedier, it does not imply that human labourers' can be wholly done away with. It is humans who set the robots and ensure they start and do the required tasks. This study concludes that the use of robots only helps to complement human labourers', which remains the essential resource in this industry. Other works such as excavation, grading, and site work are carried out by autonomous heavy machinery such as self-driving cars. As compared to robots, autonomous heavy machines allow for the removal of workers because they are able to carry out the tasks

themselves. The use of this technology reduces the amount of money used in payment of workers and makes work more efficient.

As analysed in the previous literature, one of the significant issues in the construction industry is the collaboration among different professionals. The sector is made up of diverse and necessary professions for one job to attain completion. Engineers, workers, other stakeholders, customers, construction managers, and other parties of interest make it hard to make direct decisions. The chain is long, and so is the decision-making process since everybody has to be aware of the decision being made. In such cases, advanced technologies such as mobile phones or smartphones are used. The use of smartphones has simplified communication, which has led to simplified collaboration processes. The off-site stakeholders do not need to leave their daily jobs to visit the site to understand the changes being made. Information is easily transmitted through mobile phones in different modes. Mobile technology also enhances how meetings are conducted since nobody has to stop their tasks and listen. Each person contributes as they attend to their duties, thus saving time which would have been wasted if mobile technology was not applied. Moreover, this study asserts that fast communication helps solve issues that would have also wasted enormous amounts of time.

Ahmed (2018) investigated how BIM enhances collaboration in the construction industry. First, the author says that BIM involves presenting 3D models of the buildings to the relevant stakeholders to ensure that people agree on what design the building will be. As a result, the company designs better buildings due to the quick understanding among the members involved. The required changes are usually made clear immediately, and all the stakeholders can make these changes from their end. BIM is also essential in making sure that

everyone is always working with the updated design. Every stage of the construction is efficiently planned by all the members at individual rates since visual presentations allow for integrated work. VR is one of the factors that allow for better implementation of BIM. Moreover, most VR uses BIM to make the environment being observed. Through AR, the construction manager or the contractor views the model and compares it with the building being made to see whether their work is of standard quality. The contractor can also attend to the daily checklist of the building and compare the required work with that which has been completed.

A study by Hoonakker et al. (2015) also asserted that advanced technologies have been put in place due to the new expectations from clients. As compared to traditional times where construction was not complicated, and a high percentage of buildings were made to resemble each other, modern clients are quite demanding and creative thinkers. Therefore, they provide their new ideas and expect the contractors to develop a building that is a replica of their descriptions. The study adds that this is why it is easier to observe never-before-seen structures around different towns in the world. The urge to meet client expectations has resulted in the adoption of advanced technologies in this industry. Changes in client expectations are mostly due to their creativity as well as wanting to fulfil their ambitions and dreams. A parallel study by De Wilde and Spaargaren (2019) showed that the clients are aware that the market is tough and, as a result, they ask for more unique designs which meet their desires for their homes, offices, or other spaces. As the clients' expectations increase, there is an expectation that each company will improve itself gradually to meet its unique needs. The

use of improved health and security parameters is one way of ensuring that sites remain better places of work.

Redwood et al. (2017) believed that advanced technology has more significant capacities in this industry, leading to new possibilities. On one side, the use of hardware tools has been dropping while, on the other side, the use of technology has experienced improved efficiency and productivity. All these achievements can be traced back to client desires and expectations. When a client trusts a company with a particular project, the expectation is that this company can design the means of achieving the client's needs. Some of the technologies applied have already been mentioned earlier since they were studied by different scholars. The modern-day client is unique in terms of their expectations, and past data may not provide an exact outline of these clients' needs. However, the application of different elements of advanced technologies has brought about the success of many construction sites and fulfilled the clients' desires.

A study conducted by Fahmi et al. (2016) on the factors influencing artisans' productivity in Indonesia showed that low productivity of artisans is the worst experience that contractors can have during their building process. However, this problem is rampant in developing countries compared to developed nations. The study surveyed more than 200 artisans, including bricklayers and steel fixers, over four months. The tasks involved the issuing of questionnaires as well as sampling surveys. According to this study, the crafters only spent 70 percent of their time working productively. The problems that revolve around these workers include inadequate materials, absenteeism, rework, and others. According to the study, some of the productivity problems are like those experienced in developed nations such

as the UK and US. As a result, this industry has begun embracing the idea of employing tech-savvy individuals who can apply their technical knowledge to solve the existing problems in the construction industry. For instance, advanced technology is capable of adequately dealing with absenteeism by bringing about the use of robots in different areas. The new generation of artisans is good at controlling the machines and ensuring that they are maintained, and that work runs as swiftly as possible. The study showed that appreciation of this new generation and incorporating them into the industry will enhance the changes required to adapt to new technologies like other sectors are doing.

The construction industry has also begun to seem like other industries where only skilled labourers' is required for most of the work. Only people who can properly run the machines will find employment in the industry, which will be a unique experience. According to the critics of this study, construction workers do not need to be skilled since they are given directions by other professionals. However, this belief is not entirely accurate as machines are taking up the unskilled labourers' workforce and they have proven to be more reliable and do not pose a significant threat to the health and wellbeing of the people carrying out the control activities. Moreover, the transition to new ways of doing things is an implication of a changed generation, and thus the construction industry needs to move in line with these changes.

According to the study by Ye et al. (2013), legal frameworks are headed in the same direction as the incorporation of advanced technology in the construction industry. The frameworks are based on environmental conservation, according to this study; the use of advanced technology minimizes the rates of environmental degradation, leading to the conclusion that advanced technology has the capability of reducing the rates or degrading the

environment at different rates and in different manners. Governments worldwide are working extremely hard at reducing the amount of CO₂ gas being released into their environments (Peng & Bai 2018). The use of advanced technology thus finds its space and support from legal frameworks because it enhances a safe and clean environment for all the members of society involved. The authors further add that governments and other private entities are more likely to support businesses that only apply eco-friendly techniques in their processes. The construction industry is one of the most destructive industries in the world. This happens without trying since most of the processes involved require the emission of substances into the environment. The emitted substances may be harmful to both the construction workers and the people living around the site. The use of different forms of technology reduces the number of harmful substances emitted into the environment by minimizing the use of traditional machines which only rely on non-renewable sources of energy such as petroleum (Huang et al., 2018). Modern advanced technological machines rely on electricity, and they do not emit hazardous substances into the environment. This makes it safe for the workers and the people living in the vicinity of the construction site. However, the construction industry might never be fully eco-friendly because, most of the time, the items used release dust into the air, leading to air pollution (Li, Chalvatzis & Pappas 2018).

2.9.4 Building Information Modelling (BIM) Capabilities

BIM is an integrated technology with borderline intelligence that changes the digital building's representation throughout the project lifecycle (Sacks et al., 2018). Several studies have shown that BIM can perform an essential function of combining risk management throughout the entire project lifecycle from initiation to the closure stage. BIM risk

management capabilities will reduce the problems that may arise from unsafe design, which, on the other hand, leads to lower labourers' productivity (Zou et al., 2017). Zou et al. (2017) also explained the necessity of a formal risk management scheme due to a significant gap in risk management application on construction sites. BIM is expected to have a significant effect on the management of projects; according to Smith and Tardif (2009), BIM's proper implementation would ensure a healthier workplace. BIM is a platform for collaboration and communication with several advantages: faster and more effective service, better design, and higher quality. It has an effect on designers, developers, and health and safety workers, and provides team leaders with the required tools and skills which would enhance project performance.

BIM is a rational system helping early recognition and analysis of risks at the pre-construction and execution stages via a three-dimensional digital representation of a building (Grilo & Jardim-Goncalves 2010), four-dimensional conception of timelines (Zhang & Hu 2011), and five-dimensional budget estimation (Mitchell 2013). Zuppa et al. (2009) reviewed the impact of BIM on numerous project key performance indicators comprising project timeline, productivity, safety, cost, and quality. They noted that BIM has been seen as a tool for photography, coordination, and presentation; however, they realized that BIM had a robust positive effect on the quality, budget, and construction projects' schedule as essential indicators for project success. Choi et al. (2014) developed a system based on BIM application that validates the evacuation of complex and high-rise structures, which allows designers, engineers, and vendors to assess the design and make sure that it fulfils required obligations

before construction starts. The system also provides continuous checking through computerized tools that incorporate specific policies and procedures.

2.9.4.1 BIM and Cloud Technology

Cloud computing is a quickly evolving technology that can be utilized by communication tools such as computers, phones, and tablets. Though the perception of cloud technology was introduced in 2004, knowledge of it has risen since the end of 2007 (Vouk 2008). Mell and Grance (2011) defined cloud computing as a framework for enabling global, suitable, on-demand network access to a shared pool of configurable computing information that can be promptly provisioned and published with minimum management engagement or service provider interaction. Wong et al. (2014) stated that the cloud technology concept is novel to the construction sector, and so there were few scholarly works on it at that time. Moreover, while it is documented in the literature that cloud technology helps enhance collaboration and communication among construction project participants on and off site, the main concern is the complication and costs associated with technological implementation (Wong et al., 2014).

While BIM continues to develop the conventional construction industry practices by providing visualization technology for different design and construction elements (Li et al., 2008, Baldwin et al., 2009, Dunston & Wang 2005, Park et al., 2013 & Wonga et al., 2014), auspicious advancement technologies such as cloud and mobile applications are anticipated to introduce the next stage of technological growth, which would drive the construction sector to the next stage of technological progression (Wang et al., 2013). McGraw Hill Construction (2014) showed that implementing BIM in a construction project improves the collaboration

between the project participants and results in a positive yield on the investment in BIM by decreasing mistakes and oversights. However, BIM has been considered a standalone application that limits project participants' access to a shared amount of data or material (Chuang et al., 2011). Therefore, the evolving cloud technology is perceived as a supporting tool that provides a solution to the traditional standalone BIM approach. It could also lead to better collaboration, coordination, and cooperation, and an efficient concurrent communication system for internal project participants and external stakeholders. Based on the above, it could be concluded that cloud technology can support BIM application to achieve a higher level of its capabilities. Hence, this research will provide an integrated framework between BIM and cloud technology that can be used to improve the level of construction labourers' productivity in building construction projects.

2.9.5 Impact of Advanced Digital Construction Technologies on Labourers' Productivity

Labourers' productivity in other industries experienced a growth of 25 percent within the last decade (Naoum 2016). The construction industry only witnessed an increase of slightly above four percent. The manufacturing sector had the highest percentage, which stands at above 59 percent. Therefore, low labourers' productivity in the construction industry has ignited the need for research by various scholars on improving the issues and the innovations that can be done to ensure this percentage increases to meet the level of other industries. The construction industry is still facing the problem of unmet demands from the customers it serves. According to Kamaruddin et al. (2016), lack of productivity implies hiring more employees, which creates another problem since these employees cannot be retained over a long time. Low productivity makes the construction industry a problematic field to be

competitive compared with other industry. Innovations in technology are the driving power behind high productivity levels in other industries. Most of the modern companies have moved from a manual approach of recording and storing data to the use of cloud technology, where this data can be easily accessed using the right software. The use of paper within some of the firms has reduced to make the industries more agile. Oesterreich and Teuteberg (2016) revealed that the construction industry does not invest in technological advancements as the other sectors do. It is estimated that the sector only spends three percent of its revenue on advanced technology. Companies accept projects that pay less yet take a long period to complete, and some of the projects are significantly higher in terms of the amount they have been budgeted for. Therefore, the construction industry needs to fully adopt new technology methods to ensure that they can make high-quality products through increased productivity.

The use of advanced technology during the construction process simplifies the contractors' work by enabling them to communicate with all the other stakeholders and professionals efficiently (Saieg et al., 2018). The contractor or site manager can gather information through posing questions to workers of different levels and getting their answers. Moreover, they can quickly inform their teams of what is expected of them and receive direct feedback. Technologies that enhance this form of productivity include smartphones and their applications. They also enhance other activities such as sharing of documents; managing the site, collection of data, and at times helps in auto-saving of data. BIM, mobile trackers, virtual meeting platforms, and other tools such as GPS are used to track workers as they carry out their duties. This monitoring ensures that all persons are working under the right circumstances, increasing their opportunity to be productive.

Moreover, these advances can help increase immediate communication and collaboration among stakeholders, decreasing delays and mistakes. The use of clear modelling allows the users to adjust to the building model as quickly as possible and thus can predict the impact that will be created because of cost and labourers. As a result, the designers and the contractors can visualize the different ways in which the building might appear while considering the price and period that will be required in the process. At the end of the process, the team carrying out the project can make better and informed decisions without wasting time. Moreover, it enables the team to stick to the budget and meet the deadline.

Those in charge of supervision can record information about the employees and deliver it to the field office wirelessly. Paperwork is eliminated and this makes the time-sheet approval process a simple one (Sharma & Kumar 2020). The data is then effortlessly incorporated into the firm's primary system, where the errors are reduced, and the inefficiencies involved in paper-based record keeping are eliminated. The use of software solutions to keep track of employees' time data helps the company to save time and cut on costs. Application of technology in the construction site helps the team to meet the documentation and compliance regulations by allowing for timely completion of applications as well as maintain accuracy. For instance, documentation by digital pictures and motion pictures can be kept in electronic software management applications. This software can then be used via an online organizational portal from any mobile device, which ensures that time is saved. Mobile technology such as smartphones, when used together with cloud-based data storage and other management systems, helps improve the workflow efficiency on the job site. Contractors can access ideas, documents, contracts, and important information immediately

from the job site, which decreases the time required to do so which can cause severe delays and allows contractors to avoid costly mistakes.

The use of analytics helps the contractors to determine various issues such as the cost of materials, and the time available, and this allows them to make decisions that are not prone to failure (Borthick & Smeal 2020). Such information is vital in increasing the rate of labourers' productivity as well as work efficiency. Moreover, analytics can be applied to multiply the number of projects that contractors want to deal with. The construction industry also uses the advantage of SEO to gain more clients and increase its income. The rate of productivity via digital technology influences the construction industry in a way that was not experienced before. Establishing the use of technology in business is no longer a choice but a mandatory requirement. Businesses that do not change as soon as possible may not fit the market in the next few years. Currently, contractors and site managers or supervisors can easily see what workers are doing without necessarily attending the field physically; this helps save time and resources such as money used for transport. The act of controlling work remotely is exceptionally time saving and still ensures that each person is productive. Workers can use their mobile phones to call or text each other and give out the recent information to their colleagues. They can also send photos or videos of work being done and what contractors should bring to them.

Use of special applications can also help in work organization, management, and compiling a report to be sent back to the main office (Omar & Nehdi 2016). It improves the rate of labourers' productivity and enhances the accuracy of the work being delivered. Most of this software is cloud-based. Therefore, it enables each person to gain access to the data

remotely without delays. Their study emphasized that the use of technology helps companies to save many hours throughout the year. Technological companies generate other software such as those that can detect clashes and unstable structures; a tool that helps to prevent accidents and thus enhance the safety of employees. Moreover, ordinary people have also embraced the idea of technological advancement in their modern homes, and this is the reason why there is a rise in the number of smart buildings. However, for this to be made possible, companies must accept advancements in technology and be willing to apply them appropriately to their work and make significant contributions to their growth through new inventions. The use of software enhances the transparency and accountability of all workers as information cannot be easily altered once saved in the system. All the professionals working towards a particular project have to be diligent and careful in ensuring that they present work with minimal or no errors.

In recent years, the construction industry has paid detailed attention to technology that enhances efficiency and labourers' productivity (Omar & Nehdi 2016). Technology such as sensors, drones, and GPS is now able to track how the workers move and generate visual maps. Technological advancements also help in the provision of training through the use of AR. Technology is simplifying the processes of training for workers by making it easily accessible and minimizing the risks involved; this aids in the production of a labourers' force that is skilful. Drones have been regarded as one of the greatest of all advancements since they allow for pre-construction evaluation and real-time creation of a map. Companies can use visual updates to change the methods immediately before the matter becomes a safety issue. Moreover, supervisors can locate workers in different places by just turning on the video

instead of going around the site to supervise them. A study by Juszczuk et al. (2015) showed that some companies around the globe, for instance, Skanska USA, are using BIM-integrated GPS wearables to track workers on dangerous job sites and ensure they are safe at all times.

In contemporary society, photos are used as the most reliable form of evidence. Concurrently, smartphones have become easily affordable, giving people the ability to capture an incident using their phone and then identify the places where problems have occurred. Keeping pictures as documents for future reference as well has enabled the collection of different types of information for many companies, and this makes it easy for them to measure the number of incidents that occur in a particular time. Moreover, using smartphones minimizes paperwork, which has enabled companies to have more precise and direct forms of communication and provide quick updates from the construction site, which allows workers to respond to issues immediately, and therefore avoid delays. The presence of technology such as speech-to-text, a camera on smartphones, and automatic formatting has enabled the generation of reports as data is being collected. Time and other resources are then saved and put into more meaningful and productive work. Advancements in technology have improved how different stakeholders can meet and discuss various issues affecting their sections. Apps such as Google Meet, and Skype have been common in this practice. They allow people to meet virtually.

Technology has simplified the concept of remote working, and the global workforce has embraced the idea of mobile working or freelancing. As a result, technology has become essential in the transmission of documents. It has made it easy to move information and documents from one person to another while maintaining traces of these movements (Guo et

al., 2017). Digital information storage is mandatory for better visibility and smooth data collection, which will avoid major mistakes in the field. When less time is spent on writing report, the cost of expenditure is reduced, and savings are increased, making the process more efficient as it improves productivity. Further, the presence of many devices on the job site implies that there is maximum control, and the site is safe for work. Previously, construction companies could not share their work immediately after production due to the absence of adequate means. The designers and other professionals, such as architects, would draw their sketches and present them manually. After sketching, they had to send the manual paperwork to the customer to see it and give their views, which would take some time if they did not live close to each other. However, the emergence of advanced technology has enabled them to receive immediate feedback and send their work in real time.

Construction technology has allowed users to organize information and disseminate it to different departments and share it with their clients (Guo et al., 2017). As a result, the operational model becomes less costly and streamlined, where there is no miscommunication and no change orders. Establishing construction technology implies that companies must make appropriate use of the most current technological tools. The companies can make good use of tools such as 3D imaging to create models that are highly interactive and send clear messages to their clients. Another tool which is currently being used is laser scanning, which works as a foundation for excellent renovations. Advancements can also be utilized to create systems which enable the production of high-quality work at reduced costs. In the past, the construction industry had numerous problems communicating with their clients and different departments. For owners to be sure of what was going on at the site, they would have to

conduct frequent visits. However, the invention of cloud technology has allowed them to get immediate news about their projects in a clear and precise manner; some companies may choose to give step-by-step details of the activities. For instance, three-dimensional sketches and models can be transferred to the clients in actual time for approval, and documents can be processed and shared almost immediately. Most of the innovations in this industry are due to advancements in technology, and the addition of new software developments to different websites has presented new development opportunities. Creativity and innovation culture is one of the fascinating parts of working in the sector recently, and scholars believe it will continue to yield positive outcomes in the future.

2.9.6 Impact of Building Information Modelling (BIM) on Labourers' Productivity

Within the context of this research, BIM is defined as an information-building model that works on a digital demonstration of its material and functional characters. Therefore, it delivers a standard information system by which data can be acquired about the service that shapes a significant foundation for decisions during the project lifecycle from start to end. There is explicit confirmation of the realization of BIM, and it is a positive influence on project achievement – although it is difficult to obtain empirical proof for this. However, a significant number of researchers have increasingly tried to calculate the influence of BIM on project achievement over the past decade. Therefore, this section provides a literature review on the impact of BIM on labourers' productivity.

Bryde et al. (2013) studied the benefits stated by the project team on 35 construction projects that implemented BIM in their operations. They observed that reducing cost and fostering control and timesaving are the biggest advantages of using BIM in construction

projects. They also argued about the possible advantages for project managers in using BIM, such as more efficient coordination and effective communication between project stakeholders. Giel and Issa (2013) examined BIM's return on investment in projects and found that it enabled such projects to avoid the additional costs that could occur due to conflict detection, which means increasing efficiency by reducing changes in the design and preventing additional work during implementation. Suermann and Issa (2009) analyzed the effect of BIM on six primary performance indicators defined by Cox et al. (2003) as the most critical indicators in the construction sector. These indicators are quality management, completion of the project on schedule, expense, health and safety, percentage of finished work, and completion of individual work per working hour. In their conclusion, Cox et al. (2003) claimed that BIM might have a substantial effect on efficiency, quality performance, and project execution, as well as on-time management.

Atul Khanzode et al. (2008) determined fundamental principles for using BIM to coordinate mechanical and electrical works in construction projects. Their findings showed that proper understanding of project scope improves productivity rate from 5 to 25 percent and reduces.

Rework by 0.2 percent of the overall fieldwork hours. Sacks and Barak (2008) examined the impact of BIM on structural engineering works' productivity. They predicted that productivity would rise from 15-41 percent, which relates to the fewer hours used in drawing output. Chelson (2010) identified the leading indicators of BIM's impact on productivity as the amount of information & clarification, request, amount of rework, project schedule adherence, and change orders due to different designs and drawings. Based on the above, it is clear that

some researchers tackled the impact of BIM on productivity for some construction disciplines such as mechanical and electrical. Other researchers studied the impact of BIM on several project performance indicators, including productivity. Hence, this research is designed to tackle the way to improve construction labourers' productivity by using BIM and cloud technology as an integrated approach.

Poirier (2015) conducted a study investigating the impact of building information modelling on collaboration in the architecture, engineering, construction, and operations industry. The author collected data from eight projects; two were non-BIM projects, and the others implemented BIM during the project lifecycle. The researcher established some critical performance indicator criteria to estimate cost predictability for several parameters, such as overall project cost and labourers' productivity. The study's findings showed considerable cost predictability improvement on overall project cost and labourers' cost in the projects that implemented BIM compared with those that had not implemented BIM. In his conclusion, the author stressed that this study required further investigation of different projects as this study was performed on a mechanical contractor. The author further highlighted those future studies on measuring cost predictability as a benefit of using BIM in construction projects are needed. This study provided tangible proof that using BIM in construction projects significantly impacts cost-saving in terms of labourers' productivity. In other words, cost-saving means the actual cost incurred less than budgeted cost or tender cost; this is evidence that using BIM in construction projects could significantly impact labourers' productivity. This impact could be by providing detailed design via a 3D model or comprehensive planning, better collaboration, effective communication, faster decision-making, or coordination between different project

disciplines. The conclusion of this study confirmed those of many previous studies performed on improving construction labourers' productivity. Based on the above, although several studies have confirmed the benefits of using BIM on construction labourers' productivity, there is a shortage of studies proposing a framework that links significant factors affecting labourers' productivity and BIM capabilities. Thus, this research is needed to fill this gap by proposing a conceptual framework for improving construction labourers' productivity by using BIM capabilities.

A study conducted by Teo Ai Lin et al. (2017) aimed to explore the potential of employing BIM to enhance the construction industry's productivity and safety performance in Singapore. The authors interviewed 30 participants from 12 organizations and institutions to establish a baseline of productivity and safety enhancement for the Singapore construction industry. They also collected quantitative data through a questionnaire-based survey from 59 construction companies. The researchers revealed that BIM for productivity enhancement has not been widely utilized compared to BIM for safety improvement. The authors focused their study on the buildability design score given to the project design by the Building Construction Authority (BCA) of Singapore. The BCA can provide a score for each project to ensure fewer hazards during construction and avoidance of risk to ensure better project productivity rate, and therefore the government ensures improvement at the construction sector productivity level. The study proposed a framework comprising BIM with safety and productivity for structures, walls, and other design systems. The authors also provided a set of scoring criteria for each element in the design, and, by using this model, the design buildability score can be automatically generated. The study further provided a model for productivity to identify and

mitigate risk. The authors claimed that, by using this model, construction practitioners would be able to identify and mitigate potential risks early during the design stage, and therefore they can ensure that the productivity rate is enhanced during execution. Moreover, Teo Ai Lin et al. (2017) study provided a considerable contribution to the industry whereby their proposed approach will be very beneficial for governments to encourage contractors to use BIM in their projects and identify potential design risks before execution. However, the authors did not consider linking their model to the most significant factors affecting construction labourers' productivity or provide a set of guidelines for construction practitioners on how they can use BIM to improve each of those main factors affecting labourers' productivity. Hence, the gap between identifying the relationship between using BIM in construction projects and construction labourers' productivity rate and a model for improving construction labourers' productivity rate by using the BIM capability remains. Therefore, this research aims to provide an empirical study to investigate the significant factors affecting construction labourers' productivity and propose a model for improving construction labourers' productivity by using BIM.

Hwang et al. (2019) carried out a study on the impact of BIM on rework in construction projects in Singapore. The study suggested a set of policies that can assist prevent rework in projects with BIM implementation utilizing a fuzzy established theory-based model. The research also found that projects with BIM implementation incurred fewer design errors and fewer changes during execution. As a result of this study, the researchers proposed strategies to use BIM in construction projects to reduce rework. They stated that using BIM during the design and construction phase for design reviews, verifications, and audit to decrease system

mistakes and rework tracking system to avoid repetitive future rework would reduce the amount of rework in the project, and therefore improve project cost and time parameters and optimize project delivery.

Mesároš et al. (2020) conducted a study on the use of BIM technology and its influence on construction project management productivity. The study aimed to deliver a review of present research on BIM development and its application in the infrastructure sector. The study concluded that, when BIM is first implemented, project members might reject it; however, acceptance levels start to increase after they receive the necessary training. The researchers' finding confirmed that BIM has a real positive impact on construction labourers' productivity. Moreover, Wong et al. (2020) conducted a study assessing the effect of BIM on the labourers' productivity of construction projects in Malaysia. The researchers focused on BIM-related factors affecting labourers' productivity in architecture engineering and construction projects in Malaysia. They surveyed 103 participants from different employment levels. They concluded that the positive impact of BIM on labourers' productivity is much greater than the negative impact. It has been observed from this study that the researchers tackled only factors affecting labourers' productivity that are BIM-related, as they claimed. Their conclusion provided a formalization of the hypothesis that BIM implementation in construction projects positively impacts labourers' productivity. The study confirmed the importance of using BIM to improve labourers' productivity.

Quiso et al. (2021) recently studied the application of integrating concurrent engineering and BIM to improve productivity in construction. The authors surveyed family building construction projects in the city of Lima, Peru. They identified seven causes of low

productivity, namely: project complexity, lack of management, ineffective communication, using old systems, lack of innovation, equipment failure, and lack of labourers' skills. This study's outcome was a flowchart of applications of integrated concurrent engineering (ICE) and BIM. The authors further proposed an ideal processes scheme table that illustrated the causes of low productivity as input, and, by using their proposed methodology, the output becomes the low impact of those causes of low productivity. This study proposed a methodology that could be understood as process reengineering for a virtual design and construction approach using integrated concurrent engineering and BIM to improve productivity in the construction industry. However, the researchers used very few projects to collect their data; they did not pay attention to the international journals concerning significant factors affecting labourers' productivity; they concentrated on a virtual design and construction approach; and they did not provide a framework to show the relationship between BIM capabilities and significant factors affecting labourers' productivity. Therefore, their study could be considered very localized research and cannot be generalized. Hence, this research is intended to fill the knowledge gap in using BIM capabilities integrated with cloud technology to improve construction labourers' productivity in building construction projects.

Additionally, Quiso et al. (2021) stressed that much effort and research is still required in the future to precisely, effectively, and realistically appraise the impact of BIM on construction labourers' productivity. The study neither proposes a model nor framework of using BIM to improve construction labourers' productivity, nor does it provide any recommendations for integrating BIM with other digital technologies to strengthen the BIM capabilities related to significant factors affecting construction labourers' productivity. Hence,

this research aims to fill this knowledge gap by proposing a framework for improving construction labourers' productivity using BIM and cloud technology as advanced digital construction technology.

2.10 Comparison of Studies Identified in the Literature

Numerous literatures were found about factors affecting construction labourers' productivity with different findings and different conclusion presentations. Thus, the researcher in this section provides a literature review in the form of comparing several studies across the world. Hence, Table 2.3 below shows a comparison between studied literatures on the most significant factors affecting construction labourers' productivity. The information provided in the table comprises the country where the study was performed, author/authors, the number of factors affecting construction labourers' productivity identified by the author/s, factors group indicating how the author/s classified the factors into different groups, and the set of significant factors indicated in that study.

Table 2. 3*Comparison of Studies Identified in the Literature*

Country	Author(s)	Number of factors	Factors group	Significant factors affecting labourers' productivity
USA	Dai <i>et al.</i> (2007)	83	Supervision factors, communication factors, health and safety factors, tools factors, material factors, design management factors, human factors, site management factors, superintendent factors, project management factors and equipment.	Tools and equipment availability, shortage of material, rework, poor planning, delay of work inspection, poor site management, absenteeism, supervisors' relocation, project team competences
	Dai & Goodrum (2011)	83		Design mistakes, inadequate supervision, poor site management, poor planning, availability of facility, tools and equipment availability
UK	Yi & Chan (2014)	N/A		Project funding, site management, project planning, government regulations and labourers' contracts
	Naoum (2016)	46		Design mistakes, labourers' experience, project planning, construction method, effective communication, site management, procurement management, material management, lack of proper project information system
Malaysia	Abdul Kadir <i>et al.</i> (2005)	50		Material availability, payment delay, variations in orders, poor site management, inadequate supervision, rework, late issuance of workshop drawings, poor planning, lack of design coordination, coordination between contractor and

				subcontractor
	Ohueri <i>et al.</i> (2018)	14		Lack of proper site management, lack of supervision, lack of incentive scheme, lack of training and development, shortage of tools and equipment, lack of recognition and award programme, lack of labourers' commitment, ineffective communication, weather condition, and health and safety
Thailand	Hickson & Elli (2014)	42	Management factors, Technological factors, Human factors and Exogenous factors.	Lack of supervision, impractical schedule, lack of labourers' experience, inadequate site management. information sharing, delay of payment, ineffective communication, lack of proper management, lack of leadership skills, rework and weather condition
	Porntepkasemsant & Charoenpornpattana (2014)	16		Workers lack experience and skills, absenteeism, payment problems, delay of work inspection, incomplete design, lack of incentive scheme, shortage of material, rework, inadequate site management, and technology
Palestine	Enshassi <i>et al.</i> (2007)	45	Labourers' factors, leadership factors, motivation factors, time factors, tools and equipment factors, supervision factors, project factors, health and safety factors, quality factors and exogenous factors	Shortage of material, inadequate labourers' experience, lack of labourers' monitoring, lack of effective communication between labourers's and supervisors, design changes during execution, payment deferment, delay of work inspection, labourers' commitment, long working hours, and shortage of tools and equipment
	Mahamid (2013)	31	Human factors, Management factors, Environmental factors, Equipment and	Labourers' skills and experience, labourers' commitment, inadequate coordination ,inappropriate scheduling,

			equipment factors and financial factors.	inadequate site management, site logistic plan, payment delay, shortage of materials, shortage of equipment and poor planning
UAE	Ailabouni <i>et al.</i> (2007)	42	Organizational factors, Group factors, Environmental factors, and Group factors.	Overtime, health and safety, payment delay, weather condition, construction method, inadequate project management, shortage of material, project complexity, lack of incentive, lack of supervision
	Singh (2010)			Payment delay, experience and skills problem, project planning and scheduling, training, supervision, shortage of material, stakeholders' coordination and material production
Nigeria	Odesola & Idoro (2014)	15		Ineffective supervision, rework, lack of experience, and insufficient skills
India	(Thomas & Sudhakumar, 2013)	44	Tools and machinery factors, labourers' factors, supervision factors, site management factors, design and engineering factors, leadership factors, communication factors, teamwork factors, planning factors and human factors	Shortage of tools and material, incomplete drawings, shortage of equipment, poor project management, management of material, ineffective communication, payment delays, lack of award scheme, lack of supervision
	Dixit & Saurabh (2019)	27		Poor project planning, unclear scope of work, lack of coordination, contractual disputes, design variations, construction method, labourers' skills, payment delay, inappropriate working schedule and ineffective supervision.
	Yi & Chan (2014).	34	Material factors, Organizational factors, Technological factors, Human factors and	Lack of material, shortage of tools and equipment, material delivery, payment delay, communication between labourers'

			Exogenous factors.	and supervisor, poor site management, inadequate planning and scheduling, lack of labourers' skills and experience, unclear project specification, and lack of design coordination.
Qatar	Jarkas <i>et al.</i> (2012)	35		Lack of material, inadequate supervision, lack of labourers' skills and experience, site management, leadership, weather condition, subcontractor involvement, site logistics planning
Australia	Hughes & Thorpe (2014)	47		Shortage of material, lack of supervision, rework, preliminary construction drawings
	Nasirzadeh <i>et al.</i> (2022)	26		Shortage of material, method of construction, shortage of tools and equipment, management of material, labourers' commitment, lack of labourers' experience, lack of training, ineffective communication, labourers' contract, and change orders
Saudi Arabia	Choudhry (2015)	31		Effective communication, lack of skills, lack of experience, project financing, and health and safety
Turkey	Kazaz <i>et al.</i> (2008)	37	Management factors, Economic factors, Physical factors, and Emotional factors.	Management of material, ineffective site management, lack of supervision, site plan, project planning, payment delay, design mistakes, lack of incentive scheme, labourers' commitment, and health and safety
Jordan	Hiyassat <i>et al.</i> (2016)	23		Lack of workers' experience, management of machinery, planning, communication, technology, labourers' training

	Bekr (2016)	37	Labourers' factors, technical factors, Project factors, financial factors and Equipment and tools factors.	Inadequate planning and scheduling, shortage of material, shortage of tools and equipment, lack of labourers' experience, inadequate site management, rework, lack of supervision, delay of payments, delay of work inspection, and variations
Yemen	Alaghbari <i>et al.</i> (2017)	52	Human factors, Management factors, Technical and technological factors and Exogenous factors.	Lack of labourers' skills and experience, shortage of material, weak site management, ineffective communication, subcontractor management, inefficient leadership, shortage of material, incomplete construction drawings, variation orders, and unclear project specification.
Nepal	Palikhe <i>et al.</i> (2019)	30	Labourers' factors, Material factors, Project management factors and Technological factors.	Management of material, payment delays, lack of labourers' skills and experience, lack of incentive scheme, shortage of tools and equipment, inadequate leadership, inadequate supervision, unclear project specification, design changes, and rework.
Lithuania	Shoar & Banaitis (2019)	27		Payment delay, rework, poor planning and scheduling, poor

				site management.
Egypt	El-Batreek <i>et al.</i> (2013)	45		Shortage of material, labourers' recognition, health and safety, shortage of tools and equipment, incomplete drawings, absenteeism, site layout, stakeholders coordination, site logistics, and communications.
	M. Hafez (2014)	27	Technological factors, Human factors, Management factors and Exogenous factors.	Unclear project specifications, shortage of material, poor site management, labourers' skills and experience, inadequate supervision, poor planning, lack of leadership, lack of design coordination, delay of payment, and method of construction.
Oman	Jarkas <i>et al.</i> (2015)	33	Labourers' factors, Technological factors, Management factors and External factors.	Design mistakes, variation orders, inadequate supervision, delay of information, unclear specifications, coordination between various design aspects, long working hours, rework, weather condition, poor planning and scheduling.
Cambodia	Durdyev & Mbachu (2017)	36	Site management factors, Exogenous factors, Workforce factors and Resources factors.	Inadequate leadership, inadequate planning and coordination, poor method of construction, lack of proper communication plan, site overcrowding, poor health and safety measures, shortage of tools and equipment, lack of supervision, and low deployment of resources, and variations.

Bahrain	Jarkas (2015)	37	Management factors, Technological factors, Human factors and Exogenous factors.	Design coordination, work overtime, shortage of material, poor supervision, design mistakes, site management, delay of inspection, rework, lack of incentive scheme, and weather condition.
Kuwait	Jarkas & Bitar (2012)	45	Management factors, Technological factors, Human factors and Exogenous factors.	Unclear project specification, change orders, design coordination problems, insufficient supervision, subcontractor involvement, leadership style, inspection delay, lack of proper communication, and information sharing.

Note. Author (2023)

As a part of this section, the author summarized the findings from the studies that have been reviewed on advanced digital construction technologies in the form of a comparison discussion. For instance, Tay et al. (2017) asserted that it is a computer-controlled sequencing layering of materials to create shapes in a three-dimensional order. This technology is commonly used in the construction of complex buildings that require geometrically complex elements. Jiang et al. (2019) argued that, in modern times, the essential resource in the construction industry is data. Bilal et al. (2016) stated that big data can also be kept in the Building Information Modelling (BIM), which helps when information on maintenance is required. The construction industry was also set to benefit from the innovation of artificial intelligence (AI) and machine learning (ML), where Artificial Intelligence (AI) entails creating machines and programming them to function like human beings. Zhou, Goh and Li (2015) also supported the idea that AI reduces the amount of time wasted by workers and improves productivity. Ghosh, Edwards and Hosseini (2021) explore using the Internet of Things (IoT) in the construction industry, which refers to technological devices that can transmit data to one another and can easily be controlled from one central location. The authors explained that the main problem that has hindered the use of robots is the construction site itself, as robots are good at carrying out repetitive work under a controlled environment. The authors also explained that drones are useful in enhancing the site's security when they are fixed with a camera; they can guide the site manager to identify threats to safety without the manager being present. Drones are also an essential tool of delivery in that they can be used to bring different materials to the site, thus reducing the number of vehicles in use, which is cost-efficient. A study by Ahmed (2019) suggested that the work that VR can do is enormous and may not be precisely quantified with relation to the construction industry. VR helps the

construction professionals as well as the client to have a view of the final product even before it is commenced. Turk and Kline (2017) acknowledged that blockchain technology has widely affected the activities of the construction industry.

2.11 Key Research Problems Identified from the Reviewed Literature

From the above literature reviewed, it was found that there was numerous research on factors affecting construction labourers' productivity. However, Antunes and Gonzalez (2015) stated that the construction industry's low labourers' productivity phenomenon had ignited the need for research by various scholars to improve the issues and the innovations that can be done to ensure construction productivity increases meet the level of other industries. Moreover, according to several past and recent literatures that the researcher has examined in this literature review chapter, there is a shortage of studies on factors affecting construction labourers' productivity in the UAE. Therefore, the researcher specified objective number two of this study to fill this gap by identifying significant factors affecting construction labourers' productivity in building construction projects in the UAE.

Moreover, it was also observed from the reviewed literature that alignment of labourers' productivity factors and the use of advanced digital construction technologies abilities had not been extensively examined. Very few of the studies discussed the method for improving construction labourers' productivity. Even studies that did tackle this subject merely mentioned some suggestions and recommendations without proposing a specific model for improving construction labourers' productivity. It was also noticed that most of the previous studies dealt with construction labourers' productivity as a separate variable, without considering other variables that could have a positive impact on improving the construction

labourers' productivity rate, such as using advanced digital technologies during execution. The review of previous literature on advanced digital construction technologies illustrated a wide range of digital technologies available in the construction market with very high capabilities in different construction disciplines. However, these studies neither address a particular framework for these technologies together so that construction projects can benefit from all their capabilities in one application form nor discuss a model of using some of these technologies to enhance construction labourers' productivity. Thus, this research proposes a model comprised of labourers' productivity key determinants and advanced digital construction technologies.

2.12 Chapter Summary

As established in this chapter, the construction sector is a key contributor to nations' economy globally. Construction labourers' productivity is an essential component in project success; it is the key to optimizing project delivery: several factors, organizational, technological, human, and external, affect construction labourers' productivity. Among the 42 factors identified from 34 pieces of literature covering 21 countries, the most significant factors affecting labourers' productivity are: inadequate supervision, lack of labourers' skills and experience, poor planning and scheduling, poor site management, shortage/management of material, payment delay, ineffective communication, shortage of tools and equipment, rework, lack of design coordination, and variations during execution. Extensive pieces of research have been conducted on factors affecting labourers' productivity. The construction sector is still facing labourers' productivity problems, and the industry has one of the lowest productivity levels of all industries. Studies on improving labourers' productivity are

continuously needed – no specific framework is proposed by the previous studies to improve construction labourers' productivity.

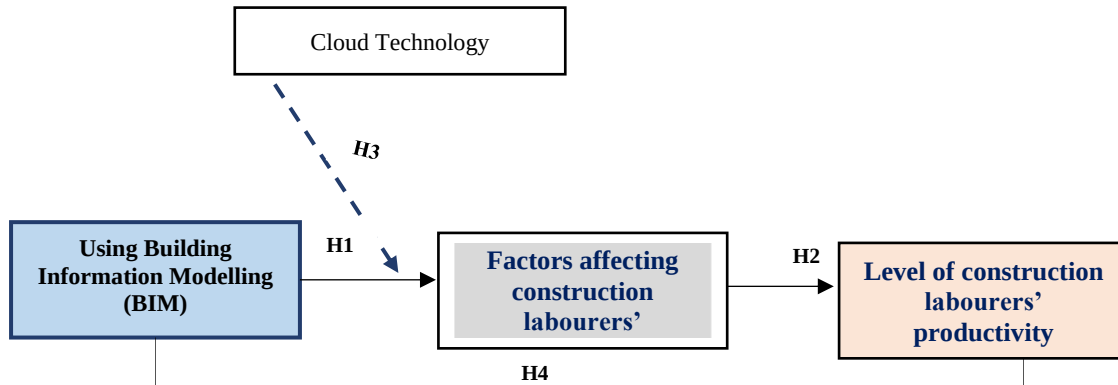
Chapter 3 : Proposed Conceptual Framework

3.1 Introduction

This chapter summarises the vital components for this research as appraised in the literature review chapter. The chapter details the main variables and their theoretical relationship, and provides the theoretical view of the study constructs, and the research's proposed conceptual framework and hypothesis. Miles and Huberman (1994) described a conceptual framework as a graphical or written product, one that “explains, either graphically or in narrative form, the main things to be studied—the key factors, concepts, or variables the presumed relationships among them”.

3.2 Research Conceptual Framework

Based on the literature review, this research study proposes a conceptual framework that illustrates the relationship between using advanced digital construction technologies (BIM and cloud technologies) and the level of construction labourers' productivity. The conceptual framework proposed that factors affecting construction labourers' productivity mediate the relationship between using BIM and the level of construction labourers' productivity, and cloud technology moderates the relationship between using BIM and the factors affecting construction labourers' productivity. Accordingly, the four main hypotheses were developed and are further discussed and examined in the next chapters.

Figure 3. 1*Theoretical Framework***3.2.1 Hypotheses**

H1: There is a direct relationship between using Building Information Modelling (BIM) in construction projects and factors affecting construction labourers' productivity.

H2: Factors affecting construction labourers' productivity mediate the relationship between using Building Information Modelling (BIM) in construction projects and the level of construction labourers' productivity.

H3: Cloud technology moderates the relationship between using Building Information Modelling (BIM) in construction projects and factors affecting construction labourers' productivity.

H4: There is a direct relationship between using Building Information Modelling (BIM) in construction projects and the level of construction labourers' productivity.

3.3 Theoretical Coherence

3.3.1 Theoretical View of Construction Labourers' Productivity

Several theories in the literature identify the factors that impact labourers' productivity in the construction sector. One of these is the personal construct theory (PCT) (Nurhendi, Khoiry & Hamzah 2019). The founder of the theory, George Kelly, specified that an individual's procedures are emotionally channelized by the mediums in which s/he anticipates the events. It specifies that people enlarge their encounters in daily life make sense of them and indicate the outcomes. In addition, table 3.1 below by Nurhendi *et al.* (2019) illustrates the result of interviews with construction workers with different job experiences, identified the differences between a good project and a bad project that integrate several factors that affect labourers' was considered as reference on this research.

Table 3. 1

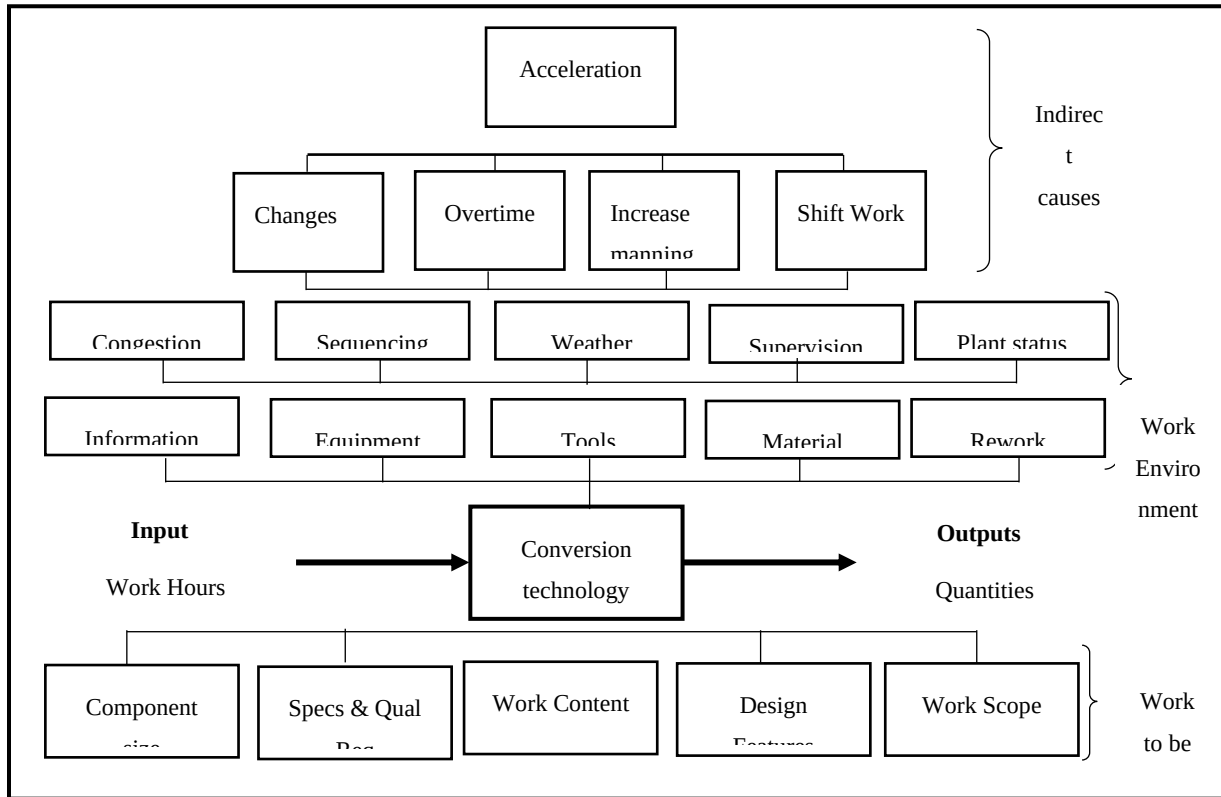
Projects with High Productivity Vs. Projects with Low Productivity

Well-thought out, realistic plan	Poor planning, inexperienced planner
Building design that enables the use of trade skills	Repetitive, simple design that uses very few or no trade skills
Good communication between senior management and operatives	Them and Us attitude between senior management and operatives
Training investment	Lack of training

Experienced staff	Inexperienced staff
High staff morale	Low staff morale
Good welfare	Little or no welfare
Experienced and self-motivated site manager	Inexperienced site manager
Site near to home	Site far away from home
Job security and retention of staff	Subcontractors

Note. Nurhendi et al. (2019)

Moreover, Thomas and Yiakoumis' (1999) factors model of labour construction productivity shown in Figure 3.2 below identifies the key variables affecting construction labourers' productivity. Thomas and Yiakoumis stated that work type, physical element, construction method, and design requirements were the major factors that negatively affect labourers' productivity. By reducing or eliminating them from overall labourers' productivity, the construction project's labourers' productivity rate would increase. Thomas and Yiakoumis' model indicates that, by using conversion technology, the impact of the factors on the input would be reduced and therefore the output would be increased. Hence, their model proposed using conversion technology as a mediator between the input and the output.

