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Strategic planning to improve the construction industry in Palestine: Lean Construction and BIM in Palestine

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Thesis Approval

Strategic planning to improve the construction industry in Palestine: Towards BIM and Lean in Palestine.

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Declaration

I declare that all the work in this thesis titled “Strategic planning to improve the construction industry in Palestine: Towards BIM and Lean in Palestine” has been done to fulfill the requirements for the degree of Master’s in Strategic Planning and Fundraising and submitted to Arab American University Palestine. All work is original, and it has been written by me and I have duly acknowledged all the sources of information have been used in this thesis.

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Dedication

As I begin this new phase of my educational journey, I want to take a moment to thank the people who have had the greatest impact on me thus far: my family.

To my mother, father, and brothers Yazan and Dina, your presence was the background to my studies, the motivation behind my efforts, and the joy that illuminated my life.

To the martyrs, who had sacrificed their lives to our freedom, and taught us that with the power of love, human beings can fight arrogance, war and violence.

With love and gratitude,

Wissam Sbeih

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Your contributions were essential to the completion of this thesis.

Abstract

The construction industry in Palestine is experiencing significant changes due to the adoption of advanced technologies such as lean construction and Building Information Modeling (BIM). The purpose of this thesis is to explore the possibility of implementing these innovative methods in the Palestinian construction sector, and to create a strategic conceptual framework for their implementation.

The research starts with acknowledging the crucial role of lean construction in eliminating waste, improving value, and meeting customer requirements. Similarly, BIM provides an intelligent, model-based approach to building design and operation. However, implementing these technologies in Palestine faces challenges such as limited capital and skills, and concerns about cost-effectiveness.

To address these challenges, 150 questionaries were conducted among construction professionals, government officials, and stakeholders to comprehensively analyze implementation challenges in Palestine, including limited capital, skills, cost concerns, and cultural factors. The analysis informs targeted capacity-building strategies to ensure the workforce is well-equipped to harness the capabilities of Lean and BIM. Statistical analysis using SPSS and smartpls indicates that perceived barriers explain a substantial portion of variances in strategic planning for Lean and BIM integration. Additionally, a significant effect of expected benefits on the desire to implement these technologies is observed, with perceived benefits playing a crucial role.

The objectives of this study are to identify barriers and challenges to BIM and Lean implementation, assess industry readiness to implement these technologies, examine the impact of strategic planning on their implementation, and develop a strategic framework linking strategic planning and technology implementation.

The study conclude that company demographics and readiness are crucial factors to ensure the successful implementation of BIM and Lean methods in the construction industry of Palestine. The research findings suggest that larger companies with more experience in the construction industry are willing to adopt these methods, while smaller companies are more hesitant due to many challenges like resources' constraints and limited knowledge in the field.

Keywords: Lean Construction, Building Information Modeling (BIM), Strategic Planning, Construction Industry, Palestine, Technology Integration, Industry Transformation, Framework Development, Sustainable Construction, Performance Optimization, SPSS, smartpls.

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List of Abbreviations

Abbreviation	Meaning
AEC	Architecture, Engineering, and Construction
BIM	Building Information Modeling
CPI	Construction Productivity Improvement
GDP	Gross Domestic Product
ICT	Information and Communication Technology
ISO	International Organization for Standardization
KPI	Key Performance Indicator
Lean	Lean Construction or Lean Management
PLS	Partial Least Squares
PMO	Project Management Office
PMBOK	Project Management Body of Knowledge
R&D	Research and Development
ROI	Return on Investment
SPSS	Statistical Package for the Social Sciences
SWOT	Strengths, Weaknesses, Opportunities, Threats

Chapter One

Introduction

1.1 Background

The industry of construction in Palestine, which is considered to be a vital component for growth, and infrastructure, faces challenges and obstacles that hinder the process of development. Such problems are classified as delays in the project implementation, cost overruns, and lack of efficiency as well as professionality. In order to address and handle such issues, leveraging Building Information Modeling (BIM) and Lean approaches as well as methodologies can meaningfully be significant tools for such purpose.

Project delays and cost overruns in construction are of great importance to be taken into consideration since they can have substantial economic ramifications, which in turn underscores the importance of exploring innovative solutions. BIM is described as a powerful technology that plays a major role in facilitating intelligent planning, design, construction, and operation of buildings, as well as addressing key challenges through real-time collaboration and error reduction. BIM technology together with Lean methodologies provide a systematic approach that aims to eliminate waste and optimize processes. This results in streamline workflows and enhance efficiency in construction all over the world.

The integrated use of BIM, which stands for Building Information Modelling is an important development strategy in the world of construction. The National Building Information Modeling Standards (NBIMS) committee of USA defines BIM as follows: “BIM is a digital representation of physical and functional characteristics of a facility. A BIM is a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life cycle; defined as existing from earliest conception to demolition (Azhar, 2012). Also, the use of Lean seems likely to be effective and successful in changing the landscapes of the Palestinian construction, fostering operational excellence and contributing to economic sustainability. This term is defined as a way to design production systems in order to minimize waste of materials, time, and effort so as to generate the maximum possible amount of value (Koskela, 2007). Strategic planning is considered to be a pivotal element in the process of transformation, highlighting the importance of conducting careful planning to maximize the benefits of BIM and Lean in the specific context of Palestine. The ultimate aim of this study is to provide practical insights and a roadmap for professionals and decision-makers, facilitating a shift towards improved project delivery and industry success.

Despite of the serious political, economic and geographical challenges that the construction industry in Palestine is facing nowadays, it is still growing and progressing in residential and infrastructural areas. However, there are ongoing issues like poor project management, overspending, and a lack of clear planning that would limit its achievement and ability at both national and international levels.

Building Information Modeling (BIM) is considered to be a tech-driven way of creating detailed digital plans for construction projects (Daoor, 2018). It brings together data and tools, which makes it easier for everyone involved to work together. Using BIM in Palestine can change every single aspect of project management, making communication more efficient. By doing so, construction together with the projects are delivered faster with less costs.

Lean principles, originates from manufacturing, aim to cut waste, improve efficiency, and give more value to customers (Abu Hamdiya, 2017a). In the field of construction, it means to find better ways to do tasks, cut out things that don't add value, and make projects run smoother.

Using both BIM and Lean will bring extensive opportunities and can be seen as the ultimate approaches to support the Palestinian construction business, in which an opportunity for solving old problems lies. This study looks closely at the plan of using BIM and Lean together. This study is important because it looks at unique problems in the Palestinian construction industry., and provides a tool that assist Palestinian people in using the correct ideas in the right times and ways. Not to mention that having the right understanding of the current approaches helps Palestinians to enhance communication, which will then make the best use of resources and make processes better.

1.2 The Significance of the Study

Lean construction, which is characterized by waste reduction, value addition, and improved customer satisfaction, is used to operate an intelligent system facilitating building design, planning, construction, and operation. It is done in tandem with Building Information Modeling (BIM). These methodologies bring great benefits in enhancing construction schedules, operational speed, and project efficiency, offering the potential to diminish errors, fostering collaboration among stakeholders, and elevating project success, more specifically in intricate construction projects.

In the light of the Palestinian construction industry, which holds substantial economic significance contributing approximately 17.3% to the Palestinian GDP in 2019 (Obaid, 2019), there exists a transformative potential. Recognizing the economic importance of this sector, there is an opportunity to stimulate productivity, thereby fortifying economic development, employment, and infrastructure in Palestine.

This study serves as a basis for professionals in the Palestinian construction sector, offering details about the utilization of Building Information Modeling (BIM) and Lean technologies. The offered plan is significant in enhancing work practices, addressing critical gaps in understanding such technologies in the Palestinian context.

Additionally, the study provides a detailed implementation plan for incorporating BIM and Lean methodologies into Palestinian construction practices. While practical aspects are discussed, the primary emphasis is on theoretical frameworks and their implications for the adoption of these technologies.

Combining BIM and Lean in the Palestinian aligns the construction industry practices with global standards, contributing to the broader narrative of international advancements in construction management and technology. The study highlights the interdisciplinary nature of BIM and Lean methodologies, spanning technology, management, and construction domains, showcasing the researcher's capacity to synthesize knowledge for a comprehensive understanding of modern construction practices.

The study's results can help decision-makers in the Palestinian construction sector, since it offers them with guidance for formulating rules and plans at governmental and organizational levels. The proposed plan contains the potential to improve sustainability, efficiency, and global competitiveness of the industrial sector in Palestine. Moreover, the study underscores the importance of education in the construction sector, contributing to discussions on the development of programs and training tailored to the evolving needs of the workforce.

1.4 The Questions of the Study

According to the study's objectives, the study will address the following research questions:

1. What are the main obstacles and challenges facing the Palestinian construction industry in applying BIM and Lean technologies?
2. To what extent do stakeholders in the AEC industry (“Architectural Engineering and Construction) in Palestine want to apply BIM and Lean techniques in their projects?
3. How does strategic planning affect the successful implementation of BIM and Lean technologies in the Palestinian construction industry?
4. What strategic conceptual framework can be developed to facilitate the implementation of BIM

And Lean technologies in the AEC sector in Palestine?

1.5 Methodology of the Study

This study will apply a mixed-methods approach, incorporating both quantitative and qualitative methods to achieve its objectives and address its research questions. Survey data from Palestinian construction professionals, government officials, and stakeholders will be used as a main component to statistical analysis in order to identify barriers, assess desires, and evaluate strategic planning. This approach aims to provide a more comprehensive understanding by combining numerical data with qualitative insights, enriching the conceptual framework and allowing for a more nuanced interpretation of the results.

1.6 Aim and objectives of the Study

The primary aim of this study is to explore the potential implementation of BIM and Lean technologies in the Palestinian construction industry. Specifically, the study aims to achieve the following specific objectives:

1. Identify the barriers and challenges that hinder the implementation of BIM and Lean technologies in the Palestinian construction sector.
2. Assess the willingness of Architecture, Engineering, and Construction (AEC) industry stakeholders in Palestine to embrace BIM and Lean technologies.
3. Examine the impact of strategic planning on the successful implementation of BIM and Lean technologies in the Palestinian context.
4. Develop a strategic conceptual framework that establishes a relationship between strategic planning and the implementation of BIM and Lean technologies in the AEC sector in Palestine.

1.7 The Hypotheses of the Study and the Conceptual Framework

Hypothesis **1:** There are no effect of obstacles and challenges of implementing BIM and LEAN on the willingness to implement BIM and LEAN in the Palestinian AEC sector

Hypothesis **2:** There is no effect of the prospected benefits of implementing BIM and LEAN on the willingness to implement BIM and LEAN in Palestinian AEC sector.

Hypothesis **3:** There are no significant differences between AEC companies in Palestine in their obstacles and challenges of implementing BIM and LEAN with respect to their demographic profiles.

Hypothesis **4:** There are no significant differences between AEC companies in Palestine in their prospected benefits of implementing BIM and LEAN with respect to their demographic profiles.

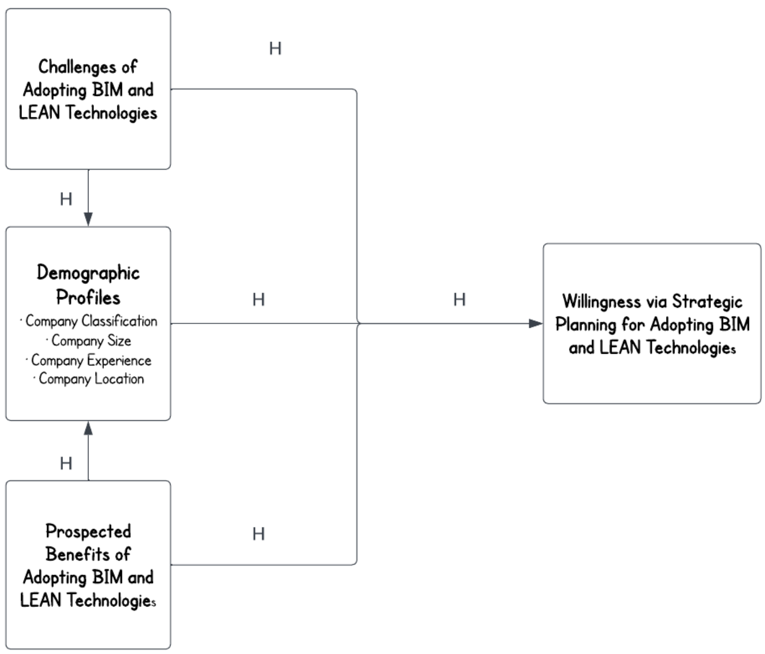


Figure 1 The conceptual framework

Hypothesis **5:** There are no significant differences between AEC companies in Palestine in the willingness to implement BIM and LEAN with respect to their demographic profiles.

Figure 1 summarizes the conceptual framework of the study.

1.8 The Structure of the Thesis

This study is organized into four chapters and they are as the following:

1. Chapter One: Introduction

This chapter introduces the research, outlining the problem, hypotheses, and objectives. It includes a thorough review of literature on strategic planning in the construction industry, focusing on integrating BIM and lean methods.

2. Chapter Two: Literature Review

   This chapter delves into existing literature, exploring the relationship between strategic planning and the adoption of BIM and lean methodologies. It identifies gaps in current research, setting the stage for the study's contributions.