Figure 3. 2*Factors Model of Labour Construction Productivity*

Note: Thomas & Završki (1999)

Additionally, the base of the conceptual framework is another theory linked to the factors influencing labourers' productivity. The Herzberg Two-Factor Theory (1959) specifies that hygiene and motivation factors influence worker productivity. Hygiene factors are linked to financial rewards such as working conditions, work-life balance, competitive salary, etc. On the other hand, motivation factors are associated with non-financial rewards, such as training and development, recognition, and empowerment. Accordingly, while evaluating the solutions to these issues affecting labourers' productivity, some literature identifies the solution based

on the technology (Alshmemri, Shahwan-Akl & Maude 2017). Various studies have identified that the latest technologies could be used to improve labourers' productivity. The conceptual model was also aligned with the technologies that facilitate increased labourers' productivity. For example, Craveiro et al. (2019) defined the concept of the 4th construction revolution as a transformation of the construction sector. It ranges from automated manufacturing to an increased level of digitalization, involving a BIM system linking virtual and actual buildings. BIM is aligned with AR and improves decision-making. It enables the construction players to visualize how building design is incorporated on site before actual construction. In addition, it helps to manage conflicts and provides an overview of the structural safety issues during construction. Building performance is optimized by assisting with building performance simulation and energy efficiencies. In addition, the 4th Construction Revolution is aligned with the integration of cloud computing with BIM, which helps project managers to work in real time while located in different areas of the world. Moreover, IoT, drones, and RFID are the technologies that make construction smart and increase labourers' productivity.

Craveiro et al. (2019) identified the outcomes of the digital technologies in the construction sector that are based on the Technology Acceptance Model (TAM). The theory entails that the stakeholders in any company use advanced technologies due to their perceived usefulness and ease of use (Hong & Yu 2018). For instance, Ahmed (2019) stated that 4th Construction technologies like VR help companies train their workers before initiating a construction project. Also, digital technologies ensure safety management, defect and quality management, and visualization, which ultimately increase performance and labourers' productivity in the construction sector. Below are further details of the key aspects of the

conceptual framework. Therefore, the main theories for this this research study are personal construct theory (PCT) by Nurhendi et al. (2019), Factors Model of Labourers' Construction Productivity by Thomas and Završki (1999), as shown in Figure 3.2 above, and the concept of 4th Construction Revolution by , Craveiro et al. (2019) In addition, several seminal articles were also considered as a base for this research study, such as Enshassi et al. (2007), Jarkas and Bitar (2012), Alaghbari et al. (2017) and Yi & Chan (2014).

In reference to the above-mentioned theories, and specifically to Thomas and Yiakoumis's theory, which stated that work type, physical element, construction method, and design requirements were the major factors that affect labourers' productivity by reducing or eliminating them from overall labourers' productivity, the construction project's labourers' productivity rate would increase and further to and Nurhendi *et al.* (2019) table above. In section 3.3.2, the researcher listed the factors impacting construction labour productivity identified from the literature review and grouped them based on the same category of factors used in this study. The main three variables are construction management factors, project management factors and technical management factors. Using advanced technology such as BIM could eliminate or reduce the effect of factors impacting construction labour productivity (Thomas & Završki 1999) and (Nurhendi *et al.* 2019).

Factors affecting labourers' productivity

It has been observed that extensive studies have been performed about construction labourers' productivity (Gopal & Murali 2015, Nyoni & Bonga 2016 & Ghate, More & Minde 2016). Numerous theories have been advanced by various scholars in the last four decades to improve labourers' productivity in the construction industry. However, most of these theories

are all built on one leading theory by Thomas and Završki (1999). Table 3.2 below demonstrates the theoretical overview of factors affecting construction labourers' productivity and their grouping (Enshassi et al., 2007, Jarkas & Bitar 2012, Alaghbari et al., 2017 & Yi & Chan (2014).

Table 3. 2

The Theoretical Overview of Factors Affecting Construction Labourers' Productivity

Serial Number	Factors that cause low construction labourers' productivity	References
1.0	Construction management factors - Lack of labourers' supervision - Poor construction method - Inspection delay - Site congestion - Lack of health and safety - Crew size - Poor site management - Work sequencing problems. - Lack of appropriate temporary facilities - Unavailability of material on time at the site - Management of material delivery and storage - Shortage of tools and equipment - Lack of on-time equipment repair	Naoum (2016), Nasirzadeh <i>et al.</i> (2022), Odesola & Idoro (2014), Palikhe <i>et al.</i> (2019), Yi & Chan (2014),
2.0	Project management factors - Lack of training and development programme - Lack of leadership - Inadequate project planning and scheduling - Subcontractor involvement - Lack of appreciation for valuable workers - Ineffective communication	Nasirzadeh <i>et al.</i> (2022), Dixit & Saurabh (2019), Durdyev & Mbachu (2017), Hiyassat <i>et al.</i> (2016), Jarkas <i>et al.</i> (2015), Kazaz <i>et al.</i> (2008), M. Hafez (2014), Mahamid (2013), Naoum (2016), Yi & Chan (2014),

	- Delay of response to the request for information by the engineer - Slow decision-making process - Payment delay - Lack of incentive scheme	
3.0	Technical management factors	Nasirzadeh <i>et al.</i> (2022), Hickson & Elli (2014), Hughes & Thorpe (2014), Jarkas (2015), Jarkas <i>et al.</i> (2015), Odesola & Idoro (2014), Palikhe <i>et al.</i> (2019), Porntepkasemsant & Charoenpornpattana (2014) & Shoar & Banaitis (2019).
	- Change orders during execution - Rework - Lack of design coordination - Design buildability - Unclear technical specification - Inappropriate site layout - Drawing mistakes - Design mistakes	
4.0	Human resources management factors	Enshassi <i>et al.</i> (2007), Jarkas (2015), Jarkas & Bitar (2012), Jarkas <i>et al.</i> (2015), M. Hafez (2014)
	- Inadequate labourers' skills and experience - Lack of supervisor experience - Work overtime - Absenteeism - Labourers' transportation - Fatigue - Accidents - Low wages	
5.0	External factors	Enshassi <i>et al.</i> (2007), Jarkas (2015), Jarkas & Bitar (2012), Jarkas <i>et al.</i> (2015), M. Hafez (2014)
	- Weather condition - Delay in authority approvals	

Table 3.2 above shows details of factors affecting construction labourers' productivity and their grouping concept.

3.3.2 Theoretical View of Advanced Digital Construction Technologies

Research carried out by Ansah and Sorooshian (2018) shows that the construction industry has been criticized for an extended period over its inability to implement technologies. Since Roman times, construction has witnessed minimal changes in the techniques and methods used. The projects involved in construction are usually varied, and each site has its unique requirements. The construction industry consists of frequent relocation of both the workers and machinery, which interferes with the application of advanced technologies since different weather conditions and other environmental factors may hinder previous methods. Bilal et al. (2016) further defined the term advanced technology in the construction industry as a comprehensive range of modern methods, techniques, and activities that entail the newest development in material technology, facility management, structural analysis, quantity surveying, design processes, and services. In their study, Bilal et al. (2016) suggested that integrating advanced technology in the construction industry ensures high-quality work, safety and sustainability. Advanced technology also enhances the value for money and increases the rate of efficiency at work. The study also indicates that different types of technology have found their place in the construction industry. These technologies include LiDAR, material advancements, BIM software, mobile technologies and drones, building information technology, virtual reality, wearable AR, artificial intelligence, three-dimensional printing, and other equipment discussed in this review. Based on the above and further to the comprehensive literature review provided by the researcher in Chapter two of this study, a theoretical overview of several advanced digital construction technologies and their capabilities is summarized in Table 3.3 below.

Table 3. 3*Theoretical Overview of Advanced Digital Construction Technologies*

Serial number	Digital Construction Technologies	References	Capabilities
1	LiDAR A tool that has sensors that are mounted on construction equipment used in light detection and ranging and can scan the surrounding work areas and produce 3D images of high resolution.		Work can be performed from a long distance, reducing the chance of any of the workers getting hurt. Take clear photos of the site and pinpoint where any correction type is needed, thus creating enough room for improvement.
2	Building Information Modelling (BIM).	Ahmed (2018)	Architecture, engineering, and other construction professionals can quickly design, plan, and change building structures to fit their needs. Enhance site management.

Collaboration among the different professionals to contribute to the construction process's various stages.

Review of the project progress and the functional outcomes in real time.

Changes can be made clear immediately.

Essential in making sure that each individual is working with the updated design at all times.

Every stage of the construction is efficiently planned by all the members at individual rates since visual presentations allow for integrated work.

			Most VR is using BIM to make the environment being observed. Through AR, the construction manager or the contractor views the model and compares it with the building being made to see whether their work is of standard quality and as per technical specifications. The contractor can also attend to the building's daily checklist and compare the required work with completed activities.
3	Drones	Ghosh and Edwards (2021), Karimi and Walter (2015) and Chen <i>et al.</i> (2017)	Drones are useful in enhancing the site's security when they are fixed with a camera; they can guide the site manager to identify threats to safety without the manager being present. An essential delivery tool can be used to bring different materials to the site.

			Drones can quickly inspect a construction site and identify any problems on site on a specific day. Drones are also useful in monitoring workers during the day and ensuring that they are carrying out their task as expected and they are all working in a safe environment. Drones can take photos as the work continues to keep everyone posted on the different activities.
4	Virtual reality	Ahmed (2019) and Hickman et al. (2018)	VR helps the construction professionals and the client view the final product even before it is commenced. VR provides collaboration among the different professionals to analyse a finished product and know what needs to be improved and how.

			VR ensuring there are no potential risks during the building and after the full process has been completed.
			Virtual Reality (VR) is believed to be one of the tools that enhance on-site safety.
			VR can train workers on the operation of cranes.
5	Augmented Reality	Noghabaei et al. (2020) and Awolusi et al. (2018)	AR can promote worker safety.
			AR allows for the creation of plans to enhance security.
6	Artificial Intelligence	Bilal et al. (2016), Pillai and Matus (2019) and Zhou, Goh and Li (2015)	Artificial Intelligence (AI) entails creating machines and programming them to function similar to human beings.

It helps in the reduction of operation costs and enhances efficiency.

Using AI can provide better financial management strategies due to the available labourers's predictability and the highly reliable nature of this labourers.

AI can analyse historical information and predict unusual costs and achievable timelines, which helps the respective company to only focus on what is beneficial to the company and the client.

AI helps workers to make well-informed decisions, which is a crucial element in increasing the rate of productivity.

			AI reduces the amount of time wasted by workers and improves productivity.
7	Three-Dimensional Printing	Tay <i>et al.</i> (2017)	The printer can read and lay down the required printing layers, which can be in a solid, liquid, or powder state depending on the specifications. The layers are joined to create the required object.
8	Computer-Aided Manufacturing (CAM)	Tay <i>et al.</i> (2017)	CAM can produce mechanical components that closely match the original design.
9	Big Data	Jiang <i>et al.</i> (2019)	Big data is used to give out historical information on the patterns and procedures used in particular construction sites to develop the best knowledge on carrying out a specific task without repeating the same mistakes for better outcomes. Big data from sources that explore the weather also helps constructors to determine the phasing of a construction site to avoid damage due to weather issues.

10	Machine Learning (ML)	Bilal <i>et al.</i> (2016)	Machine learning (ML) is a section of AI where statistical strategies are used to give a machine data and enable it to synthesize this data to work as a human with minimal control.
11	The Internet of Things (IoT) technological devices that can transmit data to one another and can easily be controlled from one central location	Ghosh, Edwards and Hosseini (2021)	IoT can ensure that there is a high rate of efficiency and safety. IoT is also known for its enhancement of workers' management; for instance, footfall can be tracked on site, and the applications can be used in checking workers in and out and inducting them.
12	Robots	Ghosh, Edwards and Hosseini (2021) and Tanie (2019).	Robots can handle tasks such as bricklaying and masonry work. Robots can destroy structural components at the end of a project.

Robots can perform tasks such as installing drywalls without the help of real humans.

Robots can complement human labourers', which remains the essential resource in this industry.

- | | | | |
|----|--|------------------------------------|---|
| 13 | Robot Swarms
(a collection of many tiny robots working together like insects) | Ansah and Sorooshian (2018) | Robot swarms are highly advantageous as they can reach places the workers may not be able to access, and construct features that humans would not be able to do with their own hands. |
| 14 | 5G and Wi-Fi 6 | Ghosh, Edwards and Hosseini (2021) | It supports significant data transfer and enhances speed. |
| 15 | Blockchain Technology | Turk and Klinc (2017). | Blockchain technology helps the construction industry establish smart contracts since it helps implement contract generation's error-free procedure. |
-

16

Cloud Technology

Bilal *et al.* (2016) and
García De Soto et al.
(2018)

It helps contractors to engage themselves in truthful relations with their clients.

Cloud technology enables people to access data stored in remote servers by using various software applications.

It allows for data sharing from one site to other entities related to the construction work going on at the exact same time, allowing for a real-time response from the respective sections.

Cloud technology enables the restoration of data as well as necessary changes and modifications.

It is, moreover, compiling a report to be sent back to the main office.

			It allows the clients to get immediate news about their projects in a clear and precise manner.
17	Wearables (such as hard hats, gloves, and safety vests) fitted with different sensors.	Tanie (2019 and Awolusi <i>et al.</i> (2018)	Wearables can monitor the location, movement, and temperature of the worker. The tool can also warn that a specific worker has fallen and call for emergency services to attend to such cases. Wearables provide information on workers while they continue with their jobs.
18	Smartphone Technologies		Smartphone technologies such smart mobile phones have simplified communication, which has led to simplified collaboration processes. This enhances how meetings are conducted.

It saves time which would have been wasted if mobile technology was not applied.

Smartphone technologies can faster communication between various project team members.

3.3.3 Connection between Advanced Digital Construction Technologies and Construction Labourers' Productivity

As illustrated in Table 3.2, there are 42 factors affecting construction labourers' productivity classified into five groups: construction management, project management, technical management groups, labourers'/human group, and external group. Moreover, as per Table 3.3, 18 advanced digital construction technologies were identified that could play an essential role in enhancing construction labourers' productivity and construction project delivery. However, to make this study more valuable and due to the research limitations, the researcher focused on the significant group of factors affecting construction labourers' productivity and the most important advanced digital construction technologies that could positively impact construction labourers' productivity. Hence, the proposed conceptual framework has captured the critical technologies and linked them to the significant group of factors affecting labourers' productivity.

The use of advanced technology during the construction process simplifies the contractor's work by efficiently communicating with all the other stakeholders and professionals (Saieg et al., 2018). The contractor or site manager can gather information by posing questions to workers of different levels and getting their answers. For instance, BIM helps to increase effective communication and collaboration among stakeholders and decreases delays and mistakes. Moreover, by using BIM visualization features, contractors and site managers or supervisors can easily see what workers are doing without necessarily attending the field physically; this helps save time and resources. Visualization with cloud technology can provide live progress reports to the senior management, which may result in faster decision making and minimal disruption to construction activities.

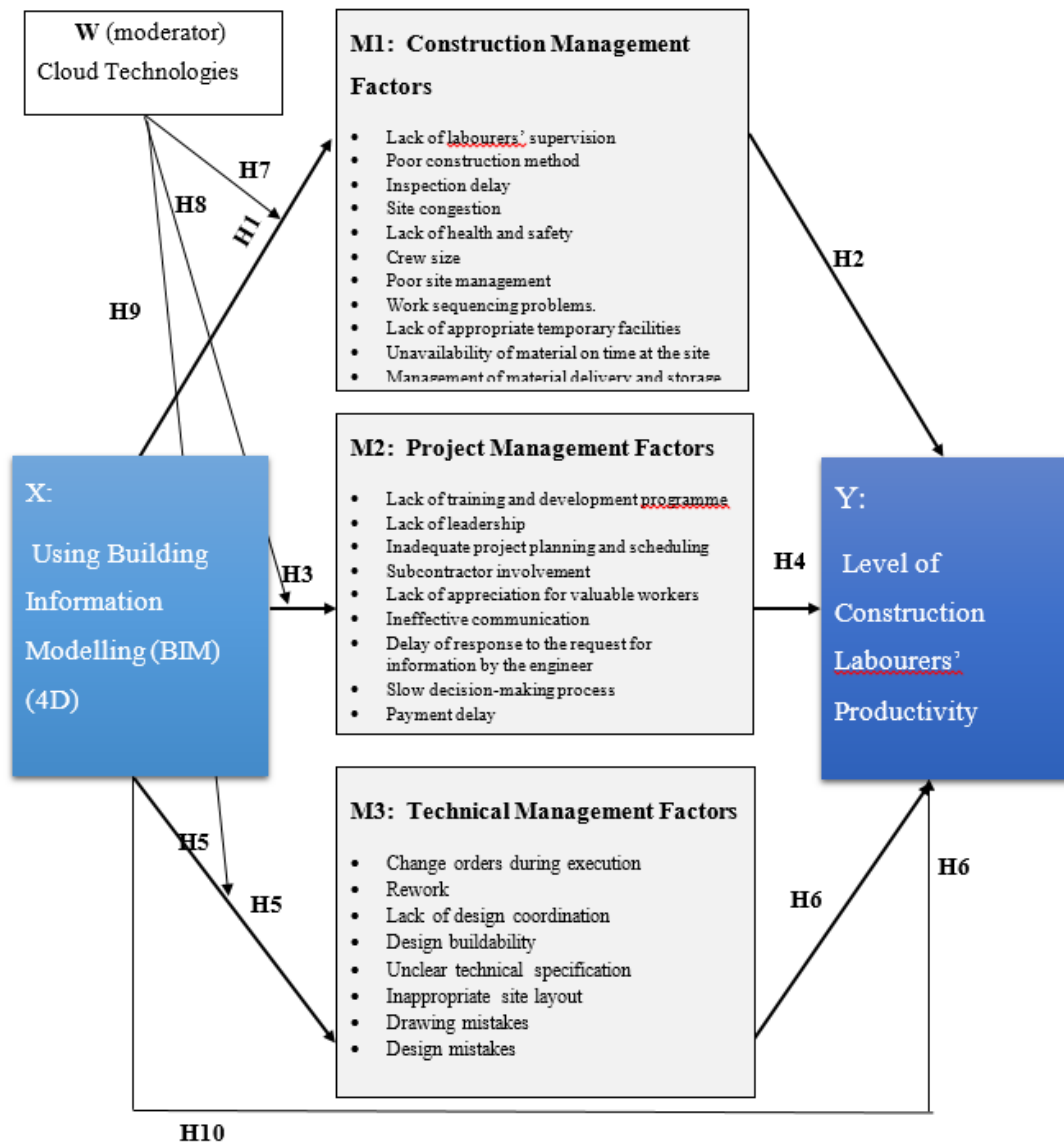
The use of building information modelling (BIM) in construction projects provides visual presentations that allow for the integration of all work disciplines, prevent mistakes in the construction drawings, and reduce requests for information (RFIs) (Hadi 2020). It has been found to be a quick tool that architecture, engineering, and other construction professionals can use to plan and change building structures to fit client requirements. Moreover, during the project it enhances site management, and collaboration among different professionals, and ensures a review of project progress (Hadi 2020).

Cloud technology was found to be a vital advanced technology for this study. As established from the reviewed literature, it plays the role of moderator between the independent variables Building Information Modelling (BIM) and factors affecting labourers' productivity (Hadi 2020). For instance, cloud technology enables people to access data stored in remote servers using various software applications. It allows for data sharing from one site to other entities related to the construction work going on at the exact time, allowing for a real-time response from the respective sections. Cloud technology enables the restoration of data as well as necessary changes and modifications. It allows the clients to get immediate news about their projects clearly and precisely and compile a report sent back to the main office. It helps in the reduction of operation costs and enhances efficiency.

3.4 Initial Output Model

Newton and Rudestam (1992) stated that a conceptual framework is basically a kind of advanced structure of a theory, comprised of statements linked to theoretical data and empirical information. Concepts and conceptual frameworks were produced to justify or describe intellectual phenomena. Robson (1993) combined various perceptions of defining the conceptual framework; he mentioned that producing a conceptual framework requires the researcher to be explicit about the research problem. Additionally, it assists the researcher to

determine the essential variables, relationships, significance of the study, and data to be analysed. In view of the above, the researcher developed an initial output model as shown in Figure 3.3 below. Figure 3.3 illustrates the casual relationship between Building Information Modelling (BIM), the independent variables, and the construction level of labourers' productivity as the dependent variable. It shows how the relationship could exist in the real construction project environment and how it can improve labourers' productivity.

Figure 3. 3*Initial Output Model*

Based on the above Initial output model, the hypotheses to be tested are:

H1: There is a direct relationship between using Building Information Modelling (BIM) in construction projects and construction management factors group.

H2: Construction management factors group mediates the relationship between using Building Information Modelling (BIM) in construction projects and the level of construction labourers' productivity.

H3: There is a direct relationship between using Building Information Modelling (BIM) in construction projects and project management factors group.

H4: Project management factors group mediate the relationship between using Building Information Modelling (BIM) in construction projects and the level of construction labourers' productivity.

H5: There is a direct relationship between using Building Information Modelling (BIM) in construction projects and technical management factors group.

H6: Technical management factors group mediates the relationship between using Building Information Modelling (BIM) in construction projects and the level of construction labourers' productivity.

Also, cloud technology was found to be a vital advanced technology for this study. As established from the reviewed literature, it plays the role of moderator between the independent variables Building Information Modelling (BIM) and factors affecting labourers' productivity (Hadi 2020). For instance, cloud technology enables people to access data stored in remote servers using various software applications. It allows for data sharing from one site to other entities related to the construction work going on at the exact same time, allowing for a real-time response from the respective sections. Cloud technology enables the restoration of data as well as necessary changes and modifications. It allows the clients to get immediate news about their projects clearly and precisely and compile a report sent back to the main office. It helps in the reduction of operation costs and enhances efficiency (Bello et al., 2021). The hypotheses to be tested were:

H7: Cloud technology moderates the relationship between using Building Information Modelling (BIM) in construction projects and construction management factors group.

H8: Cloud technology moderates the relationship between using Building Information Modelling (BIM) in construction projects and project management factors group.

H9: Cloud technology moderates the relationship between using Building Information Modelling (BIM) in construction projects and technical management factors group.

H10: There is a direct relationship between using Building Information Modelling (BIM) in construction projects and the level of construction labourers' productivity.

3.5 Chapter Summary

This chapter summarizes the theoretical view of this study's key constructs and determines what other variables as provided by works of literature are essential to meet the study's research aim. The aim of this chapter was to present the conclusions identified from the reviewed literature in the form of an initial output model. The researcher identified Building Information Modelling (BIM) and cloud technology as important advanced technologies that could positively impact construction labourers' productivity. Additionally, it was determined that BIM and cloud technology are critical advanced technologies that could positively impact construction labourers' productivity. They improve the efficiency of the workers by simplifying complex tasks. They also optimise the use of resources and decrease costs, ultimately increasing productivity and performance.

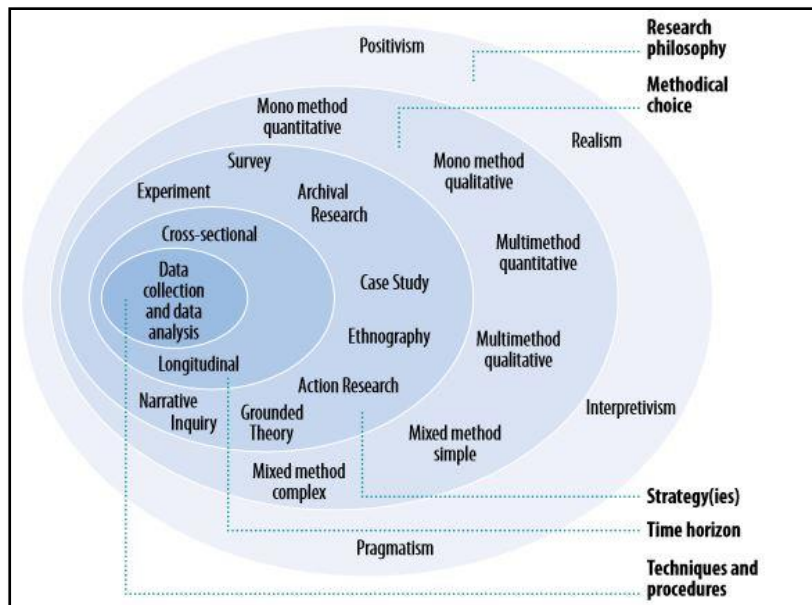
Chapter 4 : Research Methodology

4.1 Introduction

This chapter presents a comprehensive view of various stages of the methodology used in this study. The chapter covers a comprehensive dialogue of the philosophical view of the research and presents the research background, an overview of the quantitative research method, justification for using the quantitative research method, philosophical view of the research, research approach/strategy, pilot study, sample, sampling strategy, ethical consideration of the research, data collection method, data analysis, and validation and verification.

4.2 Research Philosophy

The research philosophy provides the beliefs, standards, and ethics underlying a comprehensive study. Ruona (2000) summarized the spirit of philosophy, which includes analytic queries, making clarifications, attempting some concepts, thinking of reasonable opinions for and against them, and speculating how ideas work. It also provides a context of thinking, helps grow capacities, and enhances the alignment of what a person thinks and what s/he accomplishes (Honderich 1995). A crucial element of defining the research method includes philosophical assumptions that promote the broad investigation strategy of planning to undertake research. It comprises the connection of philosophy, research strategies, and particular approaches, as shown in Figure 4.1 below.

Figure 4. 1*The Research Onion*

Note: Saunders, Lewis and Thornhill (2007)

Several philosophical assumptions could be employed to undertake research. Saunders et al. (2009) described research philosophy as confidence in the employed approach in which data about a phenomenon should be collected, examined, and utilized. For instance, realism, interpretivism, subjectivism, pragmatism, and positivism are common research philosophies (Berkeley et al., 2008). Nevertheless, Dumke (2002) stated that two interpretations, positivism and phenomenology, primarily describe research philosophy.

Positivism reveals the acknowledgement in implementing the philosophical viewpoint of researchers (Saunders 2003). Dumke (2002) illustrates that the assumption of positivism generates sophisticated methodologies and permits simplification and quantification of goals that can be assessed by statistical approaches. For this philosophical method, the researcher is

viewed as an independent spectator who should not be influenced by or influence the topic of investigation.

However, different phenomenological methods concur with the perspective that it is challenging to produce theories and rules for business and management, unlike common disciplines. Saunders et al. (2016) stated that this explains why minimizing interpretations in the actual world to specific rules and generalizations creates a feeling of truth that is a bit artificial and does not provide complexity. This study selects positivistic assumptions because of the importance of construction labourers' productivity in the construction industry and the need to improve the level of productivity in the practice. This research aims to develop a model for improving construction labourers' productivity by using advanced digital construction technologies. To ascertain a positive relationship between the independent variable and dependent variable, the researcher should use a theory to produce hypotheses that can be later examined that would allow for clarifications of policies that can be considered later.

Interpretive research methods result from the research philosophy implemented. The two key research styles are inductive and deductive approach (Dumke 2002). The inductive strategy is often referred to when a principle is derived from observations. Therefore, the research starts with a particular statement and actions and then identifies a kind of pattern where the hypothesis is established. Dumke (2002) argued that researchers who utilize an inductive method deal with qualitative details and employ different techniques to collect detailed data that generate different opinions. According to the author's philosophical statements mentioned in the prior section, it is sensible for this research to utilize the deductive approach. The study considered the essential and most widely used theory in research to build

a relationship between research and theory. Figure 4.2 below shows the process employed for the procedure of deduction.

McMillan and Schumacher (2010) defined research as an organized procedure of gathering and rationally analyzing data for a specified aim. Additionally, research philosophy refers to the assumption, knowledge, and the study's nature. It is linked to a specific mechanism of developing understanding. One of the primary philosophical approaches related to research is positivism. It is connected to objectivity, excluding the values and beliefs of the researcher. It aligns with the factual knowledge obtained through observation and quantitative tools, which is trustworthy. In positive research, the author's role is to collect data and evaluate it objectively. S/he acts as an objective analyst and does not consider personal values in conducting the research. In turn, the outcomes of these studies are observable and quantifiable. In addition, positivist studies are based on logical observations that could be quantified. Hence, statistical analysis is a significant part of the research. Positivism is integrated with the empiricist approach that knowledge originates from human experience. In other words, positivist research has an ontological perspective of the world. It involves discrete and observable components and events that communicate in a determined way. The key features of positivist research are:

- Independent observer

- Human interests are irrelevant

- Explanations indicate causality

- Research is based on hypotheses and deductions

- Concepts are operationalized to be measurable.

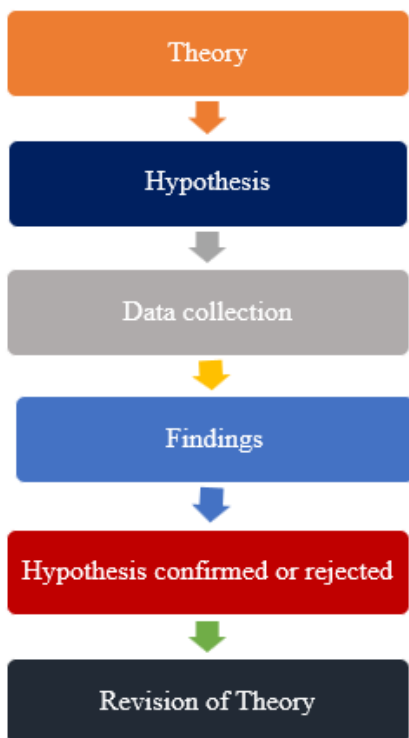
- Generalization is made through statistical probability

- Involves large samples extracted randomly

The current study aimed to determine the causal relationship between advanced technologies and labourers' productivity in the UAE construction sector. Thus, the focus was on the logical and statistical evaluation of the data collection. In addition, the research was based on setting hypotheses and testing them to make inferences. Accordingly, the positivism approach has been chosen. Therefore, personal opinions and beliefs were not considered. Moreover, aligning with the positivism view, deductive reasoning was implemented. The study considered the essential and most widely used theory in the research to build a relationship between research and theory. Figure 4.2 below shows the process employed for the procedure of deduction.

Figure 4. 2

Deduction Process



Note. Bryman & Bell (2015)

4.3 Research Methods

The three main research methods are qualitative, quantitative, and mixed. The qualitative research method is associated with the subjective approach. The study aligns with the people's experiences, events, and beliefs related to the topic. In addition, the qualitative approach focuses on the interpretive view, which means people's behaviours are essential to understanding a phenomenon. The main advantage of adopting a qualitative method is that it provides a detailed overview of the subject. In addition, people's real-time experiences and opinions are considered in explaining the topic. On the other hand, as per Williams (2011), the quantitative research method investigates and measures variables to acquire outcomes. It comprises the employment and analysis of arithmetical data. Also, it uses statistical techniques to answer questions. Moreover, Goldman et al. (1998) defined the quantitative research method as an organized investigation of phenomena by gathering measurable data and executing statistical, numerical, or computational processes. Quantitative research collects information from present and prospective clients using sampling techniques and sending out accessible surveys, questionnaires, and online polls. The outcome could be portrayed in the type of numerical information. Ormrod and Leedy (2001) and Williams (2011) stated that quantitative investigation includes data gathering. Therefore, information is usually quantified and put through statistical analysis to help contradict substitute awareness claims. Moreover, Williams (2011) noted that quantitative analysis starts with a problem declaration, produces a hypothesis and investigation query, reviews associated literature, and provides a quantitative investigation of data. Likewise, Ishtiaq (2019) illustrated that quantitative analyses use enquiry methods like surveys and experiments and gather data on predesigned instruments that produce statistical information.

According to Sukamolson (2007), there are numerous types of quantitative research, and each style has its representative features. For example, it can be investigational research, correlational research, fundamental-comparative research, and appraisal research. The survey-based research uses systematic sampling and questionnaire design to evaluate the population's attributes with statistical rigour. It tries to answer questions of how, how many, and how often. Survey analysis allows management to generate comparisons between organizations. It provides estimates out of a test that may be associated with the whole population with a rate of certainty. Survey analysis requires respondents to be casually sampled – which implies that every individual in the population has a recognized likelihood of being sampled. There are defined methods, random digit dialling and sampling treatments to guarantee a scientific test. In creating a survey, a statistician would ordinarily create a statistically legitimate sampling programme, and a researcher would create a survey instrument, investigation goals, and an established area service that can conduct huge-scale interview tasks. It is crucial to work with experts as the survey's calibre may be impacted by the research instrument (Sukamolson 2007).

Further, mixed research combines qualitative and quantitative research methods. Mixed research focuses on optimizing qualitative and quantitative research methods' advantages and overcoming limitations. The advantage of mixed research is that the researcher can explore and explain the topic in detail. In addition, it helps to include subjective and objective perspectives related to the topic and increases the validity and reliability of data. However, it is a time-consuming method and requires extensive resources. Hence, the current research used a quantitative approach to understand the impact of advanced technologies on labourers' productivity in the UAE construction sector.

4.3.1 Pilot Study

Before conducting the actual research, a pilot study was conducted to identify errors and check the comprehensiveness of the method, data, and instruments. It was considered a crucial step for providing a clear understanding of the research phenomenon and its context. Furthermore, Saunders et al. (2012) stated that a pilot study's objective is to enhance the questionnaire's validity. It ensures that respondents would not have any complications in responding to the enquiries. It also eliminates the challenges of capturing information. Moreover, it allows some evaluation of the questions before sending them to participants.

Although the questionnaire was created based on the appropriate literature, a pilot study was performed to ensure that the information acquired from the questionnaire was rational and consistent. According to Collis and Hussey (2014), it is helpful to conduct a pilot study and share the questionnaire with a small number of respondents to evaluate its appropriateness to answer the research questions and meet the research aim. Furthermore, the pilot study aimed to ascertain that the developed questionnaire was well-defined and understandable to the research sample population. Thus, the researcher developed a structure-based questionnaire survey. This survey was distributed to 10 experts from the construction industry and five from the academic community. The aim was to make sure that the survey was simple, well understood, and comprehensive to provide proper data collection. There were no significant comments provided except that the questionnaire was probably lengthy, and others advised changing some terms. Accordingly, the comments were considered, and necessary modifications to the questionnaire survey were made.

4.3.2 Sampling Strategy

According to Collis and Hussey (2014), several sampling techniques could be used to generate a particular planned sample from the research population. This research utilized direct random sampling to obtain respondents with whom the survey was conducted. Simple casual sampling is thought of as a straightforward type of prospect sampling. Under the technique, elements are chosen from the population with all components having an equivalent probability of being selected. Many construction companies are involved in building construction projects in the UAE. Hence, the focus was on the project managers and supervisors from the contractor side, and resident engineers and inspectors from the consultant side. Accordingly, the following equation was utilized to determine the sample size.

$$S = \frac{Z^2 \times p(1 - p)/e^2}{1 + (z^2 \times p(1 - p)/e^2 N)}$$

S was the sample size, N was the size of the entire population, e was the error margin, z was the rate of confidence, and p was the percentage value. This study was performed based on a 95 percent confidence rate with a margin error of 5 percent. Ultimately, the sample size was 397 consultants, resident engineers, and others from the construction sector of the UAE. The reason for choosing a sample of 397 is the resources constraints. Due to lack of time and financial resources, a small sample size was selected. It was also not possible to have access to a large number of construction stakeholders from companies in the UAE. Thus, the sample of 397 was selected through random sampling.

4.3.3 Sample

The research population comprised construction companies and consultants with previous experience in building construction projects in the UAE. On the other hand, the sample is the sub-set of the targeted population.

As per the quantitative research methodology, the Dubai Municipality, Dubai Qualification Department, Abu Dhabi Municipality and Abu Dhabi Chamber of Commerce were approached. As a result, a list of 5000 construction companies involving contractors, consultants, and employers was selected to draw the sample. Accordingly, the sample size of the research study was calculated based on a 95 percent confidence level and 5 percent margin of error. Thus, the number of responses required to answer research questions was 357. The questionnaires were distributed to more than 2000 companies, but the responses were collected from 397 companies, one respondent from each company. The sample comprised 234 males and 163 females. They were contractors (144), consultants (102), and clients (41). Additionally, 115 were project managers, 104 were construction managers, 59 were foremen, 78 were supervisors, and 41 were resident engineers. Most of the participants had a high diploma (127) or a graduate degree (126). Some of them (41) had a master's degree or above, 99 had a college degree, and four were high schoolers. Also, most of the respondents had eight to 13 years of experience. Some of them had two to seven years of experience and only 23 had one or less than one year of experience.

4.4 Justification for Using Quantitative Research Methods

In the social sciences, both qualitative and quantitative research methods can be employed. However, it depends on the research subject and research aim and objectives. According to Saunders (2003), research often comprises specific numerical data or involves quantifiable data by collecting and analysing the data. In this study, the factors affecting construction labourers' productivity were investigated from contractors' and consultants' points of view. Therefore, the researcher utilized the general factors identified from the literature review chapter and verified them and their magnitude of impact in the context of the UEA.

Moreover, it was mandatory to verify the secondary data and examine the identified theories to meet the research aim. The study of the subject phenomenon needs to involve a large sample of participants to generate results that can be generalized. Therefore, the cross-sectional deductive quantitative research method was suitable for this research. The quantitative research method provided comprehensive and significant data required to fulfil the research objectives and answer the central research question and successfully meet the aim of this study.

Nevertheless, the relationship between advanced digital construction technologies and construction labourers' productivity had to be identified. Hence, the quantitative research method was selected. Accordingly, the survey approach was deployed in the study. For example, the first part of the questionnaire identified the significant factors affecting construction labourers' productivity and the second part examined the relationship between BIM and the significant factors affecting construction labour productivity.

4.5 Research Paradigms

Research paradigms are a set of beliefs and assumptions shared among members of a research community. They determine how members of the research community view the phenomena community needs to study and the research methods required in examining the mentioned phenomena (Davies & Fisher 2018).

4.5.1 Ontology

This branch of philosophy focuses on studying things in the world that humans can use to acquire knowledge. Ontology aids researchers in examining the rate of surety they can have about nature and the presence of different research objects (Scotland 2012). It involves the philosophy of how the world is created. Various philosophical approaches are significant in understanding how and what the world is all about, with two major ontological approaches in

research: rationalist and interpretivist concepts. For instance, a rationalist views the world as clear, unmistakable, and demonstrable authenticity that can be analyzed using unbiased impartiality, whilst interpretivists view the universe as a set of social constructions (Scotland 2012). The power of language, instruments, shared meanings, and instruments defines a set of social structures that integrate human beings' interest in the study. In addition, these social constructions invoke the philosophical picture of idealism. Essentially, any research method will pick one method over the other depending on the information it wants to find out about the world.

4.5.2 Axiology

Axiology delves into the analysis of values or the theory on the state of value. It examines what is good from what is bad in life and the things those human beings find worthy (Scotland 2012). The study of axiology infuses ethics and aesthetics as forms of value. Axiology concepts prepare a researcher for an impending survey by pointing out things that make good research.

4.5.3 Epistemology

This is the branch of philosophy defining how people came to understand the universe. This concept is more applicable in the presentation of research methodology. Rationalism and empiricism are the two major approaches in understanding epistemology in research (Scotland 2012). Approaching research on an empiricist approach would require the researcher to understand that the best way of gaining information about the world is by carrying out an objective study. On the other side, a rationalist approach believes that data is not the only way to unveil the world's mysteries; the data must undergo analysis from the human brain. The study of a model for improving construction labourers' productivity through advanced digital

technologies in UAE building construction projects will require this approach. This is because of the primary data that will play an essential role in the study.

4.5.4 Phenomenology

This is a branch of psychology based on subjective experience. It focuses on the examination of structures of consciousness as experienced by the primary viewer. Phenomenology allows scholars to learn from the experience of others. The approach focuses on personal lived experiences around the world. The experiences are then used to construct themes that will allow a researcher to explain a problem under investigation (Scotland 2012). The phenomenological approach allows the researcher to develop constructive meanings of a situation, event, or experience that will help arrive at the phenomenon's thoughtful implications under investigation. The roots of philosophy, education, and psychology allow a phenomenology approach to extract pure, untainted information used in developing an effective analysis process to understand the cause of different happenings in a study topic.

4.6 Justification of Research Philosophical Stance

One of the primary philosophical approaches related to research is positivism. It is connected to objectivity, excluding the values and beliefs of the researcher. It aligns with the factual knowledge obtained through observation and quantitative tools, which is trustworthy. In positivist research, the author's role is to collect data and evaluate it objectively. S/he acts as an objective analyst and does not consider personal values in conducting the research. In turn, the outcomes of these studies are observable and quantifiable. In addition, positivist studies are based on logical observations that can be quantified. Hence, statistical analysis is a significant part of the research. Positivism is integrated with the empiricist approach that knowledge originates from human experience. In other words, positivist research has an ontological perspective of the world. Based on the above definitions of different research

philosophy and paradigms, the researcher adopted ontological paradigms and a positive research approach to achieve this research's main aim and objectives.

4.7 Research Approach/Strategy

Several definitions of research were mentioned in the literature; for instance, Phillips (1971) defined research as an investigation of facts in responses to questions and resolutions of problems. The research method presents the chain of interrelating sequential phases beginning from identifying the aim of the study to create the conceptual framework and the verification and validation and acknowledgement of the accuracy of the proposed model.

According to Saunders, Lewis and Thornhill's (2007) research onion, shown in Figure 4.1 above, there are several strategies that can be employed in a study. Numerous strategies exist for the mono-quantitative approach, such as phone interviews, mail surveys, web-based surveys, and structured questionnaires (Haq 2014). Every instrument has quality, cost of information, and time advantages and disadvantages. Bryman (2006) and Driscoll et al. (2007) noted that most researchers use structured questionnaires to collect data, knowing that they may not be able to manage and direct the respondents, which leads to a low percentage of answers. Saunders and Tosey (2015) stated that quantitative information is much easier to collect and much more concise to show. Thus, in this study, the researcher implemented a cross-sectional survey mono-method quantitative positivism and utilizes a survey-based questionnaire for data collection.

4.8 Ethical Considerations of the Research

There were various ethical aspects considered while conducting this research. For example, the topic and proposal were approved by the university's ethics committee. In addition, the university was informed about the companies from which the data was collected for analysis. Additionally, after approval, while collecting the data from the participants, they

were sent an informed consent to ensure their privacy and confidentiality. They were informed that the data provided by them would be kept confidential. In addition, after five to six months of the research, the data will be discarded to maintain privacy. Also, the study participants were offered a complete overview of the study, its topic, and the aim. They were also assured that they could leave the study at any time. They were not obliged to answer every question but could skip it if they feel uncomfortable answering a question. After signing the informed consent, the participants were sent the survey questionnaires to fill in.

4.9 Data Collection Method Used

Two main types of methods were used to collect data, primary and secondary methods. Secondary data is authentic and verified data that already existed related to the topic. The secondary data was collected using secondary sources like books, journal articles, reports, and websites. On the other hand, primary data is collected using different instruments based on the qualitative and quantitative research methods. This study was based on quantitative research. Thus, the instrument used in the study to collect primary data was a survey questionnaire (Kelley 2003). The main reason for collecting data from a survey questionnaire is cost-effectiveness. It is an easy and low-cost method because the questionnaires could be sent to a larger population through email. In addition, the method of the survey questionnaire was used because it helps to collect extensive data in less time. Accordingly, the survey questionnaire was developed to collect the primary data related to factors that impact the labourers' productivity in the construction sector in the UAE and the advantages of using digital technologies in the UAE construction sector. Nevertheless, there were some disadvantages of using a survey questionnaire for collecting primary data. One drawback was that the survey questionnaire did not provide information about the emotional and facial expressions of participants, which is important because non-verbal clues can offer insight into people's

behaviours. Another disadvantage of the survey questionnaire was that it did not allow a detailed answer to a question and a chance to ask a counter-question for further explanation on any aspect.

4.9.1 Data Collection Tool – Questionnaire

The survey questionnaire was developed according based on the initial output model presented in chapter three above. They were 5-point Likert scale questionnaires involving the level of agreement and importance. The questions included in the survey questionnaires were close-ended questions related to the main topic. Firstly, the questionnaires provided detail about the study, its aim, and the guidelines. Then, the participants were asked about their demographics. Accordingly, the questionnaire comprises three parts:

Demographic information.

Testing factors affecting construction labour productivity in building construction projects in the UAE and the frequency of occurrence of those factors to identify the most significant factors.

The impacts of using BIM and cloud technology on the factors affecting construction labourers' productivity.

Each part had questions based on the level of importance (1=very important, 2=important, 3=neutral, 4=not important, and 5= strongly not important) and frequency of occurrence (1 = high, 2= medium, and 3 = low). The third part questionnaire contained three sections on the benefits of proper implementation of 3D, 4D, and 5D BIM in the construction sector. The participants were asked to answer the questions based on their level of agreement (1= strongly agree, 2=agree, 3= neutral, 4= disagree, and 5= strongly disagree) (see Appendix A).

4.10 Data Analysis

The collected data was organised and entered into Statistical Package for Social Science (SPSS) for analysis. The statistical tools applied to evaluate the data included descriptive and inferential statistical tools, such as correlation and regression. Firstly, reliability analysis was used to understand if data, scales, and items were reliable. The procedure was focused on calculating the reliability of the commonly used measures of scale. It led to information regarding the relationship between the individual item within the tool or scale. Also, the focus was to understand if the questionnaire would measure customer satisfaction in a helpful manner. The reliability analysis helped determine the extent to which the said items within the questionnaire were related. It provided an overall index representing the repeatability and internal consistency of the scale, which helped to identify the things that were considered problematic and needed to be excluded from the measure.

One of the most common approaches for reliability is the Alpha or Cronbach model, which relies on internal consistencies and focuses on the average inter-item correlation found in the tool. The tool is mainly used when the questionnaire uses multiple Likert questions in the survey like in the research and wants to check the reliability of the scale or measure. A value that is close to 1 for the Cronbach Alpha provides a picture that shows that there is high internal consistency. The analyses offer two measures: the first is the Cronbach Alpha, which explores the reliability and is based on the covariance. The second measure in the analyses is the alpha based on the standardized items, which focuses on measuring the correlation between the different items. Based on the literature and explanations available, a measure above 0.70 is considered acceptable, while a value above 0.80 is highly preferred (Cortina 1993). Thus, Cronbach Alpha was calculated to know the reliability of the data.

Also, factor analysis was undertaken to reduce many variables present to a select few factors. The technique was used to extract that common variance identified from the different variables and put the said variance into a common score. The variance was then utilized as an index of the different variables for further analysis. Factor analysis was a part of the General Linear Model with several assumptions at the time of the tests.

Firstly, it was assumed that there is a linear relationship and no multicollinearity and that there was no correlation between variables and factors. Multiple methods are available to carry out this process, but the most common method is the Principal Component analysis, which was chosen in this research. IBM SPSS factor analysis provided an output where the factors, also referred to as components, were extracted. Each of these components was measured for quality, and a score was assigned, which was referred to as Eigenvalue (Flora, LaBrish & Chalmers 2012). The Eigenvalue was considered most critical as only those with a high Eigenvalue were representative of a real underlying factor. The common rule of selecting the factors is to select those components that have a value of at least one and ignore the others. Those with low scores below are considered not representative of the underlying traits. The rotated component matrix would allow an understanding of which variables are measured by which factors, while a component matrix test would allow understanding of the correlations between them, referred to as factor loadings (Yong & Pearce 2013).

In addition, descriptive statistics were calculated to identify the demographics' frequencies and the mean and standard deviation of respondents' answers to the survey questions. It helped to know the agreement level of all participants to a statement mentioned in the survey questionnaire. In addition, related to descriptive statistics, the correlation test or Pearson correlation analysis was conducted. The Pearson correlation ranged from -1 and +1, which indicated the extent to which the variables being compared were linearly related. A

correlation of value -1 indicated a perfect linear descending relation, meaning that, when one variable increased, the other variable decreased (Kent State University 2021). A score of 0 described a non-linear relationship, while a score of 1 meant an ascending linear relation, where, when one variable value increased, the value of the other variable increased too.

The analysis was used because it was critical in analysing the null hypothesis, which helped establish the type of relationship between the two variables or multiple variables explored under the research framework. In this, the correlation and its significance were of importance. When the correlation had a Significance (2-tailed) below 0.05, then the correlation was assumed to be of statistical significance, while the Pearson coefficient established the type of linear relationship between the two variables. The study involved individual correlation analyses to understand the behaviours individually and test each hypothesis instead of using multiple correlation analyses.

Once the correlation analysis was completed, the next step in the process was conducting linear regression. The method was used to predict the variable's value based on another variable. The variable that the researcher aimed to predict was considered the dependent variable, while the variable utilized in the prediction was considered the independent variable. Here, the regression analysis was run to test the statistical significance and relationship between the BIM and Labourers' Productivity factor, which was the main focus of the research. A scatter plot with a trend line helped to understand the type of relationship and allowed an explanation of the equation which led to calculating the value for the dependent variable (Seber & Lee 2012). In the regression analysis, the dependent variable would be the level of construction labourers' productivity. The linear regression was used to establish the relationship with BIM and a multiple regression test was implemented to

establish the relationship and significance between the different variables explored under the research. In general, the linear regression equation is represented as

$$Y = a + bX$$

Where a is the intercept on the line and b is the slope of the trend line. Y is the dependent variable, and X is the independent variable. The regression analysis was used because it provides multiple values that are critical in understanding the significance and relationship between the two variables. The first of the two is R and the second is R -squared. R -value indicates the simple correlation between the two which can be described along with the same set of conditions as explained in the correlation analysis. The R -squared value specifies the total variation in the dependent variable. Regression is considered to be an effective method, but the ANOVA is more effective to understand the variance better and find a common mean between the two variable sets (Thakur 2021).

Hence, an ANOVA test was utilized to analyse the random variables. This was largely required considering that intermediary factors having a direct or indirect relationship established through regression analysis. Moreover, the impact of random factors, of which one was a culmination of the findings across the different questions, related to the other three factors and the impact of external factors such as the cloud technology. Accordingly, ANOVA testing was appropriate and important to understand variation and relationship. In the ANOVA test, the significance is critical as it allows the statistical significance to be provided (determines if there is a variation in the means as long as the p -value is below 0.05 (Tripepi et al., 2008 & Laerd Statistics, 2015)).

Finally, mediation impact was tested. For the calculation, a Sobel test was used. It is considered a mediation test calculation that helps understand the impact of the third factor or mediator on two variables and their relationship (Preacher & Leonardelli 2001 & Abu-Bader

& Jones 2021). The Sobel test was used as it is the most suitable when the sample is larger. A variable was a mediator to the extent to which it would carry the influence for a given independent variable to a given dependent variable. In simpler terms, mediation occurs in cases when the independent variable impacts the mediator, the independent variable impacts the dependent variable, the mediator has an influence on the dependent variable, and, lastly, the effect of the independent variable on the dependent variable reduces once the mediator is added to the system (Preacher & Leonardelli 2001).

4.11 Validation and Verification

Verification and validation are the procedures used to generate the proof, and credibility is developed to ensure that the outcomes are accurate. Verification is the procedure of knowing that a model's implementation accurately specifies the conceptual description and solution to the model. In addition, validation refers to the process under which the logical and statistical predictions are evaluated and compared to the experimental data. The aim is to assess the modelling error (Heale & Twycross 2015). One of the types of validity is construct validity, which is linked to the use of the right strategy for research. Another type of validity is the identification of a causal relationship between variables. Also, external validity is the development of and degree to which the study's outcomes could be generalized to an extensive population. Furthermore, reliability is associated with the credibility of the data and tools. Triangulation is a method that validates data. The use of survey questionnaires and focus groups to ensure the data's credibility facilitated data validation. Additionally, Cronbach Alpha was used to test the reliability (Heale & Twycross 2015).

4.12 Chapter Summary

This chapter presents a comprehensive description of the approaches and techniques deployed in this research. This research has been conducted using a quantitative research method, a deductive approach, and cross-sectional techniques and procedures with a mono, quantitative method that comprises a questionnaire survey instrument for collecting data. Moreover, the study adopts positivism as the research philosophy. The chapter also presented the data analysis procedure, descriptive statistics via frequency examination and regression analysis.

Chapter 5 : Data Collection and Analysis

5.1 Introduction

This chapter provides details on the data collected and also provides a summary and findings based on the different analyses conducted to gain the required results. The chapter will first focus on the various tests carried out in the research and what the research aims to achieve by carrying out the said analyses. The survey was distributed online, and the responses were collected, and the data was analyzed using IBM SPSS and Hayes process macro.

5.2 Analysis

Multiple analyses have been undertaken to fulfill the objectives of this study. The first of these tests undertaken in the research was the reliability analysis. This is used to understand if the tools used to collect the data and the scales and items are reliable. The procedure focuses on calculating the reliability of the commonly used measures of scale. It also leads to information regarding the relationship between the individual items within the tool or scale. The focus here will be to understand if the questionnaire can measure, for example, customer satisfaction in a helpful manner. The reliability analysis helps determine the extent to which the said items within the questionnaire are related. It provides an overall index representing the repeatability and internal consistency of the scale, which would help identify the things that are considered problematic and would allow these to be excluded from the measure. One of the most common approaches for reliability is the Alpha or Cronbach model, which relies on internal consistencies and focuses on the average inter-item correlation found in the tool. The tool is mainly used when the questionnaire uses multiple Likert questions in the survey, like in the research, and the researcher wants to check the reliability of the scale or measure. A value that is close to 1 for the Cronbach Alpha provides a picture that shows that there is high

internal consistency. The analyses offer two measures: the first is the Cronbach Alpha, which explores the reliability and is based on the covariance. The second measure in the analyses is the alpha based on the standardized items, which focuses on measuring the correlation between the different items. Based on the literature and explanations available, a measure above 0.70 is considered acceptable, while a value above 0.80 is highly preferred (Cortina 1993).

The next analysis that was carried out was the normality test to check whether the data are normally distributed or not. Next was factor analysis, to reduce a large number of variables to a few select factors. The technique extracted the common variance identified from the different variables and put the said variance into a common score. This was then used as an index of the different variables for further analysis. Factor analysis is part of the General Linear Model, and there are several assumptions at the time of the tests. Firstly, it assumes that there is a linear relationship and no multicollinearity and that there is no correlation between variables and factors. There are multiple methods to carry out the process, but the most common method used is Principal Component analysis. IBM SPSS Factor analysis provides an output where the factors, also referred to as components, are extracted. Each of these components is measured for quality, and a score is assigned, which is referred to as Eigenvalue. The Eigenvalue is considered most critical as only those with a high Eigenvalue would represent a real underlying factor. The common rule of selecting the factors was to select those components that have a value of at least 1 and ignore the others. Those with low scores below 1 are considered not representative of the underlying traits. The rotated component matrix would allow an understanding of which variables are measured by which factors, while a component matrix test would allow understanding of the correlations between them, referred to as factor loadings.

The researcher also undertakes the most common form of testing, descriptive statistics, as it allows the mean and standard deviation to be extracted in values, which is critical when analysing the demographic data. All the questions under the themes of project management, construction, and technical management factors were considered to measure labourers' productivity. With this, the compiled data is put through descriptive statistics to understand the average rating and the standard deviation in the responses, which would allow an understanding of the overall variations in the respondents' views. The measures or data would be the summary or total of all the respondents' responses to the questions under the respective themes. Frequency analysis, which is mostly used in providing a graphical representation of the data, is also used as this would allow us to better understand the distribution of the responses and allow us to see the distribution of the responses.

The next test that was carried out was the correlation test or Pearson correlation analysis. The Pearson correlation would be a number between -1 and +1, which would indicate the extent to which the variables being compared are linearly related. A correlation of value -1 would indicate that there is a perfect linear descending relation, meaning that, when one variable increases, the other variable would decrease (Kent State University 2021). A score of 0 would describe a non-linear relationship, while a score of 1 would mean that there is an ascending linear relation, where, when one variable value increases, the value of the other variable would increase too. Analysis is often critical in analyzing the null hypothesis, which helps establish the type of relationship between the two variables or multiple variables explored under the research framework. In this, the correlation and its significance are of importance. When the correlation has a Significance (2-tailed) below 0.05, then the correlation would be assumed to be of statistical significance, while the Pearson coefficient would establish the type of linear relationship between the two variables. The researcher runs

individual correlation analyses in the testing to understand the behaviours individually and help test each hypothesis instead of using multiple correlation analyses.

After the correlation analysis was completed, the next step was the linear regression. This is used to predict the variable's value based on another variable. The variable that has to be predicted is considered the dependent variable, while the variable that is going to be used in the prediction is considered the independent variable (Kent State University 2021). Here, the regression analysis was undertaken to test the statistical significance and relationship between the BIM and Labourers' productivity factor, which is the focus of the research. A scatter plot with a trend line has also been done, which would allow a better understanding of the type of relationship and an explanation of the equation that would eventually provide or allow for calculation of the value for the dependent variable. In general, the linear regression equation is represented as

$$Y = a + bX$$

Where a is the intercept on the line and b is the slope of the trend line. Y is the dependent variable, and X is the independent variable. The analysis provides multiple values that are critical in understanding the significance and relationship between the two variables. The first of the two is R and the second is R -squared. R -value represents the simple correlation between the two, which can be described along with the same set of conditions as explained in the correlation analysis. The R -squared value would indicate the total variation in the dependent variable. The regression could be considered an effective method, but the ANOVA is used to understand the variance better and find a common mean between the two variable sets. In this case, the researcher also uses the ANOVA test to analyse the random variables (Thakur, 2021). This is largely required considering that intermediary factors have a direct or indirect relationship established through regression analysis. However, the impact of these

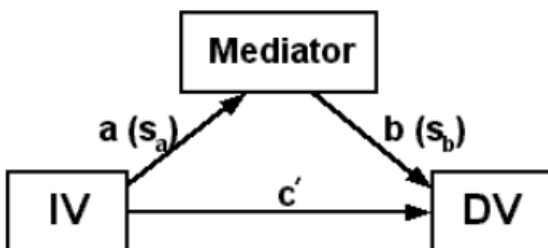
random factors, of which one is a culmination of the findings across the different questions relating to the other three factors and external factors like the cloud, would mean the ANOVA testing here is appropriate and important to understand variation and relationship. In the ANOVA test, the significance is critical as it allows the researcher to provide the statistical significance (determines if there is a variation in the means as long as the p-value is below 0.05). Following this would be the coefficient table that would provide the required information that would help in understanding the prediction factor or the values of a and b in the linear regression equation. The residual statistics are also observed along with this, which focus on the difference in the observed value and the mean value. This is critical in regression and ANOVA as it helps indicate the extent to which the models are said to account for the variation that is seen in the data. In the regression analysis, the dependent variable would be the level of construction labourers' productivity. The researcher used the linear regression to establish the relationship with BIM and undertake a multiple regression test to establish the relationship and significance between the different variables explored under the research (Tripepi et al., 2008 & Laerd Statistics 2015). This would establish the relationship between the different variables and cover all the hypotheses on their relationship and significance.

Next would be testing the mediation impact. For the calculation, we use the Sobel test, which is considered a mediation test calculation that would help understand the impact of the third factor or mediator on two variables and their relationship (Preacher & Leonardelli 2001 & Abu-Bader & Jones 2021). The Sobel test is used here as it is the most suitable when the sample is larger. A variable would be a mediator to the extent to which it would carry the influence for a given independent variable to a given dependent variable. In simpler terms, mediation could occur in cases when the independent variable would impact the mediator, the independent variable would impact the dependent variable, the mediator has an influence on

the dependent variable, and, lastly, the effect of the independent variable on the dependent variable would reduce once the mediator is added to the system (Preacher & Leonardelli 2001). The example below in Figure 5.1 is used to clarify the impact of the mediator on the other variables. There are three path coefficients represented by a , b , and c' in the figure. The coefficient a would be the raw regression coefficient between the independent variable and mediator, while b would be between the mediator and dependent variable. Standard errors of both these coefficients are also calculated, which would help calculate c' and the Sobel test statistic. Here in this test too the p -value is critical as a p -value below 0.05 shows that it has a mediating effect and if the value is above 0.05 then the mediator does not significantly reduce the influence of the independent variable on the dependent variable (Pierce 2003).

Figure 5. 1

Mediator Effect



Note. Pierce (2003)

The final part of the testing was the SPSS – Hayes process macro has become the standard for modern mediation and moderation analyses (Bolin 2014). Hayes process macro is the integration of mediation and moderation analysis used to examine the effect of moderation on the mediation relationship between two variables (Hayes & Preacher 2013).

SPSS Process Macro is a bootstrapping statistical computing tool designed to study how one or more mediating or moderating variables affect the relationship between the independent and dependent variables (Hayes & Preacher 2013). The program computes t and p values, R², unstandardized and standardized regression coefficients, standard errors, and the direct, indirect, and cumulative effects of X on Y. Furthermore, unlike the Sobel test, which assumes a continuous result (Y), Process Macro can be used with both continuous (linear regression analysis) and dichotomous (logistic regression analysis) outcomes.

SPSS Hayes Process is used for the purposes of:

Mediation analysis is used to explain how one variable (the independent variable) influences another variable (the dependent variable) through the presence of a third variable (the mediator) (Hayes & Preacher 2013). It assists researchers in determining whether the influence of the independent variable on the dependent variable is direct or indirect (mediated through the mediator variable) (Hayes & Preacher 2013). The Hayes Process streamlines the process of conducting mediation analysis by offering simple tools within SPSS (Hayes & Preacher 2013).

Moderation analysis is used to determine whether a third variable influences or moderates the relationship between two variables (the independent variable and the dependent variable) (Hayes & Preacher 2013). In other words, it assists researchers in determining whether the relationship between the independent and dependent variables is stronger or weaker under what conditions or for whom (Hayes & Preacher 2013). The Hayes Process also makes moderation analysis inside SPSS easier. The SPSS Hayes Process simplifies these difficult statistical studies by delivering detailed output that includes information on direct and indirect effects, bootstrapped confidence ranges, and other important statistics (Hayes & Preacher 2013). The Hayes Process consists of the following steps (Hayes & Preacher 2013).

Hayes Process employs multiple regression studies to determine the relationship between X and M (path a), the relationship between M and Y while adjusting for X (route b), and the relationship between X and Y (total impact, c). Bootstrap Confidence Intervals: To test the importance of the indirect (mediation) effect, the Hayes Process employs bootstrapping, which includes resampling your data many times. It computes the indirect impact (ab) in each resampled dataset and generates a distribution of indirect effects. This allows you to calculate confidence intervals for the indirect effect. Interpret the Results: The Hayes Process will generate the following critical information:

The direct effect (c') is the effect of X on Y while controlling for the mediator.

The indirect effect (ab) is the effect of X on Y through the mediator.

The total effect (c) is the total effect of X on Y without considering the mediator.

The indirect statistical impacts can be ascertained by looking at the confidence intervals for the effect. Indicators of a mediation effect are present if the confidence interval does not contain zero. To aid with understanding and graphically communicating the mediation effect, the Hayes Process can also produce visualization aids like mediation charts. Consider your research question when interpreting the findings. The relationship between the independent and dependent variables can be explained by the mediator if the indirect impact is considerable, which suggests that there is evidence of mediation.

In summary, the SPSS Hayes Process assists in establishing the mediation effect by performing the relevant statistical analyses, including estimating indirect effects using bootstrapping (Hayes & Preacher 2013). Researchers can utilize the findings to assess whether the mediator is actually important in explaining the relationship between the independent and dependent variables (Hayes & Preacher 2013). As a result, the researcher used the Hays process method with SPSS Process Macro to examine the mediation and moderation effect, as

well as the direct and indirect relationship between the variables, as well as to validate the results generated by the standard SPSS regression tests performed in the previous section.

5.3 Results

In evaluating the factors that affect construction labourers' productivity, the research ranked several variables. This ranking was purely based on the opinions of the participants. According to the outcome of the data received from 397 participants, their opinion is presented in Table 5.1 and Figure 5.2 below. The most important issue or factor related to workplace productivity can be attributed to the training and the development of the labourers'. This is followed by other factors such as the weather conditions during the project execution, project planning and scheduling, and the supervisor's lack of experience in the industry. The participants also suggested that productivity is affected by lack of leadership, poor wages, inadequate skills and experience, and delay in authority approvals, as well as poor methods of construction. Moreover, other variables that have been considered central to the equation of labourers' productivity include issues such as lack of health and safety planning, unclear technical specification, changes of orders during project execution, and inappropriate layout of the construction site. The research also suggested that a shortage of tools and equipment, material delivery and storage, rework, and lack of coordination and the design works could influence these projects. In the ranking, the research outcome ranked the unavailability of materials at the site and inspection delays at positions 19 and 20, respectively, based on the responses of the research participants. The table below illustrates the ranking of the factors affecting the labourers' productivity level as per the responses received from the 397 participants.

Table 5. 1*Ranking of Factors Affecting Construction Labourers' Productivity*

Factors affecting labourers' productivity	Frequency of Occurrence			Percentage of high frequency of occurrence out of total number of participants (397)	Ranking
	High	Medium	Low		
Lack of training and development for labourers's	365	23	9	92 percent	1
Weather condition	355	36	6	89 percent	2
Inadequate project planning and scheduling	353	29	15	89 percent	3
Lack of supervisor experience	353	30	14	89 percent	4
Lack of leadership	351	33	13	88 percent	5
Low wages	350	28	19	88 percent	6
Inadequate labourers' skills and experience	350	22	25	88 percent	7
Delay in authority approvals	348	44	5	88 percent	8
Lack of labourers' supervision	346	40	11	87 percent	9
Poor construction method	344	43	10	87 percent	10
Lack of health and safety planning	340	50	7	86 percent	11
Unclear technical specification	340	49	8	86 percent	12
Change orders during execution	336	47	14	85 percent	13
Inappropriate site layout	336	47	14	85 percent	14
Shortage of tools and equipment	333	48	16	84 percent	15
Management of material delivery and storage	330	52	15	83 percent	16
Rework	330	54	13	83 percent	17

Lack of design coordination	330	55	12	83 percent	18
Unavailability of material on time at the site	330	57	10	83 percent	19
Inspection delay	327	55	15	82 percent	20
Poor site management	325	54	18	82 percent	21
Payment delay	325	54	18	82 percent	22
Design buildability problems	325	54	18	82 percent	23
Accidents	325	54	18	82 percent	24
Drawing mistakes	323	60	14	81 percent	25
Absenteeism	322	61	14	81 percent	26
Labourers' transportation	322	61	14	81 percent	27
Slow decision-making process	322	61	14	81 percent	28
Lack of appropriate temporary facilities	320	66	11	81 percent	29
Site congestion	320	65	12	81 percent	30
Ineffective communication	316	67	14	80 percent	31
Delay of response to the request for information from the engineer	314	69	14	79 percent	32
Lack of on-time equipment repair	311	70	16	78 percent	33
Design errors	310	70	17	78 percent	34
Work sequencing problems	310	74	13	78 percent	35
Unrealistic schedule	310	74	13	78 percent	36
Lack of appreciation for useful workers	309	77	11	78 percent	37
Subcontractor involvement	307	78	12	77 percent	38
Fatigue	307	79	11	77 percent	39
Crew size	306	80	11	77 percent	40
Work overtime	305	81	11	77 percent	41
Lack of incentive scheme for workers	305	83	9	77 percent	42

As shown in Table 5.1 above, factors affecting labourers' productivity have been ranked from highly significant to low significance pertaining to their impacts on labourers'

productivity. It has been noticed that lack of training and development for workers, weather conditions, inadequate project planning and scheduling, lack of supervisor experience, lack of leadership, low wages, inadequate labourers' skills and experience, delay in authority approvals, lack of labourers' supervision, poor construction method, and lack of health and safety planning were classified as the top 10 factors that affected labourers' productivity.

Figure 5. 2

Ranking of Factors Affecting Construction Labourers' Productivity

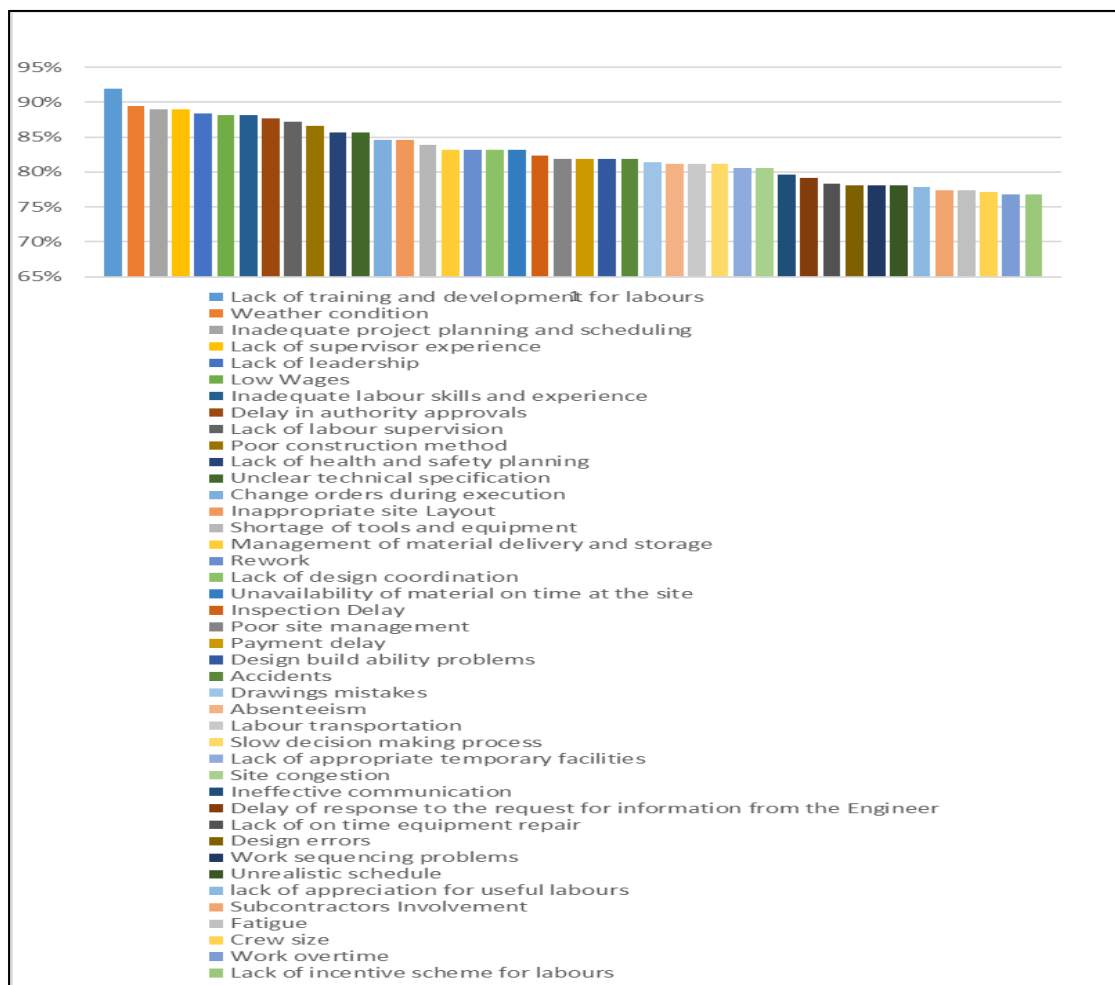


Figure 5.2 shows the ranking of the factors affecting labourers' productivity as per the data received from the participants.

Table 5. 2

Reliability Statistics

Cronbach Alpha	Cronbach Alpha Based on Standardized Items	N of Items
.953	.965	71

Table 5.2 identified the Cronbach Alpha value as 0.953, closer to 1, which is considered perfect reliability. This high value means there was a high level of internal consistency and the questions, and the measurement tools used were optimal in providing the required responses, and the research data was valid and accurate and could be used in future research. The research questionnaire was divided into three questions. The first section covers the respondents' demographic information, while the second section is focused on the factors that could impact construction labourers' productivity. The final section is a measure of the benefit that can be achieved with the use and successful implementation of BIM in building projects.

Accordingly, relative to participants' demographics, as shown in Table 5.3 below, 58.9 percent of the study's participants were male, and 41.1 percent were female.

Table 5. 3

Gender

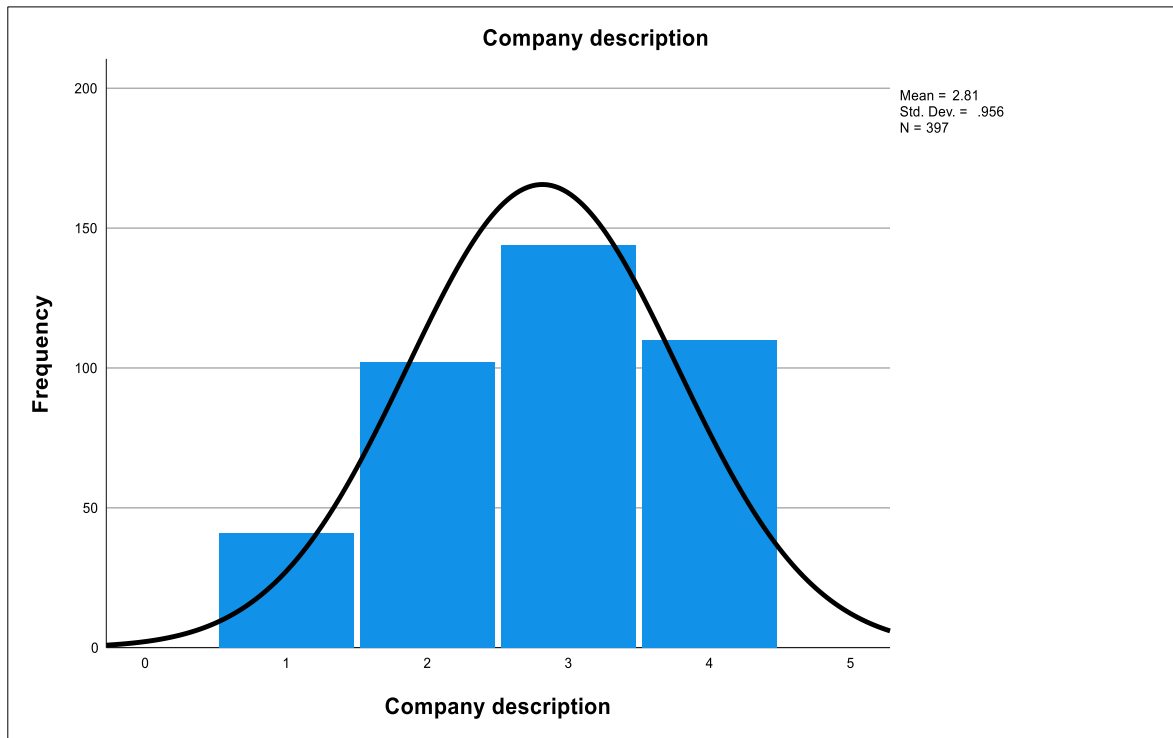
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	234	58.9	58.9	58.9
	Female	163	41.1	41.1	100.0

Total	397	100.0	100.0
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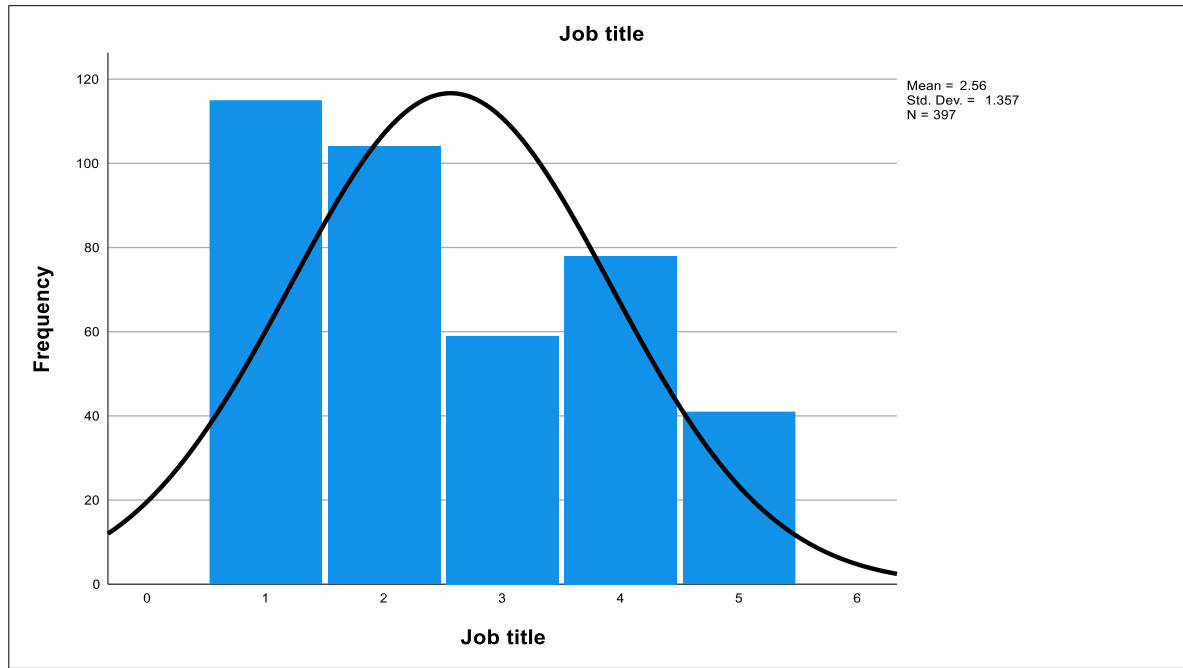
Also, the majority of respondents (36.27) percent were contractors, whilst 27.7 percent were subcontractors. In addition, 25.69 percent were consultants and 10.33 percent were clients who became a part of the research, as shown in Figure 5.3 below.

Figure 5. 3

Company Description



Moreover, regarding the respondents' jobs, 28.97 percent were project managers, while 26.20 percent were construction managers. The remaining 14.86 percent were foremen, 19.65 percent were supervisors, and 10.33 percent were resident engineers, as shown in Figure 5.4 below.

Figure 5. 4*Job Title*

As per the education of the respondents, 32 percent had a high diploma, 31.7 percent had a graduate degree, 24.9 percent had a college degree, 10.3 percent had a master's or above degree, and one percent were high schoolers, as shown in Table 5.4 below.

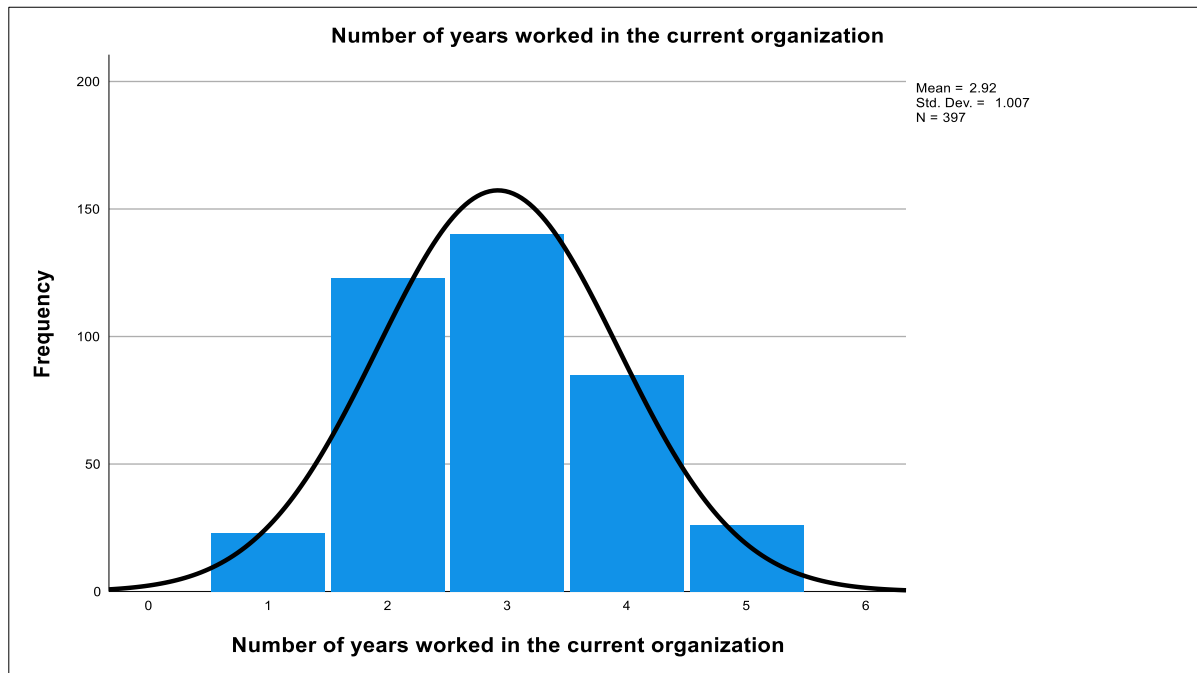
Table 5. 4*Level of Education*

		Frequency	Percent	Valid Percent	Cumulative
Valid	High school	4	1.0	1.0	1.0
	College degree	99	24.9	24.9	25.9
	Graduate degree	126	31.7	31.7	57.7
	High Diploma	127	32.0	32.0	89.7
	Master's or above	41	10.3	10.3	100.0
	Total	397	100.0	100.0	

Note: Author (2023)

Figure 5. 5

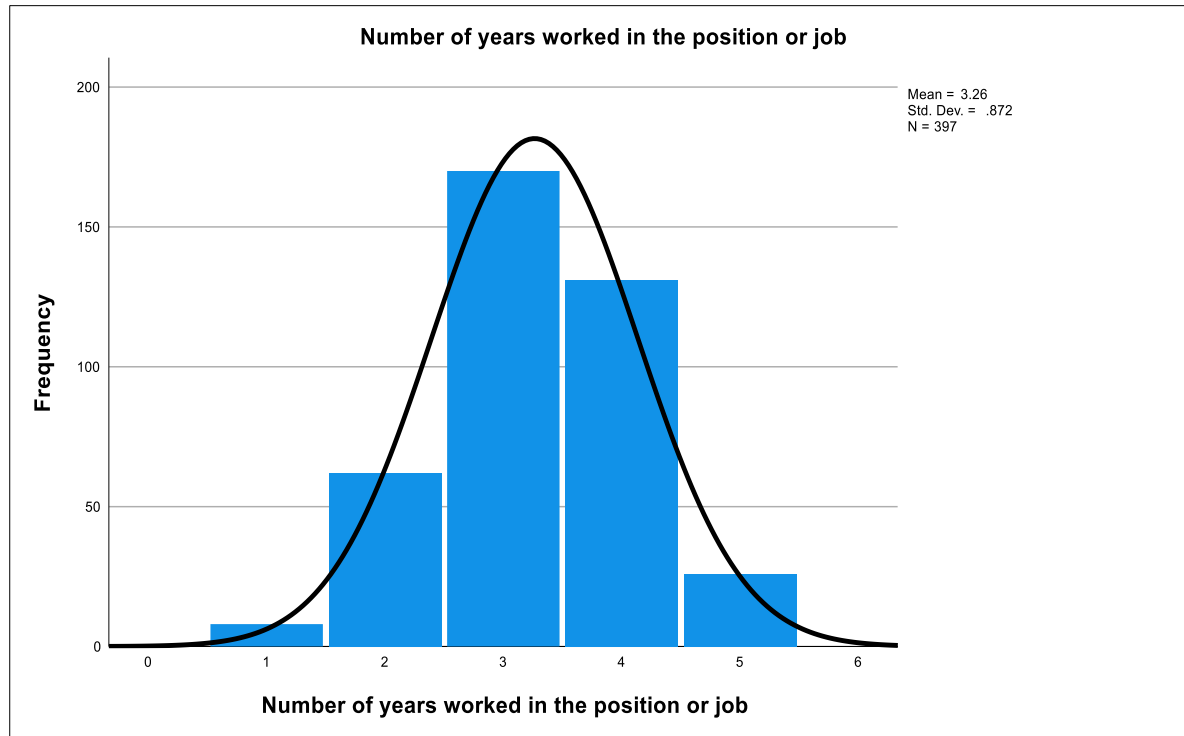
Number of Years in Organization



Reference to Figure 5.5 above, 35.3 percent of the respondents had 8-13 years of experience of working in their current organization, whilst 31 percent had been working there for 2-7 years, and the number of people working in the organization for one year or less was 57.93 percent. This shows that most of the respondents had less experience of working in their current organization. It is an indication of the respondents having less knowledge of their current organization's issues and culture and norms in handling construction work.

Figure 5. 6

Number of Years Working in the Position or Job



Regarding the number of years, they had worked in the said position, as shown in Figure 5.6 above 170 of the total 397 respondents had been in the said position for eight to 13 years while 131 of them had been in the position for 14-19 years. This huge experience in the position is relevant to the study again on the basis that these individuals have been seeing the changes and new practices being introduced in the field and are in the middle of these projects and are hence aware of the changes and how they have impacted the organization and the projects at large. This wealth of experience allows them to gain a more in-depth understanding of the situation, and the knowledge could provide more accurate data that expresses a concrete understanding of the situation.

The above was the last of the demographics. Before proceeding further, the normality tests have been conducted to ensure that the data are normally distributed.