3. Chapter Three: Research Methodology

   This chapter explains the research approach, sampling techniques, and data collection methods. It justifies these choices, ensuring alignment with research objectives for reliable analyses.

4. Chapter Four: Data Analysis and Evaluation

   This chapter analyzes data from the hypothesized model, focusing on strategic planning in Palestine's construction industry. Findings are discussed in the context of the literature review.

5. Chapter Five: Results, Conclusions, and Recommendations

   The final chapter presents statistical results, summarizes findings, and concludes. It acknowledges limitations and proposes recommendations for future research, providing insights for strategic planning in construction using BIM and lean methods.

Chapter Two

Literature Review

2.1. Overview

The objective of this chapter is to provide a comprehensive analysis of the existing literature, with a particular emphasis on strategic planning within the construction industry. In this chapter, a critical analysis of the relationship between strategic planning and the implementation of lean methodologies and Building Information Modeling (BIM) is presented. The examination of pertinent studies and frameworks it makes it possible to identify gaps in the existing body of research, thereby paving the way for the study to make significant contributions. The framework for the chapters is formed by this comprehensive literature review, which will improve our understanding of the contextual landscape, and contribute to the development of the insights that are unique to the research.

2.2 Theoretical background

Strategic planning is fundamental to the development of the modern construction industry (Betts & Ofori, 1992a) . In the Palestinian context, where the construction industry is a major driver of economic growth, policy implementation is essential to increase productivity and competitiveness. This literature review addresses the theoretical foundation and basic policy concepts are applied to reform construction projects in Palestinian road simplification

2.2.1 Strategic planning in the construction industry

Strategic planning is crucial for determining the future direction of the construction sector. It is described by as being the deliberated process of setting strategic organizational goals that are followed by resources allocation and an action plan for competitive (Chinowski & Meredith, 2000) advantage. Such multi-faceted approach cannot be avoided if projects are to be in line with strategic objectives of an organization and support the sustainability of the whole construction industry.

Establishing the goals and navigating mechanism in the complexities of building environments are the core of Strategic planning. Proactive thinking Throughout the strategic planning process helps stakeholders to envision future problems, detect potential opportunities, and choose appropriate decisions that will impact project success. A proactive stance is especially important for an industry which includes dynamic external factors, shifting technologies, and many stakeholders.

Construction strategic planning includes a full understanding of the market dynamics, clients' needs, and industry trends. It requires a proactive approach that enhance future industry innovations rather than the current project issues. Strategic planning in construction industry helps to synchronize available capabilities to new opportunities, embrace technological innovations, and take prevent measure for such changes like regulatory adjustments or economic instability. Additionally, strategic planning helps in the full allocation of financial, human and technological resources at the right time and place.

2.2.3 Benefits of strategic Planning:

Planning can improve project management, reduce costs and allocate resources, establish clear goals and work plans to ensure smooth and effective implementation of the construction project, especially in Palestine where resources are rare. In the construction industry, strategic planning is an important process for project success (Walker, 2018). It involves a systematic analysis of Both internal and external variables, which facilitates the formulation of clear objectives and strategies to guide project operations. SWOT analysis, PESTEL analysis, and Porter's Five Forces framework are among the tools widely used in this role (Smith & Jones, 2020). Effective planning in construction requires identifying the project's specific strengths, weaknesses, opportunities, and threats (SWOT) (Al-Ghurairi , 2021) . This comprehensive analysis helps in the process of decision making, risk management, and alignment of project objectives with broader organizational goals. Furthermore, PESTEL analysis, which assesses technological, environmental, political, economic, social and technological concerns, is crucial to understanding the external environment of the construction industry.

Porter's Five Forces framework assesses the following factors: bargaining power of suppliers and customers, threat of new entrants, substitute products and services, and threat of substitutes (Betts & Ofori, 1992a) . Competition services help construction professionals assess the competitive landscape and identify potential risks and opportunities (Betts & Ofori, 1992a) . A comprehensive strategic planning approach takes into account these tools and techniques to ensure that construction projects are adequately equipped to meet the challenges and opportunities to be implemented.

2.3.4 Fundamental Elements of Strategic Planning:

1. Vision and Mission: A clear and compelling vision is the cornerstone of strategic planning. It articulates the organization's aspirations for the future, providing a sense of direction and purpose. The mission statement, in conjunction with the vision, defines the organization's core values.

2. Goal Setting: Strategic planning transforms aspirations into tangible objectives, establishing measurable goals that provide focus and direction. SMART (Specific, Measurable, Achievable, Relevant, and Time-bound) goals ensure that the organization's efforts are aligned with meaningful outcomes.

3. Resource Allocation: Strategic planning highlights the importance of a judicious allocation of resources, and encompasses financial, human, and technological assets. By optimizing resource utilization, organizations can maximize productivity, minimize costs, and enhance their competitive edge.

4. Action Plans: Strategic planning translates goals into actionable steps, crafting detailed action plans with tasks, timelines, and responsibilities for each goal. These plans guide execution., ensuring that efforts are coordinated and aligned with the organization's strategic direction.

5. Monitoring and Evaluation: Strategic planning is an ongoing process, not a static document. Continuous monitoring and evaluation are essential to assess progress, identify deviations, and make necessary adjustments to maintain the organization on track.

2.4 Building Information Modeling (BIM)

BIM is a digital tool used to model a complete construction project. It provides many strategic outcomes, including real-time collaboration, improved decision-making, and improved project visualization (Daoor , 2018) . In the Palestinian context, BIM can be leveraged strategically to enhance design and construction, ultimately leading to better project outcomes.

Integrating BIM into the strategic planning framework allows construction companies in Palestine to leverage its capabilities for project design improvement reduce errors, and promote improved communication between project stakeholders. Integrating BIM into strategic planning improves the overall approach to project management

2.5. Lean Principles and Strategic Planning

Lean principles reduce waste, improve productivity, and improve customer value. In construction, lean principles eliminate inefficiencies and tasks that do not add value Strategic planning using simple methods can save time, money and resources. The construction industry in Palestine can promote continuous improvement through the strategic implementation of simple methods. Lean principles can also reduce costs and improve construction quality by streamlining project processes.

2.6. Obstacles to implementing BIM and Lean in Palestine

In the fragmented AEC industry, BIM implementation is hampered by many factors. Gu et al. (2008) classify the factors that influence AEC BIM implementation. These factors include the product, process, and people. Multiple issues contribute to slowing down BIM implementation. In order to determine the limits of BIM application in the AEC industry, these issues must be taken into consideration.

There may be many constraints that prevent the use of BIM and Lean in Palestinian construction, for example:

- Lack of BIM and Lean knowledge: Many construction professionals in Palestine may not be knowledgeable about BIM and Lean concepts and benefits, which may make it difficult to obtain support for implementation

- Inadequate Training and Education: Without proper training and education, construction professionals may lack the skills and knowledge to implement BIM and Lean effectively.
- Limited technical skills: BIM and Lean require the use of advanced technology and digital tools, which may be difficult to access and maintain due to the limited availability of goods and services in Palestine
- Resistance to change: Changes may be necessary for BIM and Lean implementation.in construction project management and implementation, which may be difficult to implement due to resistance from industry professionals due to the presence of traditional methods.
- Cost: Implementing BIM and Lean may require significant investments, which may be difficult for many companies in Palestine.
- Limited access to international best practices and standards: The lack of an established BIM and Lean culture in Palestine may lead to limited access to international best practices and standards, which may hinder the adoption of these methods in the process
- Government laws and regulations: Palestine may not have regulations that promote BIM and Lean.
- Political instability: Palestinian companies may have difficulty investing in BIM and Lean due to political instability and insecurity.

2.7 Advantages and disadvantages of applying BIM and Lean in Palestine

- There are advantages and disadvantages to applying Building Information Modeling (BIM) and lean construction in Palestine. The benefits of applying BIM and Lean in Palestine are as the following:

• Reduce costs: BIM and lean manufacturing are designed to use materials efficiently less waste, which can help keep costs down in the construction process.

• Improved productivity: BIM provides better visualization of the constructing throughout the design and construction phases, reducing product defects and increasing productivity.

• Improved quality control: BIM improves building visualization and modeling, improving quality control, and reduce the number of errors and defects in the final product.

• Improve delivery: BIM improves collaboration and communication between stakeholders Construction projects can be delivered faster and with fewer delays.

• Environmental Benefits: Lean aims to reduce waste during the construction process, which can help the environment by reducing the amount of waste that is produced. Of materials and materials, which reduces the number of floors.

• Job creation: Palestine needs training and resources to implement BIM and lean construction.

On the other hand, applying BIM and Lean in Palestine has many disadvantages, which are:
• Lack of understanding and experience: Many innovation professionals in Palestine may not be aware of the blessings and strategies of BIM and lean innovation.

• Limited training and resources: production professionals in Palestine will need education and resources that include software and hardware when implementing BIM and lean production.
• Lack of government assistance: Without government support, it may be difficult to expand the appropriate bases for BIM and lean innovation in Palestine.

• Financing: Implementing BIM and lean manufacturing requires education, software and infrastructure that may be difficult to obtain in Palestine, with limited investments from the private and non-private sectors.

• Limited use of virtual technology: Although BIM is a virtual technology, its implementation can be difficult for companies, and even difficult for creating Lean, which is not a virtual method and is mainly based on the principles of continuous improvement in BIM and lean production in Palestine

• Political instability: The construction sector and its operations suffer from ongoing political instability in Palestine, which can also affect financing and choice-making in each governmental and private area.

In order to understand as well as investigate the various industry dynamics in the building information model (BIM) and lean, the five forces model and competitive advantage must be taken into consideration, which in turn is important in providing a the following is a structured framework for analyzing competitive rivalry, entry barriers, substitute threat, supplier power, and buyer power:

• Threat of new entrants: The simplicity with which new entrants can enter the market. To implement BIM and Lean in Palestine, newer entrants may have a better chance if there are fewer barriers to access and more capable competitors

• Threat of Substitution: Alternative goods or offerings that can be used in the field of BIM and Lean. In Palestine, opportunity products or services can be traditional building strategies or other less advanced digital tools consisting of BIM and Lean.

• Capacity of service providers: The capacity of suppliers can have an impact on price and suppliers can have an impact on price and location Provides materials, tools and other resources required to implement BIM and Lean. Suppliers in Palestine can also get more negotiated electricity if they are the sole suppliers of goods or appliances.

• Customer bargaining power is defined as Customers' ability to influence fees and acceptance for BIM and Lean initiatives. In Palestine, if there is a wide and restricted pool of potential clients and few BIM and Lean service companies, clients may also have higher negotiating power.

• Competitive opposition: There is an intense competition among a few existing competitors within the market. Competitive competition in Palestine could be higher if there were a number of competitors offering the same BIM and Lean services.

Weak or strong competition in Palestine is important to consider in this regard. Competition will likely be perceived as weak, as there are few companies currently providing BIM and Lean services in Palestine and there may not be much strong competition. Moreover, the lack of BIM and Lean skills and knowledge in the construction industry in Palestine may also lead to failure in competition (Obaid, n.d.).

Adopting BIM across the construction industry can dramatically bring different advantages, such as:

• BIM has developed the construction industry and integrated all its aspects, providing a dynamic approach to project management (Qasim and Girgis, 2019). It is considered to be a digital environment that creates, shares, and manages project information, which in turn helps improving stakeholder productivity. BIM is extensive sourceof project information that improves visualization and conflict detection. With BIM, accurate cost estimates have significant implications for project budgeting and preparation (Smith, 2017).

• BIM goes beyond construction and design. It assists in project planning, designing, construction, operation and maintenance. This comprehensive approach keeps project information available and relevant throughout building lifecycle,, making BIM valuable to the construction industry (Kassem & Gerges, 2019).

• Collaboration enabled by BIM improves communication and coordination between cross-functional teams, reducing errors and rework. As a result, BIM has become a key tool for improving construction efficiency and quality. It enables project stakeholders to provide a common platform for decision-making, and facilitates informed choices that lead to project success (Smith, 2017).

2.9. Lean principles affect the construction sector positively in different ways

• Lean principles have a significant impact on construction, especially in the field of waste reduction and efficiency (Pinto & Slevin, 2018). Lean manufacturing principles emphasize eliminating non-value-added tasks, continuous improvement, and optimal use of resources. By identifying and reducing inefficiencies in the construction process, the Lean principle seeks to improve all project outcomes, such as project speed, cost, and quality (Jones et al., 2019).

• A key feature of lean design is value stream mapping, which helps identify and remove bottlenecks and overlapping tasks. This method improves business efficiency by streamlining processes and reducing resources, which reduces expenses, which is essential for maintaining project timelines and budgets. The 5S methodology, which focuses on sorting, sorting, shining, standardizing, and sustaining, promotes continuous improvement in manufacturing teams, and helps maintain a well-organized and productive work environment (Jones et al., 2019).

• Lean principles prioritize providing value to customers while reducing waste and unnecessary costs. By improving processes, promoting continuous improvement and producing high-quality construction projects that meet customer and industry standards (Pinto & Slevin, 2018).