Table 5. 5

Case Processing Summary

Case Processing Summary						
	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
PMFG	39 7	100.0%	0	0.0%	397	100.0%
CMFG	39 7	100.0%	0	0.0%	397	100.0%
TMFG	39 7	100.0%	0	0.0%	397	100.0%
X	39 7	100.0%	0	0.0%	397	100.0%
Mod	39 7	100.0%	0	0.0%	397	100.0%
Y	39 7	100.0%	0	0.0%	397	100.0%

Table 5. 6*Descriptives*

Descriptives			Statistic	Std. Error
Project Management Factors Group (PMFG)	Mean		15.1612	.07497
	95% Confidence Interval for Mean	Lower	15.0138	
		Upper	15.3086	
	5% Trimmed Mean	Lower	15.1460	
		Upper	15.1460	
	Median		15.0000	
	Variance		2.232	
	Std. Deviation		1.49383	
	Minimum		12.00	
	Maximum		18.00	
	Range		6.00	
	Interquartile Range		2.00	
	Skewness		.033	.122
	Kurtosis		-.757	.244
Construction Management Factors Group (CMFG)	Mean		16.2670	.07352
	95% Confidence Interval for Mean	Lower	16.1225	
		Upper	16.4115	
	5% Trimmed Mean	Lower	16.2551	
		Upper	16.2551	
	Median		16.0000	
	Variance		2.146	

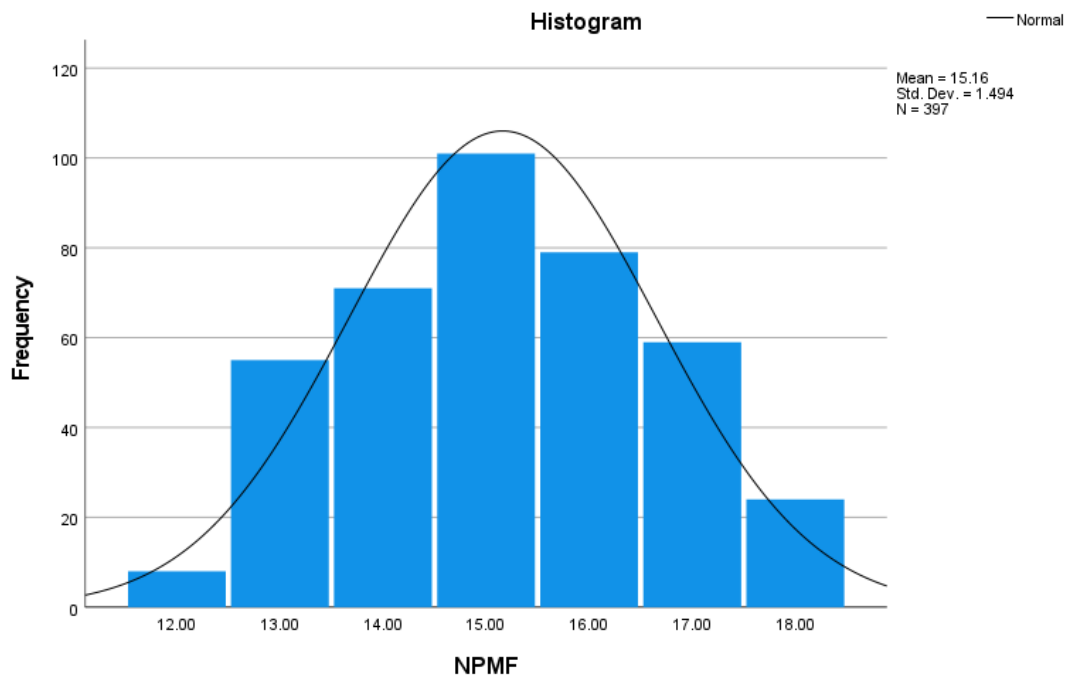
Technical Management Factors Group (TMFG)	Std. Deviation		1.46482	
	Minimum		13.00	
	Maximum		21.00	
	Range		8.00	
	Interquartile Range		2.00	
	Skewness		.106	.122
	Kurtosis		-.297	.244
	Mean		10.9698	.07042
	95% Confidence Interval for Mean	Lower	10.8313	
		Bound		
		Upper	11.1082	
		Bound		
	5% Trimmed Mean		10.9524	
	Median		11.0000	
	Variance		1.969	
	Std. Deviation		1.40313	
	Minimum		8.00	
	Maximum		14.00	
Using Building Information Modeling (BIM)	Range		6.00	
	Interquartile Range		2.00	
	Skewness		.115	.122
	Kurtosis		-.396	.244
	Mean		42.3980	.15953
	95% Confidence Interval for Mean	Lower	42.0843	
		Bound		

		Upper	42.7116	
		Bound		
	5% Trimmed Mean		42.4146	
	Median		43.0000	
	Variance		10.104	
	Std. Deviation		3.17865	
	Minimum		33.00	
	Maximum		51.00	
	Range		18.00	
	Interquartile Range		4.00	
	Skewness		-.067	.122
	Kurtosis		-.099	.244
Cloud Technology	Mean		7.8514	.05927
	95% Confidence	Lower	7.7349	
	Interval for Mean	Bound		
		Upper	7.9679	
		Bound		
	5% Trimmed Mean		7.8349	
	Median		8.0000	
	Variance		1.395	
	Std. Deviation		1.18090	
	Minimum		6.00	
	Maximum		10.00	
	Range		4.00	
	Interquartile Range		2.00	
	Skewness		.050	.122

	Kurtosis		-.899	.244
Level of Construction	Mean		22.0025	.08660
Labour Productivity (LCLP)	95% Confidence	Lower	21.8323	
	Interval for Mean	Bound		
		Upper	22.1728	
		Bound		
	5% Trimmed Mean		22.0056	
	Median		22.0000	
	Variance		2.977	
	Std. Deviation		1.72548	
	Minimum		17.00	
	Maximum		28.00	
	Range		11.00	
	Interquartile Range		2.00	
	Skewness		-.039	.122
	Kurtosis		-.002	.244

Figure 5. 7

Project Management Factors Distribution Histogram

**Figure 5. 8**

Project Management Factors Normal Q-Q Plot

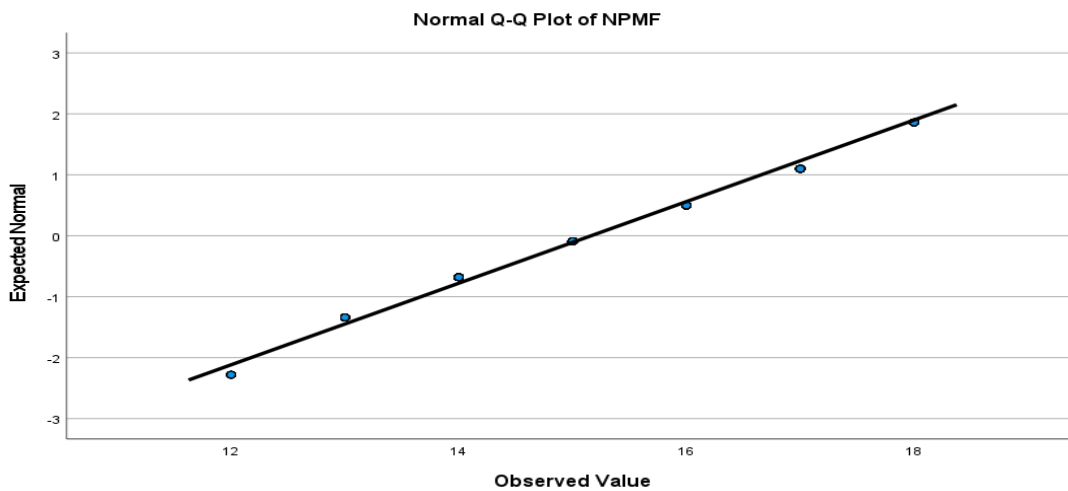


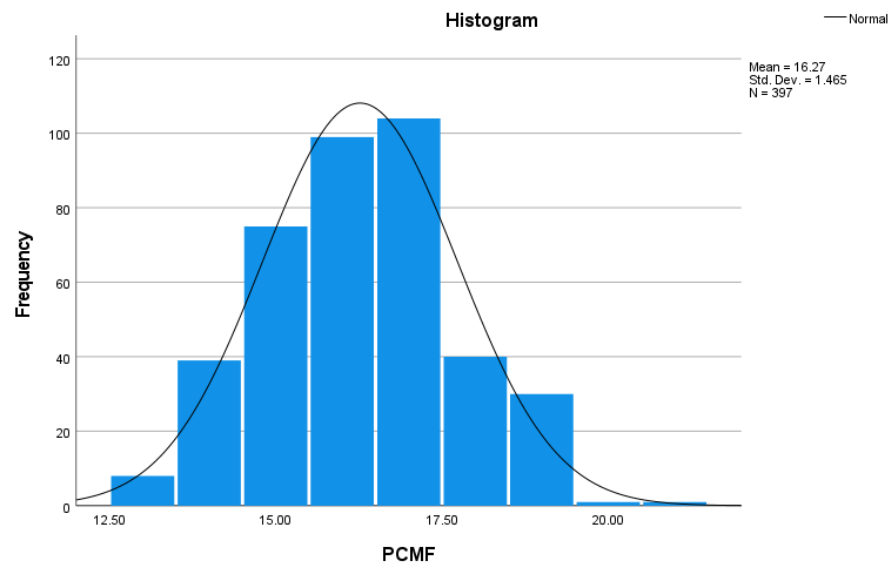
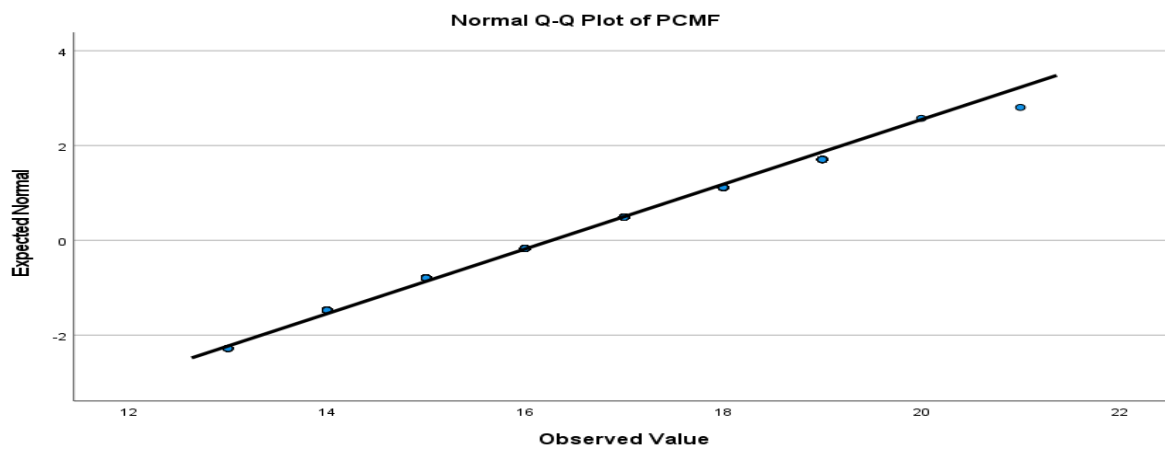
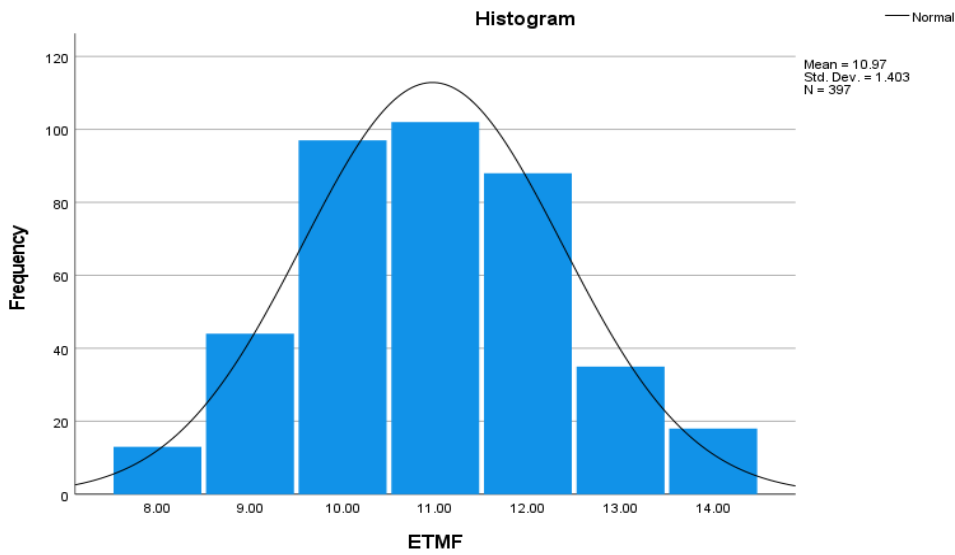
Figure 5. 9*Construction Management Factors Distribution Histogram***Figure 5. 10***Construction Management Factors Normal Q-Q Plot*

Figure 5. 11

Technical Management Factors Distribution Histogram

**Figure 5. 12**

Technical Management Factors Normal Q-Q Plot

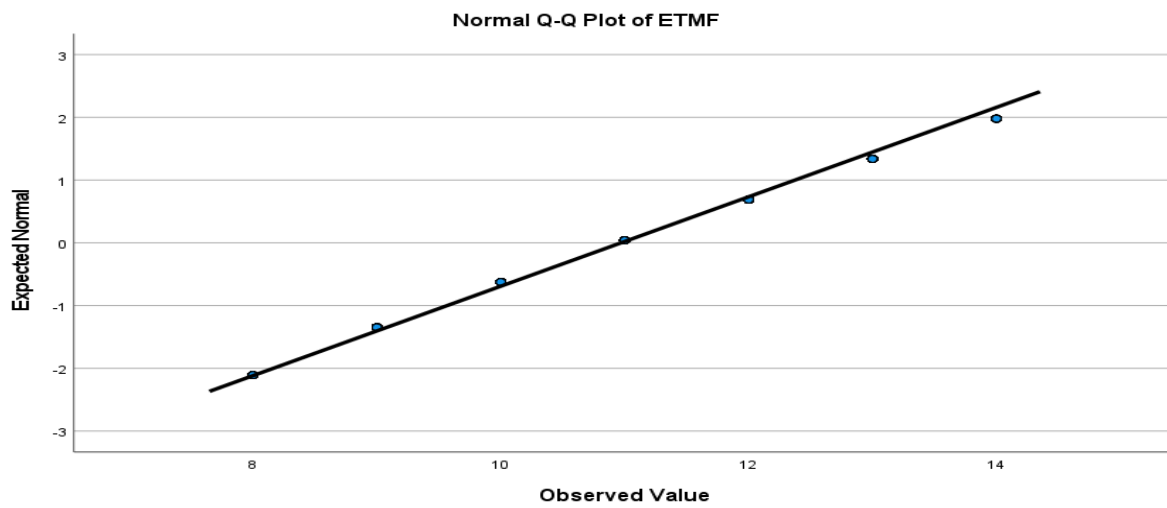
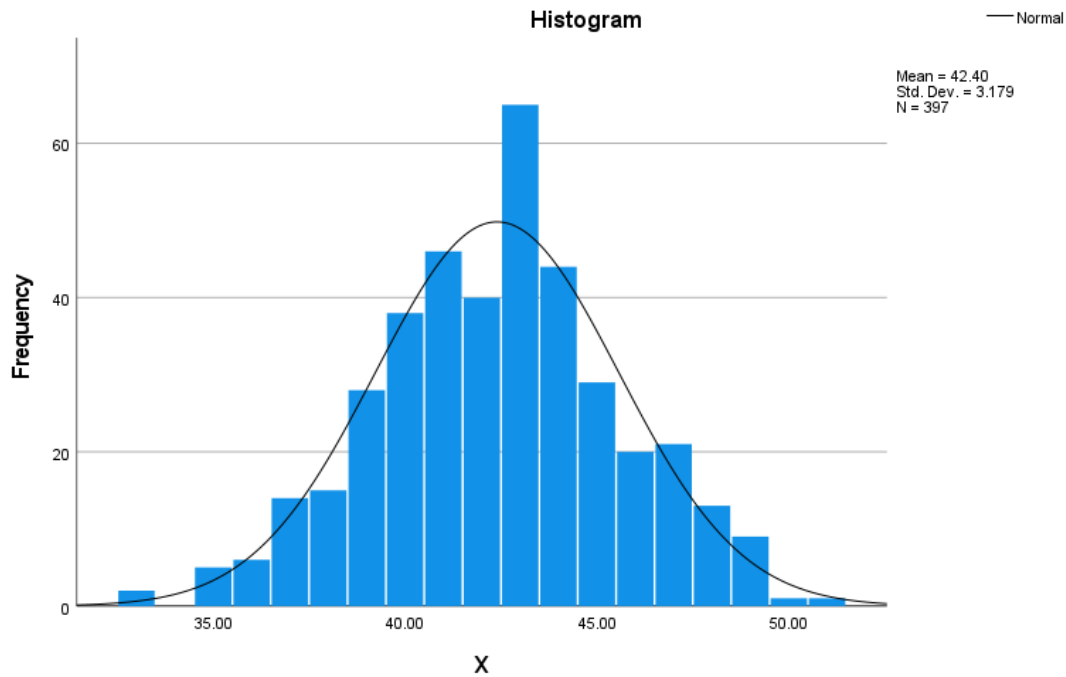


Figure 5. 13

Using Building Information Modelling (BIM) Factors Distribution Histogram

**Figure 5. 14**

Using Building Information Modelling (BIM) Factors Normal Q-Q Plot Source

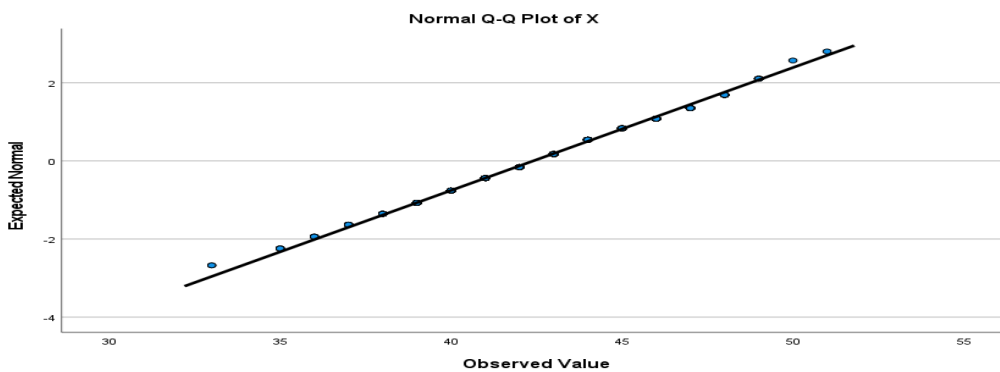
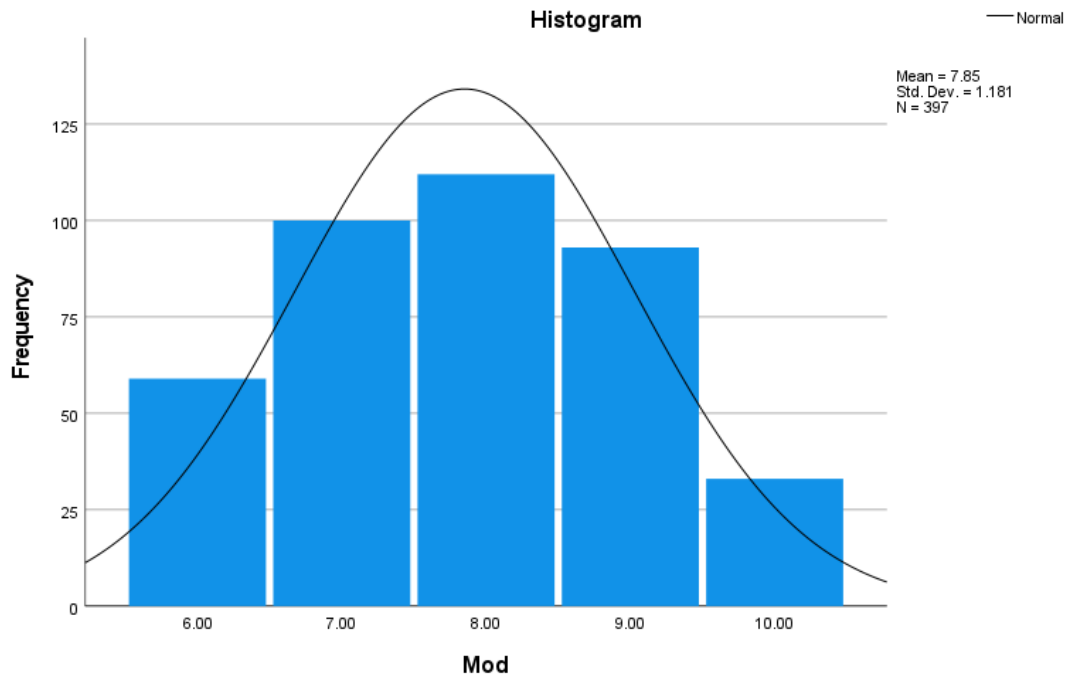


Figure 5. 15

Cloud Technology Factors Distribution Histogram

**Figure 5. 16**

Cloud Technology Factors Normal Q-Q Plot

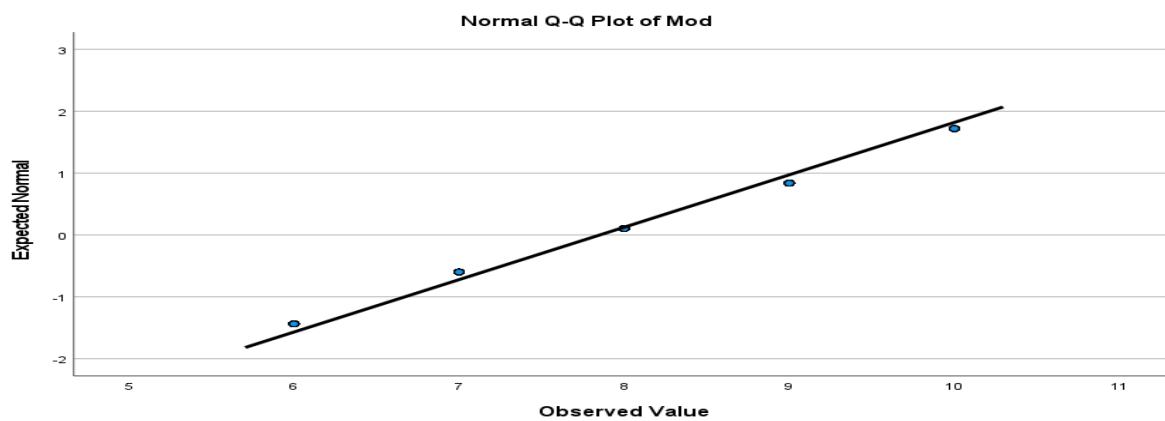
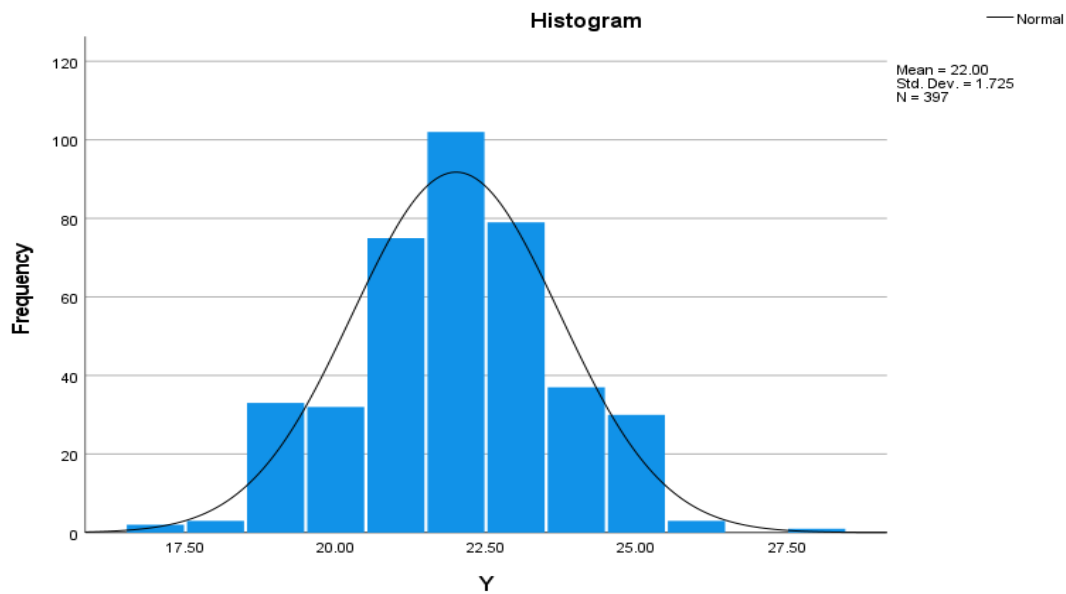
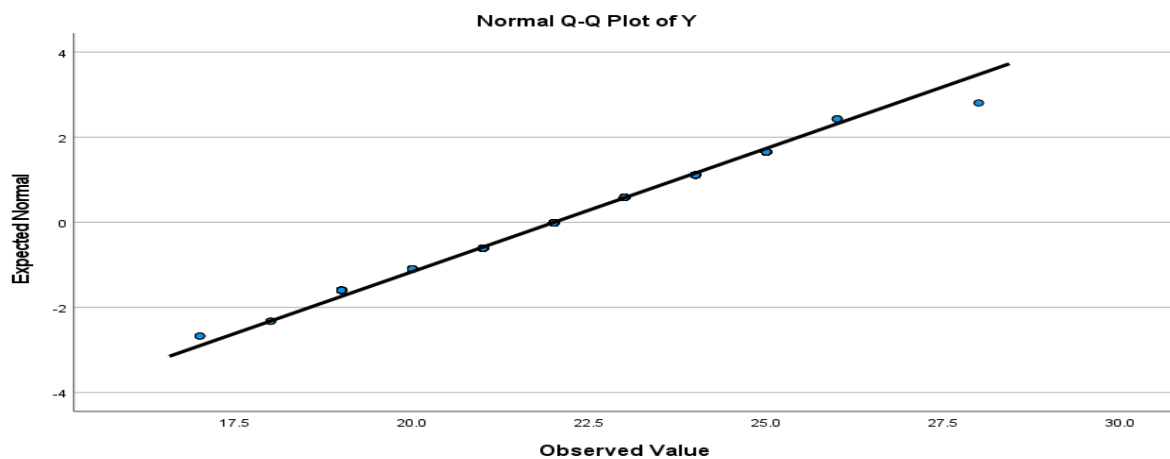


Figure 5. 17

Level of Construction Labourer Productivity Factors Distribution Histogram

**Figure 5. 18**

Level of Construction Labourer Productivity Factors Normal Q-Q Plot



The above figures from 5.7 to 5.18 present all variables used in this study, the figures show that the data are normally distributed.

5.3.1 Descriptive Analysis of Questionnaire Covering Objectives One to Three

The three objectives of the study involve the factors that influence construction labourers' productivity in the UAE, the advanced technologies that could improve labourers' productivity, and the integration of advanced technologies and labourers' productivity in the construction sector. After identifying the appropriate factors, the responses to the questionnaire related to the factors that influence construction labourers' productivity were evaluated using SPSS. The questionnaire was focused on the conceptual framework. Hence, the four themes mentioned in the framework involved construction management factors, project management factors and technical management factors, and cloud technology benefits realization. Then, looking at the framework expressed in chapter three, the hypotheses based on the relationship of these factors with BIM and the Level of construction labourers' productivity were tested. The four themes were the direct factors that influence the BIM and level of labourers' productivity, which in turn led to an indirect impact or influence on the two variables. Hence, the questions that measure each of the four themes and their responses were measured and totalled, providing the values that are considered for scoring and were used to determine their impact on the BIM and level of labourers' productivity. For the level of labourers' productivity, the total scores of the responses based on specific questions within the questionnaire measured the labourers' productivity from the questionnaire and then the scores were summed across the different themes and finally gained a single total value that was used for the comparison, and same was done for building information modelling factors. Also, descriptive statistics were used for the themes and the two variables for which the relationship was being explored.

Table 5. 7*Descriptive Statistics*

	N	Minimum	Maximum	Mean	Std. Deviation
Level of construction labourers' productivity	397	42.00	100.00	71.0000	14.22404
Construction management factors	397	13.00	34.00	21.6625	5.65077
Project management factors	397	12.00	34.00	21.9849	3.09117
Technical Management factors	397	8.00	22.00	12.8640	3.90889
Building Information Modelling Factors	397	16.00	42.00	23.8489	6.43988
Cloud Technology Benefits realization factors	397	7.00	23.00	11.0025	3.61220
Valid N (listwise)	397				

Based on Table 5.7 above, descriptive statistics showed that the minimum value was 42 while the maximum was 100. The mean value was 71, with a standard deviation of 14.22. It shows that the respondents responded significantly to the questions related to the level of construction labourers' productivity. The cloud technology benefits realization factors had the lowest mean of 11.00 with a standard deviation of 3.61. Construction management factors and project management factors almost had a similar mean with little difference (21.66 and 21.98 respectively) with the standard deviations of 5.65 and 3.09. It specifies that respondents' third and fourth most important factors for labourers' productivity were construction management and project management factors. The third critical point for respondents relative to

construction labourers' productivity was BIM factors, with a mean value of 23.84 and a standard deviation of 6.43.

In addition, Table 4 in Appendix A, named frequency analysis level of labourers' productivity, shows the frequency distribution of the level of labourers' productivity. For example, about 5.3 percent of the respondents agreed 82 times that labourers' productivity is critical to the organization's performance. The second highest frequency was 83, as 5 percent of the respondents specified 83 times the importance of labourers' productivity. The lowest frequencies were 42, 43, 44, 62, and 100 times because, in all these cases, 0.3 percent of the participants agreed about the labourers' productivity.

Table 5. 8

Frequency Analysis – Project Management Factors

Project Management Factors					
		Frequen cy	Percent	Valid Percent	Cumulative Percent
Valid	12.00	1	.3	.3	.3
	13.00	3	.8	.8	1.0
	14.00	2	.5	.5	1.5
	15.00	3	.8	.8	2.3
	16.00	7	1.8	1.8	4.0
	17.00	17	4.3	4.3	8.3
	18.00	16	4.0	4.0	12.3
	19.00	32	8.1	8.1	20.4
	20.00	35	8.8	8.8	29.2
	21.00	44	11.1	11.1	40.3
	22.00	60	15.1	15.1	55.4

23.00	51	12.8	12.8	68.3
24.00	46	11.6	11.6	79.8
25.00	39	9.8	9.8	89.7
26.00	20	5.0	5.0	94.7
27.00	11	2.8	2.8	97.5
28.00	4	1.0	1.0	98.5
29.00	3	.8	.8	99.2
30.00	1	.3	.3	99.5
31.00	1	.3	.3	99.7
34.00	1	.3	.3	100.0
Total	397	100.0	100.0	

In addition to referring to Table 5.8 above, relative to project management factors, about 15.1 percent of respondents stated 22 times that project management factors impact the labourers' productivity in the construction sector of the UAE. The second highest frequency was 23 because 12.8 percent specified the factor of project management aspects, and the third highest frequency was 24 as 11.6 percent identified the project management factors. The fourth highest frequency was 21 because 11.1 percent agreed on project management factors. On the other hand, the lowest frequencies were 12, 30, 31, and 34, as 0.3 percent of respondents indicated project management factors in the case of these frequencies.

Table 5. 9*Frequency Analysis – Construction Management Factors*

Construction Management Factors					
		Frequenc	Percent	Valid	Cumulative Percent
		y		Percent	
Valid	13.00	61	15.4	15.4	15.4
	14.00	28	7.1	7.1	22.4
	15.00	12	3.0	3.0	25.4
	16.00	8	2.0	2.0	27.5
	17.00	6	1.5	1.5	29.0
	18.00	11	2.8	2.8	31.7
	19.00	9	2.3	2.3	34.0
	20.00	8	2.0	2.0	36.0
	21.00	15	3.8	3.8	39.8
	22.00	17	4.3	4.3	44.1
	23.00	22	5.5	5.5	49.6
	24.00	28	7.1	7.1	56.7
	25.00	39	9.8	9.8	66.5
	26.00	55	13.9	13.9	80.4
	27.00	38	9.6	9.6	89.9
	28.00	14	3.5	3.5	93.5
	29.00	10	2.5	2.5	96.0
	30.00	7	1.8	1.8	97.7
	31.00	5	1.3	1.3	99.0
	32.00	2	.5	.5	99.5
	33.00	1	.3	.3	99.7
	34.00	1	.3	.3	100.0

In the case of Table 5.9 above, the highest percentage of respondents who identified construction management factors that impact the labourers' productivity was 15.4 percent and 13.9 percent because they specified 23 and 26 times that construction management factors affect construction labourers' productivity. On the other hand, the lowest frequencies were 33 and 34 because 0.3 percent indicated the construction management factors.

Table 5. 10

Frequency Analysis – Technical Management Factors

Technical Management Factors					
		Frequen cy	Percent	Valid Percent	Cumulative Percent
Valid	8.00	132	33.2	33.2	33.2
	9.00	8	2.0	2.0	35.3
	10.00	2	.5	.5	35.8
	11.00	5	1.3	1.3	37.0
	12.00	14	3.5	3.5	40.6
	13.00	17	4.3	4.3	44.8
	14.00	30	7.6	7.6	52.4
	15.00	59	14.9	14.9	67.3
	16.00	65	16.4	16.4	83.6
	17.00	31	7.8	7.8	91.4
	18.00	17	4.3	4.3	95.7
	19.00	8	2.0	2.0	97.7
	20.00	5	1.3	1.3	99.0
	21.00	3	.8	.8	99.7
	22.00	1	.3	.3	100.0
	Total	397	100.0	100.0	

Also, Table 5.10 above specified the highest frequency of 132, which meant that 33.2 percent of the respondents selected the technical management factors that influence the labourers' productivity construction factors. The second highest frequency was 65, which meant that 16.4 percent of respondents identified technical management factors. The third highest frequency was 59 (14.9 percent). Finally, the lowest frequency was 22, which meant that 0.3 percent of respondents indicated technical management factors.

Table 5. 11

Frequency Analysis – BIM

Using Building Information Modelling (BIM)					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	16.00	97	24.4	24.4	24.4
	17.00	28	7.1	7.1	31.5
	18.00	23	5.8	5.8	37.3
	19.00	7	1.8	1.8	39.0
	20.00	6	1.5	1.5	40.6
	21.00	7	1.8	1.8	42.3
	22.00	5	1.3	1.3	43.6
	23.00	2	.5	.5	44.1
	24.00	5	1.3	1.3	45.3
	25.00	9	2.3	2.3	47.6
	26.00	18	4.5	4.5	52.1
	27.00	27	6.8	6.8	58.9
	28.00	31	7.8	7.8	66.8
	29.00	48	12.1	12.1	78.8
	30.00	30	7.6	7.6	86.4

31.00	25	6.3	6.3	92.7
32.00	12	3.0	3.0	95.7
33.00	6	1.5	1.5	97.2
34.00	2	.5	.5	97.7
35.00	2	.5	.5	98.2
37.00	2	.5	.5	98.7
38.00	2	.5	.5	99.2
41.00	2	.5	.5	99.7
42.00	1	.3	.3	100.0
Total	397	100.0	100.0	

Table 5. 12*Frequency Analysis – Cloud Technology*

<i>Cloud Technology</i>				
<i>Valid</i>	<i>Frequency</i>	<i>Percent</i>	<i>Valid Percent</i>	<i>Cumulative Percent</i>
<i>7.00</i>	<i>140</i>	<i>35.3</i>	<i>35.3</i>	<i>35.3</i>
<i>8.00</i>	<i>24</i>	<i>6.0</i>	<i>6.0</i>	<i>41.3</i>
<i>9.00</i>	<i>10</i>	<i>2.5</i>	<i>2.5</i>	<i>43.8</i>
<i>10.00</i>	<i>9</i>	<i>2.3</i>	<i>2.3</i>	<i>46.1</i>
<i>11.00</i>	<i>14</i>	<i>3.5</i>	<i>3.5</i>	<i>49.6</i>
<i>12.00</i>	<i>20</i>	<i>5.0</i>	<i>5.0</i>	<i>54.7</i>
<i>13.00</i>	<i>38</i>	<i>9.6</i>	<i>9.6</i>	<i>64.2</i>

<i>14.00</i>	<i>65</i>	<i>16.4</i>	<i>16.4</i>	<i>80.6</i>
<i>15.00</i>	<i>40</i>	<i>10.1</i>	<i>10.1</i>	<i>90.7</i>
<i>16.00</i>	<i>22</i>	<i>5.5</i>	<i>5.5</i>	<i>96.2</i>
<i>17.00</i>	<i>10</i>	<i>2.5</i>	<i>2.5</i>	<i>98.7</i>
<i>18.00</i>	<i>3</i>	<i>.8</i>	<i>.8</i>	<i>99.5</i>
<i>19.00</i>	<i>1</i>	<i>.3</i>	<i>.3</i>	<i>99.7</i>
<i>23.00</i>	<i>1</i>	<i>.3</i>	<i>.3</i>	<i>100.0</i>
<i>Total</i>	<i>397</i>	<i>100.0</i>	<i>100.0</i>	

Moreover, Table 5.11 above indicated that the highest frequency was 97, meaning that 24.4 percent of the participants revealed that BIM could be used as an advanced technology to improve labourers' productivity. On the other hand, the second highest frequency was 48, as 12.1 percent of respondents indicated BIM as an advanced technology. In addition, the lowest frequency was 1 because 0.3 percent of respondents indicated BIM as an advanced technology to improve productivity.

Table 5.12 above identified that 140 was the highest frequency as 35.3 percent of respondents indicated that cloud technology improves construction labourers' productivity. In addition, 65 was the second highest frequency, and 40 was the third highest frequency. Conversely, the lowest frequency was 19 because 0.3 percent of respondents specified that cloud technology could improve labourers' productivity.

Therefore, the researcher proceeds to the next test which is a factor analysis test was carried out for each variable as below.

Table 5. 13

Correlation Matrix (Project Management Factors)

Correlation Matrix ^a													
		NPMF01	NPMF02	NPMF03	NPMF04	NPMF05	NPMF06	NPMF07	NPMF08	NPMF09	NPMF10	NPMF11	NPMF12
Correlation	NPMF01	1.000	-.303	.362	-.216	-.081	-.185	-.206	.487	-.137	-.230	-.207	.284
	NPMF02	-.303	1.000	-.173	-.133	.167	.288	.219	-.412	-.106	.420	.110	-.397
	NPMF03	.362	-.173	1.000	-.203	.089	-.193	-.018	.055	-.145	-.203	-.062	.073
	NPMF04	-.216	-.133	-.203	1.000	-.264	-.093	.024	.396	.015	-.113	-.086	.381
	NPMF05	-.081	.167	.089	-.264	1.000	.088	-.114	-.053	-.128	.302	-.221	-.034
	NPMF06	-.185	.288	-.193	-.093	.088	1.000	-.151	-.240	-.067	.455	-.092	-.216
	NPMF07	-.206	.219	-.018	.024	-.114	-.151	1.000	-.270	.084	-.048	.210	-.247
	NPMF08	.487	-.412	.055	.396	-.053	-.240	-.270	1.000	-.177	-.299	-.262	.787
	NPMF09	-.137	-.106	-.145	.015	-.128	-.067	.084	-.177	1.000	-.065	.173	-.159
	NPMF10	-.230	.420	-.203	-.113	.302	.455	-.048	-.299	-.065	1.000	-.077	-.268
	NPMF11	-.207	.110	-.062	-.086	-.221	-.092	.210	-.262	.173	-.077	1.000	-.253
	NPMF12	.284	-.397	.073	.381	-.034	-.216	-.247	.787	-.159	-.268	-.253	1.000
Sig. (1-tailed)	NPMF01		<.001	<.001	<.001	.053	<.001	<.001	<.001	.003	<.001	<.001	<.001
	NPMF02	.000		.000	.004	.000	.000	.000	.000	.017	.000	.014	.000
	NPMF03	.000	.000		.000	.038	.000	.364	.136	.002	.000	.109	.074
	NPMF04	.000	.004	.000		.000	.032	.320	.000	.380	.012	.044	.000
	NPMF05	.053	.000	.038	.000		.040	.012	.147	.005	.000	.000	.249
	NPMF06	.000	.000	.000	.032	.040		.001	.000	.091	.000	.034	.000
	NPMF07	.000	.000	.364	.320	.012	.001		.000	.047	.170	.000	.000
	NPMF08	.000	.000	.136	.000	.147	.000	.000		.000	.000	.000	.000
	NPMF09	.003	.017	.002	.380	.005	.091	.047	.000		.098	.000	.001
	NPMF10	.000	.000	.000	.012	.000	.000	.170	.000	.098		.063	.000
	NPMF11	.000	.014	.109	.044	.000	.034	.000	.000	.000	.063		.000
	NPMF12	.000	.000	.074	.000	.249	.000	.000	.000	.001	.000	.000	
a. Determinant = .030													

a. Determinant = .030

Table 5. 14

KMO and Bartlett's test (Project Management Factors)

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.628
Bartlett's Test of Sphericity	Approx. Chi-Square	1376.257
	df	66
	Sig.	<.001

Table 5.14 above presents KMO and Bartlett's test values for the project management factors group. The KMO value of 0.628 and significance level for Bartlett's test less than .001, suggested that there is substantial correlation in the data.

Table 5. 15*Communalities Results (Project Management Factors Group)*

Communalities		
	Initial	Extraction
NPMF01	1.000	.636
NPMF02	1.000	.626
NPMF03	1.000	.602
NPMF04	1.000	.770
NPMF05	1.000	.444
NPMF06	1.000	.571
NPMF07	1.000	.676
NPMF08	1.000	.826
NPMF09	1.000	.623
NPMF10	1.000	.638
NPMF11	1.000	.445
NPMF12	1.000	.761
Extraction Method: Component Analysis.		

Table 5. 16*Total Variance Explained Results (Project Management Factors Group)*

Total Variance Explained						
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.119	25.992	25.992	3.119	25.992	25.992
2	1.847	15.390	41.382	1.847	15.390	41.382

3	1.60 1	13.340	54.722	1.601	13.340	54.722
4	1.05 1	8.758	63.481	1.051	8.758	63.481
5	.908	7.565	71.046			
6	.745	6.210	77.257			
7	.672	5.598	82.855			
8	.611	5.091	87.946			
9	.510	4.252	92.197			
10	.466	3.885	96.083			
11	.330	2.746	98.829			
12	.141	1.171	100.000			

Extraction Method: Principal Component Analysis.

Figure 5. 19

Screen Plot (Project Management Factors Group)

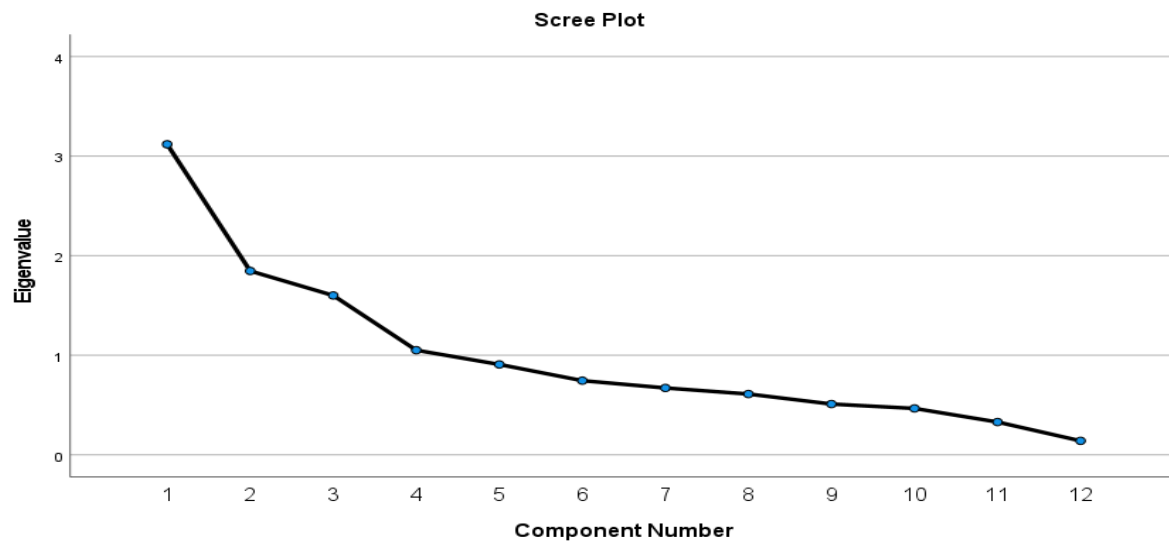


Table 5.15 and figure 5.16 above shows Eigenvalue for the project management factors group, there are four components above, the rest steadily reduced to 0.330 except components 12 has an Eigenvalue of 0.14, moreover, the first 4 components accounted for 63% of the cumulative variance.

Moreover, factor analysis correlation in table 5.15 and 5.16 above, shows the R and R-square values, and referred to as the commonalities. Here, the guideline was set that anything lower than 0.40 would not contribute much to measuring the underlying factors, and these factors would have to be removed. As shown in Table 5.15 above no variables had a value of less than 0.40; thus, no omission was required. However, component number 8 which is slow decision-making process was seen to have the highest R-squared value of around 0.826 and the lowest was 0.444, which is component number 5, the lack of appreciation for useful labourers.

Table 5. 17*Correlation Matrix (Construction Management Factors)*

Correlation Matrix ^a														
		PCMF01	PCMF02	PCMF03	PCMF04	PCMF05	PCMF06	PCMF07	PCMF08	PCMF09	PCMF10	PCMF11	PCMF11	PCMF12
Correlation	PCMF01	1.000	-.284	.218	-.230	-.011	-.186	-.166	.185	-.152	-.232	-.144	-.225	.281
	PCMF02	-.284	1.000	-.213	-.079	.127	.276	.080	-.290	-.086	.405	-.101	.080	-.295
	PCMF03	.218	-.213	1.000	-.126	-.166	-.116	-.098	.155	-.105	-.167	-.125	.018	.016
	PCMF04	-.230	-.079	-.126	1.000	-.286	-.077	.111	.293	.040	-.079	-.041	-.086	.397
	PCMF05	-.011	.127	-.166	-.286	1.000	-.013	-.089	-.113	-.162	.188	-.185	.101	-.147
	PCMF06	-.186	.276	-.116	-.077	-.013	1.000	-.101	-.176	-.056	.415	-.053	.144	-.187
	PCMF07	-.166	.080	-.098	.111	-.089	-.101	1.000	-.201	.138	-.023	.000	-.066	-.182
	PCMF08	.185	-.290	.155	.293	-.113	-.176	-.201	1.000	-.169	-.258	-.160	-.033	.840
	PCMF09	-.152	-.086	-.105	.040	-.162	-.056	.138	-.169	1.000	-.051	.245	-.058	-.159
	PCMF10	-.232	.405	-.167	-.079	.188	.415	-.023	-.258	-.051	1.000	-.017	.142	-.260
	PCMF11	-.144	-.101	-.125	-.041	-.185	-.053	.000	-.160	.245	-.017	1.000	-.055	-.163
	PCMF11	-.225	.080	.018	-.086	.101	.144	-.066	-.033	-.058	.142	-.055	1.000	-.231
Sig. (1-tailed)	PCMF12	.281	-.295	.016	.397	-.147	-.187	-.182	.840	-.159	-.260	-.163	-.231	1.000
	PCMF01		<.001	<.001	<.001	.411	<.001	<.001	<.001	.001	<.001	.002	<.001	<.001
	PCMF02	.000		.000	.058	.006	.000	.056	.000	.043	.000	.022	.055	.000
	PCMF03	.000	.000		.006	.000	.010	.025	.001	.018	.000	.006	.361	.377
	PCMF04	.000	.058	.006		.000	.063	.014	.000	.212	.057	.208	.043	.000
	PCMF05	.411	.006	.000	.000		.400	.038	.012	.001	.000	.000	.022	.002
	PCMF06	.000	.000	.010	.063	.400		.022	.000	.133	.000	.147	.002	.000
	PCMF07	.000	.056	.025	.014	.038	.022		.000	.003	.321	.496	.096	.000
	PCMF08	.000	.000	.001	.000	.012	.000	.000		.000	.000	.001	.257	.000
	PCMF09	.001	.043	.018	.212	.001	.133	.003	.000		.155	.000	.126	.001
	PCMF10	.000	.000	.000	.057	.000	.000	.321	.000	.155		.364	.002	.000
	PCMF11	.002	.022	.006	.208	.000	.147	.496	.001	.000	.364		.139	.001
PCMF11	.000	.055	.361	.043	.022	.002	.096	.257	.126	.002	.139		.000	
PCMF12	.000	.000	.377	.000	.002	.000	.000	.000	.001	.000	.001	.000		

a. Determinant = .038

Table 5. 18*KMO And Bartlett's Test (Construction Management Factors)*

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.587
Bartlett's Test of Sphericity	Approx. Chi-Square	1282.998
	df	78
	Sig.	<.001

Table 5.18 above presents KMO and Bartlett's test values for the project management factors group. The KMO value of 0.587 and significance level for Bartlett's test less than .001, suggested that there is substantial correlation in the data.

Table 5. 19

Communalities Results (Construction Management Factors)

Communalities		
	Initial	Extraction
PCMF01	1.000	.698
PCMF02	1.000	.586
PCMF03	1.000	.764
PCMF04	1.000	.734
PCMF05	1.000	.807
PCMF06	1.000	.685
PCMF07	1.000	.748
PCMF08	1.000	.817
PCMF09	1.000	.492
PCMF10	1.000	.607
PCMF11	1.000	.689
PCMF11	1.000	.849
PCMF12	1.000	.895

Extraction Method: Principal Component Analysis.

Table 5. 20

Total Variance Explained Results (Construction Management Factors)

Total Variance Explained						
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.864	22.028	22.028	2.864	22.028	22.028
2	1.735	13.344	35.372	1.735	13.344	35.372
3	1.574	12.108	47.479	1.574	12.108	47.479
4	1.134	8.724	56.203	1.134	8.724	56.203
5	1.059	8.145	64.348	1.059	8.145	64.348
6	1.006	7.737	72.085	1.006	7.737	72.085
7	.747	5.747	77.832			
8	.666	5.127	82.959			
9	.615	4.728	87.687			
10	.590	4.538	92.225			
11	.526	4.044	96.269			
12	.373	2.867	99.136			

13	.112	.864	100.000
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Extraction Method: Principal Component Analysis.

Figure 5. 20

Screen Plot (Construction Management Factors)

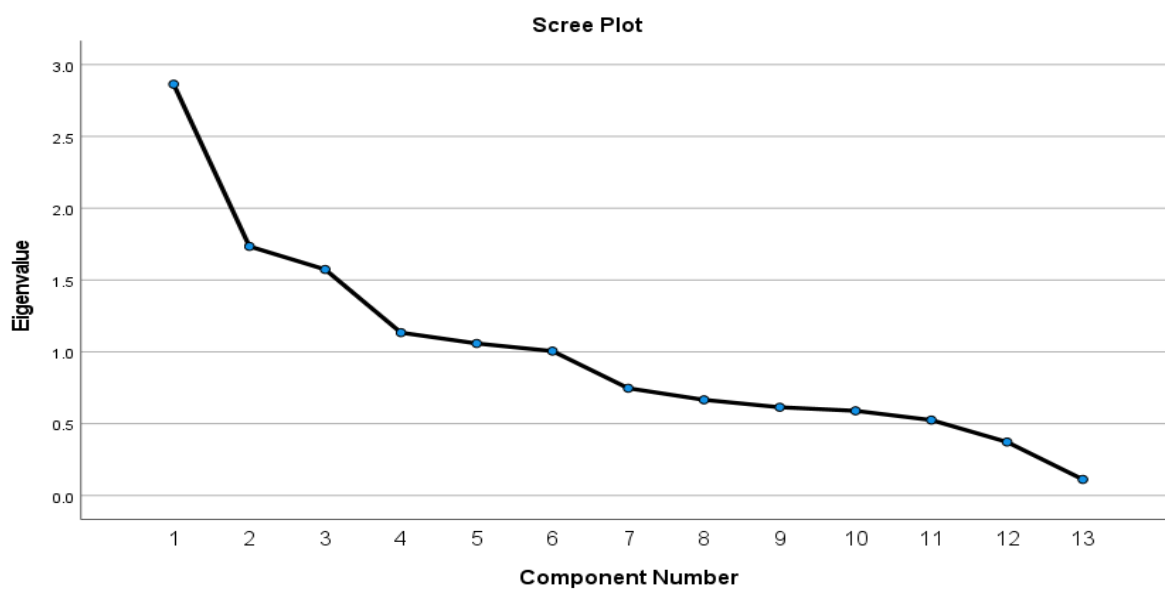


Table 5.19 and figure 5.20 above shows Eigenvalue for the construction management factors, there are 6 components above 1, the rest steadily reduced to 0.373 except components 13 has an Eigenvalue of 0.112, moreover, the first 6 components accounted for 72% of the cumulative variance.

Moreover, factor analysis correlation in table 5.19 and 5.20 above, shows the R and R-square values, and referred to as the commonalities. Here, the guideline was set that anything lower than 0.40 would not contribute much to measuring the underlying factors, and these factors would have to be removed. As shown in Table 5.19 above no variables had a value of less than 0.40; thus, no omission was required. However, component number 12 which is

Shortage of tools and equipment was seen to have the highest R-squared value of around 0.895 and the lowest was 0.494, which is component number 9, the Lack of appropriate temporary facilities.

Table 5. 21

Correlation Matrix (Technical Management Factors)

		Correlation Matrix^a							
		VAR00026	VAR00027	VAR00028	VAR00029	VAR00030	VAR00031	VAR00032	VAR00033
Correlation	VAR00026	1.000	-.195	-.008	-.030	-.014	.086	.062	.126
	VAR00027	-.195	1.000	-.245	-.149	.261	.185	.023	-.320
	VAR00028	-.008	-.245	1.000	-.057	.125	.055	-.225	.030
	VAR00029	-.030	-.149	-.057	1.000	-.360	.046	-.054	.478
	VAR00030	-.014	.261	.125	-.360	1.000	-.026	-.007	-.358
	VAR00031	.086	.185	.055	.046	-.026	1.000	-.240	.008
	VAR00032	.062	.023	-.225	-.054	-.007	-.240	1.000	-.292
	VAR00033	.126	-.320	.030	.478	-.358	.008	-.292	1.000
Sig. (1-tailed)	VAR00026		<.001	.435	.274	.391	.044	.109	.006
	VAR00027	.000		.000	.001	.000	.000	.323	.000
	VAR00028	.435	.000		.128	.006	.136	.000	.276
	VAR00029	.274	.001	.128		.000	.179	.143	.000
	VAR00030	.391	.000	.006	.000		.306	.443	.000
	VAR00031	.044	.000	.136	.179	.306		.000	.436
	VAR00032	.109	.323	.000	.143	.443	.000		.000
	VAR00033	.006	.000	.276	.000	.000	.436	.000	

a. Determinant = .340

Table 5. 22

KMO and Bartlett's Test (Technical Management Factors)

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.536
Bartlett's Test of Sphericity	Approx. Chi-Square	423.798
	df	28
	Sig.	<.001

Table 5.22 above presents KMO and Bartlett's test values for the technical management factors. The KMO value of 0.536 and significance level for Bartlett's test less than .001, suggested that there is substantial correlation in the data.

Table 5. 23

Communalities Results (Technical Management Factors Group)

Communalities		
	Initial	Extraction
VAR00026	1.000	.905
VAR00027	1.000	.750
VAR00028	1.000	.734
VAR00029	1.000	.630
VAR00030	1.000	.569
VAR00031	1.000	.756
VAR00032	1.000	.694
VAR00033	1.000	.689
Extraction Method: Principal Component Analysis.		

Table 5. 24

Total Variance Explained Results (Technical Management Factors Group)

Total Variance Explained						
Component	Total	Initial Eigenvalues		Extraction Sums of Squared Loadings		
		% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.043	25.542	25.542	2.043	25.542	25.542
2	1.379	17.241	42.783	1.379	17.241	42.783
3	1.249	15.612	58.395	1.249	15.612	58.395
4	1.055	13.192	71.587	1.055	13.192	71.587
5	.747	9.339	80.926			
6	.663	8.290	89.216			
7	.471	5.882	95.097			
8	.392	4.903	100.000			

Extraction Method: Principal Component Analysis.

Figure 5. 21

Screen Plot (Technical Management Factors Group)

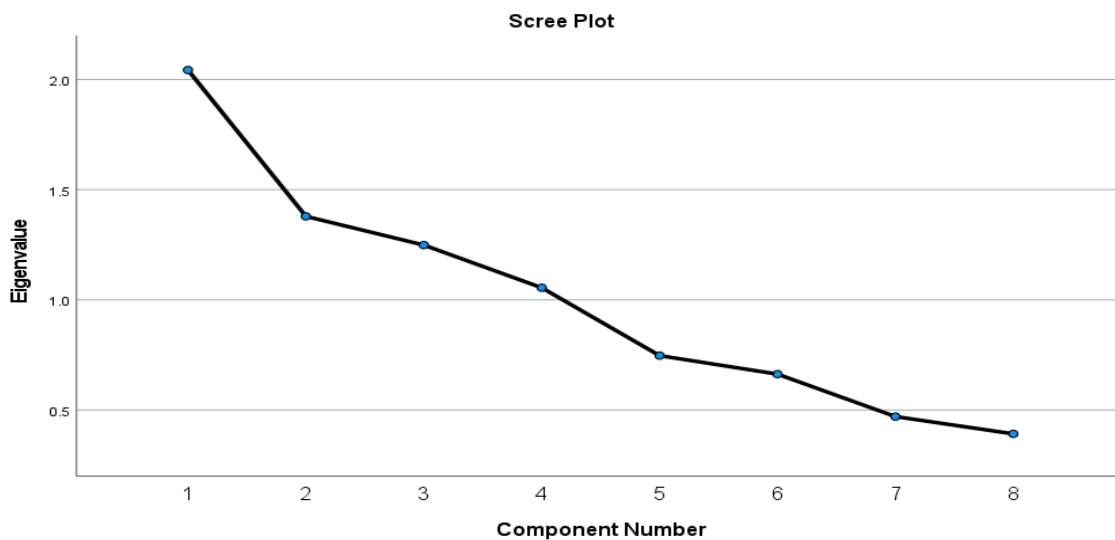


Table 5.23 and figure 5.21 above shows Eigenvalue for the technical management factors, there are 4 components above 1, the rest steadily reduced to 0.392. Moreover, the first 4 components accounted for 71.5% of the cumulative variance.

Moreover, factor analysis correlation in table 5.23 and 5.24 above, shows the R and R-square values, and referred to as the commonalities. Here, the guideline was set that anything lower than 0.40 would not contribute much to measuring the underlying factors, and these factors would have to be removed. As shown in Table 5.23 above no variables had a value of less than 0.40; thus, no omission was required. However, component number 1 which is change orders during execution was seen to have the highest R-squared value of around 0.905 and the lowest was 0.569, which is component number 5, unclear technical specification.

Table 5. 25

Correlation Matrix (Using Building Information Building (BIM) Factors)

Correlation Matrix ^a															
	VAR00034	VAR00035	VAR00036	VAR00037	VAR00038	VAR00039	VAR00040	VAR00041	VAR00042	VAR00043	VAR00044	VAR00045	VAR00046	VAR00047	VAR00048
Correlation	VAR00034	1.000	.026	-.079	-.150	.091	.270	-.075	-.034	-.036	.153	-.272	-.246	.782	-.078
	VAR00035	.026	1.000	-.133	-.267	-.035	.363	.033	.080	-.174	.257	-.206	-.115	-.007	.675
	VAR00036	-.079	-.133	1.000	-.327	.120	-.027	.203	-.084	-.224	.046	-.071	.056	.001	-.189
	VAR00037	-.150	-.267	-.327	1.000	-.117	-.310	-.209	-.146	.351	-.305	-.058	.267	-.067	-.168
	VAR00038	.091	-.035	.120	-.117	1.000	-.088	.294	-.058	.006	-.055	-.157	.009	-.008	.061
	VAR00039	.270	.363	-.027	-.310	-.088	1.000	-.086	.200	-.141	.298	-.174	-.108	.220	.199
	VAR00040	-.075	.033	.203	-.209	.294	-.086	1.000	-.042	-.100	.045	-.040	-.068	.007	-.163
	VAR00041	-.034	.080	-.084	-.146	-.058	.200	-.042	1.000	-.198	.197	-.030	-.071	-.063	.056
	VAR00042	-.036	-.174	-.224	.351	.006	-.141	-.100	-.198	1.000	-.332	.227	-.267	-.005	-.002
	VAR00043	.153	.257	.046	-.305	-.055	.298	.045	.197	-.332	1.000	-.190	-.090	.040	.126
	VAR00044	-.272	-.206	-.071	-.058	-.157	-.174	-.040	-.030	.227	-.190	1.000	-.155	-.233	.020
	VAR00045	-.246	-.115	.056	.267	.009	-.108	-.068	-.071	-.267	-.090	-.155	1.000	-.274	-.133
	VAR00046	.782	-.007	.001	-.087	-.008	.220	.007	-.063	-.005	.040	-.233	-.274	1.000	-.131
	VAR00047	-.078	.675	-.189	-.168	-.116	.199	-.163	.056	-.002	.126	.020	-.133	-.131	1.000
	VAR00048	-.073	-.122	.798	-.237	.061	-.052	-.017	-.002	-.194	.041	-.115	.146	-.100	-.137
	VAR00049	-.220	-.247	-.172	.594	-.213	-.310	-.146	-.188	.183	-.341	.157	.264	-.167	-.040
Sig. (1-tailed)	VAR00034		.305	.058	.001	.035	<.001	.067	.247	.238	.001	<.001	<.001	<.001	.059
	VAR00035	.305		.004	.000	.242	.000	.254	.056	.000	.000	.011	.446	.000	.007
	VAR00036	.058	.004		.000	.008	.294	.000	.047	.000	.182	.079	.131	.494	.000
	VAR00037	.001	.000	.000		.010	.000	.000	.002	.000	.000	.126	.000	.042	.000
	VAR00038	.035	.242	.008	.010		.041	.000	.125	.451	.137	.001	.426	.441	.010
	VAR00039	.000	.000	.294	.000	.041		.044	.000	.002	.000	.000	.016	.000	.150
	VAR00040	.067	.254	.000	.000	.000	.044		.204	.023	.185	.213	.087	.441	.001
	VAR00041	.247	.056	.047	.002	.125	.000	.204		.000	.000	.273	.078	.107	.134
	VAR00042	.238	.000	.000	.000	.451	.002	.023	.000		.000	.000	.462	.485	.000
	VAR00043	.001	.000	.182	.000	.137	.000	.185	.000	.000		.000	.037	.214	.006
	VAR00044	.000	.000	.079	.126	.001	.000	.213	.273	.000	.000		.001	.000	.348
	VAR00045	.000	.011	.131	.000	.426	.016	.087	.078	.000	.037	.001		.000	.004
	VAR00046	.000	.446	.494	.042	.441	.000	.441	.107	.462	.214	.000	.000		.004
	VAR00047	.059	.000	.000	.000	.010	.000	.001	.134	.485	.006	.348	.004	.004	
	VAR00048	.075	.007	.000	.000	.113	.150	.369	.483	.000	.209	.011	.002	.024	.003
	VAR00049	.000	.000	.000	.000	.000	.000	.002	.000	.000	.001	.000	.000	.215	.000

a. Determinant = .003

Table 5. 26

KMO And Bartlett's Test (Using Building Information Building (BIM) Factors)

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.

.577

Bartlett's Test of Sphericity Approx. Chi-Square

2242.322

df	120
Sig.	.000

Table 5.26 above presents KMO and Bartlett's test values for the Using Building information Building (BIM) Factors group of factors. The KMO value of 0.577 and significance level for Bartlett's test .000, suggested that there is substantial correlation in the data.

Table 5. 27

Communalities Results (Using Building Information Building (BIM) Factors)

Communalities		
	Initial	Extraction
		n
VAR00034	1.000	.840
VAR00035	1.000	.842
VAR00036	1.000	.869
VAR00037	1.000	.739
VAR00038	1.000	.621
VAR00039	1.000	.492
VAR00040	1.000	.634
VAR00041	1.000	.598
VAR00042	1.000	.616
VAR00043	1.000	.480
VAR00044	1.000	.688
VAR00045	1.000	.717
VAR00046	1.000	.823
VAR00047	1.000	.821
VAR00048	1.000	.867
VAR00049	1.000	.635
Extraction Method: Principal Component Analysis.		

Table 5. 28

Total Variance Explained Results (Building Information Building (BIM) Factors)

Total Variance Explained						
Component	Total	Initial Eigenvalues		Extraction Sums of Squared Loadings		
		% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.084	19.275	19.275	3.084	19.275	19.275
2	2.323	14.521	33.796	2.323	14.521	33.796
3	1.975	12.343	46.139	1.975	12.343	46.139
4	1.473	9.204	55.344	1.473	9.204	55.344
5	1.276	7.973	63.317	1.276	7.973	63.317
6	1.152	7.201	70.518	1.152	7.201	70.518
7	.863	5.394	75.912			
8	.711	4.445	80.357			
9	.700	4.373	84.730			
10	.664	4.150	88.880			
11	.513	3.207	92.087			
12	.413	2.578	94.665			
13	.296	1.849	96.514			
14	.226	1.412	97.926			
15	.209	1.303	99.230			
16	.123	.770	100.000			

Extraction Method: Principal Component Analysis.

Figure 5. 22

Scree Plot (Using Building Information Building (BIM) Factors)

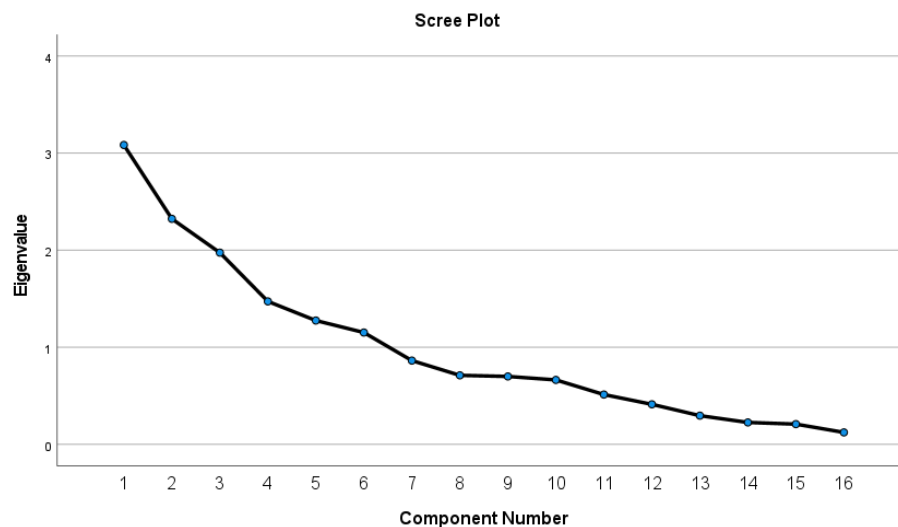


Table 5.28 and figure 5.22 above shows Eigenvalue for the Using Building information Building (BIM) factors, there are 6 components above 1, the rest steadily reduced to 0.392. Moreover, the first 4 components accounted for 71.5% of the cumulative variance.

Moreover, factor analysis correlation in table 5.27 and 5.28 above, shows the R and R-square values, and referred to as the commonalities. Here, the guideline was set that anything lower than 0.40 would not contribute much to measuring the underlying factors, and these factors would have to be removed. As shown in Table 5.27 above no variables had a value of less than 0.40; thus, no omission was required. However, component number 3 which is using BIM improves productivity due to easy retrieval of information was seen to have the highest R-squared value of around 0.869 and the lowest was 0.480, which is component number 5, using BIM improves construction site management.

Table 5. 29

Correlation Matrix (Cloud Technology Factors)

Correlation Matrix								
		VAR00050	VAR00051	VAR00052	VAR00053	VAR00054	VAR00055	VAR00056
Correlation	VAR00050	1.000	.355	-.305	.049	-.165	.730	.947
	VAR00051	.355	1.000	-.274	-.152	.146	.111	.231
	VAR00052	-.305	-.274	1.000	-.125	-.100	-.138	-.296
	VAR00053	.049	-.152	-.125	1.000	-.136	-.024	.086
	VAR00054	-.165	.146	-.100	-.136	1.000	-.215	-.169
	VAR00055	.730	.111	-.138	-.024	-.215	1.000	.723
	VAR00056	.947	.231	-.296	.086	-.169	.723	1.000
Sig. (1-tailed)	VAR00050		<.001	<.001	.167	<.001	<.001	<.001
	VAR00051	.000		.000	.001	.002	.014	.000
	VAR00052	.000	.000		.006	.024	.003	.000
	VAR00053	.167	.001	.006		.003	.317	.043
	VAR00054	.000	.002	.024	.003		.000	.000
	VAR00055	.000	.014	.003	.317	.000		.000
	VAR00056	.000	.000	.000	.043	.000	.000	

Table 5. 30

KMO And Bartlett's Test (Cloud Technology Factors)

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.651
Bartlett's Test of Sphericity	Approx. Chi-Square	1457.253
	df	21
	Sig.	<.001

Table 5.30 above presents KMO and Bartlett's test values for Cloud Technology factors. The KMO value of 0.651 and significance level for Bartlett's test <.001, suggested that there is substantial correlation in the data.

Table 5. 31

Communalities Results (Cloud Technology Factors)

Communalities		
	Initial	Extraction
VAR00050	1.000	.930
VAR00051	1.000	.600
VAR00052	1.000	.690
VAR00053	1.000	.849
VAR00054	1.000	.566
VAR00055	1.000	.771
VAR00056	1.000	.898

Extraction Method: Principal Component Analysis.

Table 5. 32

Total Variance Explained Results (Cloud Technology Factors)

Total Variance Explained						
Component	Total	Initial Eigenvalues		Extraction Sums of Squared Loadings		
		% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.866	40.938	40.938	2.866	40.938	40.938
2	1.357	19.390	60.329	1.357	19.390	60.329
3	1.080	15.435	75.764	1.080	15.435	75.764
4	.731	10.444	86.208			
5	.626	8.948	95.157			
6	.296	4.229	99.386			
7	.043	.614	100.000			

Extraction Method: Principal Component Analysis.

Figure 5. 23

Scree Plot (Cloud Technology Factors)

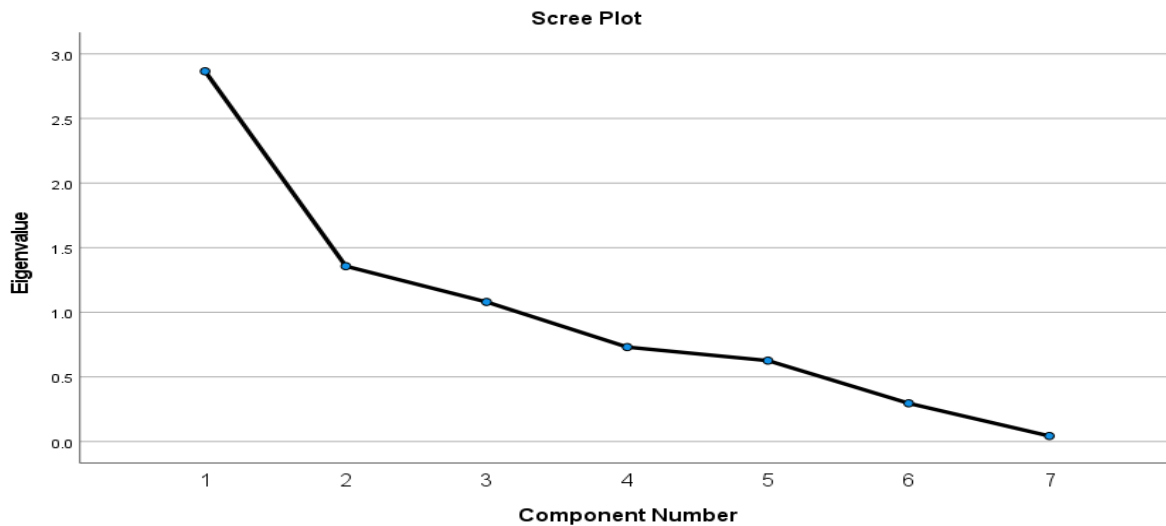


Table 5.32 and figure 5.23 above shows Eigenvalue for cloud technology factors, there are 3 components above 1, the rest steadily reduced to 0.296 except component 7 Eigenvalue is 0.043. Moreover, the first 3 components accounted for 75.7% of the cumulative variance.

Moreover, factor analysis correlation in table 5.31 and 5.32 above, shows the R and R-square values, and referred to as the commonalities. Here, the guideline was set that anything lower than 0.40 would not contribute much to measuring the underlying factors, and these factors would have to be removed. As shown in Table 5.31 above no variables had a value of less than 0.40; thus, no omission was required. However, component number 1 which is using BIM and cloud technology reduces drawing errors was seen to have the highest R-squared value of around 0.930 and the lowest was 0.566, which is component number 5, BIM and Cloud technology speed up senior management decision making.

Next, the regression analysis, the data of the 46 questions were considered as independent variables and the total value of the questions represents the level of construction labour productivity as “X” dependent variable. Then a stepwise regression test was run between the 46 independent variables and X (the level of construction labour productivity) the

dependent variable which would remain constant for all variables. Table 5.33 below represents summary of the models resulted from the stepwise regression test explained above.

Table 5. 33

Model Summary

Model Summary				
Model	R	R Squar e	Adjuste d R Square	Std. Error of the Estimate
1	.445 ^a	.198	.196	1.91645
2	.678 ^b	.459	.457	1.57542
3	.782 ^c	.612	.609	1.33602
4	.820 ^d	.673	.669	1.22887
5	.847 ^e	.717	.714	1.14381
6	.868 ^f	.753	.749	1.07065
7	.880 ^g	.775	.771	1.02270
8	.893 ^h	.797	.793	.97203
9	.907 ⁱ	.823	.819	.90939
10	.923 ^j	.851	.848	.83448
11	.939 ^k	.881	.877	.74813
12	.949 ^l	.900	.897	.68723
13	.958 ^m	.919	.916	.62003
14	.967 ⁿ	.934	.932	.55775
15	.974 ^o	.949	.947	.48983
16	.978 ^p	.956	.954	.45788
17	.979 ^q	.958	.956	.44597
18	.979 ^r	.958	.956	.44587
19	.980 ^s	.960	.958	.43569
20	.981 ^t	.963	.961	.42207
21	.983 ^u	.967	.966	.39629
22	.983 ^v	.967	.966	.39577
23	.984 ^w	.969	.967	.38789
24	.985 ^x	.970	.968	.38161
25	.985 ^y	.971	.969	.37444
26	.986 ^z	.972	.970	.36986

From Table 5.33 above, it can be noticed that there were 26 models resulting from the stepwise regression test. It can be also observed that the model number 26 has the highest R - Square value, Therefore, the researcher would consider model number 26 as the best option to present the researcher conceptual framework.

Table 5. 34:

ANOVA

ANOVA ^a						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	358.057	1	358.057	97.489	<.001 ^b
	Residual	1450.754	395	3.673		
	Total	1808.811	396			
2	Regression	830.922	2	415.461	167.393	<.001 ^c
	Residual	977.889	394	2.482		
	Total	1808.811	396			
3	Regression	1107.327	3	369.109	206.790	<.001 ^d
	Residual	701.484	393	1.785		
	Total	1808.811	396			
4	Regression	1216.848	4	304.212	201.450	<.001 ^e
	Residual	591.963	392	1.510		

	Total	1808.811	396			
5	Regression	1297.264	5	259.453	198.312	<.001 ^f
	Residual	511.547	391	1.308		
	Total	1808.811	396			
6	Regression	1361.754	6	226.959	197.993	<.001 ^g
	Residual	447.057	390	1.146		
	Total	1808.811	396			
7	Regression	1401.952	7	200.279	191.488	<.001 ^h
	Residual	406.859	389	1.046		
	Total	1808.811	396			
8	Regression	1442.213	8	180.277	190.801	<.001 ⁱ
	Residual	366.599	388	.945		
	Total	1808.811	396			
9	Regression	1488.768	9	165.419	200.026	<.001 ^j
	Residual	320.043	387	.827		
	Total	1808.811	396			
10	Regression	1540.018	10	154.002	221.154	<.001 ^k
	Residual	268.793	386	.696		
	Total	1808.811	396			
11	Regression	1593.327	11	144.848	258.796	<.001 ^l

	Residual	215.484	385	.560		
	Total	1808.811	396			
12	Regression	1627.453	12	135.621	287.159	<.001 ^m
	Residual	181.358	384	.472		
	Total	1808.811	396			
13	Regression	1661.570	13	127.813	332.463	<.001 ⁿ
	Residual	147.241	383	.384		
	Total	1808.811	396			
14	Regression	1689.975	14	120.713	388.032	<.001 ^o
	Residual	118.836	382	.311		
	Total	1808.811	396			
15	Regression	1717.395	15	114.493	477.179	<.001 ^p
	Residual	91.416	381	.240		
	Total	1808.811	396			
16	Regression	1729.141	16	108.071	515.465	<.001 ^q
	Residual	79.670	380	.210		
	Total	1808.811	396			
17	Regression	1733.433	17	101.967	512.689	<.001 ^r
	Residual	75.378	379	.199		
	Total	1808.811	396			

18	Regression	1733.269	16	108.329	544.927	<.001 ^s
	Residual	75.542	380	.199		
	Total	1808.811	396			
19	Regression	1736.866	17	102.169	538.215	<.001 ^t
	Residual	71.945	379	.190		
	Total	1808.811	396			
20	Regression	1741.472	18	96.748	543.087	<.001 ^u
	Residual	67.339	378	.178		
	Total	1808.811	396			
21	Regression	1749.604	19	92.084	586.346	<.001 ^v
	Residual	59.207	377	.157		
	Total	1808.811	396			
22	Regression	1749.604	18	97.200	620.560	<.001 ^w
	Residual	59.207	378	.157		
	Total	1808.811	396			
23	Regression	1752.088	19	92.215	612.889	<.001 ^x
	Residual	56.723	377	.150		
	Total	1808.811	396			
24	Regression	1754.055	20	87.703	602.241	<.001 ^y
	Residual	54.756	376	.146		

	Total	1808.811	396			
25	Regression	1756.233	21	83.630	596.472	<.001 ^z
	Residual	52.578	375	.140		
	Total	1808.811	396			
26	Regression	1757.649	22	79.893	584.027	<.001 ^{aa}
	Residual	51.162	374	.137		
	Total	1808.811	396			

From Table 5.34 above, shows the ANOVA test results for 26 models resulted from the stepwise regression test. It can be also observed that the model number 26 has F test of 584 and significance less than .001.

Table 5. 35:

Coefficients

Coefficients ^a					
Model		Unstandardized Coefficients		Standardized Coefficients	Sig.
		B	Std. Error	Beta	
1	(Constant)	20.923	.255		<.001
	PCMF12	1.496	.152	.445	<.001
2	(Constant)	17.318	.335		<.001
	PCMF12	1.823	.127	.542	<.001
	PCMF06	2.678	.194	.520	<.001
3	(Constant)	15.307	.327		<.001
	PCMF12	1.768	.108	.526	<.001

4	PCMF06	3.031	.167	.589	18.153	<.001
	NPMF03	1.104	.089	.398	12.444	<.001
	(Constant)	14.164	.329		43.044	<.001
	PCMF12	1.941	.101	.577	19.212	<.001
	PCMF06	2.517	.165	.489	15.259	<.001
	NPMF03	1.205	.082	.434	14.621	<.001
	PCMF10	1.121	.132	.279	8.516	<.001
5	(Constant)	13.586	.315		43.123	<.001
	PCMF12	1.054	.147	.313	7.165	<.001
	PCMF06	2.614	.154	.508	16.970	<.001
	NPMF03	1.227	.077	.442	15.979	<.001
	PCMF10	1.203	.123	.300	9.788	<.001
	NPMF08	1.039	.133	.346	7.840	<.001
6	(Constant)	12.111	.354		34.171	<.001
	PCMF12	1.170	.139	.348	8.443	<.001
	PCMF06	2.552	.144	.496	17.670	<.001
	NPMF03	1.286	.072	.463	17.787	<.001
	PCMF10	1.027	.117	.256	8.746	<.001
	NPMF08	1.180	.126	.392	9.403	<.001
	NPMF02	1.025	.137	.218	7.501	<.001
7	(Constant)	10.157	.463		21.955	<.001
	PCMF12	1.218	.133	.362	9.187	<.001
	PCMF06	2.614	.138	.508	18.896	<.001
	NPMF03	1.371	.070	.494	19.469	<.001
	PCMF10	1.069	.112	.267	9.517	<.001
	NPMF08	1.287	.121	.428	10.625	<.001
	NPMF02	1.194	.133	.254	8.953	<.001
	NPMF09	1.160	.187	.158	6.200	<.001
8	(Constant)	9.357	.456		20.500	<.001
	PCMF12	1.177	.126	.350	9.324	<.001
	PCMF06	2.650	.132	.515	20.141	<.001
	NPMF03	1.056	.082	.380	12.800	<.001
	PCMF10	1.118	.107	.279	10.440	<.001
	NPMF08	1.407	.117	.468	12.071	<.001
	NPMF02	1.247	.127	.265	9.820	<.001
	NPMF09	1.213	.178	.166	6.819	<.001
	VAR00044	.658	.101	.193	6.528	<.001
9	(Constant)	7.812	.474		16.478	<.001

	PCMF12	1.374	.121	.409	11.362	<.001
	PCMF06	2.770	.124	.538	22.313	<.001
	NPMF03	1.063	.077	.383	13.770	<.001
	PCMF10	1.030	.101	.257	10.216	<.001
	NPMF08	1.385	.109	.460	12.691	<.001
	NPMF02	1.394	.120	.297	11.579	<.001
	NPMF09	1.330	.167	.182	7.951	<.001
	VAR00044	.748	.095	.219	7.865	<.001
	VAR00030	.500	.067	.171	7.503	<.001
	(Constant)	6.887	.448		15.367	<.001
10	PCMF12	1.283	.112	.382	11.507	<.001
	PCMF06	2.845	.114	.553	24.900	<.001
	NPMF03	1.174	.072	.423	16.310	<.001
	PCMF10	1.017	.093	.253	10.986	<.001
	NPMF08	1.230	.102	.409	12.097	<.001
	NPMF02	1.398	.110	.298	12.655	<.001
	NPMF09	1.269	.154	.173	8.264	<.001
	VAR00044	.798	.087	.234	9.127	<.001
	VAR00030	.621	.063	.213	9.897	<.001
	NPMF04	.711	.083	.197	8.579	<.001
11	(Constant)	5.524	.425		12.986	<.001
	PCMF12	1.512	.103	.450	14.724	<.001
	PCMF06	2.896	.103	.563	28.235	<.001
	NPMF03	1.021	.066	.368	15.367	<.001
	PCMF10	1.006	.083	.251	12.121	<.001
	NPMF08	.636	.110	.211	5.797	<.001
	NPMF02	1.525	.100	.325	15.267	<.001
	NPMF09	1.303	.138	.178	9.460	<.001
	VAR00044	.813	.078	.238	10.366	<.001
	VAR00030	.734	.057	.251	12.769	<.001
12	NPMF04	1.108	.085	.307	13.079	<.001
	NPMF01	.951	.097	.251	9.759	<.001
	(Constant)	4.260	.418		10.190	<.001
	PCMF12	1.584	.095	.471	16.723	<.001
	PCMF06	2.872	.094	.558	30.473	<.001
	NPMF03	1.020	.061	.368	16.718	<.001
	PCMF10	.997	.076	.248	13.073	<.001
	NPMF08	.620	.101	.206	6.157	<.001

	NPMF02	1.410	.093	.300	15.194	<.001
	NPMF09	1.387	.127	.189	10.929	<.001
	VAR00044	.810	.072	.238	11.248	<.001
	VAR00030	.805	.053	.275	15.066	<.001
	NPMF04	1.165	.078	.323	14.917	<.001
	NPMF01	1.048	.090	.277	11.608	<.001
	PCMF11	.855	.101	.149	8.500	<.001
13	(Constant)	2.559	.418		6.119	<.001
	PCMF12	1.657	.086	.493	19.315	<.001
	PCMF06	2.999	.086	.583	34.835	<.001
	NPMF03	1.066	.055	.384	19.291	<.001
	PCMF10	1.023	.069	.255	14.856	<.001
	NPMF08	.734	.092	.244	8.002	<.001
	NPMF02	1.444	.084	.307	17.231	<.001
	NPMF09	1.376	.115	.188	12.013	<.001
	VAR00044	.862	.065	.253	13.212	<.001
	VAR00030	.866	.049	.296	17.803	<.001
	NPMF04	1.105	.071	.306	15.622	<.001
	NPMF01	1.046	.081	.276	12.837	<.001
	PCMF11	.965	.091	.168	10.543	<.001
	VAR00048	.821	.087	.149	9.420	<.001
14	(Constant)	2.087	.379		5.499	<.001
	PCMF12	1.075	.098	.320	10.933	<.001
	PCMF06	2.949	.078	.573	37.993	<.001
	NPMF03	1.228	.053	.442	23.378	<.001
	PCMF10	1.014	.062	.253	16.369	<.001
	NPMF08	.783	.083	.260	9.469	<.001
	NPMF02	1.475	.075	.314	19.556	<.001
	NPMF09	1.376	.103	.188	13.362	<.001
	VAR00044	.683	.062	.200	11.089	<.001
	VAR00030	.978	.045	.335	21.591	<.001
	NPMF04	1.047	.064	.290	16.376	<.001
	NPMF01	.970	.074	.256	13.158	<.001
	PCMF11	1.024	.083	.178	12.404	<.001
	VAR00048	.874	.079	.159	11.116	<.001
	VAR00033	.841	.088	.230	9.556	<.001
15	(Constant)	.757	.356		2.128	.034
	PCMF12	1.136	.087	.338	13.130	<.001

	PCMF06	3.063	.069	.595	44.394	<.001
	NPMF03	1.273	.046	.459	27.485	<.001
	PCMF10	1.067	.055	.266	19.537	<.001
	NPMF08	.798	.073	.265	10.988	<.001
	NPMF02	1.482	.066	.315	22.368	<.001
	NPMF09	1.265	.091	.173	13.886	<.001
	VAR00044	.640	.054	.188	11.806	<.001
	VAR00030	1.029	.040	.352	25.677	<.001
	NPMF04	1.080	.056	.299	19.211	<.001
	NPMF01	1.047	.065	.276	16.082	<.001
	PCMF11	.899	.073	.156	12.245	<.001
	VAR00048	.940	.069	.171	13.561	<.001
	VAR00033	.882	.077	.241	11.394	<.001
	NPMF11	.799	.075	.137	10.690	<.001
16	(Constant)	.067	.345		.194	.846
	PCMF12	1.119	.081	.333	13.825	<.001
	PCMF06	3.080	.065	.599	47.725	<.001
	NPMF03	1.339	.044	.482	30.304	<.001
	PCMF10	1.010	.052	.252	19.562	<.001
	NPMF08	.896	.069	.298	12.961	<.001
	NPMF02	1.166	.075	.248	15.547	<.001
	NPMF09	1.254	.085	.171	14.729	<.001
	VAR00044	.642	.051	.188	12.673	<.001
	VAR00030	1.030	.037	.352	27.502	<.001
	NPMF04	1.060	.053	.294	20.145	<.001
	NPMF01	.987	.061	.261	16.073	<.001
	PCMF11	1.015	.070	.177	14.431	<.001
	VAR00048	.986	.065	.179	15.150	<.001
	VAR00033	.924	.073	.253	12.728	<.001
17	NPMF11	.883	.071	.151	12.472	<.001
	VAR00043	.548	.073	.119	7.485	<.001
	(Constant)	-.200	.341		-.586	.558
	PCMF12	1.122	.079	.334	14.229	<.001
	PCMF06	3.100	.063	.602	49.200	<.001
	NPMF03	1.347	.043	.486	31.285	<.001
	PCMF10	1.009	.050	.251	20.063	<.001
	NPMF08	.899	.067	.299	13.351	<.001
	NPMF02	1.157	.073	.246	15.844	<.001

	NPMF09	1.232	.083	.168	14.826	<.001
	VAR00044	.638	.049	.187	12.925	<.001
	VAR00030	1.059	.037	.362	28.616	<.001
	NPMF04	1.060	.051	.294	20.676	<.001
	NPMF01	.993	.060	.262	16.602	<.001
	PCMF11	1.018	.069	.177	14.857	<.001
	VAR00048	.170	.187	.031	.910	.363
	VAR00033	.943	.071	.258	13.323	<.001
	NPMF11	.950	.070	.162	13.485	<.001
	VAR00043	.555	.071	.121	7.791	<.001
	PCMF07	.906	.195	.159	4.646	<.001
18	(Constant)	-.202	.341		-.594	.553
	PCMF12	1.121	.079	.333	14.229	<.001
	PCMF06	3.100	.063	.602	49.218	<.001
	NPMF03	1.347	.043	.486	31.289	<.001
	PCMF10	1.008	.050	.251	20.056	<.001
	NPMF08	.896	.067	.298	13.328	<.001
	NPMF02	1.156	.073	.246	15.833	<.001
	NPMF09	1.228	.083	.168	14.803	<.001
	VAR00044	.637	.049	.187	12.904	<.001
	VAR00030	1.062	.037	.363	28.869	<.001
	NPMF04	1.061	.051	.294	20.718	<.001
	NPMF01	.995	.060	.263	16.634	<.001
	PCMF11	1.016	.068	.177	14.837	<.001
	VAR00033	.945	.071	.259	13.358	<.001
	NPMF11	.960	.070	.164	13.806	<.001
	VAR00043	.555	.071	.121	7.784	<.001
	PCMF07	1.072	.066	.189	16.212	<.001
19	(Constant)	.251	.349		.718	.473
	PCMF12	1.145	.077	.341	14.835	<.001
	PCMF06	3.076	.062	.598	49.773	<.001
	NPMF03	1.408	.044	.507	31.770	<.001
	PCMF10	1.056	.050	.263	20.980	<.001
	NPMF08	.916	.066	.305	13.904	<.001
	NPMF02	1.224	.073	.261	16.759	<.001
	NPMF09	1.210	.081	.165	14.904	<.001
	VAR00044	.562	.051	.165	10.993	<.001
	VAR00030	1.110	.038	.380	29.528	<.001

	NPMF04	.987	.053	.273	18.657	<.001
	NPMF01	.932	.060	.246	15.492	<.001
	PCMF11	.977	.068	.170	14.480	<.001
	VAR00033	.948	.069	.259	13.709	<.001
	NPMF11	.895	.070	.153	12.871	<.001
	VAR00043	.518	.070	.113	7.383	<.001
	PCMF07	1.074	.065	.189	16.610	<.001
	NPMF05	-.257	.059	-.060	-4.353	<.001
20	(Constant)	.008	.341		.024	.980
	PCMF12	1.179	.075	.351	15.707	<.001
	PCMF06	3.096	.060	.602	51.601	<.001
	NPMF03	1.358	.044	.489	30.854	<.001
	PCMF10	1.057	.049	.263	21.688	<.001
	NPMF08	.934	.064	.311	14.618	<.001
	NPMF02	1.250	.071	.266	17.622	<.001
	NPMF09	1.222	.079	.167	15.529	<.001
	VAR00044	.645	.052	.189	12.368	<.001
	VAR00030	1.077	.037	.368	29.129	<.001
	NPMF04	.999	.051	.277	19.475	<.001
	NPMF01	.947	.058	.250	16.228	<.001
	PCMF11	.979	.065	.170	14.974	<.001
	VAR00033	.902	.068	.247	13.354	<.001
	NPMF11	.919	.068	.157	13.615	<.001
	VAR00043	.470	.069	.102	6.860	<.001
	PCMF07	1.097	.063	.193	17.469	<.001
	NPMF05	-.710	.106	-.165	-6.707	<.001
	VAR00034	.551	.108	.130	5.085	<.001
21	(Constant)	.078	.321		.245	.807
	PCMF12	1.131	.071	.336	15.968	<.001
	PCMF06	3.044	.057	.592	53.620	<.001
	NPMF03	1.333	.041	.481	32.147	<.001
	PCMF10	1.034	.046	.258	22.523	<.001
	NPMF08	.964	.060	.321	16.030	<.001
	NPMF02	.929	.080	.198	11.588	<.001
	NPMF09	1.218	.074	.166	16.496	<.001
	VAR00044	.677	.049	.199	13.764	<.001
	VAR00030	1.072	.035	.367	30.863	<.001
	NPMF04	.967	.048	.268	19.991	<.001

	NPMF01	.884	.055	.233	15.938	<.001
	PCMF11	1.001	.061	.174	16.278	<.001
	VAR00033	.922	.064	.252	14.520	<.001
	NPMF11	1.033	.065	.177	15.809	<.001
	VAR00043	-.004	.092	-.001	-.040	.968
	PCMF07	1.057	.059	.186	17.857	<.001
	NPMF05	-1.004	.107	-.233	-9.343	<.001
	VAR00034	.835	.109	.196	7.653	<.001
	PCMF02	.868	.121	.172	7.196	<.001
22	(Constant)	.076	.313		.242	.809
	PCMF12	1.131	.071	.336	15.999	<.001
	PCMF06	3.045	.056	.592	54.060	<.001
	NPMF03	1.334	.041	.481	32.742	<.001
	PCMF10	1.033	.046	.258	22.601	<.001
	NPMF08	.964	.060	.321	16.092	<.001
	NPMF02	.929	.080	.198	11.629	<.001
	NPMF09	1.218	.074	.166	16.518	<.001
	VAR00044	.677	.049	.199	13.808	<.001
	VAR00030	1.072	.035	.367	30.907	<.001
	NPMF04	.967	.048	.268	20.051	<.001
	NPMF01	.884	.055	.233	15.975	<.001
	PCMF11	1.001	.061	.174	16.436	<.001
	VAR00033	.922	.063	.252	14.549	<.001
	NPMF11	1.033	.065	.177	15.852	<.001
	PCMF07	1.058	.059	.186	18.027	<.001
	NPMF05	-1.003	.099	-.233	-10.132	<.001
	VAR00034	.834	.102	.196	8.157	<.001
	PCMF02	.864	.084	.171	10.268	<.001
23	(Constant)	.197	.309		.640	.523
	PCMF12	1.098	.070	.327	15.740	<.001
	PCMF06	3.030	.055	.589	54.768	<.001
	NPMF03	1.371	.041	.494	33.466	<.001
	PCMF10	1.036	.045	.258	23.115	<.001
	NPMF08	.936	.059	.311	15.814	<.001
	NPMF02	.917	.078	.195	11.693	<.001
	NPMF09	1.205	.072	.165	16.653	<.001
	VAR00044	.731	.050	.215	14.663	<.001
	VAR00030	1.125	.036	.385	30.858	<.001

	NPMF04	.956	.047	.265	20.200	<.001
	NPMF01	.878	.054	.232	16.177	<.001
	PCMF11	1.019	.060	.177	17.025	<.001
	VAR00033	.993	.065	.272	15.390	<.001
	NPMF11	1.032	.064	.177	16.158	<.001
	PCMF07	1.058	.057	.186	18.396	<.001
	NPMF05	-1.098	.100	-.255	-11.002	<.001
	VAR00034	.859	.100	.202	8.556	<.001
	PCMF02	.880	.083	.174	10.652	<.001
	VAR00028	-.148	.037	-.051	-4.063	<.001
24	(Constant)	-.032	.310		-.104	.917
	PCMF12	1.103	.069	.328	16.068	<.001
	PCMF06	2.771	.089	.539	31.129	<.001
	NPMF03	1.380	.040	.497	34.174	<.001
	PCMF10	1.042	.044	.260	23.607	<.001
	NPMF08	.959	.059	.319	16.381	<.001
	NPMF02	.889	.077	.189	11.475	<.001
	NPMF09	1.173	.072	.160	16.362	<.001
	VAR00044	.756	.050	.222	15.261	<.001
	VAR00030	1.139	.036	.390	31.577	<.001
	NPMF04	.957	.047	.265	20.545	<.001
	NPMF01	.871	.053	.230	16.304	<.001
	PCMF11	1.058	.060	.184	17.683	<.001
	VAR00033	1.007	.064	.276	15.833	<.001
	NPMF11	1.020	.063	.175	16.223	<.001
	PCMF07	1.099	.058	.193	19.056	<.001
	NPMF05	-1.127	.098	-.262	-11.447	<.001
	VAR00034	.890	.099	.209	8.981	<.001
	PCMF02	.916	.082	.181	11.190	<.001
	VAR00028	-.150	.036	-.052	-4.166	<.001
	VAR00035	.284	.077	.064	3.676	<.001
25	(Constant)	.148	.307		.480	.631
	PCMF12	1.144	.068	.340	16.783	<.001
	PCMF06	2.701	.089	.525	30.291	<.001
	NPMF03	1.379	.040	.497	34.794	<.001
	PCMF10	1.028	.043	.256	23.658	<.001
	NPMF08	.964	.057	.320	16.765	<.001
	NPMF02	.888	.076	.189	11.677	<.001

	NPMF09	1.191	.071	.163	16.888	<.001
	VAR00044	.755	.049	.221	15.535	<.001
	VAR00030	1.130	.035	.387	31.874	<.001
	NPMF04	.942	.046	.261	20.552	<.001
	NPMF01	.869	.052	.229	16.571	<.001
	PCMF11	1.043	.059	.181	17.721	<.001
	VAR00033	.934	.065	.255	14.341	<.001
	NPMF11	1.020	.062	.175	16.533	<.001
	PCMF07	1.321	.080	.232	16.535	<.001
	NPMF05	-1.118	.097	-.260	-11.562	<.001
	VAR00034	.903	.097	.212	9.279	<.001
	PCMF02	.900	.080	.178	11.189	<.001
	VAR00028	-.167	.036	-.058	-4.709	<.001
	VAR00035	.348	.078	.078	4.495	<.001
	VAR00032	-.265	.067	-.057	-3.941	<.001
26	(Constant)	.112	.304		.368	.713
	PCMF12	1.017	.078	.302	13.026	<.001
	PCMF06	2.689	.088	.523	30.504	<.001
	NPMF03	1.410	.040	.508	34.936	<.001
	PCMF10	1.039	.043	.259	24.133	<.001
	NPMF08	.963	.057	.320	16.965	<.001
	NPMF02	.855	.076	.182	11.288	<.001
	NPMF09	1.189	.070	.162	17.076	<.001
	VAR00044	.713	.050	.209	14.344	<.001
	VAR00030	1.141	.035	.390	32.427	<.001
	NPMF04	.983	.047	.272	20.913	<.001
	NPMF01	.854	.052	.226	16.434	<.001
	PCMF11	1.011	.059	.176	17.162	<.001
	VAR00033	.898	.065	.246	13.741	<.001
	NPMF11	.980	.062	.168	15.747	<.001
	PCMF07	1.337	.079	.235	16.914	<.001
	NPMF05	-1.149	.096	-.267	-11.971	<.001
	VAR00034	.933	.097	.219	9.661	<.001
	PCMF02	.924	.080	.183	11.580	<.001
	VAR00028	-.170	.035	-.059	-4.832	<.001
	VAR00035	.370	.077	.083	4.813	<.001
	VAR00032	-.275	.066	-.059	-4.147	<.001
	VAR00055	.212	.066	.054	3.217	.001

a. Dependent Variable: Y (Level of construction labourer productivity)

From Table 5.35 above, shows the coefficients test results for the 26 models resulted from the stepwise regression test.