2.10. Challenges and Obstacles Faced by the Implementation of BIM in Palestine

Increasing BIM implementation complexity and challenges in Palestine is the Cultural refusal to adopt new methods and technological change (El- Korashi et al., 2019). Furthermore, infrastructure limitations, including low-speed Internet access and advanced computing resources, may hinder BIM-Lean implementation. (El- Korashi et al., 2019). Additionally, legal and political restrictions specific to Palestine also pose challenges. Harmonizing construction project codes with BIM and lean methods can be a complex task, requiring high collaboration among industry stakeholders (El- Korashy et al., 2019). Thus, identifying and overcoming these obstacles is crucial for success. Cultural awareness and educational strategies can help reduce resistance, and addressing infrastructure and legal issues is critical to successful implementation.

2.11 Integration of BIM and Lean in construction

- • BIM and Lean principles show promise in construction. Research suggests that combining these methodologies can significantly improve construction projects. (Gonzalez and Miller, 2021).
- BIM allows stakeholders to share project data on a single platform. This collaborative environment is consistent with Lean principles of teamwork and communication, enabling efficient decision making and problem-solving (Chen & Shih, 2020). When BIM and Lean are integrated, project teams can identify and address issues in real-time, reducing the need for costly rework and change orders.

  • BIM and Lean have strong synergies in areas such as value stream mapping. BIM helps project teams visualize processes and identify tasks that do not add value. Integrating these methodologies can reduce waste and inefficiency, which is consistent with Lean principles (Chen & Shih, 2020). Using BIM for 4D and 5D simulation, project teams can improve scheduling and control costs, reducing project delays and budget overruns (Gonzalez & Miller, 2021). Figure 2 depicts the integration of BIM and lean.

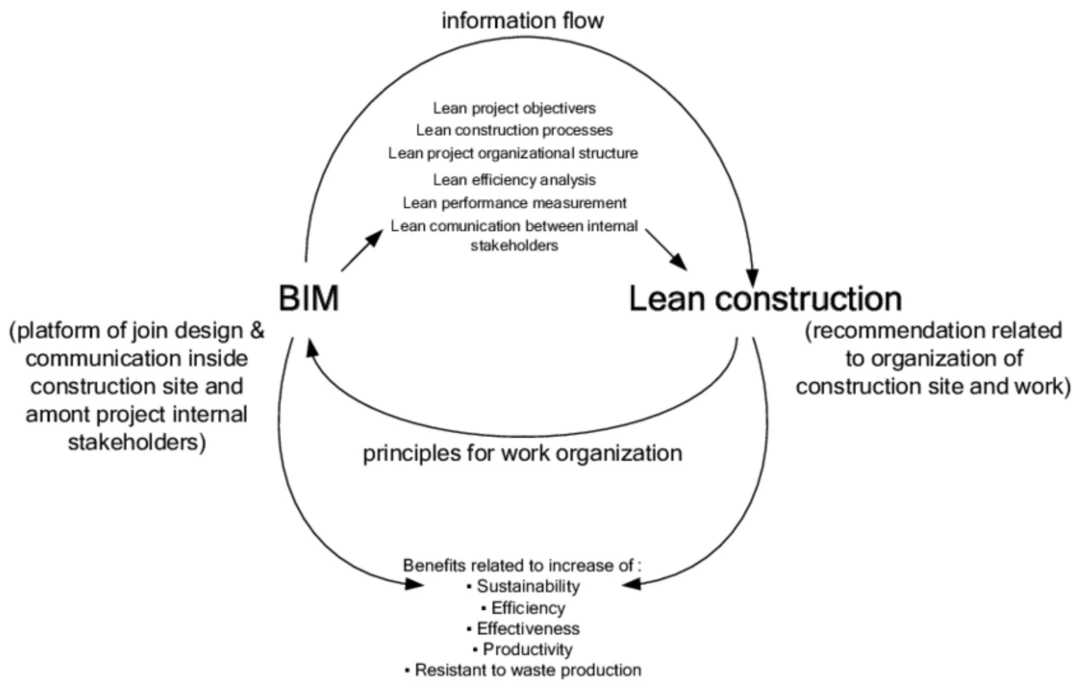


Figure 2 Integration of Lean and BIM

2.12 The impact of BIM and Lean on construction efficiency and quality:

• The impact of BIM and Lean principles on construction efficiency and quality is an important topic of study. These Techniques have the potential to enhance project management, decrease expenses, and improve quality. (Gonzalez and Miller, 2021).

• The impact of BIM and Lean on construction efficiency and quality can be measured through several metrics. For example, 4D and 5D BIM capabilities provide improved project scheduling and cost control (Chen & Shih, 2020). This can reduce project delays and budget overruns, which in turn will improve project’s efficiency.

• Lean principles emphasize the importance of identifying and eliminating waste, which directly impacts project efficiency. Value stream mapping and 5S methodology support Lean projects in this regard. By eliminating non-value-added activities and maintaining an organized work environment, manufacturing teams can streamline operations, reduce waste, and improve efficiency (Jones et al., 2019).

• Quality control is another area where BIM and Lean principles play an important role and have great results. Through improved communication, communication, and error detection enabled by BIM, project teams can reduce design and construction errors and improve project quality (Kassem & Gerges, 2019). Lean principles also help in the process of quality control throughout reducing repetitive work and optimizing resources (Pinto & Slevin, 2018).

• Research shows that BIM and Lean improve construction efficiency, cost and quality. Combining these strategies gives the industry the tools it needs to move construction projects forward.

2.13 Future trends in the Palestinian construction industry:

The Palestinian construction industry will be developed and enhanced with the emerging technologies and trends. These developments may help the industry overcome its problems and improve its sustainability (Haddad and Ghazaawneh, 2020).

Sustainable building methods are becoming more popular. Energy-efficient, environmentally friendly and sustainable construction is one of a great importance and it is booming in Palestine nowadays. As environmental awareness raises, Sustainable design is prioritized in building.

The construction industry is adopting augmented reality and virtual reality technologies. These technologies have great effects in improving project visualization, real-time data sharing and collaboration, which will lead to improved business outcomes and customer engagement.

The use of Digitalized buildings and construction is also becoming a common field in Palestine, since it draws many good results, such as speeding up construction schedules, reducing waste, and improving quality control. This is done by transferring the construction project from site to a more controlled construction environment. That is why it is important to keep up with these future aspects as the Palestinian construction sector develops. These aspects include sustainability, emerging technologies and new construction techniques, which are very important in brining profits at the short and long terms.

2.14. Previous Studies

Table 1 below summarizes a set of similar previous studies related regarding lean and BIM in construction.

Table 1 Similar Research

Author/Year	Title	Purpose	Findings
Al-Jabi, A. Et al. (2018)	BIM Implementation for Infrastructure Projects in the Middle East: A Review of Current Practices and Future Directions	To review the current practices of BIM implementation for infrastructure projects in the Middle East and to identify future directions	BIM is increasingly being used for infrastructure projects in the Middle East, but there are still a number of challenges to overcome, such as the lack of standardization, the need for training, and the resistance to change
Akbulut, A. Et al. (2015)	BIM Adoption and Implementation in the Construction Industry of Qatar: A Theoretical Framework	To develop a theoretical framework for BIM adoption and implementation in the construction industry of Qatar	The framework identifies a number of factors that influence BIM adoption and implementation, including the level of government support, the organizational culture, and the availability of resources
Alzahrani, H. Et al. (2019)	BIM Adoption in the Saudi Arabian Construction Industry: A Literature Review	To review the current literature on BIM adoption in the Saudi Arabian construction industry	BIM adoption is still in its early stages in Saudi Arabia, but there is a growing awareness of the benefits of BIM and a number of initiatives are underway to promote its adoption
El-Diraby, T. Et al. (2018)	BIM Adoption in the United Arab Emirates Construction Industry: A Literature Review	To review the current literature on BIM adoption in the United Arab Emirates construction industry	BIM adoption is growing in the UAE, but there are still a number of challenges to overcome, such as the lack of skilled BIM professionals and the fragmentation of the construction industry

Hashem, S. Et al. (2019)	Integrating Lean Construction Principles with BIM for Construction Efficiency Enhancement in the Middle East	To explore the integration of Lean Construction principles with BIM for construction efficiency enhancement in the Middle East	Integrating Lean Construction principleswith BIM can improve construction efficiency by reducing waste, improving communication, and increasing collaboration
Jarkas, A. Et al. (2019)	BIM and Lean Construction in the Middle East: A Review of Challenges and Opportunities	To review the challenges and opportunities associated with the implementation of BIM and Lean Construction in the Middle East	The challenges include the lack of standardization, the need for training, and the resistance to change. The opportunities include improved project performance, increased collaboration, and reduced waste
Khamal, D. Et al. (2018)	BIM Implementation in the Middle East: A Case Study of a Construction Project in Oman	To present a case study of BIM implementation on a construction project in Oman	The case study demonstrates the benefits of BIM in terms of improved communication, collaboration, and project performance
Sweis, G. Et al. (2019)	BIM Adoption in Jordan: A Roadmap for Future Implementation	To develop a roadmap for BIM adoption in Jordan	The roadmap identifies a number of steps that require taken to promote BIM adoption in Jordan, such as developing BIM standards, providing training, and raising awareness of the benefits of BIM
Yamin, H. Et al. (2018)	Critical Success Factors for BIM Implementation in the Middle East Construction Industry	To identify the critical success factors for BIM implementation in the Middle East construction industry	Senior management commitment, resource availability, and BIM standards are key success factors.

Azhar, N. Et al. (2017)	A Review of BIM and Lean Construction Implementation: From Theory to Practice	To review the current literature on the implementation of BIM and Lean Construction in the construction industry and to identify the key challenges and opportunities	Lean Construction and BIM can improve project cost, schedule, quality, and safety. The lack of practitioner training and experience, resistance to change, and need for integrated project delivery make these practices difficult to implement.
Sacks, R. Et al. (2010)	The Impact of Lean Construction on Project Performance: A Research Synthesis	To synthesize the existing research on the impact of Lean Construction on project performance	Lean Construction has been shown to improve project performance in terms of cost, schedule, quality, and safety. However, the effectiveness of Lean Construction is contingent on a number of factors, such as the specific Lean tools and techniques used, the level of implementation, and the organizational culture
Thomas, S. Et al. (2013)	Building Information Modeling (BIM) and Lean Construction: Synergistic Application for Construction Efficiency Enhancement	To explore the synergistic application of BIM and Lean Construction for construction efficiency enhancement	BIM and Lean Construction can be used together to improve construction efficiency by reducing waste, improving communication, and increasing collaboration
Zhang, W. Et al. (2015)	A Review of BIM-Lean Integration in Construction Project Delivery	To review the current literature on the integration of BIM and Lean Construction in	The integration of BIM and Lean Construction can lead to significant improvements in project performance. However, there are a number of challenges

		construction project delivery	to integrating these practices, such as the need for a common data environment, BIM-Lean tool incompatibility, and the need for training and education
Sacks, R. (2010)	Building a Lean Construction Field Guide: Practical Strategies for Project Success	To provide a practical guide to implementing Lean Construction principles and practices in the field	The guide provides Implementing Lean Construction step-by-step, including how to identify and eliminate waste, how to improve communication and collaboration, and how to measure and track progress
Koskela, L. (2008)	The Last Planner System: An Agile Way to Manage Construction	To introduce the Last Planner System (LPS), a lean planning and control system for construction projects	The LPS is a system for planning and controlling work that is based on the principles of pull, takt time, and visual management. It has been shown to be effective in improving cost, schedule, and quality project performance
Formoso, B. Et al. (2019)	5D BIM-Lean for Construction Project Management: A Review	To review the current literature on the use of 5D BIM-Lean for construction project management	5D BIM-Lean is a comprehensive approach to construction project management that integrates 5D BIM with Lean Construction principles and practices. It has been shown to be effective in improving project performance in terms of cost, schedule, quality, and safety
Azhar, N. Et al. (2013)	Building Information Modeling for Construction: A	To provide a practical guide to using BIM in construction projects	The guide covers the basics of BIM, as well Using BIM for

	Practical Guide for Students and Engineers		design, construction, operation, and maintenance

Samad M. E. Sepasgozar and others indicated in their study entitled “Lean Practices Using Building Information Modeling (BIM)and Digital Twinning for Sustainable Construction that there is a need to apply lean approaches in construction projects. Both BIM and IoT (“ Internet of things”) are increasingly being used in the construction industry. However, using BIM in conjunction with IoT for sustainability purposes has not received enough attention in construction. In particular, the capability created from the combination of both technologies has not been exploited. There is a growing harmony that the future of construction operation tends to be smart and intelligent, which would be possible by a combination of both information systems and sensors. This investigation aims to find out the recent efforts of utilizing BIM for lean purposes in the last decade by critically reviewing the published literature and identifying dominant clusters of research topics. More specifically, the investigation is further developed by identifying the gaps in the literature to utilize IoT in conjunction with BIM in construction projects to facilitate applying lean techniques in a more efficient way in construction projects. A systematic review method was designed to identify scholarly papers covering both concepts “lean” and “BIM” in construction and possibilities of using IoT. A total of 48 scholarly articles selected from 26 construction journals were carefully reviewed thorough perusal. The key findings were discussed with industry practitioners. The transcriptions were analyzed employing two coding and cluster analysis techniques. The results of the cluster analysis show two main directions, including the recent practice of lean and BIM interactions and issues of lean and BIM adoption. Findings revealed a large synergy between lean and BIM in control interactions and reduction in variations, and surprisingly there are many uncovered areas in this field. The results also show that the capability of IoT is also largely not considered in recent developments. The number of papers covering both lean and BIM is very limited, and there is a large clear gap in understanding synergetic interactions of lean concepts applying in BIM and IoT in specific fields of construction such as sustainable infrastructure projects.