Table 5. 36:

Excluded Variables

Excluded Variables^a						
Model		Beta In	t	Sig.	Partial Correlation	Statistics Tolerance
26	NPMF06	.006 ^{aa}	.184	.854	.010	.063
	NPMF10	-.011 ^{aa}	-.560	.576	-.029	.189
	PCMF01	.022 ^{aa}	1.274	.203	.066	.260
	PCMF04	-.013 ^{aa}	-.558	.577	-.029	.146
	PCMF05	.021 ^{aa}	.824	.411	.043	.112
	PCMF08	.035 ^{aa}	1.222	.223	.063	.090
	PCMF11	.014 ^{aa}	.588	.557	.030	.135
	VAR00050	-.051 ^{aa}	-1.378	.169	-.071	.056
	VAR00051	-.008 ^{aa}	-.396	.692	-.021	.184
	VAR00052	.025 ^{aa}	1.453	.147	.075	.246
	VAR00053	.008 ^{aa}	.531	.596	.027	.303
	VAR00054	.024 ^{aa}	.817	.415	.042	.091
	VAR00056	-.024 ^{aa}	-1.060	.290	-.055	.143

Table 5.36 above shows the factors that excluded from Model number 26 which has the highest R- Square. The result indicated that there were 13 factors has been excluded from the model. The factors from VAR 00050 to VAR00056 presents the cloud technology variable and the factors NPMF06 which is ineffective communication and NPMF10 factors the lack of incentive scheme for labourers'ers and the other factors PCMF01,04,05,08 and 11. After considering the above excluded variables from the selected model, the next are the Correlation and the regression tests between the remaining variables represented on the three main groups, construction management factors, project management factors and technical management factors.

5.3.2 Correlation between Using BIM and Construction Management Factors, Project Management Factors and Technical Management Factors

Based on the data attained from the responses, a factor or correlation was statistically significant with a significant value of less than 0.001. The rest found that, for the construction management factors, for every increase in BIM value by 1, the construction management factors value would increase by 0.722. In short, this can be summarized to mean that these two factors positively influence each other, and the efficiency or improvement in construction management factors would directly impact BIM: thus, establishing a clear relationship between the two and rejecting the null hypothesis.

Table 5. 37:*Correlation BIM vs Construction Management Factors*

Correlations			
		Using Building Information Modelling (BIM)	Construction management factors
Using Building Information Modelling (BIM)	Pearson Correlation	1	.722**
	Sig. (2-tailed)		<.001
	N	397	397
Construction management Factors	Pearson Correlation	.722**	1
	Sig. (2-tailed)	<.001	
	N	397	397
**. Correlation is significant at the 0.01 level (2-tailed).			

In addition, Table 5.37 covered objectives 2 and 3, involving identifying advanced technologies to improve labourers' productivity and integration of advanced technologies and labourers' productivity to increase performance. Also, Table 5.37 specifies the correlation between BIM and construction management factors.

Table 5. 38:*Correlation BIM and Project Management Factors*

Correlations			
		Using Building Information Modelling (BIM)	Project management Factors
Using Building Information Modelling (BIM)	Pearson Correlation	1	.333**
	Sig. (2-tailed)		<.001
	N	397	397
Project management factors	Pearson Correlation	.333**	1
	Sig. (2-tailed)	<.001	
	N	397	397
**. Correlation is significant at the 0.01 level (2-tailed).			

Similarly, Table 5.38 represents the correlation analysis between project management factors and BIM relative to the first two objectives and hypothesis 3. Again, the analysis showed a 0.333 correlation coefficient. Again, the coefficient was lower than construction management factors. However, these values were also statistically significant correlation which established a positive linear relationship between the two factors, thus rejecting the null hypothesis 3.

Table 5. 39:*Correlation BIM and Technical Management Factors*

		Using Building Information Modelling (BIM)	Technical management factors
Using Building Information Modelling (BIM)	Pearson Correlation	1	.813**
	Sig. (2-tailed)		<.001
	N	397	397
Technical management factors	Pearson Correlation	.813**	1
	Sig. (2-tailed)d	<.001	
	N	397	397
**. Correlation is significant at the 0.01 level (2-tailed).			

Also, Table 5.39 identified the correlation between BIM and technical management factors. It was determined that there is a significant correlation between the two variables, which is statistically significant with a Pearson value of 0.813. This positive linear relationship helps reject the null hypotheses.

Considering that the relationship between BIM and the three themes of construction, project, and technical management factors has been proven to be valid and statistically significant, the focus was shifted to understanding the role cloud technology plays or its influence on the relationship between the two variables. Therefore, BIM with cloud

technology and construction management was analysed in the first correlation analyses for multiple factors as shown in Table 5.39 below.

Table 5. 40:

Correlation Analysis BIM vs Cloud Technology vs Construction Management Factors

Correlations				
		Using Building Information Modelling (BIM)	Cloud Technology	construction management factors
Using Building Information Modelling (BIM)	Pearson Correlation	1	.923**	.722**
	Sig. (2-tailed)		<.001	<.001
	N	397	397	397
Cloud Technology	Pearson Correlation	.923**	1	.721**
	Sig. (2-tailed)	<.001		<.001
	N	397	397	397
Construction management factors	Pearson Correlation	.722**	.721**	1
	Sig. (2-tailed)	<.001	<.001	
	N	397	397	397
**. Correlation is significant at the 0.01 level (2-tailed).				

Table 5.40 above shows a statistically significant relationship between the three variables, and cloud technology has some influence on the other two variables. When the relationship of BIM with the two variables was assessed, it was seen that both are positive and cloud technology, in all the analyses of BIM with different variables, has the exact high correlation Pearson value of 0.923. The relationship between BIM and construction management factors had already been established. So, the focus was on how cloud technology is related to the factors. When checking the Pearson value for the cloud technology against the two variables, it was observed that a positive linear relationship above 0.70 and closer to 1 existed with a significance value below 0.001, which shows statistical importance. Thus, null hypothesis 7 is rejected.

Similarly, the same analysis for project management factors and technical management factors was performed. Tables 5.41 and Table 5.42 below provide the result. The correlation between cloud technology and BIM has been established to be positive and linear. Additionally, the Pearson value remained the same throughout the research with no changes. When focused on the relationship between cloud technology against technical management factors and project management factors, it was identified that the Pearson correlation value is 0.798 and 0.326, respectively. It means that the relationship between the two variables is statistically significant and therefore, in both cases, null hypotheses 8 and 9 could be rejected.

Table 5. 41:

Correlation Analysis BIM vs Cloud Technology and Project Management Factors

	Using Building Information	Cloud Technology	Project management factors
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		Modelling (BIM)		
Using Building Information Modelling (BIM)	Pearson Correlation	1	.923**	.333**
	Sig. (2-tailed)		<.001	<.001
	N	397	397	397
Cloud Technology	Pearson Correlation	.923**	1	.326**
	Sig. (2-tailed)	<.001		<.001
	N	397	397	397
Project management factors	Pearson Correlation	.333**	.326**	1
	Sig. (2-tailed)	<.001	<.001	
	N	397	397	397
**. Correlation is significant at the 0.01 level (2-tailed).				

Table 5. 42:

Correlation Analysis BIM vs Cloud Technology vs Technical Management Factors

		Using Building Information Modelling (BIM)	Cloud Technology	Technical management factors
Using Building Information Modelling (BIM)	Pearson Correlation	1	.923**	.813**
	Sig. (2-tailed)		<.001	<.001
	N	397	397	397
Cloud Technology	Pearson Correlation	.923**	1	.798**

From Table 5.43 above, it can be noticed that the coefficient, which was based on Figure 5.1 to be 'a', would be the value of B in Table 5.43, which is -1.338. The p-value here is below 0.001, is not statistically significant. Next, the regression between the construction management factors and cloud technology was run, presented in Table 5.44 below.

Table 5. 44:

Regression Testing Cloud Technology Benefits Realization Factors vs Construction Management Factors

Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	9.256	.632		14.652	0.6
	Cloud Technology Benefits realization factors	1.128	.055	.721	20.668	0.7
a. Dependent Variable: Construction management factors						

Table 5.44, the values for the second part (advanced technologies and their impact on productivity) were extracted, which was the mediator's influence on the dependent variable. The Sobel test calculator stated that the mediating effect is negative at -4.7, and the p-value is below 0.05. There is a suppression that indicates that the indirect negative effect cancels out the positive direct impact. In this case, it was found to be the relationship is not statistically

significant and revealed that cloud technology as a mediating factor doesn't play a role in the relationship between the two variables. The results from the regression test between BIM and construction management factors were also undertaken, and the results are provided in Table 5.45 below.

Table 5. 45:

Regression Testing BIM vs Construction Management Factors

Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	6.543	.754		8.678	<.001
	Building Information Modelling Factors	.634	.031	.723	20.770	<.001
a. Dependent Variable: Construction management factors						

From Table 5.45, it has been noticed that there is a significant statistical relationship between the two, with a p-value below 0.001, and this proves hypothesis H1 to be accurate. And the same time, the Sobel test and mediating effect have provided that the relationship is not significant and the mediator, which in this case was the Cloud Technology Benefits Realization factors, has no influences the relationship between construction management factors and BIM, thus proving hypothesis 7 to be false. Similarly, the results of project management and technical management factors were examined as shown in tables 5.46 and 5.47 below.

Table 5. 46:*Regression Testing BIM Vs Project Management Factors*

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	18.174	.563		32.307	<.001
	Building Information Modelling Factors	.160	.023	.333	7.016	<.001
a. Dependent Variable: Project management factors						

Table 5. 47:*Regression Testing BIM vs Technical Management Factors*

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.094	.439		2.492	.013
	Building Information Modelling Factors	.494	.018	.813	27.756	<.001
a. Dependent Variable: Technical Management factors						

Using the regression test with BIM in Tables 5.46 and 5.47 above, it was established that the two dependent variables have a significant relationship with a p-value below 0.001.

Therefore, it helps in proving Hypotheses 3 and 5 to be true. Following this, the Sobel test was undertaken where the values for the relationship between cloud technology and BIM would

remain the same. In contrast, the other relationship coefficient was updated to match technical management factors and project management factors. For project management factors, the Sobel test was similar to the previous dependent variable with a value of 1.02, which again provides a suppressing role of the mediator. The same effect was seen for technical management factors with a 3.3 value in the Sobel test. Finally, it establishes that cloud technology benefits realization factors are not significant as the p-value is below 0.8. It also indicates that Hypotheses 8 and 9 to be false, which states that the cloud technology factor has a mediatory role and influences the relationship between BIM and the dependent variables.

The first analysis that was carried out focused on understanding the relationship between the level of construction labourers' productivity and construction management factors. The results are provided in Table 5.48.

Table 5. 48:

Correlation Construction Management Factors vs Level of Construction Labourers' Productivity

Correlations			
		construction management factors	Level of construction labourers' productivity
Construction management Method	Pearson Correlation	1	.929**
	Sig. (2-tailed)		<.001
	N	397	397
Level of construction labourers' productivity	Pearson Correlation	.929**	1
	Sig. (2-tailed)	<.001	

	N	397	397
**. Correlation is significant at the 0.01 level (2-tailed).			

From Table 5.48 above, the Pearson value for the relationship was 0.929, which is close to 1, which means that, for every increase in construction management factors, there was a 0.929 increase in the level of construction labourers' productivity, which describes a positive linear relationship. The remaining tables are provided in Appendix A. The test results showed that the level of labourers' productivity also has a significant positive relationship with project management factors with a Pearson correlation coefficient of 0.568 and a statistically significant association. The same was identified for technical management factors with a Pearson correlation coefficient of 0.906, which is also statistically significant. Therefore, it establishes a positive correlation between the variables. Finally, the test was undertaken to understand the relationship between the level of labourers' productivity and using BIM, and the results showed a positive linear relationship and statistically significant with a correlation coefficient of 0.803. It means they have a positive relationship, but a regression analysis was run to explore their actual influence. The results are provided in the Table 5.49 below:

Table 5. 49:

BIM vs Labourers' Productivity Regression

Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	28.689	1.638		17.518	<.001

	Using Building Information Modelling (BIM)	1.774	.066	.803	26.758	<.001
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Table 5.49 shows a p-value below 0.001, which specifies a statistical significance between the dependent variable, labourers' productivity, and the independent variable, BIM. It proves hypothesis 10, that there is a significant direct relationship between BIM and labourers' productivity in construction, to be true. Proving the hypothesis, tests were undertaken to identify the mediating role of construction management factors, project management facts, and technical management factors on the relationship between BIM and labourers' productivity. First, the focus was on the construction management factors. Then, a multiple regression was used with BIM and construction management factors being the independent variable and labourers' productivity level being the dependent variable. The results are provided below:

Table 5. 50:

Multiple Regression BIM vs Labourers' Productivity vs Construction Management

Coefficients ^a						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	16.686	.952		17.529	<.001
	Building Information Modelling Factors	.609	.051	.276	11.917	<.001
	Construction management factors	1.837	.058	.730	31.557	<.001

a. Dependent Variable: Level of construction labourers' productivity

Table 5.50 specified the statistically significant relationship between level of construction labourers' productivity and BIM factors and construction management factors as the p-values were less than 0.05.

Table 5. 51:

Multiple Regression BIM vs Labourers' Productivity vs Project Management

Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.400	2.641		.151	.880
	Building Information Modelling Factors	1.525	.059	.690	25.662	<.001
	Project management factors	1.557	.124	.338	12.584	<.001
a. Dependent Variable: Level of construction labourers' productivity						

Also, Table 5.51 identified the statistically significant association between level of construction labourers' productivity and using BIM factors and project management factors. The p-values were less than 0.001, which is less than 0.05.

Table 5. 52:

Multiple Regression BIM vs Labourers' Productivity vs Technical Management

Coefficients^a						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	25.727	1.128		22.814	<.001
	Building Information Modelling Factors	.430	.078	.195	5.530	<.001
	Technical management factors	2.722	.128	.748	21.231	<.001
a. Dependent Variable: Level of construction labourers' productivity						

Based on Table 5.52 above, a statistically significant relationship between the two variables exists, which helps prove hypothesis H2 to be accurate or true. Following this, the results were used for the Sobel test, where the coefficient was input into the Sobel test calculator. The result showed a Sobel test mediation value that is much higher than 2 and is positive at 15.32. Also, the p-value was found to be 0, showing a statistically significant mediator impact. This means there is a positive mediator effect that improves overall labourers' productivity. Though this was not a testing hypothesis, the findings could be considered critical and could be useful for the future. In the same way, the tests were carried out for project management factors and technical management factors. As shown in tables 5.29 and 5.30, they prove a significant relationship between labourers' productivity and the

two independent variables with a p-value below 0.001. This proves hypotheses H4 and H6 to be true. Using the Sobel test, we see that both project management factors and technical management factors have a positive Sobel mediation value and p-value of 0, which shows that there is a robust mediating influence of these factors on the relationship between BIM and labourers' productivity.

Moreover, the researcher performed the SPSS-Hayes test to analyse the moderator effect and validate the model. Conceptual diagram process 7 in Hayes has been used as a base for the Hayes test as it describes the study's conceptual framework.

Table 5. 53:

Model Constructs

Y (Dependent Variable)	Level of Construction Labourers' Productivity	LOCLP
X (Independent Variable)	Using Building Information Modelling (BIM) for design visualization, time and cost	BIMF
M1 (Mediator #1)	Construction Management Factors	CMF
M2 (Mediator #2)	Project Management Techniques	PMF
M3 (Mediator #3)	Technical Management Practices	TMF
W (The Moderator)	Cloud Technologies	CloudF

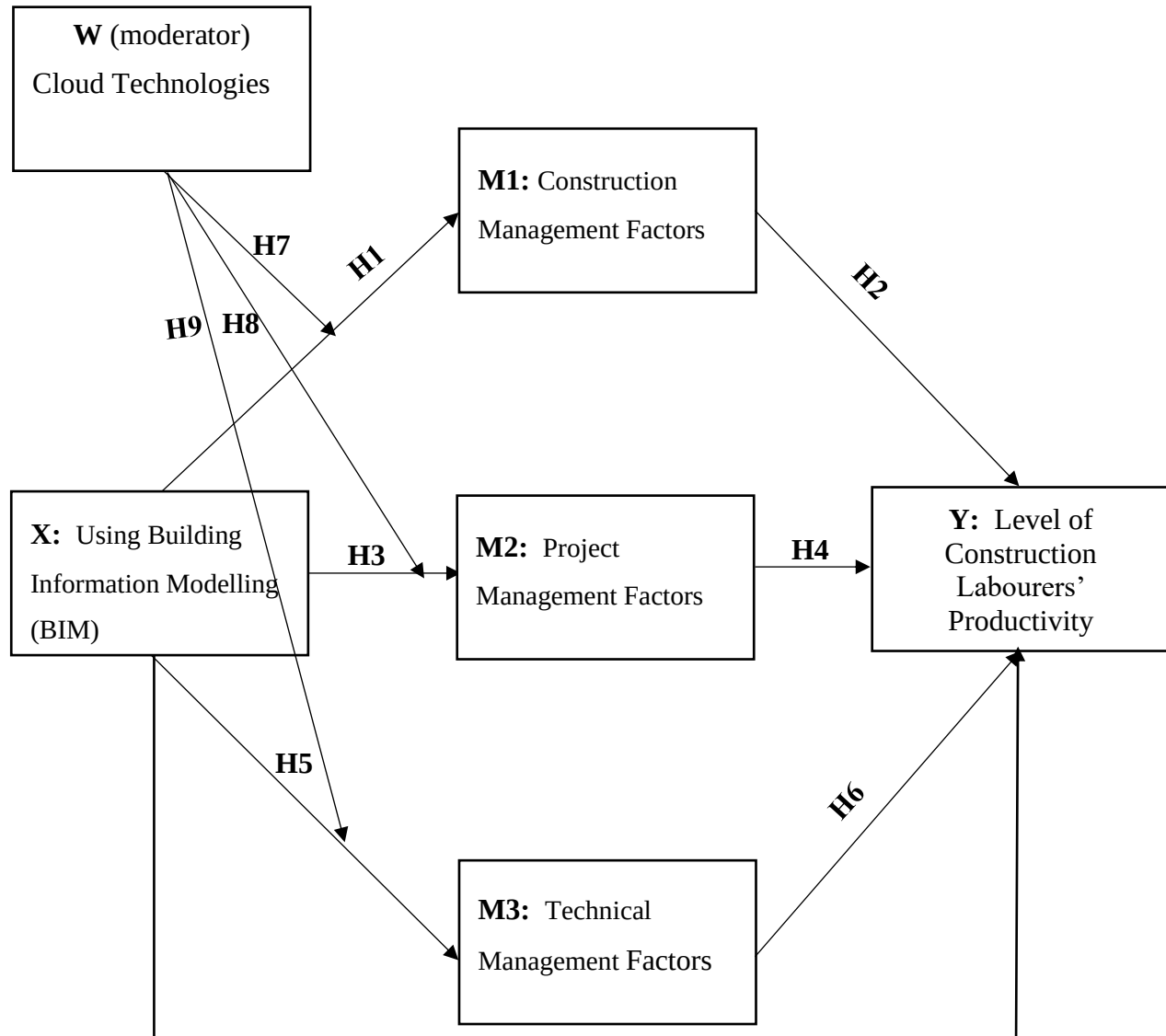
Figure 5. 24:*Initial Output Model*

Figure 5.24 shows the initial output model proposed by the researcher. It comprises testing for the indirect effect of X (the independent variable) on Y (dependent variable) via the proposed mediator (M), with the indirect effect being moderated by W. The model involves one moderator W (cloud technology), with three moderation effects on hypotheses 1, 3, and 5.

Hypotheses 7, 8, and 9 represent the moderation effect that cloud technology has on the relationship between using BIM and the three proposed mediators. Based on the above, the entire model comprises six regression sub-models as follows:

Figures 5.25, 5.27, 5.29, 5.31, 5.32, 5.33 and 5.34 show the regression sub-model relationship that was tested using the SPSS- Hayes process. The following data analysis and results have been concluded from the Hayes process test.

Figure 5. 25:

Regression Sub-Model Number 1

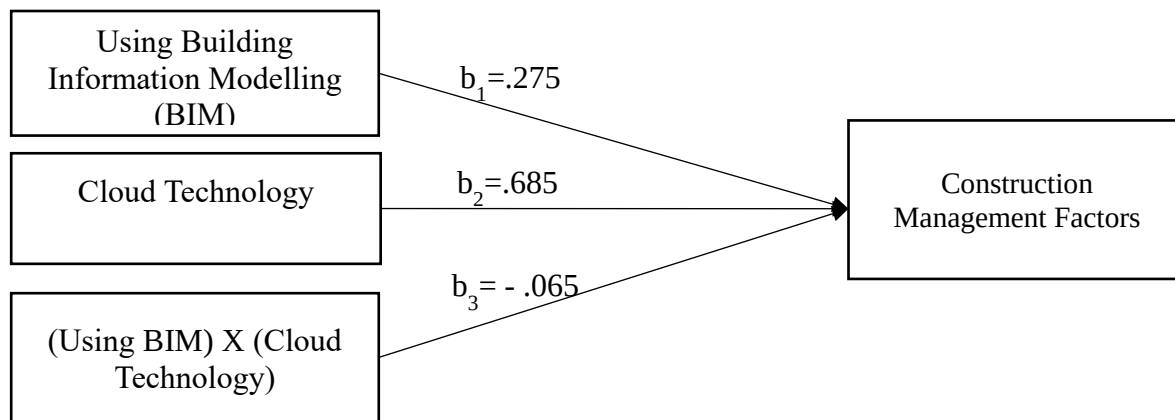


Figure 5.25 shows that sub-model number 1 involves regressing the mediator (construction management method) onto the independent variable (Using Building Information Modelling (BIM)), the moderator (Cloud technology), and the interaction term (Using BIM) X (Cloud Technology).

Table 5. 54:

Outcome variable, construction management factors (CMF)

OUTCOME VARIABLE:						
CMF						
Model Summary						
	R	R-sq	MSE	F	df1	df2
	.760	.577	13.600	178.915	3.000	393.000
						p
						.000
Model						
	coeff	se	t	p	LLCI	ULCI
constant	23.044	.303	75.957	.000	22.447	23.640
BIMF	.275	.075	3.646	.000	.127	.423
CloudF	.685	.134	5.097	.000	.421	.950
Int_1	-.065	.011	-5.746	.000	-.087	-.042
Product terms key:						
Int_1	:	BIMF	x	CloudF		
Test(s) of highest order unconditional interaction(s):						
	R2-chng	F	df1	df2	p	
X*W	.036	33.013	1.000	393.000	.000	

Focal predict: BIMF (X)						
Mod var: CloudF (W)						
Conditional effects of the focal predictor at values of the moderator(s):						
CloudF	Effect	se	t	p	LLCI	ULCI
-3.612	.508	.080	6.337	.000	.350	.666
.000	.275	.075	3.646	.000	.127	.423
3.612	.042	.091	.461	.645	-.137	.220

In Table 5.54 above, the first part of the output shows that the predictors accounted for significant variation in construction management factors (CMF) $R^2=.577$; $F= 178.915$, $p< .001$. The second part of the output shows that the interaction between BIM and Cloud technology was statistically significant in the model ($b = -.065$, $se=.011$ and $P< .001$, suggesting that the cloud technology moderates the effect of Using building information modelling (BIM) on construction management method (CMF).

The slope for the interaction term (BIM and Cloud) describes the moderating effect of cloud technology on the relationship between Using building information modelling (BIM) and construction management factors (CMF). Using BIM was positive and significant ($b_1=.275$, $se=.303$, $p<.001$). Cloud technology was positive and significant ($b_1=.685$, $se=.134$, $p<.001$). Also, the interaction term was negative and significant, meaning the slope for the effect of Using building information modelling (BIM) on the construction management factors (CMF) varies across levels of cloud technology; please refer to Figure 5.26 below.

Figure 5. 26:

Graphical presentation showing the change of slope between BIM and CMF variables across levels of cloud technology

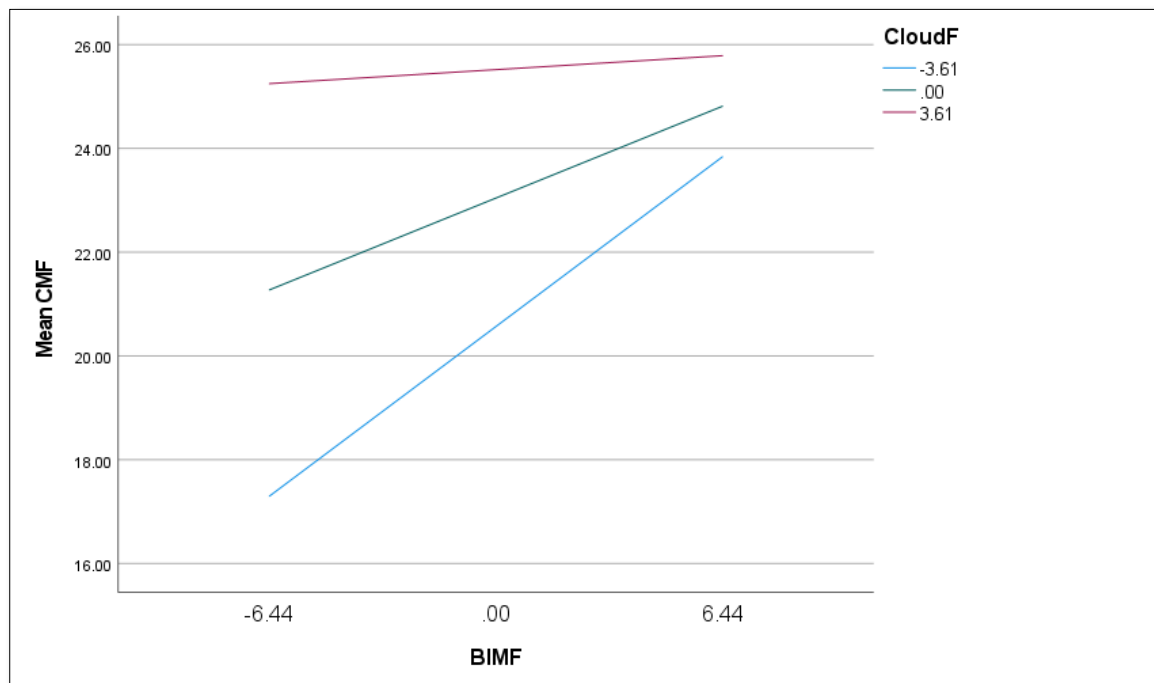


Figure 5.26 shows simple slopes for the effect of Using building information modelling (BIM) on the construction management factors (CMF) at three levels (mean-1sd, mean, mean+1sd) of the moderator (cloud technology). Simple effects tests are one way to examine the significant interaction between BIM and CMF.

At -1sd on the centred cloud technology variable, the simple slope for BIM was positive and statistically significant ($b = .508$, $se = .080$, $p < .001$). At the mean on cloud technology, the slope for BIM was positive and significant ($b = .275$, $se = .075$, $p < .001$). At +1sd of the cloud technology variable, the simple slope for BIM was also positive and significant ($b = .042$, $se = .091$, $p < .001$). Hence, the slopes for the effect of BIM on the construction management factors (CMF) were increasingly positive with increasing levels of cloud technology. The above confirms hypothesis 7 in the model.

Figure 5. 27:

Regression Sub-Model Number 2

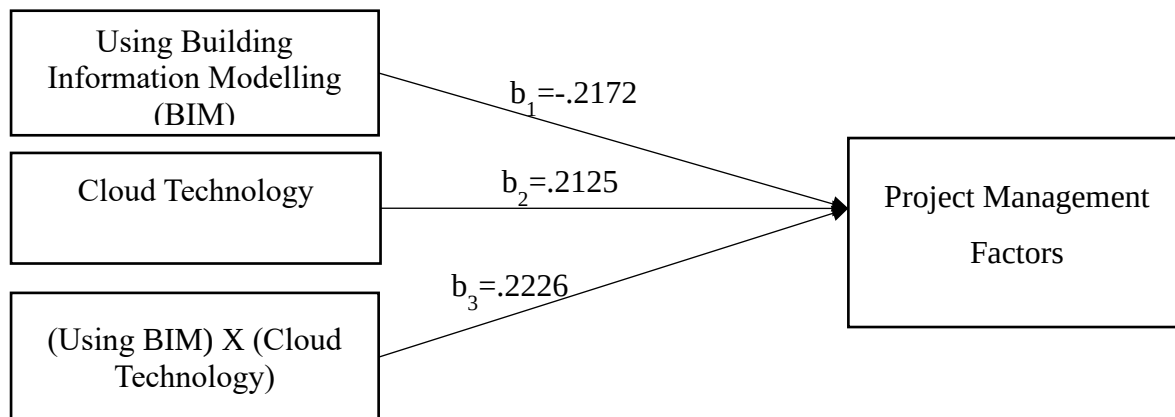


Figure 5.27 shows that sub-model # 2 involves regressing the mediator (Project Management factors) onto the independent variable (Using Building Information Modelling

(BIM)), the moderator (Cloud technology), and the interaction term (Using BIM) X (Cloud Technology).

Table 5. 55:

Outcome Variable, Project Management Factors (PMF)

OUTCOME VARIABLE:							
PMF							
Model Summary							
	R	R-sq	MSE	F	df1	df2	p
	.361	.130	8.376	19.579	3.000	393.000	.000
Model							
	coeff	se	t	p	LLCI	ULCI	
constant	21.465	.238	90.158	.000	20.997	21.934	
BIMF	.127	.059	2.151	.032	.011	.244	
CloudF	.066	.106	.626	.532	-.141	.273	
Int_1	.024	.009	2.753	.006	.007	.042	
Product terms key:							
Int_1	:	BIMF	x	CloudF			
Test(s) of highest order unconditional interaction(s):							
	R2-chng	F	df1	df2	p		
X*W	.017	7.582	1.000	393.000	.006		

Focal predict: BIMF (X)							
Mod var: CloudF (W)							
Conditional effects of the focal predictor at values of the moderator(s):							
CloudF	Effect	se	t	p	LLCI	ULCI	
-3.612	.040	.063	.630	.529	-.084	.163	
.000	.127	.059	2.151	.032	.011	.244	
3.612	.215	.071	3.018	.003	.075	.355	

In Table 5.55, the first part of the output shows that the predictors accounted for significant variation in project management factors (PMF) R-square=.130; F= 19.579, p<. 001. The second part of the output shows that the interaction between using BIM and Cloud technology was statistically insignificant in the model (b = .024, se=.009 and P>.001),

suggesting that the cloud technology does not moderate the effect of Using Building Information Modifying (BIM) on project management factors (PMF).

The slope for the interaction term (BIM and Cloud) describes the moderating effect of cloud technology on the relationship between Using building information modelling (BIM) and project management factors (PMF). BIM was positive and but not significant ($b_1=.127$, $se=.059$, $p>.001$). Cloud technology was positive but not significant ($b_1=.066$, $se=.106$, $p>.001$).

Figure 5. 28:

Graphical Presentation Shows the Change Of Slope Between Using BIM and PMF Variables Across Levels of Cloud Technology

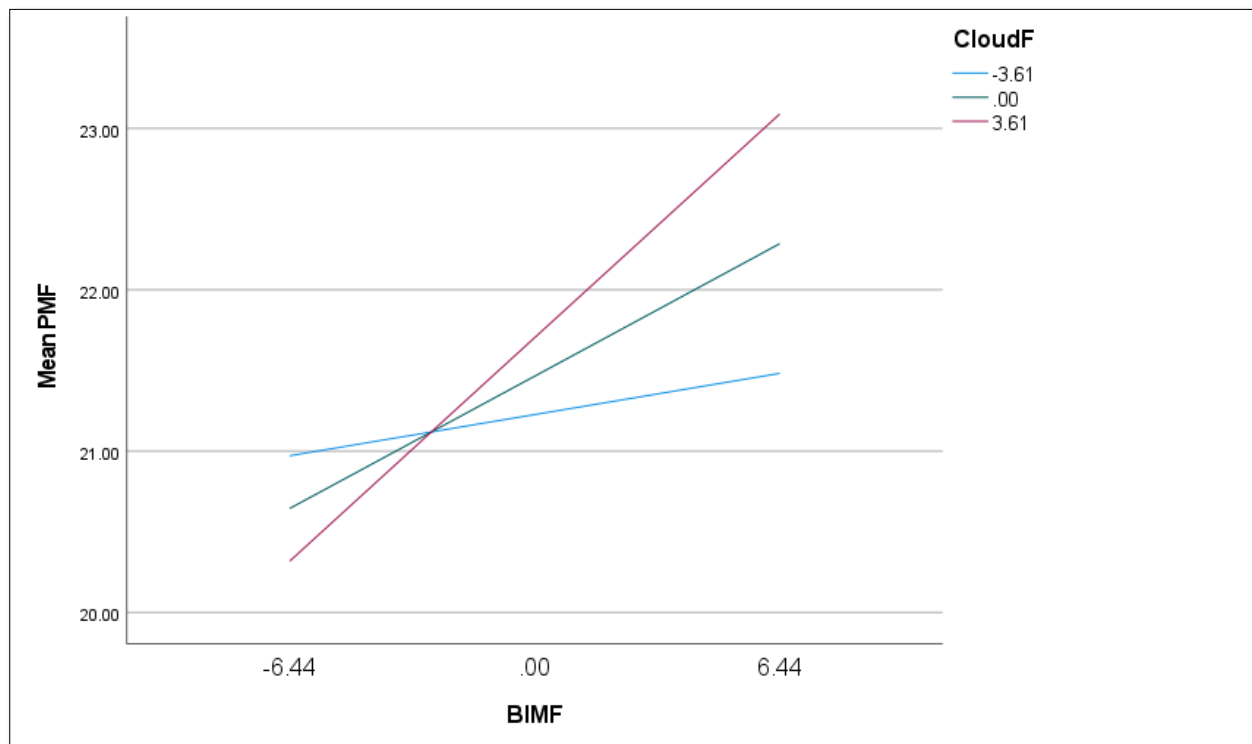


Figure 5.28 shows simple slopes for the effect of Using building information modelling (BIM) on project management factors (PMF) at three levels (mean-1sd, mean, mean+1sd) of

the moderator (cloud technology). Simple effects tests are one way to examine the significant interaction between BIM and PMF.

At -1sd on the centred cloud technology variable, the simple slope for BIM was positive and statistically significant ($b = .040$, $se = .063$, $p > .001$). At the mean on cloud technology, the slope for BIM was positive and significant ($b = .127$, $se = .059$, $p > .001$). At +1sd of the cloud technology variable, the simple slope for BIM was also positive but insignificant ($b = .215$, $se = .071$, $p > .001$). The above rejects hypothesis 8 in the proposed model.

Figure 5. 29:

Regression sub-model number 3

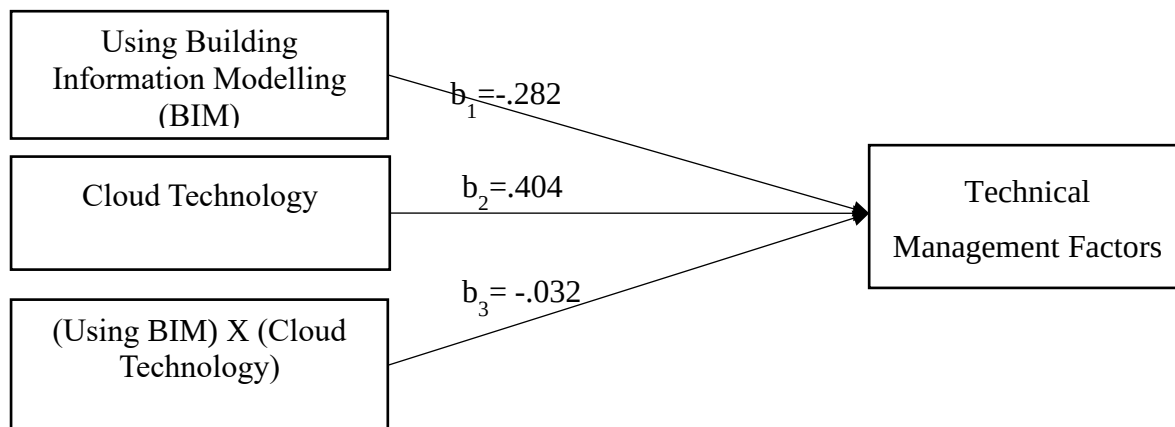


Figure 5.29 shows that sub-model 3 involves regressing the mediator (technical management factors) onto the independent variable (Using building information modelling (BIM)), the moderator (Cloud technology), and the interaction term (Using BIM) X (Cloud Technology).

Table 5. 56:

Outcome Variable, Technical Management Factors (TMF)

OUTCOME VARIABLE:
ETMF

Model Summary

	R	R-sq	MSE	F	df1	df2	p
	.834	.695	4.697	298.371	3.000	393.000	.000

Model

	coeff	se	t	p	LLCI	ULCI
constant	13.556	.178	76.032	.000	13.205	13.906
BIMF	.282	.044	6.373	.000	.195	.370
CloudF	.404	.079	5.109	.000	.248	.559
Int_1	-.032	.007	-4.898	.000	-.045	-.019

Product terms key:

Int_1 : BIMF x CloudF

Test(s) of highest order unconditional interaction(s):

	R2-chng	F	df1	df2	p
X*W	.019	23.995	1.000	393.000	.000

Focal predict: BIMF (X)

Mod var: CloudF (W)

Conditional effects of the focal predictor at values of the moderator(s):

CloudF	Effect	se	t	p	LLCI	ULCI
-3.612	.399	.047	8.473	.000	.307	.492
.000	.282	.044	6.373	.000	.195	.370
3.612	.166	.053	3.106	.002	.061	.270

In Table 5.56 above, the first part of the output shows that the predictors accounted for significant variation in technical management factors (TMF) $R^2=.695$, $F= 298.371$, $p<.001$. The second part of the output shows that the interaction between BIM and Cloud technology was statistically significant in the model ($b = -.032$, $se=.007$ and $P<.001$, suggesting that the cloud technology moderates the effect of using building information modelling (BIM) on technical management factors (TMF).

The slope for the interaction term (BIM and Cloud) describes the moderating effect of cloud technology on the relationship between using building information modelling (BIM) and technical management factors (TMF). Using BIM was positive and significant ($b_1=.282$, $se=.044$, $p<.001$). Cloud technology was positive and significant ($b_1=.404$, $se=.079$, $p<.001$). Also, the interaction term was negative and significant, meaning the slope for the effect of using building information modelling (BIM) on the technical management factors (TMF) varies across levels of cloud technology; as per Figure 5.130 below.

Figure 5. 30:

Graphical Presentation Showing the Change of Slope Between Bim and TMF Variables Across Levels of Cloud Technology

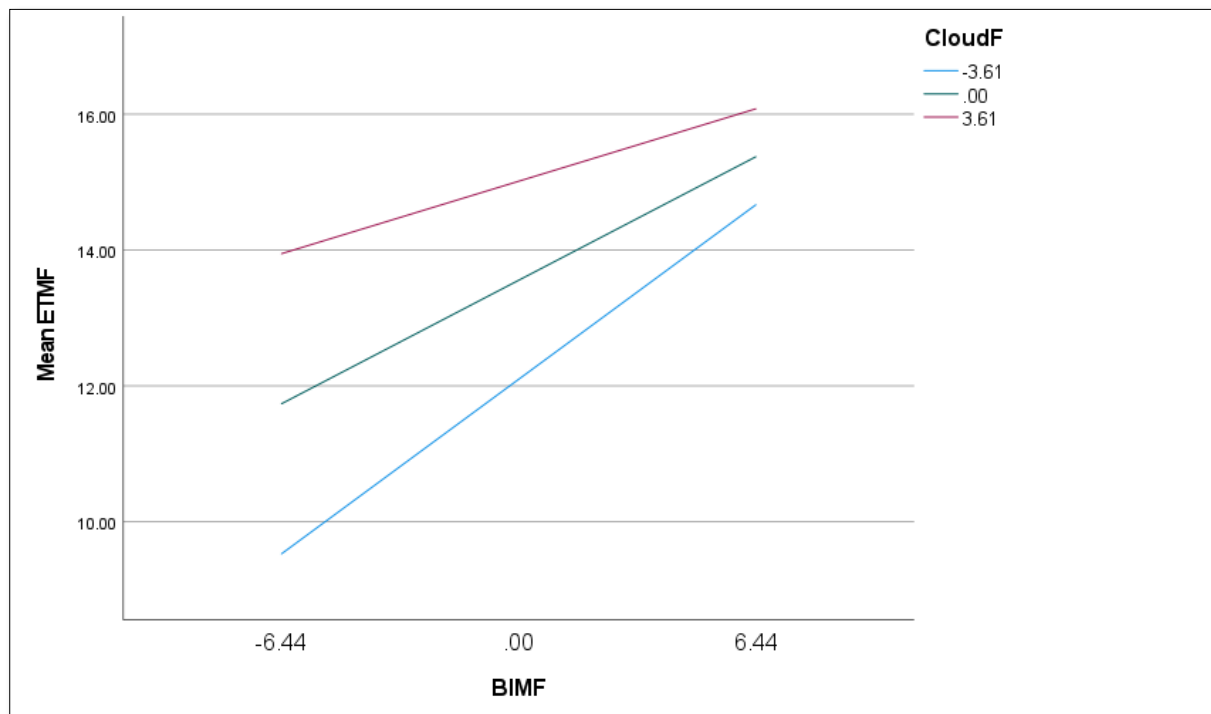


Figure 5.30 shows simple slopes for the effect of using building information modelling (BIM) on the technical management factors (TMF) at three levels (mean-1sd, mean, mean+1sd) of the moderator (cloud technology). Simple effects tests are one way to examine the significant interaction between BIM and CMF.