Likita, A. J., & Jelodar, M. B. (2019) demonstrated in the study entitled “An overview of challenges of BIM and lean construction implementation in the New Zealand construction industry” that BIM is a digital representation of a building geometric and non-geometric data, used as a reliable, shared knowledge platform to make decision on a facility throughout its lifecycle. On the other hand, the focus in Lean construction is reduction of waste, increase of value of the customer, and continuous improvement for sustainable outcomes. Hence BIM can be the platform or facilitator of lean philosophy in construction. The aim of this paper was to review and discuss the challenges of BIM, Lean construction in implementation globally and within New Zealand construction sector. A systematic and comprehensive review of relevant literature was used to identify various stages of challenges in the adoption and implementation of BIM and lean construction. Twenty-nine previous articles on BIM, Lean construction have been discussed, and challenges involved in implementation of these tools and concepts were documented. The findings indicated that BIM is successfully practice in Australia, Hong Kong, Canada, Japan, Singapore, United Kingdom and North America. In conclusion the barriers of BIM, Lean construction for more sustainable and productive construction was classified in three layers of project, organization and industry.

The study entitled "A lean construction and BIM interaction model for the construction industry" by Bayhan, H. G., Demirkesen, S., Zhang, C., & Tezel, A. (2023) created An Analytical Network Process (ANP) to test the Lean and BIM concepts with data collected from U.S. companies to find the success factors of the Lean/BIM framework. After an extensive literature review, a total of 17 sub-categories for Lean/BIM are classified into three clusters, namely Communication, Production, and Visualization. An ANP network is then established to station the links between the attributes of the framework while computing their importance weights. Eight experienced civil engineers took part in the questionnaire study to assess the relations between the attributes. The main purpose of this study is to reveal the synergy between Lean and BIM with different components reflecting this synergy and present the Lean and BIM synergy on a comprehensive model. The results indicate that Production is the prominent cluster and Production Control, Standardization and Information accuracy are the most important factors in the Lean/BIM synergy. To validate the model, five construction projects were selected to test and observe the results accordingly. The study helped construction industry leaders set their priorities, benefit more from the interaction between Lean and BIM, and revise their strategies accordingly. This study identified Lean/BIM categories and subcategories as a roadmap for research and implementation. In this context, the study revealed the relationship between the categories/subcategories along with the weights and most and less important categories for Lean/BIM implementation and research.

Moud's Integrating BIM and Lean in the design phase aims to study the possibility of integrating BIM (Building Information Modelling) and lean in the design phase of construction projects by focusing on iRoom design meetings. It has been argued that the average productivity of the construction industry is below the average of other non-farm industries, particularly manufacturing. This study intended to focus only on the iRoom design meetings as a brilliant place to observe the possibility of the BIM-Lean integration. In order to examine this aim, firstly, a literature review was conducted to have enough knowledge of both concepts. In addition, since this study is a qualitative case study, interview-based research was chosen as the main source to examine the research aim. Six interviews were conducted via Skype with six employees of one of the biggest construction firms in Sweden. The interviews not only proved the possibility of integrating BIM and Lean, but also many advantages were found that are not explicitly mentioned in the literature before. For instance, easy collaboration, transparency and sharing of project knowledge between all stakeholders besides advantages of minimizing waste in the project were found for the BIM and Lean integration in the design phase of construction projects.

2.15 Conclusion and Gaps in the Literature Review

Researchers around the world have examined the advantages and disadvantages of implementing BIM and Lean methodologies in the global construction industry. Although these studies have demonstrated the job benefits provided by these technologies, the situation in Palestine creates unique and difficult obstacles. The capabilities and obstacles faced by Palestinian construction companies have been surprisingly neglected in literature. The assumption that is made on the identified barriers in Palestine is not a whole process. It may therefore be advantageous to take into account the readiness of industry stakeholders to adopt this technology, and the importance of formulating strategic plans to enhance its implementation in Palestine.

The current study examines the implementation of BIM and Lean approaches in the Palestinian context. That is why implementing BIM and Lean in Palestine requires a well-thought-out approach. To get started, a step-by-step approach is recommended, which includes initial planning, pilot projects, and gradual deployment of BIM and lean methods throughout the construction project (Zou et al., 2018). Staff needs extensive training and education to apply BIM and Lean principles (Zou et al., 2018). Training gives employees the skills and knowledge to practice well. Furthermore, it is important to recognize and address the unique challenges this technology faces in the Palestinian context (Haddad and Ghazawneh, 2020). These challenges include limited resources, political instability, and complex systems. Finding ways to address these challenges and ensure effective implementation of BIM and Lean should be the primary focus of stakeholders in the Palestinian construction industry. Implementing these strategies provides significant benefits to the Palestinian manufacturing sector, provided that they are implemented systematically; taking into account the local conditions.

Chapter Three

Research Methodology

3.1 Overview

This chapter discusses study methods. It includes research design, data collection, sampling, questionnaire design, distribution, content, reliability, processing, and analysis. There is little data on the adoption of BIM and Lean technology in the Palestinian construction sector. Exploratory research is the best research design when there is limited information about a problem or issue. It helps researchers understand business challenges and research can be utilized using both qualitative and quantitative data.

Mixed research is powerful for deep understanding and interpretation of problems because it provides a lot of detail (Amaratunga et al., 2002). This approach also helps to improve the literature-building indicators to make the questionnaire more realistic. The methodology describes how to conduct research, answer questionnaires, conduct an experiment, and analyze the results. This methodological framework highlights the complex relationships between strategic planning, building information modeling (BIM), and lean principles in construction using qualitative and quantitative research methods.

3.2. Research Types

Research categories:

- Exploratory or formative research is used when there is little information available to form new relationships between ideas.
- Descriptive or statistical research uses structured interviews, questionnaires, and observations to describe a topic, event, or variable of interest to social and societal issues.
- Causal research or explanatory research explains how two events are related; Causation states that a change in one event (the cause) affects the second event (the effect). This type of research is tested using an experimental design under controlled conditions that do not change during the experiment.

3.3 Research approach

Research methods are classified as:

The first section: depends on the deduction method used for the inference that is followed in order to formulate theories and hypotheses, and then move on to the data. In this approach, all variables and the application are related. of quantitative data should be clarified.

The second section: depends on the induction approach, through which the knowledge and understanding of behavior about things as well as the collection of qualitative data is performed (Herzog et al., 2019).

Research questions will determine the research approach.. Creswell, (2014) highlighted that the research approach includes plans, procedures, steps of assumptions, and collecting data process. Commonly, three research approaches to be used depending in the research questions and needed data; quantitative, qualitative, and mixed methods for numerical data, textural data, and both numerical and textural data respectively.

3.3.1 Mix Research Method

Taking the previous discussions into account, the nature of this research is explanatory. A deductive approach and qualitative data analysis are used to answer research questions and achieve objectives. Research questions determine the research methodology. Creswell (2014) noted that research involves plans, procedures, assumptions, and data collection. Depending on the research questions and data required, quantitative, qualitative, and mixed methods are used for numerical, synthetic, and both questions.

3.3.2 Quantitative Method

Academics use quantitative methods to collect numerical data and analyze it using mathematical models (Williams, 2007). According to Creswell (2014), the quantitative method is “the process of evaluating objective ideas by investigating the relationship between variables.” Researchers use a deductive approach to test theory with numbers and statistics before replicating and generalizing results. Research reports typically Review theory, literature, methods, results, and discussion. (Creswell, 2014).

Quantitative methods are classified into three categories, which are:

1- Descriptive research employs survey, developmental, correlational, and observational techniques. Statistical analysis determines trait relationships. A developmental design uses cross-sectional or longitudinal research to track a study population's change. Open or closed Techniques are employed to gather data from participants.during observational studies. Surveys help sociologists gather data.

2- Experimental research: This study measures and assesses the effectiveness of treatment, since it has a great impact on outcomes.

3- Causal-comparative research is about independent and dependent variables, including “causes and effects” research.

The quantitative phase of this study confirms theoretical concepts by transforming them into seventeen variables to produce four testable hypotheses. Sample proportions were determined and measured using a 95% confidence interval. Each theoretical concept was transformed into a question with Likert scale responses 1 to 5.

3.3.3 Qualitative Approach

Textual qualitative research examines social or human issues. Besides, an inductive qualitative approach is done in order to collect participant data, generalize setting codes and themes, and interpret and generalize data (Creswell, 2014).

Some qualitative research methods are discussed in the literature, which are:

1- Case study research examines a case, event, activity, process, or person in detail (Creswell, 2014).
2- Ethnography tracks a group's culture, behavior, and languages (Creswell, 2014).
3- Grounded theory study: A researcher-derived abstract theory based on participants' opinions about a process, activity, or interaction (Creswell, 2014).
4- Phenomenology studies human perceptions in specific situations (Leedy & Ormrod, 2015).
5- Content analysis work to address text trends and themes

3.3.3 Mixed Method Approach

This study collected data using quantitative and qualitative methods and sequential transformation. This study starts with the qualitative method, follows by the quantitative one. This strategy helps the researcher define the problem from different angles and various point of views. According to the collection and analysis of quantitative data, sequential interpretation was used. Quantitative results inform qualitative Collection and analysis of data. This method is used to analyze and interpret unexpected quantitative study results.

There are insufficient data exists regarding lean construction, building modeling, and innovative technologies in Palestine's construction sector, therefore the exploratory research is used to address this challenge. Hair et al. (2011) state that this qualitative or quantitative research design provides a deep understanding of business challenges. Literature studies include data collection questionnaires and relationship research. This, in turn, increases the significance of the exploratory research methods utilized in this study.

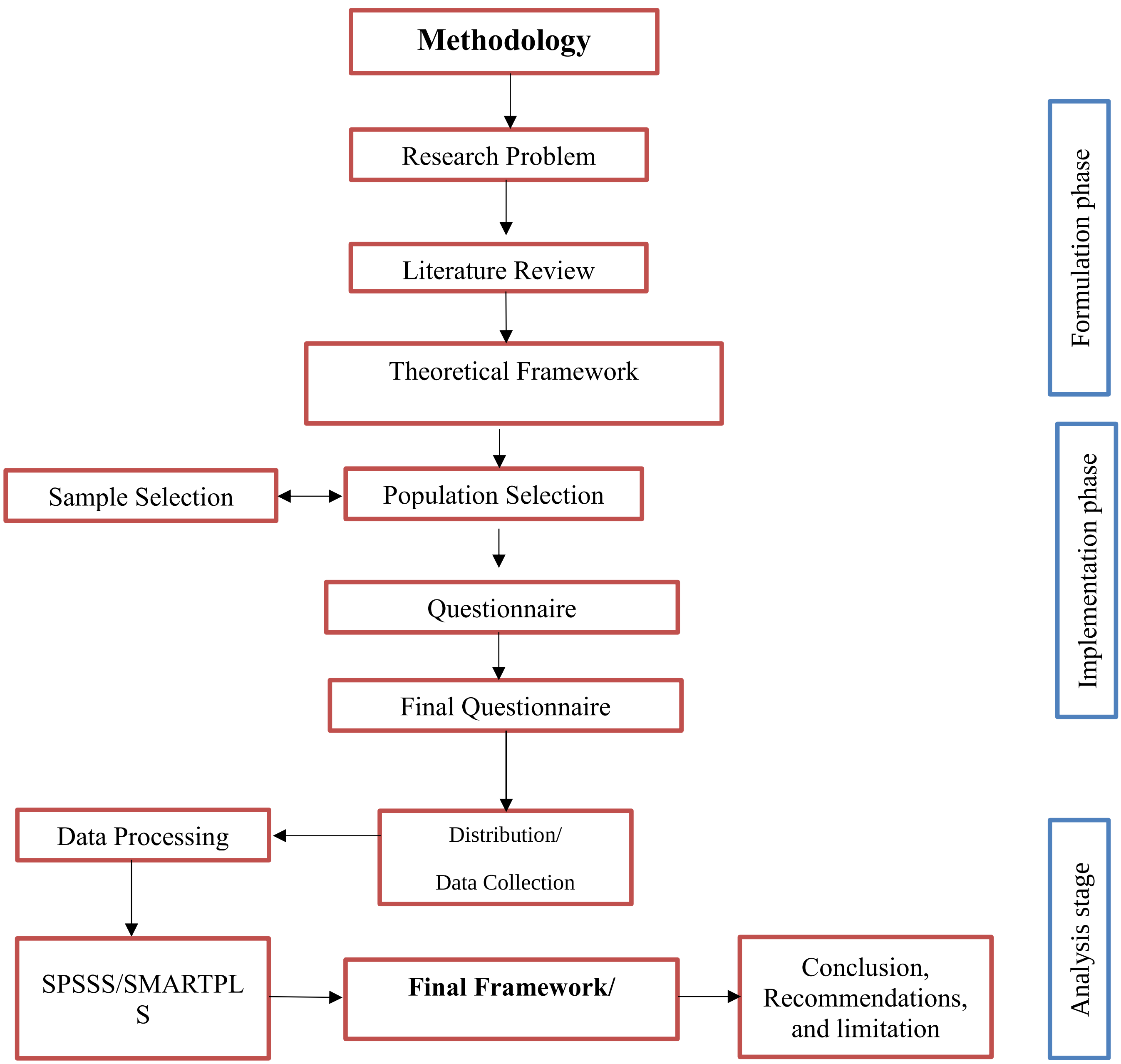
3.4 Research Methodology

Research is an essential part of any field, and a comprehensive approach is crucial for obtaining accurate and reliable results. The first step in this approach is selecting an appropriate data collection strategy, technique, or mechanism, based on several factors, such as the type of research being conducted, the available resources, and the desired outcomes. This decision is crucial in determining the accuracy and quality of the results obtained from the data collected.

This research process consists of three stages: formulation, implementation, and analysis. During the formulation stage, the researcher defines the research question or problem, assesses existing literature, and develops a hypothesis or research design. This stage is critical as it lays the groundwork for the research and ensures that the data collected will be useful in answering the research question or problem.

The implementation stage involves carrying out the research plan, and collecting data. This stage requires careful attention to detail, accuracy, and consistency in data collection in order to guarantee the validity and reliability of the results obtained. Depending on the nature of the research, this stage may involve conducting surveys, interviews, experiments, or other data collection methods.

The analysis stage involves interpreting the data collection and conclusion drawing based on the results. This stage may involve statistical analyses, qualitative analysis, or a combination of both. Data patterns, relationships, and trends should help answer the research question or problem.



3.5 Sampling Techniques

The investigation of engineering companies and AEC contractors operating in the West Bank is the focus of this study. To ensure accurate and reliable results, probability sampling using Stephen Thompson's equation is employed determine questionnaire sample size.

A simple random distribution approach is followed, ensuring each respondent has an equal chance of being chosen. The sample size is based on the total population, ensuring that all respondents belong to the same group. Additionally, each respondent is selected without considering the presence or absence of other participants in the sample, keeping each respondent's response independent.

By adhering to these three conditions for random sampling, an equitable representation of all sample members and individual respondent independence is ensured. The accuracy and validity of the results are maximized, making them more reliable and informative for the research objectives.

3.6. Measurement Development and Questionnaire Design

Research instruments' validity measures their intended use. Reliable instruments produce consistent results without changes in relation to inputs and results. The questionnaire followed the literature's conceptual framework. 150 items were created for the questionnaire in order to obtain accurate results. Appendix A and Appendix B include the questionnaires used in the study in English and Arabic, respectively. 35 items were selected to measure the adoption of BIM and Lean technologies. Nine important things were considered in the study to find out how well people prepare and plan for new technologies. A list of 13 things has been prepared to look at the issues and obstacles to the adoption of BIM and Lean Technologies. In the same way, the study investigated the benefits of using BIM and soft technologies and classified them into 13 different groups. These items have been carefully selected based on relevant research and expert opinions.

- This measurement scale was created so that the respondents can know the value of variables and how important they are. Stevens first talked about measurement scales in 1946.
- These are the following types of measurement scales: This measurement scale was created so that you can know what variables are of value and how important they are. The different

types of measurement scales, as described by Hill and Wakefield (2012) and Stephen's original work from 1946, are:

- Nominal scale is used to measure categorical data and numbers like names and identifiers.
- Ordinal scale shows relationships clearly and organized.
- Interval scale measures quantities with similar units. Zero is just another interval scale measurement point.
- Ratio scale: Like the interval scale, this scale shows quantity and unit equality but has a zero at the top.

In this study, Participants rated their agreement on a five-point Likert scale. which included options ranging from "strongly agree" to "strongly disagree". Additionally, the study used integer interval scales and five-point Likert scales to measure values and importance, allowing for a more nuanced understanding of participant responses.

To measure the statistical significance levels, the study used a service level scale that provided a detailed breakdown of mean intervals and corresponding levels of agreement. Specifically,

Level 1 represents a mean interval of 1-1.8 and described very high agreement. This level indicates that participants strongly agreed with the statements presented to them.

Level 2 represents a mean interval of 1.81-2.6 and described high agreement. This level indicates that participants agreed with the statements, but not as strongly as those in Level 1.

Level 3 represents a mean interval of 2.61-3.4 and described a neutral stance. This level indicates that participants neither agreed nor disagreed with the statements presented to them.

Level 4 represents a mean interval of 3.41-4.2 and described low agreement. This level indicates that participants disagreed with the statements, but not as strongly as those in Level 5.

Finally, Level 5 represents a mean interval of 4.21-5 and described very low agreement. This level indicates that participants strongly disagreed with the statements presented to them. Overall, this detailed approach to measuring participant agreement allowed for a more comprehensive understanding of the study's findings.

3.7 Data Analysis Techniques

A comprehensive analysis of construction companies data was conducted to create a results' sheet. The data was analyzed with precision using SPSS 22 software to calculate the mean and standard deviation for each construct. To test the hypothesis and examine the relationships within the study model, we utilized Partial Least Squares Structural Equation Modeling (PLS-SEM), a widely recognized and reliable approach. Smart PLS, a popular PLS-SEM program (Joseph F. Hair et al., 2013), was used to enter the first, second, and third-order data. A repeated cursor strategy was employed for each construct to create the model, ensuring maximum accuracy and reliability.

The PLS algorithm assessed all model indicators' reliability and validity. The statistical significance of all internal relationships and hypotheses were verified using bootstrap analysis., providing a robust and convincing basis for our findings.

Smart PLS employs advanced measurement and structural model evaluation techniques, which allow to check for convergent, discriminant, composite reliability (CR), average variance extracted (AVE), and Cronbach's alpha in the measurement model. Overall, the analysis is grounded in a rigorous and comprehensive approach, giving the confidence to stand behind results.

Chapter Four

Data analysis and Results

4.1. Introduction

This chapter presents the results of the quantitative data analysis conducted in the study. Tools used for analysis include SPSS, and PLS. The objectives of the analysis were to evaluate the reliability and internal consistency of the study tool, examine descriptive statistics, and evaluate the hypotheses formulated in the study.

4.2 Descriptive analysis

4.2.1 Overview

Table 1 presents the demographic characteristics of the study sample, highlighting the distribution of participants based on gender, qualification, and nature of work in their respective companies. The majority of respondents were males, constituted 57%, while 43% identified as females. Educational qualifications revealed that 84% of participants held a bachelor's degree, with the remaining 16% having postgraduate qualifications. In terms of professional roles within companies, 7% were General Directors, 14% Construction Engineers, 40% Office Engineers, 27% Site Engineers, and 11% fell into the category of "Other."

Also, it provides insights into company classification, the number of employees, years of experience, location, and the use of Building Information Modeling (BIM). The majority of companies in the building-contracting sector belonged to the First Class (46%), followed by the Second Class (25%), Third Class (19%), and Fifth Class (11%). In the engineering sector, 55% were classified as consultants, while others were distributed among the First Class (22%), Second Class (17%), and Third Class (5%). Regarding the number of employees, 65% of companies had 1-9 employees, 16% had 10-19, 7% had 20-50, and 12% had more than 50. Concerning the years of company experience, 27% had less than 5 years, 41% had 5-15 years, and 33% had more than 15 years. The distribution of companies across different governorates revealed varying percentages, with Ramallah and Al-Bireh having the highest representation at 46%. Finally, regarding the use of BIM, 23% indicated current usage, 43% had no plans to use it, 9% planned to use it within twelve months, 4% planned to use it within more than twelve months, and 21% were unsure. Table 6 shows the results.

Table 2 Demographic characteristics of the study sample

Characteristic	**Percentage**
Gender	
Male	57%
Feminine	43%
Qualification	
Bachelor degree	84%
Postgraduate	16%
The nature of work in the company	
General Director	7%
Construction engineer	14%
Office engineer	40%
Site engineer	27%
Classification of Companies in the Building-Contracting Sector	
First Class	46%
Second Class	25%
Third Class	19%
Fifth Class	11%
Classification of Companies in the Engineering Sector (Company/Office)	
Consultant	55%
First Class	22% (This percentage is based on the questionnaire

	distributed to companies of Engineering)
Second Class	17%
Third Class	5%
Number of Employees	
1-9	65%
10-19	16%
20-50	7%
More than 50	12%
Number of Years of Company Experience	
Less than 5 years	27%
5-15 years	41%
More than 15 years	33%
Governorate in Which the Company is Located	
Jericho	1%
Hebron	9%
Jerusalem	5%
Bethlehem	13%
Jenin	5%
Ramallah and Al-Bireh	46%
Salfit	4%
Tubas	3%
Tulkarm	6%
Qalqilya	1%
Nablus	6%
Use of BIM	
Currently used	23%
There are no plans to use it at now	43%
Plan to use it within twelve months	9%

Plan to use it within more than twelve months	4%
Not sure	21%

4.2 Questionnaires Analysis

Partial Least Squares (PLS) approach analyzes quantitative questionnaire responses by using Smart- PLS (v.4.0.8.5) software that is used to handle un-normalized data and small samples. Smart PLS is can be described as a friendly-use application utilizing Partial Least Squares (PLS) modeling method in the structural equation modeling (SEM) with graphical user interface. Smart-PLS analysis includes two major steps First.The outer model (measurement model) is assessed to determine the correlation between each latent variable and its indicators. Second, the inner model (structural model) examines latent variable relationships (path). Exogenous and endogenous variables are dependent and independent variables in a structural model, respectively (Hair et al., 2011).

Furthermore, distinctions between reflective and formative measurement models are very important in this regard. Model A in the measurement using PLS-SEM or the reflective measurement model where headed arrows are pointed from the major construct to its indicators means that the indicators of a construct represent the effects of applying the underlying construct. On the other hand, model B in the measurement using PLS-SEM or the formative measurement model where headed arrows are oriented towards the construct assumes that these indicators cause the construct; as a result, removing one indicator alters the construct's meaning since each indicator represents a different component of the main construct. Both formative and reflective measurement models can be handled by the PLS-SEM application (Hair et al., 2011).

In the application of smarts for the study, the outer loading analysis was conducted for three key constructs: P1_Obstacles, P3_Benefits, and P2_Strategic preparation and planning. Each construct has a specific number of items, with 13 items for P1_Obstacles, 13 for P3_Benefits, and 9 for P2_Strategic preparation and planning. Based upon a deep investigation of the outer loadings, it was observed that five items exhibited loading values below the recommended threshold of 0.7. Furthermore, the variance inflation factor (VIF) analysis indicated that 4 items displayed high values, suggesting that there are many multicollinearity issues. As a result, it is important to consider removing the identified items from the analysis to enhance the model's high quality and ensure the reliability of the results.

4.2.1 Assessment of Measurement Models (Outer Model)

The construct's validity and reliability are being assessed as parts of the measurement model. Validity assessment includes mainly two parts; convergent validity that is determined by assessing the indicator's reliability, composite reliability, and extracted average variance (AVE), and the discriminant validity, which is assessed through the Fornell-Larcker criteria, cross loadings, and the Heterotrait-Monotrait ratio (HTMT).

4.2.2 Convergent Validity

The degree to which a certain measure relates to other measures of the same construct in a positive way is known as the convergent validity. Identifying three tests is part of assessing convergent validity in reflective measurement models. First, factor loadings that should be 0.708 or more; greater outer loading indicates that the indicators share many characteristics with a construct. As shown in Figure 7 below, all the outer loading are more than 0.708, so they comply with the first criteria of determining convergent validity. Second, Composite reliability (CR) results are examined in order to ensure the internal consistency and reliability; the values are between 0 and 1, the higher values of CR show greater reliability levels. According to (Hair et al., 2011), the value of CR should be higher than 0.70. As shown in Table 3 below all CR values are more than 0.7's threshold; therefore, all constructs are reliable. Thirdly, Average variance extracted (AVE) that is calculated through finding the mean value of the squared outer loading of the indicators for specific construct. The AVE should be greater than 0.50 that is, the construct accounts for more than 50% of the variance of its indicators (Hair et al., 2011).