At -1sd on the centred cloud technology variable, the simple slope for BIMF was positive and statistically significant ($b = .399$, $se = .047$, $p < .001$). At the mean on cloud technology, the slope for BIM was positive and significant ($b = .282$, $se = .044$, $p < .001$). At +1sd of the cloud technology variable, the simple slope for BIM was also positive and significant ($b = .166$, $se = .053$, $p < .001$). Hence, the slopes for the effect of BIM on the technical management factors (TMF) were increasingly positive with increasing levels of cloud technology. The above confirms hypothesis 9 in the model.

Figure 5. 31:

Regression Sub-Model Number 4

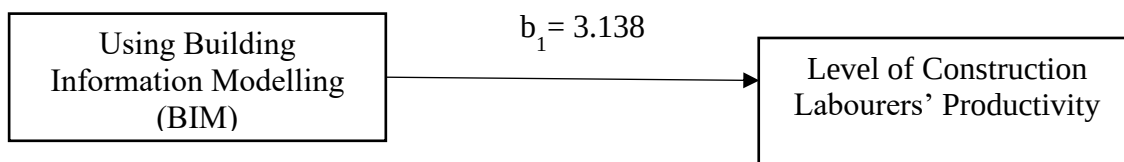


Figure 5.41 shows that sub-model 4 involves regressing the independent variable (Using building information modelling (BIM)) onto the dependent variable (Level of construction labourers' productivity).

Table 5. 57:

Outcome Variable, Level of Construction Labourers' Productivity (LOCLP)

OUTCOME VARIABLE: LOCLP						
Model Summary						
	R	R-sq	MSE	F	df1	df2
	.991	.983	3.495	5632.997	4.000	392.000
p						
						.000
Model						
	coeff	se	t	p	LLCI	ULCI
constant	3.138	.854	3.673	.000	1.459	4.818
BIMF	.127	.026	4.933	.000	.076	.177
CMF	1.246	.029	43.606	.000	1.190	1.303
PMF	1.040	.033	31.501	.000	.975	1.105
ETMF	1.399	.049	28.836	.000	1.304	1.495
***** DIRECT AND INDIRECT EFFECTS OF X ON Y *****						
Direct effect of X on Y						
	Effect	se	t	p	LLCI	ULCI
	.127	.026	4.933	.000	.076	.177
Conditional indirect effects of X on Y:						

In Table 5.57 above, the first part of the output shows that the predictors accounted for significant variation in the dependent variable (Level of construction labourers' productivity R-square=.983, F= 5632.997, $p < .001$). The second part of the output shows that the direct and indirect relationship between the independent variable and the dependent variable was statistically significant. The direct relationship shows $b = .127$, $se = .026$ and $P < .001$, suggesting that the effect of using building information modelling (BIM)) on the dependent variable level of construction labourers' productivity was statistically significant in the model. The above confirms hypothesis 10 in the model. The data also indicates that the direct relationship between the three mediators, construction management factors, construction management factors, and technical management factors, and the dependent variable level of

construction labourers' productivity were statistically significant in the model. Hence, the above confirms hypotheses 2, 4, and 6 in the model.

Figure 5. 32:

Regression Sub-Model Number 5

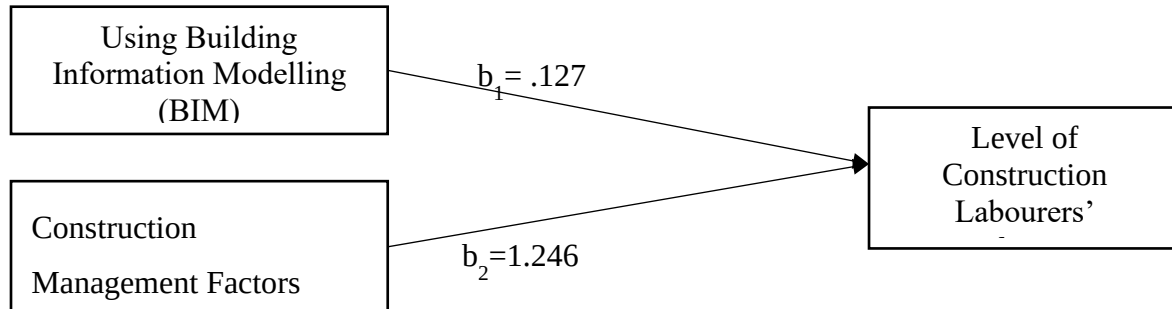


Figure 5.32 shows that sub-model 5 involves regressing the independent variable using building information modelling (BIM) and the mediator construction management factors onto the dependent variable level of construction labourers' productivity.

Table 5. 58:

Results of the Indirect Effects of BMIF Mediates By CMF on LOCLP

Model	coeff	se	t	p	LLCI	ULCI
constant	3.138	.854	3.673	.000	1.459	4.818
BIMF	.127	.026	4.933	.000	.076	.177
CMF	1.246	.029	43.606	.000	1.190	1.303
PMF	1.040	.033	31.501	.000	.975	1.105
ETMF	1.399	.049	28.836	.000	1.304	1.495

In Table 5.58 above, the output shows that the effect of the mediator construction management factors and the independent variable using building information modelling (BIM)

on the dependent variable level of construction labourers' productivity was statistically significant ($b = 1.246$, $se = .029$ and $P < .001$). The above confirms hypothesis 1 in the model.

Figure 5. 33:

Regression Sub-Model Number 6

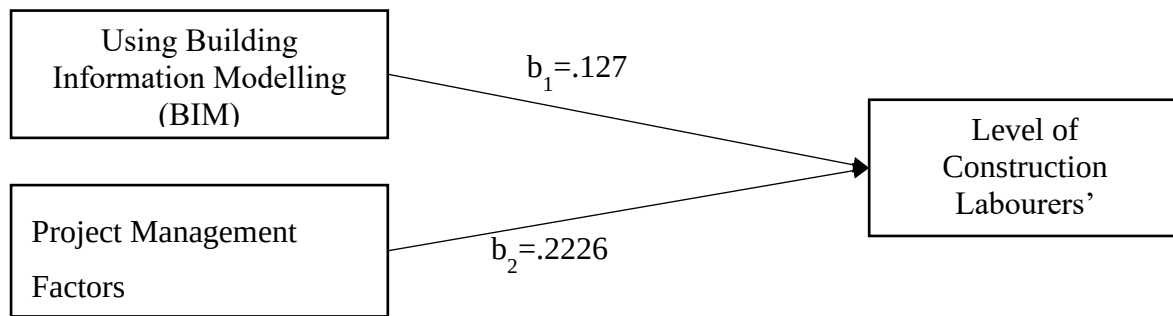


Figure 5.33 shows that sub-model 6 involves regressing the independent variable using building information modelling (BIM) and the mediator project management factors (PMF) onto the dependent variable level of construction labourers' productivity (LOPCLP).

Table 5. 59:

Results of the Indirect Effects of BMIF Mediates by PMF on LOCLP

Model	coeff	se	t	p	LLCI	ULCI
constant	3.138	.854	3.673	.000	1.459	4.818
BIMF	.127	.026	4.933	.000	.076	.177
CMF	1.246	.029	43.606	.000	1.190	1.303
PMF	1.040	.033	31.501	.000	.975	1.105
ETMF	1.399	.049	28.836	.000	1.304	1.495

In Table 5.59 above, the output shows that the effect of the mediator project management factors (PMF) and the independent variable using building information modelling (BIM) on the dependent variable level of construction labourers' productivity was

statistically significant ($b = 1.040$, $se=.033$ and $P < .001$). The above confirms hypothesis number three in the model.

Figure 5. 34:

Regression Sub-Model Number 7

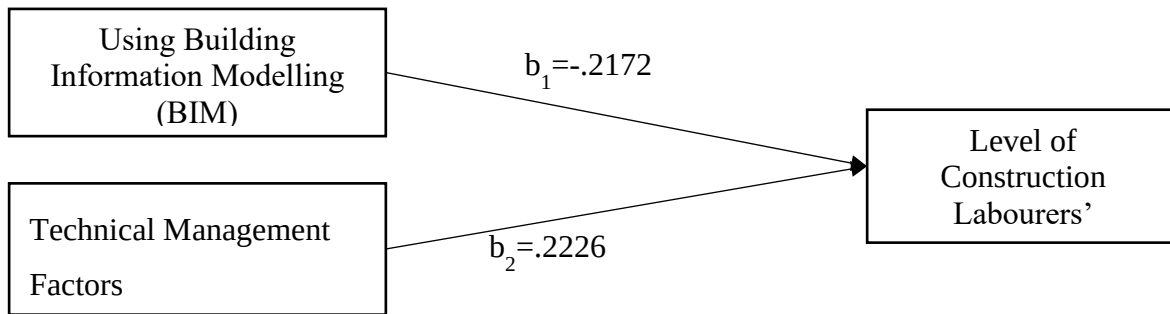


Figure 5.34 shows that sub model #7 involves regressing the independent variable using building information modelling (BIM) and the mediator technical management factors onto the dependent variable level of construction labourers' productivity (LOPCLP).

Table 5. 60:

Results of the Indirect Effects of BMI Mediates by PMF on LOCLP

Model	coeff	se	t	p	LLCI	ULCI
constant	3.138	.854	3.673	.000	1.459	4.818
BIMF	.127	.026	4.933	.000	.076	.177
CMF	1.246	.029	43.606	.000	1.190	1.303
PMF	1.040	.033	31.501	.000	.975	1.105
ETMF	1.399	.049	28.836	.000	1.304	1.495

In Table 5.60 above, the output shows that the effect of the mediator technical management factors and the independent variable using building information modelling (BIM)

on the dependent variable level of construction labourers' productivity was statistically significant ($b = 1.399$, $se = .049$ and $P < .001$). The above confirms hypothesis 5 in the model.

5.4 Hypothesis Validation

The outcomes of the data based on correlation and regression analysis and the Hayes process macro provided an overview of the hypotheses' acceptance or rejection. For example, correlation analysis was conducted to test hypothesis 1. It shows the correlation of .722. This means that there is a positive and direct relationship between BIM and construction management factors. Also, the regression analysis specified the p-values of less than 0.001, indicating a statistically significant relationship between two variables. Thus, H1 was accepted and H0 was rejected. Hypothesis 2, construction management factors mediates the relationship between using Building Information Modelling (BIM) in construction projects and the level of construction labourers' productivity, was also accepted and the null hypothesis was rejected. The reason was indicated in the outcomes of multiple regression as the p-values were less than 0.001. This means they were less than the significance level that specified that level of productivity depends on the BIM and construction management factors. It also means that construction management factors act as mediating factors in the BIM and level of productivity relationship. Also, the correlation coefficient of 0.33 specified the acceptance of H3 as the coefficient was positive though weak.

Further, H4, project management factors mediate the relationship between using Building Information Modelling (BIM) in construction projects and the level of construction labourers' productivity, was accepted. The multiple regression analysis indicated that the p-values were less than the significance value of 0.05. This means the null hypothesis was

rejected and H4 was accepted. In addition, related to H5, the correlation between BIM and technical management factors was 0.813, which was significant and positive. It specified the acceptance of H5, i.e., there is a direct relationship between using Building Information Modelling (BIM) in construction projects and technical management factors. In addition, H6 was examined through multiple regression analysis. The p-values were less than 0.001. This means the relationship is statistically significant between the three variables. Thus, H6 was accepted, and the null hypothesis was rejected. Relative to H7, cloud technology moderates the relationship between using Building Information Modelling (BIM) in construction projects and construction management factors, was rejected. The multiple regression results showed the p-values more than the significant value of 0.05. Hence, hypothesis H7 was rejected.

Moreover, H8, cloud technology moderates the relationship between using Building Information Modelling (BIM) in construction projects and project management factors, has been rejected due to p-values of more than 0.05. Finally, H9 and H10 the result shows that the H9 is not significant. Hence, H9 was rejected: that cloud technology moderates the relationship between using Building Information Modelling (BIM) in construction projects and technical management factors. H10 was accepted: that there is a direct relationship between using Building Information Modelling (BIM) in construction projects and the level of construction labourers' productivity.

5.5 Chapter Summary

This chapter provided details on the data collected and provides a summary and findings based on the different analyses conducted to gain the required results. The chapter focused on the various tests or studies carried out in the research and what the research aimed to achieve by carrying out the said analyses. The first test undertaken in the research was the reliability

analysis. The Alpha or Cronbach model has been done, and the Cronbach Alpha value was identified as 0.953, closer to 1, which was considered perfect reliability. A factor analysis test was undertaken to reduce a large number of variables present to a select few factors. Further, the collected data was analysed using quantitative methods, such as descriptive and inferential statistics. Descriptive statistics were used to identify the frequency distribution of the responses provided by the respondents. In addition, mean, median, and standard deviations were calculated to understand the average number of responses relative to the questions. As shown in this chapter, multiple regression was used to establish the relationship between dependent and independent variables.

Chapter 6 : Discussion of Findings

6.1 Introduction

This chapter discusses the findings of the research study. The chapter links the outcome of the research highlighted in Chapter five to the relevant theories of the study. In this discussion, the factors that affect the construction of labourers' productivity, as found in the previous chapter, shall be discussed. In discussing the research study's findings, this section considers some of the roles of advanced digital construction technology in improving the labourers' productivity levels in the building and construction industry in the UAE. This discussion is also centred on evaluating the modality through which building information modelling (BIM) and cloud technology can be used to improve the productivity of the labourers in the construction industry to enhance the project delivery outcomes in the building and construction sector in the UAE.

The comprehensive literature review provided in this study has highlighted that there were several studies performed in the last three decades on the topic of construction productivity and labourers' productivity in construction projects. Most of the studies classify productivity into three categories, productivity at the industry level, at the project level, and at the activity level. Indeed, the factors affecting productivity at each level have been comprehensively addressed in the literature. Some researchers classify the factors affecting labourers' productivity into different categories; for instance, Rogy (2003) categorised the factors impacting productivity into four groups as follows: environmental factors, labourers' skill, administrative system, and external factors. In this study the author classified factors affecting labourers' productivity into six categories as follows: construction management factors, project management factors, technical management factors, human resources management factors, and external factors.

The questionnaire survey examined the entire 42 factors affecting construction labourers' productivity as identified in the literature review, relating to which objective number one in this study has been successfully accomplished. Moreover, part of the results delivered by the questionnaire survey were utilized to provide the ranking of those 42 factors from high to low significance. The results show that lack of training and development for workers, weather condition, inadequate project planning and scheduling, lack of supervisor experience, lack of leadership, low wages, inadequate labourers' skills and experience, delay in authority approvals, lack of labourers' supervision, poor construction method, lack of health and safety planning, and unclear technical specification are the top 10 most significant factors affecting construction labourers' productivity. By this exercise, the author successfully achieved objective number two.

To achieve the rest of the research objectives, questionnaire survey responses have been examined via several SPSS tests. The tests undertaken were reliability analysis, factor analysis, descriptive statistics, Pearson correlation analysis, linear regression, and Sobel test to calculate the mediation effect and Hayes process were used to examine the variables' relationship.

The introduction section indicated that four main objectives were to be achieved through data collection and analysis. One of the objectives was to determine the main factors affecting construction labourers' productivity in building construction projects in the UAE. The survey questionnaires were sent to the study participants to understand the factors that influence construction labourers' productivity. The first group of factors identified by the study respondents were the project management factors. The respondents specified that aspects related to project management, if poorly implemented and used, influence labourers'

productivity in the construction sector. These factors are lack of training, poor leadership, involvement of subcontractors, low-level of appreciation for useful workers, poor communication, delay of responses to requests for information, slow decision-making, payment delays, lack of incentive scheme, working overtime, and unrealistic schedules.

The second group was the construction management factors, which are linked to lack of supervision, poor construction method, site congestion, lack of health and safety planning, crew size, ineffective site management, and other aspects. The third group was technical management factors, involving change orders during execution, rework, lack of design coordination, and design errors. The fourth and fifth groups were human resource management and external factors. A detailed discussion of some of the key factors identified in the factor analysis follows.

6.2 Factors Affecting Construction Labourers' Productivity Have Been Analysed by the Researcher

To achieve objective number one of this study, which is to determine the main factors affecting construction labourers' productivity in building construction projects in the UAE, the author undertook several SPSS tests to fulfil the aim and objectives of this study. The reliability analysis presented Cronbach Alpha values of 0.953, closer to 1, which is considered perfect reliability. This high value means there is a high level of internal consistency, and the questions and the measurement tools used were optimal in providing the required responses, and the research data is valid and accurate and could be used in future research. The second test was normality test and then the factor analysis. The result provides the R-square values, which are also referred to as the commonalities. Here, the researcher set the guideline that

anything lower than 0.40 would not contribute much to measuring the underlying factors, and these factors would have to be removed.

In evaluating some of the factors that affect construction labourers' productivity, the research ranked several variables. This ranking was purely based on the opinions of the interviewed research participants. According to the outcome, the most important issue or factor related to workplace productivity can be attributed to the training and the development of the labourers' This is followed by other factors such as the weather conditions during the project execution, project planning and scheduling, and the lack of supervisor experience in the industry. The participants also suggested that productivity is affected by lack of leadership, poor wages, inadequate skills and experience, and delay in authority approvals, as well as poor methods of construction. Moreover, other variables that have been considered central to the equation of labourers' productivity include issues such as lack of health and safety planning, unclear technical specification, changes of orders during project execution, and inappropriate layout of the construction site.

The research also suggested that the shortage of tools and equipment, material delivery and storage, rework, lack of coordination and the design works could influence these projects. In the ranking, the research outcome ranked the unavailability of materials at the site and inspection delays at positions 19 and 20, respectively, based on the responses of the research participants. Other factors such as labourers' transport, accidents, design abilities, absenteeism, and site congestion were equally observed as some of the issues related to construction labourers' productivity. Nonetheless, only the first 10 factors based on the ranking are discussed in this discussion. This research is cognizant that all the variables observed in the study are essential components of construction labourers' productivity. Nonetheless, the

ranking gives the impression that some variables are rated highly in the construction project management lifecycle.

6.2.1 Training and Development of Labourers

One of the key factors affecting the productivity levels in the construction industry is the issue of training and development of the labourers' The research findings suggest that, when the labourers are adequately trained and equipped to deal with the project complexities, they are likely to perform well in executing their mandate. The research outcome affirms the suggestions of Choudhry and Zafar (2017), who observed that the level of competence of workers on a construction site is a critical component of the productivity equation therein. Although Rivera et al. (2016) concur that training and development are essential in promoting labourers' productivity in the construction industry, Choudhry and Zafar (2017) argue that training must be looked at in terms of relevance. This means that the workers' training does not only have to be adequate but must also be the relevant training for these teams (Choudhry & Zafar 2017).

El-Batreek et al. (2013) offered a more critical discussion implying that training and development keep the workers abreast of current industry trends. In this regard, a discussion on the workers' level of competency must interrogate not only their competency levels but also the essence of the training on the productivity equation. These outcomes further affirm the proposals of Hiyassat et al. (2016) to the effect that optimizing productivity at construction sites requires a rational discussion to review the extent to which workers' training has been undertaken.

6.2.2 Weather Conditions

Weather conditions have been established as one of the biggest risk factors in the construction industry in terms of labourers' productivity. For a long time, inclement weather has limited the labourers' ability to stick to their project timelines. This issue has traditionally hindered companies in ensuring that they create value for the consumers. The outcome of the analysis directly suggests that the state of the industry's weather condition directly influences the industry's labourers' productivity. Adverse weather conditions inherently lead to poor quality in the industry (Choudhry & Zafar 2017).

From a more critical viewpoint, it is evident that adverse weather conditions present the workers with a dangerous work environment, thus limiting the site's safety. The research established that weather means that the immediate external environment becomes a health issue from where the activity is undertaken. The summary outcome of this is a significantly lowered level of productivity from the labourers. While the study's outcome looks at the problem of productivity from a purely health perspective, Forsythe (2018) has offered a more comprehensive appraisal of how these weather conditions affect construction economics. This is based on the idea that labourers' economics can assess construction productivity. Notably, by suggesting that the dangerous situations brought about by inclement weather limits workplace productivity, it could also mean that the costs associated with the project are equally affected. For instance, Hiyassat et al. (2016) argue that severe weather conditions tend to come with serious delays in the construction process, thus adding more costs. The mitigation of these adverse weather conditions in the industry thus helps manage construction labourers' productivity.

6.2.3 Planning and Scheduling

In an analysis of project success metrics, Ghoddousi and Hosseini (2012) contend that the concepts of project planning and scheduling are distinct yet connected aspects of successful construction project management. The research project's findings affirm this argument by Barbosa et al. (2017) that planning and scheduling are critical factors influencing project productivity in the construction industry. According to Forsythe (2018), the planning process principally entails selecting the relevant procedures and policies focused on achieving specific objectives. In the construction sector, the execution of these processes generally has a very strong bearing on the workers' productivity. Evidence from the work of Ghoddousi and Hosseini (2012) corroborates this assertion that planning and scheduling in construction project management positively impact the productivity of the workers. García de Soto (2018) observed that project scheduling aids in converting the project's action plans in terms of the scope and time into a timetable that can be operationalized. This means that, when the teams in the construction project do not plan adequately, they are likely to have cost overruns due to project timeline issues.

By suggesting that project scheduling and planning influence construction labourers' productivity, the discussions of Hiyassat et al. (2016) about the work breakdown structure, WBS can be integrated into the analysis. Barbosa et al. (2017) contend that the concept of work breakdown structure can assist the project management team to synthesize the scope of the project into a framework for implementation. Considering that the work breakdown structure is considered a central tool in the project planning phase, it thus reinforces the idea that project planning and scheduling have an important part in improving workplace productivity in construction projects.

Hiyassat et al. (2016) further reinforce this argument by noting that, through scheduling, the deliverables of the project, otherwise referred to as the key performance indicators of the project, can be developed. These KPIs help the project management team evaluate the project's progress within any construction project. Therefore, construction projects must develop a detailed project schedule and planning methodology to ensure project productivity. Based on the study's findings, the project management team is required to integrate a comprehensive project planning and scheduling framework to ensure that the productivity of the labourers' at the site is optimized.

6.2.4 Supervisor Experience

Project management schemes require the input of project supervisors as a key driver of project objectives. Specifically, the construction industry requires project supervisors with a wealth of experience to implement project objectives. In a review of the progress rates of huge construction projects in developing countries, Hiyassat et al. (2016) intimated that most of these projects would run into problems whenever the personnel engaged in the supervision of project progress lacked the relevant experiences to run the project. This observation corroborates the research findings that the supervisor's experience in the project management lifecycle can be an important factor in the productivity equation of the labourers' in the project.

The role of the supervisors in the construction project execution lifecycle is to affirm that the project progress is within the planned timeline. The supervisor must be the biggest connection between the labourers' and the other members of the project implementation team. The ability of the supervisor to understand the project progress and connect the progress to the

project plan is central in the construction sector. These supervisors must be equipped with a wealth of experience to understand the project progress and help advance a project. In essence, a better experience for the project supervisor equals better project outputs.

Although the study's findings affirm that the experience of the supervisors is crucial in enhancing project productivity, Hiyassat et al. (2016) also affirm that the experience of the labourers' is also essential in the process. The integration of the experiences of the supervisors and the labourers' into the construction projects is an added advantage in the construction equation. Based on this argument, the suggestions of Hiyassat et al. (2016) affirm that the supervisors' qualifications must be taken into serious consideration when discussing productivity issues at construction sites.

6.2.5 Leadership

The leadership models adopted in any construction setup influence project progress. An increased number of research studies focus on how project management teams can define their leadership contexts to optimize project outcomes. The evidence in the research study is that there is a mediating role of leadership in project outcomes. Specifically, the construction industry relies on leadership to enhance workplace productivity. (Dai et al., 2009). The research findings can be further discussed within the larger concept of leadership theory. Barima (2017) reiterated that project leadership could act as a deterrent towards achieving the project objectives or ensuring that the project objectives are adequately realized. The argument by Dai and Goo drum (2011) is based on the findings of Crawford and Vogl (2006), who observed that, when the right leadership context is developed in a project, then there is a high chance that the project deliverables are likely to be achieved.

These findings seem to suggest that project management initiatives, other than requiring the right technical skills to achieve, also require what Dixit and Saurabh (2019) call ‘people skills’. To meet the project objectives, the project management team needs to have a well-framed human capital management scaffold. To enhance workplace productivity, the workers must be adequately motivated to achieve the project objectives. This is a role played by the leadership skills of the project implementing team.

6.2.6 Wages

The research findings imply that the right remuneration and compensation package is central to productivity. When a significantly higher number of resources is committed towards the motivation of the workers, there are realistic chances that the workers' morale shall be adequately boosted towards ensuring that the project deliverables are adequately taken care of during the project. These findings further strengthen the position of Doloi (2007) that project management require a very detailed remuneration framework that is not only competitive but also adequate to address the unique needs of the staff members involved in the implementation of the project.

Dai and Goodrum (2011), while discussing this from the theory of worker turnover, observed that, other than just motivating the workers with the right package, the motivation concept is also an important issue in the retention of workers. When workers are adequately remunerated, their input levels into the project are high, thus lowering their levels of mobility. Lower worker turnover rates in any construction project thus assure the project implementing teams of a stable work environment. In contrast, when the project implementing team enforces an unsustainable wage structure, the productivity levels of the workers at the site are considerably reduced (Crawford & Vogl 2006).

6.2.7 Skills and Experience of the Labourers'

The skill portfolio of the labourers on a construction site is directly related to their productivity at the site. When talking about the skill, the issue is the technical know-how. As evidenced in the research findings, the project management team relies on the technical knowledge of the labourers to implement the project. The labourers' have to be adequately trained in several competencies to adequately meet the needs of the implementing team (Dubois & Gadde 2002).

More skills for the labourers' mean that they can translate them into meaningful project deliveries. By proposing that the workers' skills can adequately improve the workplace's productivity, the findings of this study imply that, when the labourers' teams are adequately fitted with the right knowledge, they can sustain a well-planned project execution model for the benefit of the project. Durdyev and Mbachu (2011) argue that equipping the labourers' with the right skills portfolio does not only mean that they are endowed with the right technical skills; it also means that they are capable of acting rationally during the project implementation timelines and solving any form of issues arising during the project implementation lifecycle.

6.2.8 Approvals

Bureaucratic tendencies in the project management scheme have a way of inhibiting project progress, as found in the study. Whether approvals come within the project, such as the release of payments or regulatory issues, there is a serious concern about the role of bureaucracy in the workers' productivity in the construction industry. While it appears that there is very little research focus on how the delay in authority approvals can limit workplace productivity, the suggestions of Hiyassat et al. (2016) imply that these delays come with very

serious implications for project scheduling and planning. It means that any form of delay in approval comes with a significant implication for the project timelines, which affects the productivity of the workers in the industry.

6.2.9 Equipment Management

Optimization of labourers' productivity in building and construction projects is incomplete without proper equipment management standards. The research outcomes affirm that project management teams need to develop a clear methodology for managing equipment in their operations. This is considered a factor of productivity. This admission has been the subject of discussion by Huang et al. (2008), who intimated that construction teams could harness the power of technology to maintain their equipment at the site.

The interplay between equipment management and construction productivity was further discussed by Jung and Joo (2011), evaluating artificial intelligence and AI input in construction works management. The study contends that applying various components of artificial intelligence, a sub-component of building modelling technologies, is central in managing equipment in the building and construction industry. Large construction works require consistent equipment management to enhance efficiency and productivity. The predictive ability of artificial intelligence has been applied in the recent past in the management of construction (Karthik & Rao 2019).

6.2.10 Work Inspection

The achievement of successful project delivery requires that the quality of the completed project is above board. This means that, through the duration of the project execution timelines, it is imperative that effective monitoring of the project process is undertaken to ensure successful completion. The research results indicate a special role for BIM in

monitoring the project progress through the inspection of the project sites. Essentially, the study findings resonate with the discussions of García de Soto (2018) that these BIM modules can be of great significance for the project execution team to evaluate the progress of the project by inspecting the operational site.

Froese (2010), in an appraisal of the existing construction software, suggests that the project implementing team can use a project management information system (PMIS), such as the PMWeb, to ensure that project progress is founded on quality as designed in the initial phases of the project. Several project teams consider these essential tools components of BIM to understand the project's progress. Froese (2010) has given a more nuanced discussion, intimating that a project team could adopt a pre-defined checklist to facilitate site inspections during the project execution lifecycle. For instance, the study mentions that the teams can use BIM deliverables to assess whether the project's progress is equivalent to the pre-defined checklist and deliverables templates.

The principle of applying BIM in the site inspection is that, instead of a manual approval process there will be a pre-defined template enabled through the BIM platform that shall accelerate and avoid human errors during the site documents approval process. Naturally, this is aligned to the technical and contractual terms of the project. The summary outcome of the approach is to ensure that the performance of these processes is expedited and, further, aid in the elimination of the risk of failure to inspect that which should be inspected.

6.2.11 Site Management

Like in other parts of the globe, the construction industry in the UAE is keen on entrenching safety in its operations. The site management approaches therein have prioritized safety issues in their operations. The findings in the research affirm that one of the roles of

BIM in construction sites is the management of safety in their operations. These findings resonate with Huang et al.'s (2008) suggestion that safety is an important factor in industry. At every level of construction operation, project management teams are looking at avenues to refine safety measures in their operations. In an appraisal of the use of technology in site management to enhance the safety of the workers, Forsythe (2018) points towards the application of artificial intelligence to improve site management and entrench site safety. For instance, the application of smart surveillance through drones has been observed to provide crucial data for improving site operations related to safety on construction sites. Camera feeds, through the drones, are systematically sent to an analysis system employing AI techniques to evaluate the site safety levels.

One would want to interrogate how the use of these models thus addresses the issue of workplace productivity. The argument herein is that these safety procedures are generally considered essential programmes in enhancing the workers' productivity. The reasoning here is that, when the construction sites have been well managed in terms of safety and worker security, there is an elevated level of workplace productivity. Herbsman and Ellis (1999) affirm this assertion in the sense that the productivity of an individual on a construction site is ensured when safety is guaranteed. In a sense, the sites where the individuals are assured of a safe work environment improve the workers' physical ability and the general state of their mental health.

Similarly, there is evidence that several construction sites are increasingly using drones to monitor the workers to enhance safety. Hamza et al. (2022) argue that monitoring workers is an element of site management because it assures the project management team that everything that is going on at the site is sanctioned by them and proceeds as theorized in the project execution template. When integrated with other aspects of building and construction

modelling modules, AI technology aids in analysing worker movement and any other form of operational practice. The information is relayed to the project execution teams to audit whether the activities conform to the established safety standards.

6.3 Digital Construction Technologies and Construction Labourers' Productivity was Analysed

The second objective to achieve was to identify advanced digital construction technologies that could improve labourers' productivity in the UAE building construction sector. The respondents were asked questions about the BIM and cloud technologies that positively influence construction labourers' productivity. Most of the respondents specified that labourers' productivity increased when BIM and cloud technologies were implemented. The frequency and descriptive statistics showed the importance of BIM and cloud technologies in improving labourers' productivity. In addition, correlation coefficient and regression analysis identified the positive association between BIM and cloud technologies and construction labourers' productivity. The p-values were less than the significant level of 0.05 that specified positive correlation. The result of the analysis is also supported by literature. For example, the world has witnessed a significant rise in digital technologies to drive building and construction project operations in the past decade. Disruptive technology provides many opportunities to optimize the relevant processes associated with the building and construction industry. This section of the discussion shall discuss the role of advanced digital construction technologies in improving labourers' productivity in the building and construction projects in the UAE (Faridi & El-Sayegh 2006).

As evidenced in the study outcomes, digital technologies have a big role in managing construction productivity. The factor loadings in the analysis suggested that, out of the 71 variables that denoted various aspects through which digital technologies are applied in the enhancement of productivity at the workplace, 12 were considered very critical in the context of the Dubai construction sector in the UAE. One of the applications of digital construction technologies is the reduction of variation orders. The findings in the study imply that, when the project implementation teams leverage these digital technologies in their operations, they have a significant impact on variation orders.

Notably, it is the expectation of any project manager in the construction industry that variation of the project is kept to the minimal level possible. Variation orders come with immense pressure on the timelines established for the project and affect the capital investments in the project in terms of cost overruns. Forsythe (2018) has alluded to this by suggesting that a proper communication model between the project execution team and the client must be established to address the project variations. However, most importantly, the outcome of this research indicates that, when digital components of building and construction are applied in a project, it can assist the project team to limit any form of variation in the original project instructions.

Such digital technological advancements, such as IoT, have serious implications for workplace productivity in several ways. For instance, Ghosh et al. (2021) noted applying the IoT framework in the management of construction projects. Golnaraghi et al. (2019) mention that there is bound to be an array of challenges in many construction projects, such as budgetary issues or cost overruns, time overlaps, and human capital management. According to Ghosh et al. (2021), large projects in the construction sector take up to 20 percent longer to complete and consume up to 10 percent more of the desired budget line. The research by

McKinsey 2017 shows a need to optimize operations in the sector to circumvent these issues (Barbosa et al. 2017).

This research could thus mean that the application of digital technology would help reverse some of the problems related to labourers' that McKinsey has observed in the construction industry. First, the IoT helps streamline various construction processes such as reducing waste in the projects, increasing safety, and enhancing productivity in general. The integration of these digital trends, such as the IoT, thus offers the project management teams an opportunity to streamline all the building and construction processes to enhance efficiency (Golnaraghi et al., 2019). From a broader perspective, one would argue that digital technologies in the construction industry have enhanced productivity. They provide a platform through which a project's stakeholders can share real-time data and report on the project's progress. Additionally, other than reporting and data sharing, the application of the IoT and other digital technologies has been instrumental in automating project workflows. This has been particularly observed to directly contribute to the productivity of workers in a project (Golnaraghi et al., 2019). These technologies have adequately addressed activities such as supply chain mechanisms.

Digital technologies have also emerged as important planks in reducing construction mistakes. The study findings suggest that project implementing teams adopt newer technologies to address some of the emerging challenges in the industry's operations. By observing that digital technologies have enhanced productivity in the sector, Goodrum et al. (2009) write of data analytics as an important concept in digital trends that can significantly address productivity issues at the workplace. Data analytics has been traditionally used in fine-tuning operations in project management. This means that the application of data analytics helps the project management team eliminate any operational inefficiency that may be

witnessed during project execution. This means that the project management team requires a platform to analyse operational data to develop objective decisions about the project. The research findings also support the discussions of Barbosa et al. (2017) about the optimization of contractor performance, management of project risks, and the improvement of capital budgeting in the construction process.

One of the most important elements of data analytics that has since been widely accepted in the construction industry is the concept of predictive analytics. By implying that digital technology has improved workplace productivity, the outcomes of this research could be pointing towards the application of predictive analytics in project forecasting and planning. Perhaps this is one of the most important digital technologies in managing building and construction projects in the UAE. Organizations rely on data visualization to have a clear picture of what the project has achieved so far and give accurate predictions of the project's directions. Data visualization through predictive analyses has been pivotal in the decision-making process in project productivity.

The overall findings of this research in terms of digital technology in the management of construction processes affirm that the evolution of these digital trends continues to provide opportunities for the industry to advance. Within the context of decision making, there is evidence in research affirming that disruptive technology continues to define the functional space of the construction industry in the UAE. From a more critical viewpoint, these digital platforms harness the power of technology to harvest critical data required to manage construction projects. This modelling has been labelled a revolutionary approach in the construction sector because it gives project execution teams a detailed understanding. From the suggestions of García de Soto et al. (2018), project teams leverage these digital trends to predict or forecast project outcomes. Workplace productivity can be looked at from the point

of view of time management in the project execution template. Productivity in the industry can be scaled in a way that project objectives are achieved within the specific project delivery timelines. In this regard, digital technologies capable of adequately handling project timelines are considered critical productivity elements. When this research affirms that digital technology in the construction industry has helped the project execution teams optimize productivity, time management issues can be considered. For instance, Froese (2010) argues that the adoption of digital technology in building and construction considers that these provisions can help optimize the project tendering process. This can either be securing the right suppliers to sustain the project or estimating these processes.

The other important element is the issue of collaboration. Any project execution template requires that the management team has a very clear view of the collaboration model for the project. It is in the interests of the project implementing team to design how they would engage other payers in the project and the associated terms and conditions of their engagement. Despite project collaboration being a central issue in the project management scheme, it has been established that it comes with many challenges. Nevertheless, emerging technologies have solved the collaboration problem in project management. Karthik and Rao (2019) argue that team's lack of ability to collaborate with the project stakeholders effectively has adversely affected the ability of these projects to fulfil the defined objectives. In this regard, several applications have been proposed to enhance the collaborative approaches across the various project stakeholders to ensure that these projects can realize their defined benefits.

6.4 Optimize Labourers' Productivity in Building Construction Projects

The third objective that was achieved in the study was to integrate advanced digital construction technologies and labourers' productivity to achieve optimal performance in the UAE construction sector. The respondents were asked how advanced technologies, such as BIM and cloud technologies, are integrated with labourers' productivity to achieve optimal performance. The correlation, regression, and multiple regression analysis specified the positive impact of BIM and cloud technologies on construction labourers' productivity in the UAE that ultimately enhanced the performance of the organizations. Below are the details of the aspects that show how integration of technologies enhances labourers' productivity by improving different construction aspects, which is critical to a successful project.

6.4.1 BIM and Construction Methodologies

As discussed by Goodrum et al. (2009), the concept of preventive maintenance entails all the procedures of undertaking what Mell and Grance (2011) refer to as regular equipment maintenance. Since equipment failure is one of the risks in construction management, any project management scheme must consider very deliberate strategies to address these risks in their operations. Thus, the application of technology in the preventive maintenance structure is meant to insulate companies from the risks of equipment failure by fixing the mechanical issues in the equipment when the project is still on course. This pro-active approach thus entails a comprehensive assessment of the performance levels of this equipment when it is still operational and undertaking the appropriate steps to service any in case it is not at its full efficiency (Mell & Grance 2011).

One of the major aims of the preventive maintenance framework is to increase an asset's lifetime. Moreover, the preventive maintenance approach prevents untimely breakdown in equipment operations. As Chuang et al. (2011) discussed, the evolution of technology through AI and the IoT is emboldening preventive maintenance objectives in the construction industry. The application works by collecting relevant data about the efficiency of the equipment and uses the algorithms collected in the operation of the equipment to ascertain the machine's level of efficiency. The various components of the intelligent algorithms collected in the operation of this equipment can assist technicians not only to understand the risk of failure of the equipment but also to address these failures within the right time and avoid the disruption of the progress of the work.

The component Using the BIM and cloud technology helps improve design coordination between the project stakeholders was seen to have the high R-squared value of around 0.767. The lowest was 0.447, which was for the component BIM provides a proper sub-contractor involvement strategy as well as execution plan prior to the start of the construction. The questions mentioned in the questionnaire focus on the framework and the four themes mentioned in the framework: construction management factors, project management factors, technical management factors, and cloud technology benefits realization. Looking at the framework expressed in Chapter three, the researcher tested the hypothesis based on the relationship of these factors with BIM and the Level of construction labourers' productivity. These four themes are the direct factors that influence the BIM and level of labourers' productivity, which in turn lead to an indirect impact or influence on the two variables. Here, the questions that measure each of the four themes and their responses are measured and totalled, providing the values that are considered for scoring that would be used to determine their impact on the BIM and level of labourers' productivity. The single total value was

calculated by using the sum of responses for a specific question across the different themes., and the same has been done for Building Information Modelling Factors.

Next was the correlation analysis to examine the relationship between the different variables. The first test was between BIM and construction management factors; the result shows that the significance value is less than 0.001, which means a statistically significant relationship between the two variables is confirmed (hypothesis H1), thus establishing a clear relationship between the two variables and rejecting the null hypothesis. The second test was BIM and the project management factors; the result shows that the significance value is less than 0.001, which means a statistically significant relationship between the two variables is confirmed (hypothesis H3), thus establishing a clear relationship between the two variables and rejecting the null hypothesis. The third test was BIM and the technical management factors; the result shows that the significance value is less than 0.001, which means a statistically significant relationship between the two variables is confirmed (hypothesis H5), thus establishing a clear relationship between the two variables and rejecting the null hypothesis. As illustrated above, the relationship between BIM and the three themes of construction, project, and technical management factors have been proven to be true and statistically significant, now next is to examine the role cloud technology plays or its influence on the relationship between those variables and the BIM.

After the above, the next test analysed the BIM with cloud technology and construction management factors in the first correlation analyses for the multiple factors. The result illustrated that there is a statistically significant relationship that exists between the three variables, and the cloud technology has some influence on the other two variables. By checking the Pearson value for the cloud technology against the two variables, we see a positive linear relationship above 0.70 and closer to 1 and it has a significance value above

0.001, which shows statistical not significant. This reject hypothesis H7, thus confirm the null hypothesis. Similarly, the same analysis was done for project management factors and technical management factors. When focusing on the relationship between cloud technology and technical management factors and project management factors, we see that the Pearson correlation value is 0.798 and 0.326, respectively. This shows that the relationship between the two variables is positive and linear. However, the significant result shows the relationship to be not statistically significant in both cases, which rejected hypothesis H8 and H9; therefore, the null hypotheses could be accepted.

Next was the regression analysis to examine the relationship between the variables. First, the researcher ran a regression test between cloud technology and BIM, which would remain constant for all the other factors. Here, in this regression, the dependent variable is set to be cloud technology benefits realization factors while BIM would be the independent variable. The result shows that there is a statistically significant relationship between the two variables. Next is to check the mediation effects of cloud technology on the relationship of using BIM and construction management factors. The results illustrated that cloud technology has no significant role and would mean that cloud technology as a mediating factor doesn't play a role in the relationship between the two variables, similar to the other two themes, project management factors and technical management factors. The results showed that cloud technology as a mediating factor doesn't play a role in the relationship between using BIM and the two variables stated above.

Nevertheless, back to correlation analysis, the following results were based on the focus put on the other end, which would be the level of construction labourers' productivity and the impact the different techniques identified as themes have had on it. The first analysis that was carried out was focused on understanding the relationship between the level of construction

labourers' productivity and construction management factors. The results show a positive linear relationship between construction management factors and level of labourers' productivity. Moreover, the test results show that the level of labourers' productivity also has a significant positive relationship between Project Management factors with a Pearson Correlation coefficient of 0.568 and a statistically significant relationship. The same is identified for technical management factors with a Pearson Correlation coefficient of 0.906, which is also statistically significant. Next is to examine the mediation effect of the three themes by undertaking a multiple regression test between Using building information modelling (BIM), level of labourers' productivity, and the three mediator variables. The results illustrated that a statistically significant relationship exists and has a statistically significant mediator impact. This would mean that the mediators, which would be the construction management factors, project management factors, and technical management factors, influence the relationship between using BIM and the level of labourers' productivity. This proves hypotheses H2, H4 and H6 to be true, thus rejecting the null hypotheses.

Finally, a test was undertaken to understand the relationship between the level of labourers' productivity and BIM, and the results show a positive linear relationship and statistically significant with a correlation coefficient of 0.803. This means they have a positive relationship, but the researcher ran the regression analysis to explore their actual influence. The results shows a statistical significance relationship between the dependent variable, which is the labourers' productivity, and the independent variable, BIM. This proves that hypothesis H10 that there is a significant direct relationship between the BIM and labourers' productivity in construction is true, thus rejecting the null hypothesis.

6.5 Chapter Summary

In this chapter, the researcher classified factors affecting labourers' productivity into five categories: construction management factors, project management factors, technical management factors, human resources management factors and external factors. In the context of the roles of digital construction technologies in the improvement of labourers' productivity in the UAE construction sector, research findings suggest that the evolution of digital technology has come with many benefits that drive the productivity of the labourers' in the industry. These have been discussed within project scheduling, project programming, and analytics. This research has further pointed out that the application of BIM in the UAE continues to elevate the quality of operations in the industry. This has been explored through the concept of equipment management, where issues of preventive analytics have been discussed. Moreover, such issues as site management and work inspections have been denoted as crucial elements of applying BIM in the construction sector in the UAE.

Chapter 7 : Model Development and Validation

7.1 Introduction

The last objective of the study was to propose a model based on Building Information Modelling (BIM) and cloud technology to aim to improve labourers' productivity in the UAE building construction sector. Thus, this chapter provides an overview of how the model was developed.

7.2 Background Consideration

The most important considerations for this chapter were the research objectives, hypotheses, and the proposed conceptual model. In addition, the results of the quantitative data analysis provided in the previous chapter were used to formalize the main themes that need to be addressed in the focus group discussion. The aim of the focus group discussion was to validate the proposed conceptual model. The participants were engaged from different construction businesses, i.e., clients, contractors and consultants, and the big construction industry players in the UAE. The participation of the big construction firms in the UAE in the discussion was important because they provided vital information on the use of digital construction technologies in their projects. Therefore, having people from these companies in the discussion enriched the model development discussion.

7.3 Focus Group

The validation of the proposed model was done by conducting focus group discussions. Focus group research is defined as: "A method of obtaining qualitative data that involves engaging a small group of individuals in a casual group discussion centered on a certain topic or collection of topics" (Wilkinson 2004). Researchers, mainly qualitative ones, often use the

science of social target groups, to gather information from many people simultaneously. Numerous research participants find focus groups less intimidating, and this setting is conducive to talking about opinions, ideas, and thoughts (Casey & Krueger 2000). For decades, researchers have used focus groups (Morgan 1998). It is a common experience to be in groups. People are invited, seduced, or herded into different groups to plan, learn, make decisions, share, advise, brainstorm, or self-help. Each of these groups has its pros and cons and can be exciting and productive or agonizing, time-consuming, and unproductive (Bloor, Frankland, Thomas, & Robson 2016). Every group has a purpose, including suggesting ideas, nominating candidates, recommending a course of action, expounding on probable options, or planning. The purpose of a group varies from one group to another. The leader of a group must have a clear purpose about their groups and the skills required to guide the group. Additionally, the skills possessed by the members of a group are critical to accomplishing the group's purpose. Krueger (2014) acknowledged that it is difficult to fulfil a purpose when one is oblivious of what it is.