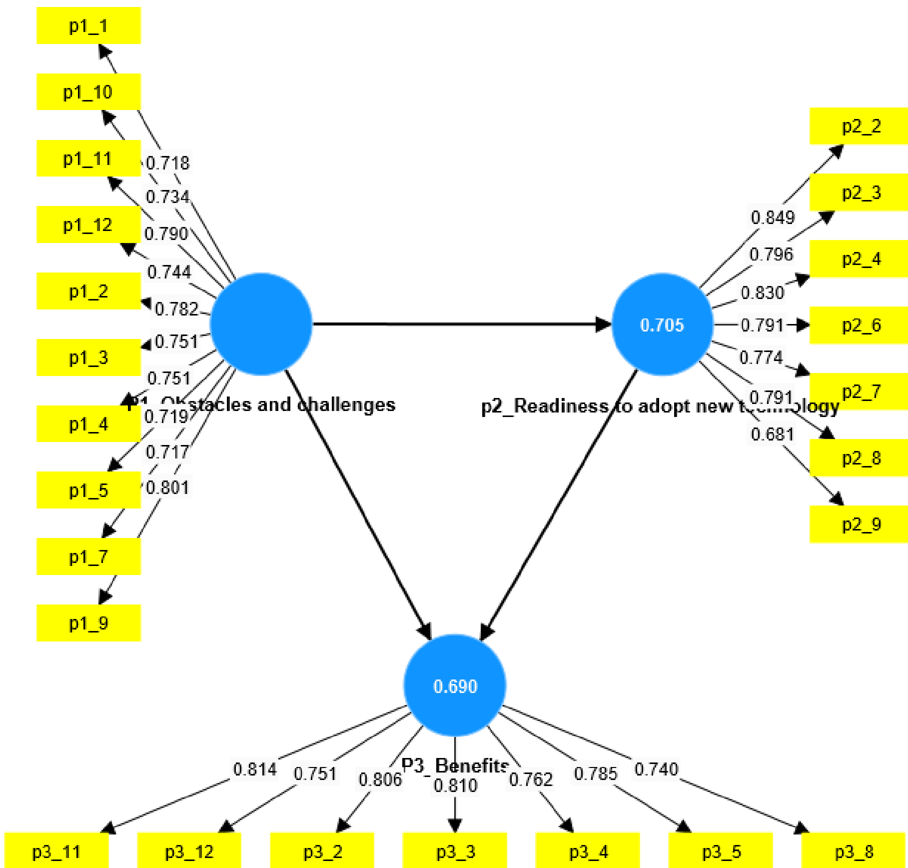


Figure 3 the measurement model

In this study, the values of AVE as shown in table 3 indicates good convergent validity. Additionally, For traditional internal consistency evaluation, a value above 0.7 is recommended.; Cronbach’s alpha, the results are reported in table 3 and indicates also a high internal consistency. Table 6 in Appendix C shows the constructs’ reflective measurement properties.

4.2.3 Discriminant validity

Within the framework of the research study, the meticulous evaluation of three distinct constructs—P1_Obstacles, P3_Benefits, and P2_Strategic preparation and planning—is complemented by an extensive examination of key reliability and validity metrics. The specified number of items assigned to measure each construct lays the groundwork for subsequent assessments. Cronbach's Alpha, a fundamental measure of internal consistency reliability, yields robust coefficients of 0.914, 0.894, and 0.898 for P1_Obstacles, P3_Benefits, and P2_Strategic preparation and planning, respectively. Concurrently, Composite Reliability, an additional gauge of internal consistency, manifests as 0.917, 0.898, and 0.901 for the aforementioned constructs, reinforcing the dependability of the measurement instruments. The Average Variance Extracted (AVE) values, measuring the proportion of variance captured by the constructs relative to measurement error, are reported as 0.564, 0.611, and 0.622 for P1_Obstacles, P3_Benefits, and P2_Strategic preparation and planning, respectively. While generally meeting acceptability thresholds, potential enhancements to AVE values are recognized.

The discriminant validity assessment is integral to scrutinizing the uniqueness of each construct concerning others (Hair et al., 2011). Employing cross loadings, the correlation of a construct's indicators is evaluated, with a requirement that these cross loadings surpass all loadings on other constructs within the model. Detailed cross loadings of model indicators are presented in Table 7 in Appendix C, unequivocally supporting the discriminant validity technique. Additionally, the Fornell-Larcker criterion is employed as a secondary discriminant validity test. This criterion involves comparing the square root of the AVE with the correlations of latent variables. Notably, the square root of each construct's AVE should exceed the highest correlation with other variables. Together, these discriminant validity assessments fortify the robustness and distinctiveness of the identified constructs, contributing to the overall rigor and reliability of the research findings.

Table 3 Cronbach’s Alpha , Composite Reliabilities And AVE values Of Constructs

Construct	**Number of items**	**Cronbach's Alpha**	**Composite Reliability**	**AVE**
P1_Obstacles	10	0.914	0.917	0.56
P3_Benefits	7	0.894	0.898	0.61
P2_Strategic preparation and planning	7	0.898	0.901	0.62

Table 4 shows the results of this test and reveals that Fornell-Larcker discriminant validity criterion is confirmed.

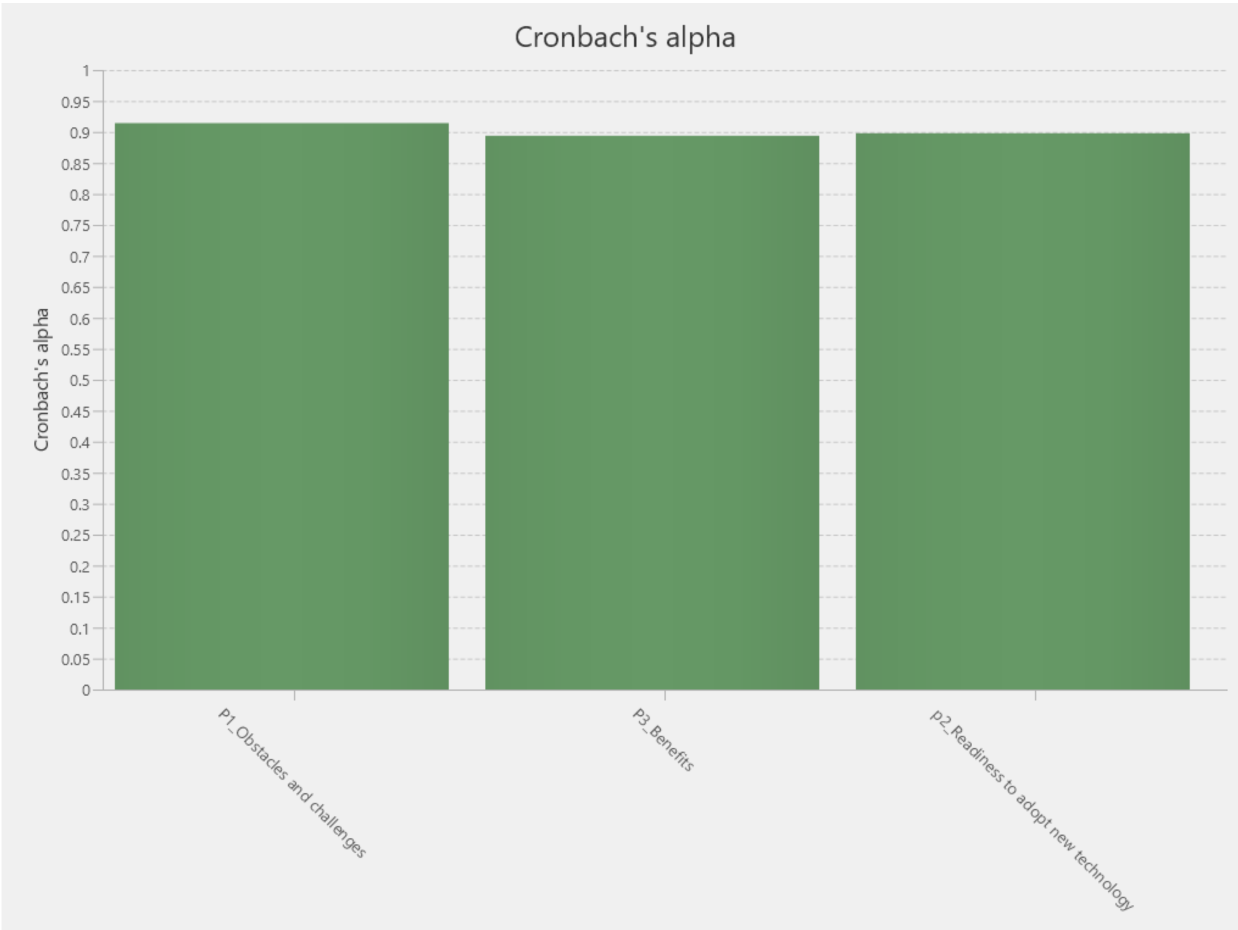


Figure 3 Cronbach's Alpha

Another criterion to assess Heterotrait-Monotrait ratio of correlations (HTMT) indicates discriminant validity. According to (Hessler et al. 2015), HTMT ratio should not exceed 1. Table 5 shows that all HTMT values are less than 1, indicating good reliability and discriminant validity.

4.2.4 Discriminant Validity Assessment of Formative Construct

Bootstrapping in PLS application is utilized to determine the importance of the constructs. Herein, it is necessary to confirm the formative model discriminant validity (i.e., Quality 4.0 acceptance and implementation construct). The critical t-values corresponds to significance level (SL) are 2.58 for a SL of 1%, 1.96 for SL of 5%, and 1.65 for a level of 10%. The t-values for each first and second order constructs are shown in Table 6.

Table 4Fornell-Larcker Criterion.

	P1_Obstacles and challenges	P3_Benefits	P2_Strategic preparation and planning
P1_Obstacles and challenges	0.751		
P3_Benefits	0.657	0.782	
P2_Strategic preparation and planning	0.839	0.828	0.789

Additionally, according to Hair et al., (2011) the Variance Inflation Factor (VIF) value is to check the collinearity of indicators and should be lower than 5 and that is demonstrated in this study and shown in Table 7 for formative indicators.

Table 5

	P1_Obstacles and challenges	P3_Benefits
P1_Obstacles and challenges		
P3_Benefits	0.71	
P2_Strategic preparation and planning	0.812	0.813

4.2.5 Assessment of the Structural Model (Inner Model)

Structural model assessment is the next step followed validity and reliability assessment and used to examine relationships between constructs through PLS bootstrapping analysis through evaluating the coefficient of determination (R^2), the effect size (F^2), Goodness of fit index (gof), and the significance of the path coefficients - hypotheses test.

Table 6Weight, T- Values And Variance Inflation Factor (VIF) Values

Construct	VIF
P1_Obstacles and challenges	3.385
P3_Benefits	1.000
P2_Strategic preparation and planning	3.85

4.2.6 The Coefficient of Determination (R^2)

Most structural models are evaluated using the coefficient of determination (R^2), which measures predictive accuracy. A higher (R^2) value indicates greater predictive accuracy, ranging from 0 to 1. Depending on the complexity of the research model, endogenous latent variable R^2 values of 0.75, 0.50, or 0.25 indicate high, moderate, or weak predictive accuracy. according to (Hair et al., 2011). The results show that R^2 for endogenous latent variables equals 0.659 and 0.772, which is relatively good for new exploratory studies.

Table 7 R^2 Values

Construct	**R Square**	**Square Adjusted**	**Result**
P3_Benefits	0.659	0.685	High
P2_Strategic preparation and planning	0.772	0.703	High

4.2.7 Goodness of Fit Index GOF

The evaluation of the model's goodness of fit (gof) in this study involves the utilization of the geometric mean of the average extracted variances (AVE) and the average R2 values of the endogenous variables.

gof=$\sqrt{(avg.R^2 \times avg.AVE)}$, serves as a critical indicator for assessing the validity of the research model and gauging the model's reliability. In the present investigation, the gof is calculated as 0.8468, derived from the values of 0.711 for the average R^2 and 0.599 for the average AVE.

According to (Wetzels et al.2009), the gof value is used to assess model fit. A gof less than 0.1 indicates no fit, between 0.1 and 0.25 indicated a small fit, between 0.25 and 0.36 indicated a medium fit, and greater than 0.36 indicated a large fit. In this study, the gof value of 0.8468 exceeds Wetzels et al0.36 .'s threshold (2009). Therefore, the Partial Least Squares (PLS) model used in this study is valid and robust in capturing the underlying relationships within the investigated variables.

4.3 Descriptive Analysis of the Main Variables

The study assessed various indicators related to the implementation of Building Information Modeling (BIM) and Lean technologies, presenting the arithmetic mean, standard deviation, and classification for each. In terms of "Preparation and Strategic Planning for New Technologies," the indicator achieved an arithmetic mean of 3.76 with a standard deviation of 0.73, classifying it as "OK." Similarly, the "Obstacles and Challenges" indicator attained a mean of 3.51 and a standard deviation of 0.59, also falling under the "OK" classification. Lastly, the "Benefits of Implementing BIM and Lean Technologies" indicator scored a mean of 3.47 with a standard deviation of 0.67, resulting in an overall classification of "OK." These findings provide a quantitative overview of the perceived Strategic preparation and planning, challenges, and benefits associated with the adoption of BIM and Lean technologies in the context of the study. Table 9 summarizes the results.

Table 3 Descriptive analysis of the main variables

Indicator	Arithmetic Mean	Standard Deviation	Classification
Preparation and Strategic Planning for New Technologies	3.76	0.73	OK
Obstacles and Challenges	3.51	0.59	OK
Benefits of Implementing BIM and Lean Technologies	3.47	0.67	OK

4.3.1 Obstacles and Challenges

The study examined various obstacles and challenges related to the implementation of Building Information Modeling (BIM) and Lean methodologies, employing statistical analysis. The Pearson correlation coefficients and corresponding significance levels were calculated for each identified challenge. Notably, a significant positive correlation was found between the lack of government support and the challenges associated with BIM and Lean implementation ($r = 0.610$, $p = 0.000$). Similarly, the absence of government policy demonstrated a positive correlation ($r = 0.540$, $p = 0.02$). Additional challenges, such as the lack of awareness of benefits, absence of technical expertise within companies, high implementation costs, lack of interoperability, resistance to change, inability to access software and hardware, lack of cooperation between companies, institutional culture, lack of understanding of BIM and Lean, and insufficient staff training in these methodologies, also exhibited positive correlations with varying degrees of significance. This statistical analysis sheds light on the interconnected nature of these challenges, emphasizing their collective impact on the effective adoption of BIM and Lean in the construction industry.

Analysis of obstacles and challenges indicated significant correlations and levels of importance, confirming the perceived importance and variation in participants' opinions.

Table 4 Correlation results for obstacles and challenges

Obstacle/challenge	Pearson correlation	Sig. (2 tail)
Lack of government support	0.610	0.000
Absence of government policy	0.540	0.02
Lack of awareness of the benefits	0.426	0.019
Lack of technical company	0.544	0.002
High cost of implementation	0.369	0.045
Lack of interoperability	0.554	0.001
Lack of Standardization	0.312	0.93
Resistance to change	0.401	0.028
Inability to access software and hardware	0.420	0.021
Lack of cooperation between companies	0.566	0.001
Institutional culture	0.425	0.019
Lack of understanding of BIM and Lean	0.460	0.011
Lack of staff trained in BIM and Lean	0.584	0.001

The indicator related to the obstacles and challenges demonstrated notable disparities in respondents' perceptions. The highest result, marked by a mean of 3.85, highlighted the obstacle related to the loss of awareness of the benefits of BIM and Lean technologies, indicating strong agreement. Conversely, the lowest result, with a mean of 3.27, was associated with the perceived obstacle of the high cost of implementation, reflecting a neutral stance. This suggests that while awareness challenges are acknowledged strongly, the financial implications pose a more neutral concern. Table 11 summarizes the results.

Table 5 Obstacles and challenge to BIM and Lean Implementation in the Construction Industry

Paragraph	Mean	Standard deviation	Classification
Loss of Awareness of BIM and Lean Benefits	3.85	0.99	Strong Agreement

Lack of Experience in BIM and Lean Implementation	3.81	0.99	Strong Agreement
Lack of Understanding of BIM and Lean Techniques	3.72	0.93	Strong Agreement
Resistance to Change	3.65	1.00	Strong Agreement
Non-availability of Trainers for BIM and Lean	3.65	0.99	Strong Agreement
Lack of Policies and Governmental Support	3.52	1.06	Agreement
Lack of Governmental Support	3.45	1.00	Agreement
Institutional Culture as a Barrier	3.43	1.01	Agreement
Lack of Cooperation Between Companies	3.37	0.92	Neutral
Lack of Compatibility with Current Systems	3.32	0.90	Neutral
Lack of Standardization	3.32	0.83	Neutral
Lack of Access to Programs and Equipment	3.31	1.16	Neutral
High Cost of Implementation	3.27	1.07	Neutral

4.3.2 Strategic preparation and planning

The study investigated various statements related to Strategic preparation and planning regarding Building Information Modeling (BIM) implementation, utilizing Pearson correlation coefficients and their associated significance levels. The results indicated robust positive correlations for several key statements. Notably, there was a significant positive correlation between the Strategic preparation and planning to invest in BIM and the belief in the existing plan ($r = 0.583$, $p = 0.001$). Moreover, the belief that the plan should include objectives ($r = 0.868$, $p = 0.000$), a timetable ($r = 0.776$, $p = 0.000$), budget considerations ($r = 0.810$, $p = 0.000$), and performance standards ($r = 0.786$, $p = 0.000$) all exhibited highly significant positive correlations. Additionally, stakeholders' interest demonstrated a notable positive correlation ($r = 0.641$, $p = 0.000$), highlighting its importance in the planning process. The perceived importance of training and support ($r = 0.890$, $p = 0.000$) and partnerships ($r = 0.627$, $p = 0.000$) also exhibited strong positive correlations. These findings underscore the interconnectedness of these statements and their collective influence on the Strategic preparation and planning and perspectives of participants toward BIM implementation in the construction industry. Analysis of preparation and strategic planning showed strong correlations, with an emphasis on preparedness and belief in the importance of strategic planning for BIM and Lean technologies. Table 5 shows the results.

Table 6 Correlation results for strategic preparation and planning

Statement	**Pearson Correlation**	**Sig. (2-tailed)**
Ready to Invest in BIM	0.583	0.001
Belief in Existing Plan	0.900	0.000
The Plan Should Include Objectives	0.868	0.000
Plan Should Include Timetable	0.776	0.000
Plan Should Include Budget	0.810	0.000
The Plan Should Include Performance Standards	0.786	0.000
Stakeholders' Interest	0.641	0.000
Training and Support Importance	0.890	0.000
Partnerships Importance	0.627	0.000

Analysis of the indicator on strategic preparation and planning for new technologies demonstrated various perceptions among participants. The highest score, with a mean of 3.95, was related to the belief in providing training and support to employees, indicating strong agreement. In contrast, the lowest score, recording a mean of 3.55, was associated with willingness to invest in BIM and Lean technologies, classified as agreement. This indicates that the level of commitment to financial investment is slightly lower despite of the fact that there is significant support for staff development. Table 10 shows the results.

Table 7 Assessment of Strategic Planning Elements for BIM and Lean Implementation in the Construction Industry

Paragraph	**Mean**	**Standard Deviation**	**Classification**
Provide Training and Support for Employees	3.95	0.96	Strong Agreement
Include Budget for BIM and Lean Implementation	3.89	0.92	Strong Agreement
Include timetable in the Strategy	3.81	0.91	Strong Agreement
Include Objectives in the Strategy	3.78	0.93	Strong Agreement
Stakeholders' Interest in Practical Planning	3.75	0.99	Strong Agreement
Partnership with Technology Providers	3.73	0.95	Strong Agreement
Existence of a Plan Strategy	3.68	0.97	Strong Agreement
Include Standards for Performance Measurement	3.66	1.02	Agreement
Ready to Invest in BIM and Lean Technologies	3.55	1.02	Agreement

4.3.3 Benefits of implementing BIM and Lean techniques

The study examined the perceived benefits of implementing Building Information Modeling (BIM) and Lean techniques, utilizing Pearson correlation coefficients and their associated significance levels. The results revealed substantial positive correlations for various statements, indicating the perceived impact of these methodologies on different aspects of construction practices. Notably, there were strong positive correlations in statements related to the overarching mission of staying competitive ($r = 0.774$, $p = 0.000$), improving efficiency and productivity (r = 0.656, p = 0.000), enhancing the quality of projects (r = 0.797, p = 0.000), improving collaboration and communication (r = 0.771, p = 0.000), enhancing accuracy and delivery speed (r = 0.627, p = 0.000), fostering innovation (r = 0.720, p = 0.000), increasing job opportunities (r = 0.776, p = 0.000), improving sustainability and environmental impact (r = 0.704, p = 0.000), and enhancing employee safety and health (r = 0.688, p = 0.000). While there was a positive correlation indicating awareness of benefits among companies (r = 0.457, p = 0.011), statements related to the current use of new technology (r = 0.268, p = 0.152), integrating new technologies into work (r = 0.385, p = 0.36), and willingness to invest in new technology (r = 0.586, p = 0.001) also exhibited positive correlations

Analysis of the benefits of implementing BIM and Lean technologies highlighted strong correlations, indicating perceived positive impacts on efficiency, collaboration and innovation. Table 6 shows the results.

Table 8 Correlation results for benefits of implementing BIM and Lean techniques

Statement	Pearson correlation	Sig. (2 tail)
Mission to Stay Competitive	0.774	0.000
Improve efficiency and productivity	0.656	0.000
Improving the quality of projects	0.797	0.000
Improve collaboration and communication	0.771	0.000
Improve accuracy and delivery speed	0.627	0.000
Increase in innovation	0.720	0.000
Increase job opportunities	0.776	0.000
Improving sustainability and environmental impact	0.704	0.000
Improving employee safety and health	0.688	0.000
Companies are aware of the benefits	0.457	0.011
Companies use new technology in their project	0.268	0.152
Companies seek to build new technologies into their work	0.385	0.36
Companies are willing to invest in new technology	0.586	0.001

The exploration of the benefits associated with implementing BIM and Lean technologies revealed distinct perspectives. The highest result, with a mean of 3.81, emphasized the belief in an increase in job opportunities, showcasing strong agreement. In contrast, the lowest result, with a mean of 2.92, indicated a more neutral stance regarding the active pursuit of BIM and Lean implementation by companies in Palestine. This implies a robust acknowledgment of potential job opportunities but a less decisive stance on proactive industry-wide adoption, as shown in Table 12.

Table 9 Perceived Benefits and Strategic preparation and planning for BIM and Lean Implementation in the Construction Industry

Paragraph	Mean	Standard deviation	Classification
Increase in Job Opportunities	3.81	0.97	Strong Agreement
Improved Sustainability and Environmental Impact	3.69	0.89	Strong Agreement
Improved Quality of Projects	3.71	0.98	Strong Agreement
Improved Efficiency and Productivity	3.69	1.06	Strong Agreement
Improved Accuracy and Speed in Project Delivery	3.69	1.00	Strong Agreement
Increase in Potential for Innovation	3.63	1.00	Strong Agreement
Stay Competitive in the AEC Sector	3.55	1.05	Agreement
Improved Cooperation and Communication	3.53	1.00	Agreement
Improved Safety and Health of Personnel	3.51	0.99	Agreement

Knowledgeable Companies Regarding Benefits	3.20	1.07	Agreement
Strategic preparation and planning of Companies to Invest in Resources	3.20	1.01	Agreement
Current Use of BIM and Lean Technologies in Projects	2.97	1.14	Neutral
Actively Seeking to Implement BIM and Lean Technologies	2.92	1.01	Neutral

4.3 Results of the Study Hypotheses

The study examined 5 main Hypotheses to answer the study questions:

Hypotheses 1 : There is no effect of obstacles and challenges of adopting BIM and LEAN on the willingness to adopt BIM and LEAN in Palestinian AEC sector

Hypotheses 2: There is no effect of the prospected benefits of adopting BIM and LEAN on the willingness to adopt BIM and LEAN in Palestinian AEC sector.

Hypotheses 3: There is no significant differences between AEC companies in Palestine in their obstacles and challenges of adopting BIM and LEAN with respect to their demographic profiles.

Hypotheses 4: There is no significant differences between AEC companies in Palestine in their prospected benefits of adopting BIM and LEAN with respect to their demographic profiles.

Hypotheses 5: There is no significant differences between AEC companies in Palestine in the willingness to adopt BIM and LEAN with respect to their demographic profiles.

Form each of H3 H4 and H5 you will have four sub-hypotheses (one for each demographic dimension

4.3.1 Hypothesis 1: In order to determine the impact of obstacles and challenges on the Strategic preparation and planning and strategic planning to adopt new technologies, linear regression analysis was used. The results indicated a statistically significant impact at a level less than or equal to 0.05. The F value was 105.90 with a statistical significance of 0.00. The R-square value showed that 41% of the variance in Strategic preparation and planning and planning is explained by obstacles and challenges. The beta value (B) representing the relationship between obstacles and challenges and the Strategic preparation and planning to adopt new technologies was 0.792, with a statistical significance of 0.00. This suggests that as the perception of obstacles and challenges as hindrances increases by one standard unit, Strategic preparation and planning to adopt new technologies increases by 0.646 standard units, as shown in Table (10).

Table 10 Results Hypothesis 1

Dependent Variable	Independent Variable	R	R Square	F	Sig. F	Beta	B	T	Sig.
Strategic preparation and planning for Adoption of New Technologies	Obstacles and Challenges	.646a	.417	105.90	0.00	0.646	0.792	10.291	.000

4.3.2 Hypothesis 2: To assess the impact of the anticipated benefits of adopting BIM and Lean technologies on Strategic preparation and planning and strategic planning to adopt new technologies, linear regression analysis was employed. The results showed a statistically significant impact at a level less than or equal to 0.05, with an F value of 186.51 and a significance of 0.00. The R-square value indicated that 56% of the variance in Strategic preparation and planning and planning is explained by obstacles and challenges. The beta value (B) representing the relationship between obstacles and challenges and the Strategic preparation and planning to adopt new technologies was 0.810, with a statistical significance of 0.00. This suggests that as the perception of obstacles and challenges as hindrances increases by one standard unit, Strategic preparation and planning to adopt new technologies increases by 0.810 standard units, as shown in Table (11).

Table 11 Results of Hypothesis 2

Dependent Variable	Independent Variable	R	R Square	F	Sig. F	Beta	B	T	Sig.
Strategic preparation for Adoption of New Technologies	Anticipated Benefits of Adopting BIM and Lean	.747a	.56	186.51	0.00	.747	.810	13.657	**.000**

4.3.3 Hypothesis 3 (H3)

Hypothesis 3 examined the relationship between different company demographics (company classification, company size, company experience, company location) and barriers and challenges. Analysis of variance showed that there were no statistically significant differences in the arithmetic means of the sample members depending on the demographic dimensions of the company and the obstacles and challenges. Table 12 summarizes the results.