There are innumerable methods of data collection for research purposes, such as surveys, observation, and interviews. Some data can only be descriptive, implying that it cannot be expressed numerically. Sometimes, researchers are interested in securing comprehensive data regarding numerous social issues. The data required is obtained purposely from a particular group of individuals rather than from a statistical sample of a broad population. Additionally, a researcher may need vital information but there is limited time to conduct interviews. The characteristics necessitate the use of a focus group discussion. According to Hennink (2017), a focus group discussion (FGD) is a data collection technique used in qualitative research that entails a pre-selected group of individuals conferring on a specific set of issues. The method attempts to identify a variety of different perceptions

concerning the research topic from various individuals and to seek a first-hand understanding of the issue from the participants.

There are several advantages for social science researchers in using focus groups. Focus groups are a great way to gather data from lots of people, and they can be a cost-effective, fast, and efficient method (Krueger & Mary Anne Casey 2015). Another advantage of focus groups is that they happen in a group setting (Hugentobler 1991). Furthermore, interactions among participants can generate crucial data, permit more spontaneous responses, and provide a forum in which the participants can discuss personal problems and propose solutions (Duggleby 2005). The research question and design ultimately guide the composition of the focus group. A focus group of six to 12 participants (Squyres et al., 2004) typically lasts between one and two hours, and it is motivated by the goal of getting enough participants to offer diversity within the information provided, although not too many because big groups can produce an atmosphere where participants do not feel free to participate.

According to Krueger (1991), having a moderator team for the focus group is preferable. A moderator and an assistant moderator are usually on this team. The moderator is responsible for facilitating the discussion, persuading members to speak, asking too talkative individuals to step aside so that others can speak, and encouraging everyone to engage. In addition, the moderator oversees taking notes that will help them prepare for any unexpected enquiries that may arise. In most instances, the moderator asks focus group participants questions. However, the moderator could provide the group with stimulus material (such as a news article, audio clip, or video clip) and invite them to respond to it. The moderator might ask the participants to participate in a brainstorming or team-building exercise and then provide feedback on the activity. The assistant moderator, on the other hand, is responsible for recording the session

(whether on audio or videotape), taking notes, creating a conducive environment for group discussion (e.g., dealing with latecomers, making sure everyone has a seat, arranging for refreshments), providing data verification, and assisting the researcher/moderator in analysing and interpreting the focus group data (Rabiee 2004).

Although there are numerous focus group data sources, most researchers simply analyse the actual text (that is, what each of the participants said during the focus group). During a focus group, various sorts of data can be collected, including audiotapes of the participants, notes taken by the moderator and assistant moderator, and items recalled by the moderator and assistant moderator (Krueger 1991). However, any of this data can be evaluated; the effort and rigour required to accomplish the study varies. Individual data, group data, and group interaction data are the three forms of data found in focus groups (Duggleby 2005). Theorists of focus groups dispute about the best unit of analysis for analysing focus group data (i.e., individual, group, or interaction). The researchers code the data and report emerging themes in this way, but they rarely specify the type of qualitative analysis they utilize. Although these themes might offer valuable and intriguing information, assessing and understanding them based on the text can be difficult.

7.3.1 Theoretical Background

In an FGD, participants are informally interviewed in a group discussion setting. To better understand what FGD entails, the following essential elements were outlined by Hennink (2014):

Focus groups may consist of six to eight people, but, depending on the purpose of the study, they can have five to 10 individuals.

The participants are pre-selected and moderately homogenous, i.e., they have a common background or shared experiences that relate to the research problem, such as mental illness.

A specific topic remains the sole focus of the FGD, and this allows for an in-depth discussion of the issue within the available time.

The FGD's main goal is to uncover varied perceptions and experiences of the research problem by the participants rather than to reach a consensus.

A trained moderator usually facilitates the discussion to gain detailed information from the participants' responses.

The questions asked by the moderator are well structured and designed to stimulate discussion and probe a variety of views.

A comfortable, non-invasive, non-threatening, and permissive environment is essential to ensure the participants contribute freely without the fear of judgement from the rest.

Krueger (2014) argued that an FGD is not just about bringing individuals together to talk; the group has a specific purpose, size, composition, and procedure for conducting the discussion. Usually, the chief purpose of the group is to obtain individuals' opinions and understanding of a given idea, issue, or topic. Hennink (2014) further mentioned that, during FGDs, participants share their perceptions, listen to the view of others, and refine their views in light of their experiences. Participants also ask questions and clarifications from others in the group, a move that usually probes them to share similar experiences, thus increasing the clarity, depth, and details of the discussion. The group discussion is conducted severally with the same participants, and this allows the researcher to identify trends and patterns in perceptions. As determined by Bloor, Frankland, Thomas and Robson (2016), a careful and systematic analysis of the findings from the discussion is essential for providing insight and clues regarding the perception of an idea, problem, or topic by the group members.

According to Krueger (2014), the label focus group has been used with different groups, such as town meetings, study circles, and study groups. However, these are disregarded as focus groups since they do not contain the essential elements of a focus group as discussed above. During the late 1930s, social scientists began doubting the authenticity of the information collected through the traditional interviews that employed a closed-ended predetermined questionnaire. The social scientists noticed that these questionnaires were disadvantageous in the sense that they had a limited response that could inadvertently be prejudiced by the researcher through oversight or omission. Therefore, an exploration of the strategies where researchers could be less directive and dominating were initiated to give the respondents more freedom to comment on the areas, they deemed most important. As a result, the emphasis was to shift to a nondirective interview that focused on gathering information conforming to the reality of the respondent. These nondirective interviews employed open-ended questions that allowed interviewees ample opportunity to comment, explain, and share their experiences without boundaries and clues for potential responses from the interviewer.

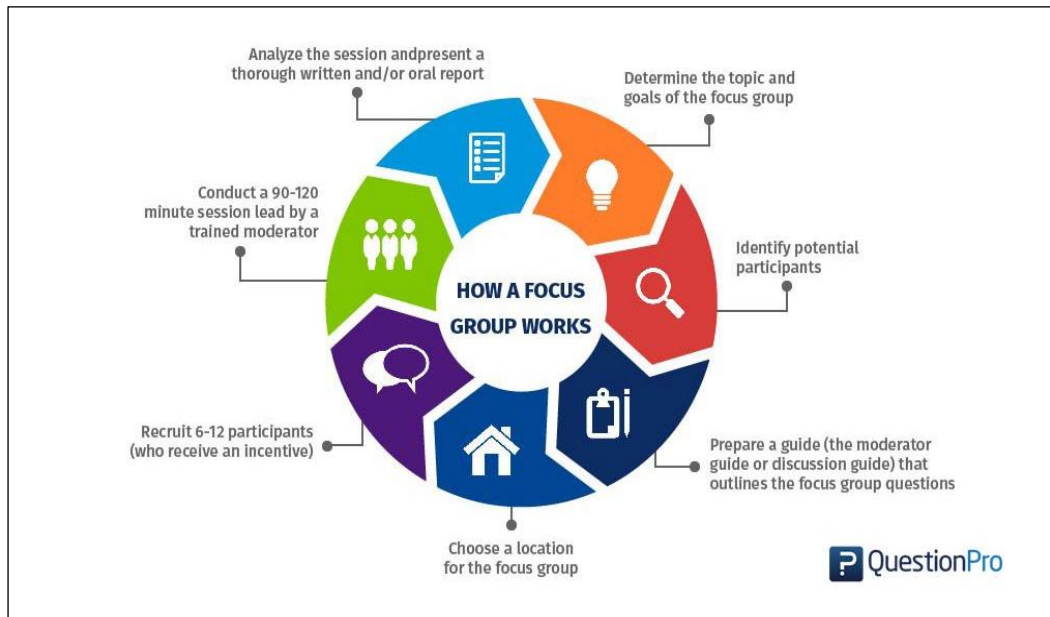
Barbour and Morgan (2017) deduced that, during World War II, social scientists began using nondirective interviews to gather data. Robert Merton (1946), particularly, used this technique to explore the morale of the U.S. Military, where he discovered that people are more likely to provide sensitive information when they are in a safe, comfortable environment with their contemporaries. This was the birth of focus groups and focus group discussions, although this important tool was not recognized or integrated into academic research until the 1980s (Krueger2014).

The main pillars of a focus group include the moderator and the participants. Hennink (2017) defined the moderator as the person conducting the discussion with confidence and

who leads the group members through the questions. The moderator should be impartial and objective throughout the process and can be the researchers themselves or a hired professional. In contrast, the participants are the carefully preselected individuals that the moderator will work with during the discussion. The participants must have a vast knowledge of the subject of the research since this is the main criterion for selecting them.

7.3.2 Process of Conducting a Focus Group

Focus group research best practice is necessary for gathering comprehensive data. Referring to Bloor et al. (2016), a focus group discussion will be successful when the researcher has a clear plan of the participants to recruit and writes focus group questions that align with the research objective and complement each other. Also, the researcher should let the participants know in advance the time, place, and duration of the discussion to enable them to prepare adequately. Additionally, the mode of conducting the discussion, such as physical or virtual, should be availed as well. Finally, informal brochures with a welcome note that outlines the meeting's agenda, and the overall rules of the discussion are necessary for the smooth running of the discussion.

Figure 7. 1:*Conducting a Focus Group Discussion*

Note: Barbour & Morgan (2017)

As illustrated in Figure 7.1 above, the process of conducting a focus group as highlighted by Barbour and Morgan (2017) entails:

Recruiting the right participants – the participants must be knowledgeable about the research topic to contribute to the discussion.

Choosing a location and time suitable to all the participants – the location should be friendly, peaceful, and permissive.

Selecting or hiring a moderator – the moderator should have a clear understanding of the topic and be able to ensure participation from all group members as well as regulate dominant members to allow others to air their views.

Setting clear discussion guidelines – the guidelines should be friendly, accommodating, and not make the participants feel compelled to answer questions. The moderator should request the participants to comply with the guidelines for a smooth discussion session.

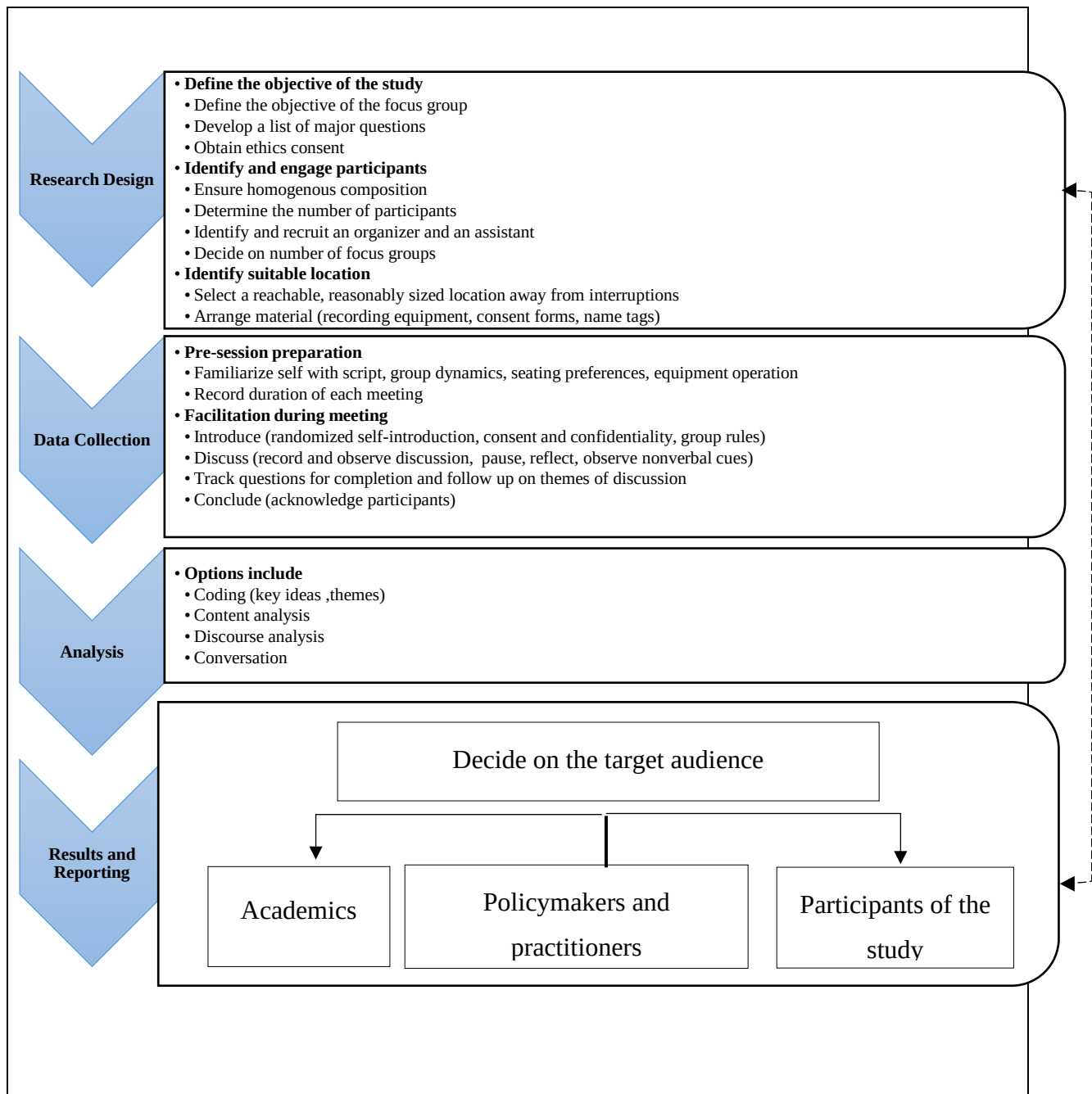
Recording the discussion and its proceedings for future reference – the participants' consent is necessary if the session is going to be recorded. Also, the recording would ensure that all that is discussed is captured.

Conducting the session and generating a comprehensive report – the moderator guides the discussion and uses the information to prepare a detailed report.

Using the generated data to make decisions or draw conclusions – a good report is one which enables the researcher to design actionable plans and improve services as raised by the participants' feedback. Bloor et al. (2016) noted that it is prudent to notify the participants of the changes the researcher makes, and the results obtained thereafter.

7.3.3 Focus Group Research Design

The procedure begins with determining the study's primary goal and defining the study's main research objectives. Each focus group discussion session is guided by a list of questions based on the study objectives. After that, the researcher seeks ethics approval. Participant identification is likely the most crucial phase, as the technique relies heavily on group dynamics and synergistic interactions between participants to generate data (Kitzinger 1994).

Figure 7. 2:*Flow Chart of the Steps of the Focus Group Discussion Technique*

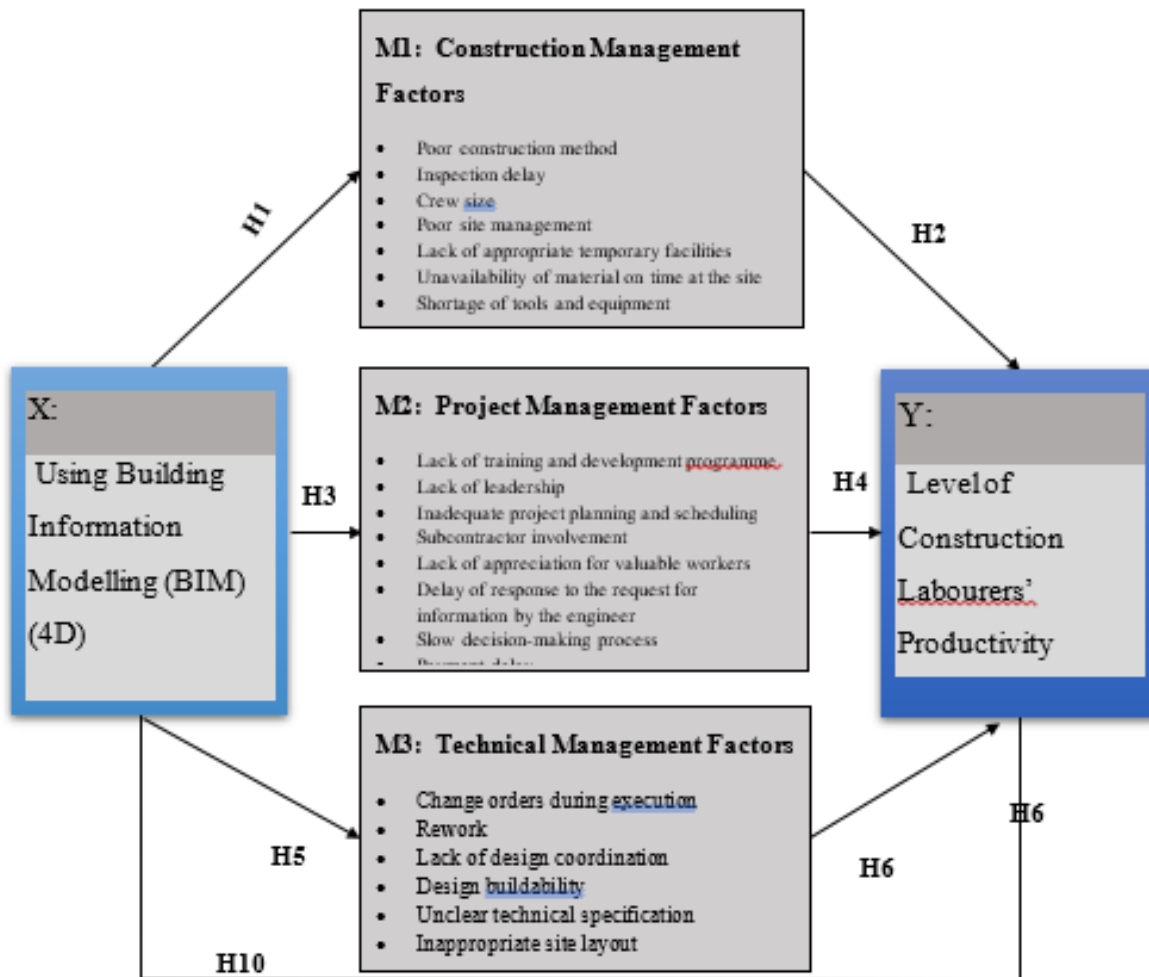
Note: Nyumba et al. (2018)

7.3.4 Purpose of the Focus Group

The purpose of conducting the focus group discussion was to validate the proposed model in this research study. The proposed model argued that the use of BIM increases construction labourers' productivity by improving the factors that could influence the productivity, such as construction management factors, project management factors, and technical management factors, as shown in Figure 7.3 below.

Figure 7. 3:

Maturity Conceptual Model for Leveraging BIM to Enhance Labourer's Productivity in UAE Building Construction Projects



Note: Author (2023)

7.3.5 Questions Used for Validation Exercise

The primary purpose of the validation exercise was to validate the model that has been proposed. The following is the list of questions that were used for the validation discussion:

Do you agree or disagree that labourers' productivity can be affected by several factors beyond labourers' control?

Do the application construction project management processes/techniques impact labourers' productivity output?

Does the use of BIM in building construction projects improve labourers' productivity?

Will the integration of cloud technology into BIM enhance construction labourers' productivity?

To ensure ethical clearance the participants were informed about the research and its limitations and confidentiality, and they were told to feel free to answer or not answer any questions before the discussion started. Thus, to validate the model and achieve the fourth objective, the researcher invited 11 participants from different construction companies. The 11 participants were selected to ensure that all disciplines within the research study were covered. Focus group participants were chosen from different companies, as shown in Table 7.1 below.

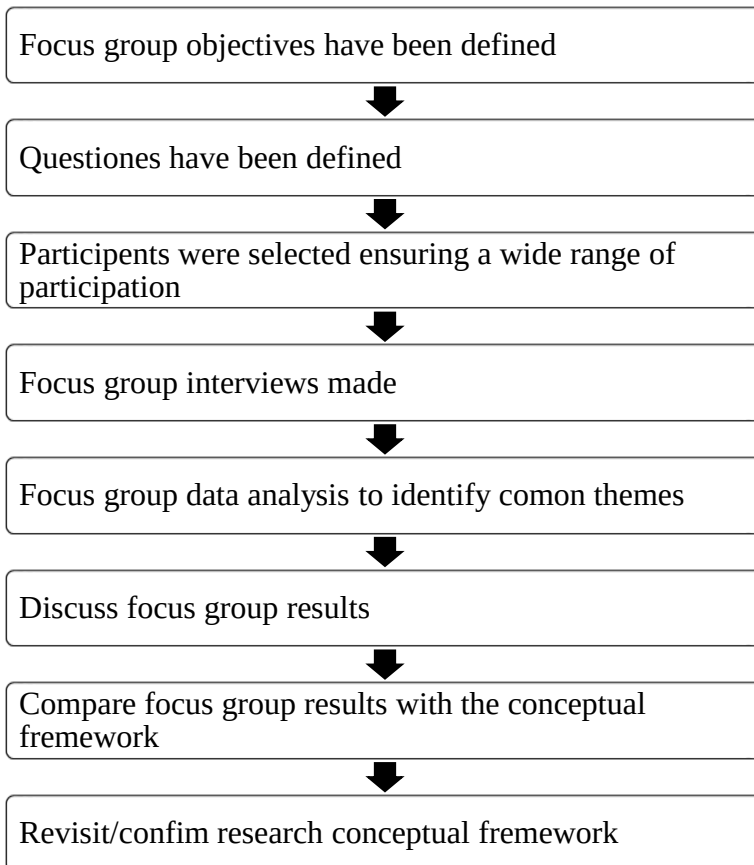
Table 7. 1:

Participants' Details

Code	Current job	Gender	Years of experience	Duties and responsibility
A	Project manager	Male	20	Managing building
B	Project manager	Female	16	Managing villas
C	Project manager	Female	18	Managing construction project
D	Construction supervisor	Male	19	Building project

E	Construction supervisor	Male	14	Building project
F	Project resident engineer	Male	22	Building project
G	Project resident engineer	Male	17	Building project
H	Subcontractor	Male	15	Construction
I	Subcontractor	Male	16	Construction
J	Construction foreman	Male	21	Building project
K	Construction foreman	Male	25	Villas project

The steps that were followed by the researcher have been summarized in Figure 7.4 below; they were: defining objectives and questions, selection of participants, interviews with focus group, data analysis, discussion, the comparison of the model with the conceptual framework, and confirmation of the research model aligning with the conceptual framework.

Figure 7. 4:*Focus Group Process*

Before the commencement of the validation exercise, the researcher sought ethical clearance. The participants were informed about the research aim and confidentiality. The researcher began the focus group discussion by welcoming the participants and introducing them to each other. After that, they were informed about the purpose of the focus group discussion. Then, they were given a short presentation about the study aim and objectives and the conceptual framework.

The participants were asked whether labourers' productivity is affected by several factors beyond labourers' control. All participants concurred with this statement and further suggested that the project management, construction management and technical management

factors identified in the model figure 7.3 impact construction labourers' productivity.

Participant A noted that it is crucial to consider new technology in implementing project management principles. Participant C suggested that it could be a good idea to formalize a framework that can show the proper implementation of digital technology and project management practices and participant B agreed with the idea. Other participants tended to concur with the suggestions that had been mentioned by participant B. In this part of the discussion, it was concluded that all the participants agreed about the critical role of digital technology in improving delivery of building construction projects.

Moving forward, the next question was what type of digital technology could have a significant impact on project management factors that have been identified in the proposed conceptual model. Participants D, E, and G's discussion specified that BIM is the key technology that improves labourers' productivity by enhancing the level of project management factors. Most of the participants supported that using BIM in building construction project has a significant impact on project management factors. The researcher emphasized some benefits of using BIM, such as it integrates the reports, plans, and activities of all stakeholders involved in the project; it also classifies the diversified components of the building and breaks them down into various groups and has the capacity to manage time and cost; and it is associated with what is allegedly known as 4D and 5D. In addition, clash identification in BIM acts similar to a quality procedure that visualizes, modifies, and evaluates the construction risks. It evaluates the soft and hard clashes. In addition, participants A and C stated that collaboration and team building in BIM are linked to HRM as a part of project management. Participants J and K highlighted that communication is the main characteristic of BIM; they said that BIM's communication feature contributes to professional linkages between all stakeholders like project managers, designers, and engineers on a

construction project by developing an effective and open communication channel. Nine of the participants (A, C, D, E, F, G, I, J, and K) emphasized that the use of BIM improves construction management such as supervision, construction methodology, and coordination between civil works and mechanical and electrical works that ultimately increase the labourers' productivity.

It was noted that BIM is the most crucial technology for construction projects nowadays. Participants were also asked how to achieve stakeholder integration and manage data in a more efficient way. Regarding this question, the participants suggested that BIM can be used to enhance stakeholder integration and data management. As a result, the project managers are integrated with all the project stakeholders, which increases labourers' productivity. Most of the interviewees in the focus groups agreed that BIM facilitates effective building construction delivery and effective management of the technical factors.

Based on the above focus group discussion, the participants confirmed and agreed that the use of BIM has an impact on project management, construction management, and technical management factors as presented to them in the said discussion. Therefore, the maturity conceptual model for leveraging BIM to enhance labourer's productivity in UAE building construction projects shown in Figure 7.3 above.

7.4 Chapter summary

This chapter addressed the necessary steps for model development, validation, and focus group discussion. Based on the above, the research achieved the aim set in the beginning of the study. Figure 7.3 above presented the validated conceptual framework model that can be used by construction practitioners in UAE building construction projects to improve the level of construction labourers' productivity.

Chapter 8 : Conclusions and Recommendations

8.1 Introduction

The aim of this study was to identify the key causes of low labourers' productivity during the delivery of building construction projects in the UAE. The research identified key advanced digital construction technologies that could be used to improve the level of labourers' productivity and proposed a model that comprised key labourers' productivity determinants BIM and cloud technology. Four objectives were presented in Chapter one to assist in accomplishing the research aim. The previous chapters contain significant discussion of the outcomes of the research in the theme of its aim, objectives, literature, theory, and research results. Thus, this chapter provides a summary of the entire research components and draws the critical conclusion of the study. In addition, contributions to research and recommendations are provided.

8.2 Conclusions

The research examined factors affecting labourers' productivity in the UAE's building construction sector and the use of BIM and cloud technology. The research identified several factors affecting construction labourers' productivity. Among the 42 factors identified from the reviewed literature, the most significant factors affecting labourers' productivity were inadequate supervision, lack of labourers' skills and experience, poor planning and scheduling, poor site management, shortage/management of material, payment delay, ineffective communication, shortage of tools and equipment, rework, lack of design coordination, and

variations during execution. From the findings of the study, it was found that the UAE construction sector is still facing labourers' productivity challenges, and the industry has one of the lowest productivity rates.

Primary and secondary data were collected to analyse the role of BIM and cloud technologies. Diversified descriptive and inferential statistical tools were used to evaluate the primary data. Correlation and regression analyses were used to address the objectives of the study. The correlation analysis identified a positive relationship between construction labourers' productivity and the factors that influence labourers' productivity. These factors were project management factors, construction management factors, technical management factors, human resource management factors, and external factors. Positive correlation and p-values of less than the significance level of 0.05 led to achieving objective one. Strong correlations indicated that poor management factors, ineffective construction management factors, inadequate technical management factors, poor human resource management factors, and external factors were found to reduce the rate of labourers' productivity in the UAE construction sector. The second objective was achieved by focusing on evaluating the link between advanced technologies and factors that impact labourers' productivity. For example, positive correlations and p-values of less than 0.001 identified a strong association between the two factors. As a result, it was revealed that implementing BIM facilitates the successful delivery of building construction projects. In addition, the study further established that BIM can be used to facilitate integrated project delivery. The application of BIM allows stakeholders to appraise various possibilities that could affect the delivery of building construction projects. BIM can be used by construction practitioners in the UAE to view

building construction projects from different angles, which can lead to better understanding of three-dimensional relationships between project components. Hence, it was corroborated that the two advanced digital construction technologies could be used to improve labourers' productivity in the UAE building construction sector.

Objective three was achieved by evaluating the relationship between advanced technologies and factors that affect labourers' productivity. From the analysis, it was found that, through the application of the two advanced digital construction technologies, practitioners in the UAE can achieve optimal performance and improve the level of productivity. It is worth noting that building construction projects can generate vast amounts of information and primary stakeholders get more involved in the entire project lifecycle of the project. Hence, it is vital for key primary stakeholders to be able to access and share information quickly. A BIM allows more frequent data exchanges among the key primary stakeholders, which augments more depth and value to the information in the lifecycle. To achieve objective four, the researcher proposed a model and validated the model through focus group discussions. Participants were asked different questions related to the BIM and labourers' productivity. Nine out of the 11 participants indicated the significance of BIM in improving labourers' productivity in the UAE building construction sector. They agreed that BIM could be used by construction teams to plan effectively, collaborate, and communicate openly. They also stated that BIM could be used in building construction projects to assist with scope management, time management, cost management, procurement management, communication management, and others.

Participants noted that BIM allows construction practitioners to easily access data in any location at any time. As discussed in the focus group discussion, participants highlighted that, by using BIM, clashes in projects can be identified quickly and changes to projects can be done in real time. Moreover, the participants noted that this enhances model coordination, project coordination, and project planning, which, if done well, leads to efficient project delivery.

8.3 Contribution to Research

The research has attained its overall aim of proposing and validating a model that comprises BIM and labourers' productivity determinants that can be used to improve labourers' productivity in the UAE building construction sector. As shown in this study, the advancement of BIM can democratise access to vital information, tools, and techniques, which can be used to create a collaborative team environment. Within the context of the UAE, this research has also shown how BIM has emerged as a means of improving labourers' productivity in the construction sector. The justification of this study was built by an empirical analysis of factors affecting labourers' productivity in building construction projects in the UAE. In turn, the latest technologies were incorporated with the factors to establish a synergy impact as part of labourers' productivity.

8.4 Recommendations from the Research

Recommendations for policymakers and the construction sector after the research discussion and findings: there are several recommendations that could be crucial to the advancement of the construction sector. This section of the study provides some

recommendations for the construction sector based on the results and several research themes assessed in this study. These recommendations are presented below in two categories.

Recommendations to policymakers

There is a need for clear policies and procedures relating to proper implementation of building information modelling and cloud technologies in construction projects. The UAE government needs to examine how the process of collaborative project delivery can be achieved across the construction supply chain members.

As shown in this study, there are several benefits which can be gained by using BIM and thus, it is vital for the government and construction leaders in the UAE to establish how more investment can be put into the implementation BIM. By making continuous investments in technology, the sector will have an opportunity to improve labourers' productivity and maintain a competitive edge in the Middle East and North Africa .

There is also a need for construction leaders and the government to work collaboratively to create BIM training programmes that can be accessed by contractors and subcontractors across the construction supply chain. This will allow registered contractors and subcontractors in the UAE to consistently enhance their technical skill sets.

8.4.1 Recommendations for Future Research

The study achieved its main aim of proposing a model that comprises BIM and labourers' productivity determinants'. Although the findings and the conclusion of the study have added value to the existing knowledge on the use of BIM to improve labourers' productivity in the UAE, it is important that further research is carried out in the form of a case study to evaluate the impact of the model's proposed context. Thus, to further augment

the findings of this research study, the following research themes are recommended for future research.

From the reviewed literature, it was found that there is still a need to ascertain how 3D printing material technology can be incorporated with other building components. Thus, this research recommends future studies to examine how 3D printing material technology can be used to improve labourers' productivity in building construction projects.

There is a need for the construction sector in the UAE to establish how artificial intelligence, drones, and virtual reality can be used to improve productivity and optimize the delivery of construction projects. This calls for comprehensive research to examine how the three technologies can be used to improve productivity and optimize the delivery of construction projects.

Within the context of construction digital transformation, there is a need for research studies to be carried out to establish how consistent working methods and collaborative digital environments can be created in the construction supply chain.

There is a growing demand for the application of digital twins (AR and VR) and BIM; however, as established from the reviewed literature, it was found that not much has been done to delve into how these two technologies can be used to improve project workflow and labourers' productivity. Further study on this would help construction practitioners to have a better understanding of how these two technologies can work together.

It was also established that there is a need to examine how artificial intelligence, machine learning, and digital twins can be used to analyse real-time project data. Therefore,

this research proposes that future studies examine how the three technologies can be used to reduce project operational downtime on construction projects.

8.5 Limitations of the Study

The study had the following limitations:

One of the main challenges was finding literature that could be linked to digital construction with labourers' productivity. Thus, this study aimed to bridge this gap from a theoretical viewpoint and develop a model that could be used in practice to improve labourers' productivity.

The other significant limitation was data collection. To tackle this limitation, government entities from Abu Dhabi and Dubai were approached. The research selected more than 2000 companies as they had previous experience in building construction projects in the UAE. From the 2000 companies, the researcher managed to collect data from 397 respondents.

Geographical limitations were also a concern as the context of this study was only focused on the UAE, where collecting data is a big challenge due to the shortage of companies having previous experience in building information modelling.

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Appendices

Appendix A: Questionnaire

Questionnaire	استبيان
Dear Sir/ Madam, I am currently undertaking a PhD entitled “Model for improving the rate of labourers’ productivity through the use of advanced digital technologies: Case UAE building construction projects”. The research aims to identify the key causes of the low labourers’ productivity during the delivery of building construction projects in the UAE. Moreover, the research will identify key advanced digital construction technologies that could be used to improve the level of labourers’ productivity, and propose a model that will comprise key labourers’ productivity determinants and Building Information Modelling (BIM) and cloud technology which can be used to improve the level of labourers’ productivity and optimize the delivery of building construction projects in the UAE construction sector.	سيدي/سيدتي أحصل حاليًا على درجة الدكتوراه بعنوان "نموذج لتحسين معدل إنتاجية العمالة من خلال استخدام التقنيات الرقمية المتقدمة: حالة مشاريع تشييد المباني في الإمارات العربية المتحدة". تهدف الدراسة إلى تحديد الأسباب الرئيسية لانخفاض إنتاجية العمالة أثناء تسليم مشاريع تشييد المباني في دولة الإمارات العربية المتحدة. علاوة على ذلك ، سيحدد البحث تقنيات البناء الرقمية المتقدمة الرئيسية التي يمكن استخدامها لتحسين مستوى إنتاجية العمل ، ويقترح نموذجًا سيتألف من محددات إنتاجية العمل والتكنولوجيا السحابية (BIM) الرئيسية ونمذجة معلومات البناء التي يمكن استخدامها تحسين مستوى إنتاجية العمالة وتحسين تنفيذ مشاريع تشييد المباني في قطاع البناء في دولة الإمارات العربية المتحدة. يمنحك هذا الاستبيان الفرصة للتعبير عن آرائك حول مجموعة واسعة من العوامل التي تؤثر على إنتاجية عمال البناء في مشاريع

This questionnaire gives you the opportunity to express your views on a wide range of factors affecting construction labourers' productivity in building construction projects in the UAE. Please note that there is no right or wrong answer. The questionnaire will be used to collect the primary data needed for a research study. Therefore, we seek your assistance to be as open, fair, and honest as possible as you can in your responses. The author assures you that no individuals will be identified from their responses and there are no requests for confidential information included in the questionnaire. The results of the analysis will be strictly used by the researchers for study purposes only. The questionnaire comprises three parts: 1. Demographic information. 2. Level of importance of factors affecting construction labourers' productivity in building construction projects in the UAE and the frequency of occurrence of those factors. 3. The impacts of BIM and cloud technology on	البناء في الإمارات العربية المتحدة. يرجى ملاحظة أنه لا توجد إجابة صحيحة أو خاطئة. سيتم استخدام هذا الاستبيان لجمع البيانات الأولية لعمل دراسة بحثية. عليه نطلب مساعدتكم في الإجابة على الأسئلة بكل وضوح وحرية وصدق وأمانة قدر المستطاع. يؤكد لكم الباحث بأنه لن يتم التعريف أو الإشارة إلى الأفراد من خلال الإجابات المقدمة ولن يكون هناك أية إجابات تستوجب السرية يتضمنها الاستبيان. سيتم استخدام نتائج التحليل من قبل الباحثين لأغراض الدراسة فقط. يتكون الاستبيان من ثلاثة أقسام: 1. معلومات عامة 2. مستوى أهمية العوامل المؤثرة في إنتاجية العمالة في مشاريع البناء والتشييد في دولة الإمارات العربية المتحدة. وتكرار حدوث العوامل المؤثرة في إنتاجية عمال البناء 3. تأثير استخدام الـ BIM and the cloud technology على إنتاجية عمال البناء. إذا كان لديك أي أسئلة أخرى أو ترغب في مزيد من المناقشة معي ، يمكنك الاتصال بي على هاتفي المحمول أو بريدي الإلكتروني (+971502710245) لأي استفسارات أخرى (munirshahatit@gmail.com) حول البحث ، لا تتردد في الاتصال بمدير الدراسات الخاص بي على (Edward.ochieng@buid.ac.ae) .
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construction labourers' productivity level. If you have any further questions or would like to discuss further with me, you may please contact me on my mobile (+971502710245) or my email (munirshahatit@gmail.com). For any further inquiries on the research, feel free to contact my Director of Studies at Edward.ochieng@buid.ac.ae. Thank you for taking the time to complete this survey. With kind regards, Muneer	شكرك على الوقت الذي أمضيته في إكمال هذا الاستبيان. مع أطيب التحيات، منىير
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Notes about the Questionnaire:

As is the case with many questionnaire surveys, there may be some questions which appear irrelevant or impertinent. However, it is necessary in this study that all questions are answered, as the questionnaire is designed to achieve particular research objectives, and it is hoped not to offend participants in any way. If there are any questions which you are unwilling or unable to answer, then it is my wish that you continue to answer the remainder of the questionnaire.

Remember that both your identity and that of the company you work for will remain strictly confidential.

Aim of the research study

The research aims to identify the key causes of the low labourers' productivity during the delivery of building construction projects in the UAE. Moreover, the research will identify key advanced digital construction technologies that could be used to improve the level of labourers' productivity, and propose a model that will comprise key labourers' productivity determinants and Building Information Modelling (BIM) and cloud technology which can be used to improve the level of labourers' productivity and optimize the delivery of building construction projects in the UAE construction sector.

To participate in the above-mentioned questionnaire, please click the link below. By clicking the link your consent to participate is assumed.

PART ONE: DEMOGRAPHIC INFORMATION

الجزء الأول : المعلومات الديموغرافية

The following questions are associated with demographics, please tick (✓) the appropriate options below.

الرجاء وضع علامة لكل سؤال:

A. Sex (1) Male (2) Female	أ – الجنس: (1) ذكر (2) أنثى
B. Contractor/Consultant (1) Contractor (2) Consultant	ب-شركة العمل مقاول / استشاري (1) مقاول (2) استشاري
C. Job title: (1) Project manager (2) Construction manager (3) Foreman (4) Site supervisor (5) Resident engineer	ج- المسمى الوظيفي (1) مدير مشروع (2) مدير انشائي (3) مراقب ابنية (4) مراقب موقع (5) مهندس مقيم

D. Level of education: (1) Less than high school (2) High school (3) College degree (4) Graduate degree (5) High diploma (6) Master's or above	د- المرحلة التعليمية: (1) أقل من الشهادة الثانوية (2) الشهادة الثانوية (3) خريج/خريجة كلية (4) متخرج/متخرجة (5) الدبلوم العالي (6) الماجستير أو أعلى
E. Number of years worked in the current organization: (1) One year or less (2) 2 - 7 (3) 8 - 13 (4) 14 - 19 (5) 20 years or above	و - عدد السنوات التي قضيتها في منظمك الحالية (1) سنة أو أقل (2) 2 - 7 (3) 8 - 13 (4) 14 - 19 (5) 20 سنة أو أكثر

F. No. of years worked in the position or job:	ز - عدد سنوات الخدمة في
(1) One year or less	نفس الوظيفة أو العمل:
(2) 2 - 7	
(3) 8 - 13	
(4) 14 - 19	(1) سنة أو أقل
(5) 20 years or above	() ()
	() ()
	(2) 7 - 2
	() ()
	(3) 13- 8
	() ()
	(4) 19 - 14
	() ()
	(5) 20 سنة أو أكثر
	() ()

PART THREE: Benefits of implementing 3D, 4D and 5D BIM in building construction projects

The following are the benefits/the results achieved by proper implementation of 3D, 4D and 5D BIM in building construction projects. Please rate each item on a scale of 1-5, where 1 is 'strongly agree'; 2 'agree'; 3 'neutral'; 4 'disagree, and 5 'strongly disagree'.

Benefits/results of implementing 3D, 4D and 5D BIM in building construction projects	1	2	3	4	5	Remarks
	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	

1.0 Project management benefits realisation factors

- 1.1 BIM improves leadership involvement.
- 1.2 BIM improves planning and scheduling before construction starts.
- 1.3 BIM provides proper subcontractor involvement strategy and execution plan prior to construction starting.
- 1.5 BIM improves productivity due to easy retrieval of information.
- 1.6 BIM improves the time required to respond to the request for information by the engineer.
- 1.8 BIM improves producing project progress payments and

facilities engineer
approvals.

2.0 Construction benefits realisation factors

- 2.1 Using BIM improves construction methods.
- 2.2 Using BIM reduces the time required for work inspection.
- 2.3 Using BIM improves health and safety measures at the construction site.
- 2.4 Using BIM improves construction site management.
- 2.5 Using BIM allows for the arrangement of proper construction site facilities.

3.0 Technical benefits realisation factors

- 3.1 Using BIM in building construction projects reduces the numbers of variation orders.
- 3.2 Using BIM in building construing helps workers to avoid construction mistakes and therefore reduces reworks.

- 3.3 Using BIM and cloud technology provides better design coordination between project stakeholders.
- 3.4 Using BIM before construction starts ensures design buildability.
- 3.5 Using BIM in building construction projects helps with a better understanding of the technical specification.
- 3.6 Using BIM assists the project team to produce proper site layouts necessary for construction works.

4.0 BIM and cloud technology benefits

- 4.1 Using BIM and cloud technology reduces drawing errors.
- 4.2 BIM and cloud technology improve communications between the project team and project stakeholders.

- 4.3 Using BIM and cloud technology reduces design mistakes.
- 4.4 BIM and Cloud technology speed up senior management decision making by providing on-time necessary project updates.
- 4.5 Using BIM and cloud technology provides a proper material schedule which results in ensuring timely material delivery.
- 4.6 Using BIM and cloud technology provides proper equipment management.

Thank you again for taking part in this survey. If you would like a summary of the results, please enter your name and contact address below.

Name:

Contact details

Appendix B: Consent letter

Consent letter

Thank you in advance for taking the time to complete this survey. Your participation is highly appreciated for adding value to theory and practice about the research.

Research title: Model for improving the level of labourers' productivity through the use of advanced digital technologies: Case of BIM and cloud technology in building construction projects in the UAE

Researcher: Muneer Mohammad Ismail Shahatit

Researchers' contact details: munirshahatit@gmail.com

Institutional contact details: The British University in Dubai (BUID), Professor Edward Ochieng, Edward.ochieng@buid.ac.ae

Research Aim: The research aimed to examine how advanced technologies such as BIM and cloud could be used to improve labourers' productivity during the delivery of building construction projects in the UAE. The research proposed a model that comprises Building Information Modelling (BIM) and cloud technology that could be used to improve labourers' productivity in the UAE building construction sector.

Risks: There is no risk associated with this research study.

Confidentiality: Your responses are nameless. No personal information or IP address will be gathered. Data will be collected through the Survey Monkey platform.

Voluntary participation and authorization: Your choice to participate in this research is voluntary, and you can withdraw at any time if you decide not to continue.

I voluntarily agree to participate in this study:

Potential adverse effects on participants and steps to deal with

Please outline if any anticipate risk or harm to participants

As mentioned above this, there are not any expected risks or harm attached to this research study

☐ Yes

☐ No

Steps to ensure confidentiality of data

Please indicate steps in case you are required to ensure confidentiality or privacy.

No personal information or IP will be collected from the participants, and the questionnaire is anonymous .data will be collected online and kept as a softcopy only. The data will be used for this study only and will not be shared for any purpose otherwise.

Any other specific matter that needs to be taken into consideration.

Please indicate any specific matter that needs to be taken into consideration.

None

PARTICIPATION IN THIS RESEARCH STUDY IS VOLUNTARY

Study ethics checklist

I have read and understood the study information dated [DD/MM/YY], or it has been read to me. I have been able to ask questions about the study, and my questions have been answered to my satisfaction. YES / NO

I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and that I can withdraw from the study at any time without having to give a reason. YES / NO

Will consent possibly be bullied out of participants by those who would likely benefit from the study? YES / NO

I understand that the information I provide will be used for the research model for improving the level of labourers' productivity through the use of advanced digital technology: case of BIM and cloud technology in building construction projects in the UAE and that the information will be anonymized. YES / NO

I agree that my (anonymized) information can be quoted in research outputs. YES / NO

Will the study include some form of an offensive of privacy? YES / NO

I give permission for the (anonymized) information I provide to be deposited in a data archive so that it may be used for future research. YES / NO

Is discomfort or a harmful effect on participants likely to result from the study? YES / NO

Will the name of the participants or the institution appear in the study? YES / NO

Will the study discuss any sensitive information YES / NO

Does the research include participants that are unable to provide consent? YES / NO

The researcher does not deviate from the original consent granted by the university research ethics committee and ethics-approval form. The researcher admits that he is wholly and solely responsible for deviations from the approved research ethics form.

Declaration by the researcher

The researcher declares that the information herein aligns with the university research policy.

I am satisfied that I covered all risks associated with this research study to the participants, researcher, or university. And the research data collection will abide by the ethics research form approved by the BUID.

Researcher signature: Muneer Mohammad Ismail Shahatit

For information, please contact: munirshahatit@gamil.com