Table 12 Results of Hypothesis 3

	Company Location	**Company exp**	**Company size**	**Classification - companies - engineering sector**	**Classification - company in - contracting**		**The company Location**
Obstacles and challenges	Sig.	F	Sig.	F	Sig.	F	Sig.
	.524	.912	.959	.041	.120	1.977	.524

4.3.4 Hypothesis 4 (H4)

Hypothesis 4 investigated the relationship between different company demographics and expected benefits from technology implementation. Analysis of variance showed that there were statistically significant differences in the arithmetic means based on the company's classification in the engineering sector. The P value reached 0.022, indicates a significance. Tables 13 and14 summarize the results.

Table 13 Results of Hypothesis 4

Benefits expected from technology implementation	**Mean**	**Std. Deviation**	**F**	**Sig.**	***Statistical Significance***
Consultant	3.65	0.69	3.39	0.02	***Statistically significant***
First	3.15	0.68			
Second	3.72	0.67			
Third	3.32	0.32			

Table 14 Scheffé test for Hypothesis 4

Dependent Variable		**Mean Difference (IJ)**	**Std. Error**	**Sig.**
Benefits of implementation of BIM and Lean technologies	Consultant-First		Std. Error	0.05
	Second	.49996	-0.0701	0.99
	Third	-.0701	.1733	0.79
First	Consultant-Second	.3222	.1916	0.05
	Third	-.49996	.3138	0.09
Second	Consultant-Third	-.5701	.1733	0.99
	First	-.1778	.2224	0.09
	Third	.0701	.3335	0.73
Third	Consultant-Third	.5701	.1916	0.79
	First	.3922	.2224	0.96
	Second	-.3222	.3433	0.73

4.3.5 Hypothesis 5 (H5)

Hypothesis 5 explored the relationship between different firm demographics and strategic preparation and planning for implementing new technologies. Analysis of variance showed that there were statistically significant differences at a level of less than 0.05 in the arithmetic means based on the company's classification in the engineering sector. The P value reached 0.04, which in turn indicates a significance. Tables 15 and 16 show the results.

Table 15 Results of Hypothesis 5

Preparation and strategic planning for the introduction of new technologies	**Mean**	**Std. Deviation**	**F**	**Sig.**	***Statistical Significance***
Consultant	3.94	0.66	2.86	0.04	***Statistically significant***
First	3.43	0.88			
Second	3.87	0.62			
Third	3.58	0.48			

Table 16 Scheffé test for Hypothesis 5

Dependent Variable		**Mean Difference (IJ)**	**Std. Error**	**Sig.**
Preparation and strategic planning for the introduction of new technologies	Consultant-First		.1814	0.05
	Second	.5104	.2005	0.99
	Third	.0710	.3284	0.75
First	Consultant-Second	.3605	.1814	0.05
	Third	-.5104	.2328	0.32
Second	Consultant-Third	-.4394	.3490	0.99
	First	-.1499	.2005	0.32

	Third	-.0710	.2328	0.88
Third	Consultant-Third	.4394	.3594	0.75
	First	.2895	.3284	0.98
	Second	-.3605	.3490	0.88

4.3.6 Hypothesis 6 (H6)

Hypothesis No. 6 examined whether the variable of expected benefits from implementing technologies is a mediating factor between obstacles and challenges and their effect on the desire to implement these technologies. The regression coefficient showed a direct effect of expected benefits from technology implementation on desire and was statistically significant (p = 0.00). In addition, there was a statistically significant effect of barriers and challenges on perceived benefits (p = 0.00).

The impact of changing obstacles and challenges without a mediator. Table 17 and 18 shows the results.

Table 17 Results of Hypothesis 6

Dependent Variable	**Independent Variable**	**R**	**R Square**	**F**	**Sig. F**	**Beta**	**B**	**T**	**Sig.**
Preparation and strategic planning for new technologies	Obstacles and challenges	0.646	0.642	105.90	0.00	0.646	0.792	10.291	**0.000**

Impact of barriers and challenges changing with mediator intervention. Table 19 shows the results.

Table 18 Total and direct effects of Hypothesis 6

Dependent Variable	**Independent Variable**	**R**	**R Square**	**F**	**Sig. F**	**Beta**	**B**	**T**	**Sig.**
Preparation and strategic planning for new technologies	Obstacles and challenges	0.801	0.64	131.62	0.00	0.344	0.422	5.874	**0.000**
	The Desired benefits of implementing BIM and Lean technologies					0.562	0.610	9.599	**0.000**

Chapter Five

Discussion of the Results

5.1 Conclusions, Implications and Recommendations

5.1.1Summary of results

The study yielded significant findings regarding the perceptions and attitudes of AEC companies in Palestine towards the implementation of BIM and Lean technologies. Important key points include:

- The respondents believed BIM and Lean will increase AEC job opportunities, with an Arithmetic mean of 3.81.
- Improved sustainability and environmental impact were also positively perceived, with an Arithmetic mean of 3.69.
- The expectation that companies in Palestine actively seek to implement BIM and Lean techniques received a more neutral response, with an Arithmetic mean of 2.92.

The study hypotheses were largely supported, revealing that barriers and challenges, as well as expected benefits, significantly influence the willingness of AEC companies in Palestine to adopt these technologies.

5.1.2 Implications for Practice

The results have several practical implications for AEC companies in Palestine, and they are as the following:

1. Strategic Planning: Companies must prioritize strategic planning to overcome obstacles. The study indicates that overcoming these obstacles positively affects the desire to implement BIM and Lean.

2. Communication and Training: Given the positive impact of perceived benefits, companies should focus on effectively communicating the potential benefits of BIM and Lean technologies. Training programs can enhance employees' understanding and skills.

3. Demographic Considerations: Classification in the engineering sector and company size have been identified as important factors influencing perceptions and willingness to adopt technology.

4. The examination of data has yielded the formulation of new research hypotheses, visually presented in Figure 3. This graphical representation encapsulates a refined conceptualization of the strategic planning intricacies involved in the implementation of Building Information Modeling (BIM) and Lean technologies within the Palestinian construction industry. The correlations and dynamics elucidated through data analysis find expression in this figure, serving as a navigational tool for subsequent exploration and validation endeavors in the course of the study.

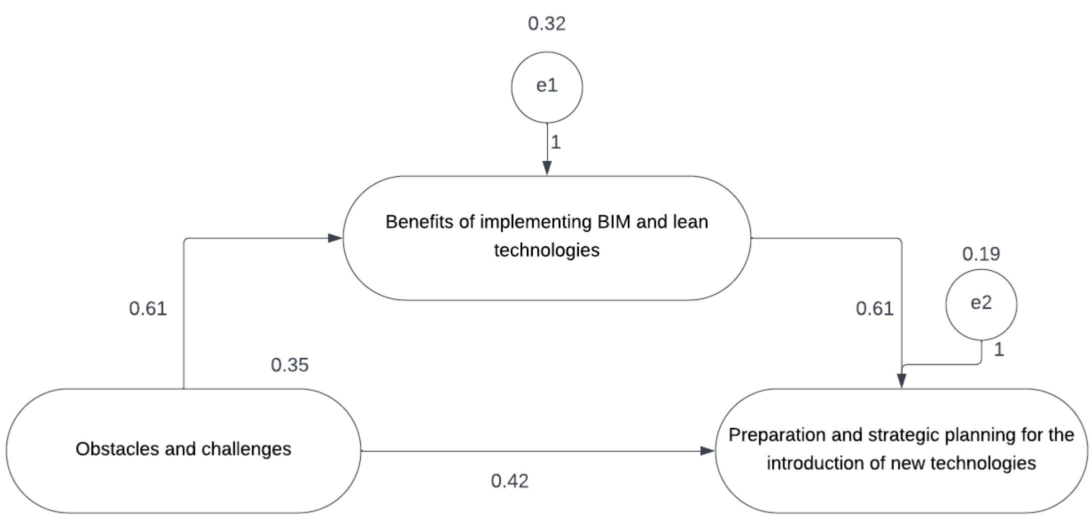


Figure 4 Refined Research Hypotheses

5.2. Discussion of the Results

5.2.1 The impact of obstacles and challenges on strategic preparation and planning

The results of the study revealed a statistically significant impact of obstacles and challenges on preparation and strategic planning for the application of new technologies, specifically BIM and Lean methods. Linear regression analysis showed a P value of 0.00, which indicates a strong statistical significance. Furthermore, an R-squared value of 0.41 indicated that 41% of variances in preparation and planning could be attributed to barriers and challenges. The positive relationship, as indicated by the B coefficient of 0.792, confirms that an increase in perceived barriers and challenges corresponds with an increase in willingness to implement new technologies.

5.2.2 The impact of expected benefits on desire and strategic planning

The second hypothesis explored the impact of expected benefits regarding the implementation of BIM and Lean technologies on desire and strategic planning. The results showed a statistically significant effect with a P value of 0.00. An R-squared value of 0.56 indicated that 56% of the variance in preparation and planning is explained by perceived benefits. The positive relationship is further highlighted by the B coefficient of 0.810, indicating that an increase in the perception of benefits corresponds to an increase in willingness to implement new technologies.

5.2.3 Relationship between company demographics and barriers/challenges

The third hypothesis aimed to study the relationship between company demographics (classification, size, experience, and location) and obstacles and challenges. Analysis of variance indicated that there are no statistically significant differences, which plays an important role in demonstrating that these demographic factors do not significantly influence perceived barriers and challenges among the companies surveyed.

5.2.4 Relationship between company demographics and expected benefits

The fourth hypothesis explored the relationship between company demographics and expected benefits from technology implementation. Analysis of variance showed that there were statistically significant differences, especially in the classification of companies in the engineering field. Consulting firms showed the highest average value of expected benefits.

5.2.5 Relationship between company demographics and preparation/planning

The fifth hypothesis examined the relationship between company demographics and strategic preparation/planning. Statistically significant differences were observed, with consulting firms again showing the highest mean value between the rating categories.

5.2.6 The mediating role of expected benefits

The sixth hypothesis addressed the mediating role of expected benefits between obstacles and challenges and their impact on willingness to apply technologies. The regression coefficient indicated a direct and statistically significant effect of expected benefits on the willingness to implement technologies. The results suggest that perceived benefits act as a partial mediator between barriers, challenges, and willingness to implement technologies.

5.3 SWOT Analysis for the Results

5.3.1 Strength:

1. Strong evidence: The research provides strong evidence, which indicates that people are willing to use Lean and BIM technologies in the Palestinian construction industry field when taking into consideration the various benefits they bring to the field.

2. Positive expectations: The results showed that those working in the industry have a generally positive outlook on the use of new technologies such as Lean and BIM. This is a good thing because it means that they are ready to trying these innovative tools.

3. Skilled workers: There are skilled and people with good knowledge in the workforce, especially those with backgrounds in the fields of civil engineering and technology. This is considered to be an important aspect since it means that some professional individuals can facilitate the implementation of these techniques.

5.3.2 Weaknesses:

1. Lack of practical experience: There is no doubt that this technology is important in achieving good results at a national level and people are open to a new technology, but it is also vital to mention that this technology is used by a staff and if experience in using Lean and BIM is missing, then it is considered a challenge to expect successful outcomes, which in turn will slow down the process of construction.

2. Limited resources: Using Lean and BIM techniques can be expensive. Some organizations may not have enough budget and resources for items like software, hardware, and training. This can hinder the process of implementation.

5.3.3 Opportunities:

1. Enhancing efficiency and quality: By using Lean and BIM, construction companies can make their projects run more smoothly and improve the quality of their work. This is an opportunity for the industry to stand out.
2. Training and Learning: Since this technology is a new one, it is an opportunity to provide training and help them become experts in using Lean and BIM. By doing so, the workforce can be well prepared for the new tools.

5.3.4 Threats:

1. Resistance to change: This threat occurs when the culture as well as norms are highly rooted in the structure of an organization, which affects the idea of accepting new methods of doing things. That is why convincing those kinds of companies of the need for change is a huge challenge.

2. Hidden factors: Some things have not been taken into account in the research that can influence people's willingness to use new technologies. Need to understand these hidden factors better to make good plans.

3. Economic and political uncertainty: The unstable situation in the region may make it difficult to obtain funds and resources for new technology projects. This means that any company, that is

willing to implement such methods, has to be careful and well-prepared for unexpected changes in politics and economics.

5.4 PESTEL Analysis

EXPLAIN YOUR ANALYSIS, PERSONALITY OF THE RESEARCHER

.4.1 **Politician:**

- Influence on strategic planning: Strategic planning for the application of new technologies, such as BIM and lean methods, is influenced by the political landscape in Palestine. Government policies and regulations can facilitate or hinder such implementation. The research revealed a statistically significant impact of political factors on strategic planning. The political situation in Palestine is a very important challenge that hinders and restricts the industrial growth in Palestine. It is considered globally as an unstable country, which means that the foreign investments are very rare and do not focus mainly on the industrial sectors. Besides, there are many global and universal companies that do not have branches in Palestine due to this unstable condition.

5.4.2 Economic:

- Influence on preparation and planning: Economic factors, including the cost associated with implementing BIM and lean methods, are crucial in strategic planning. The results of the study indicate that expected benefits have a significant impact on the preparation and planning of new technologies. Economic stability and financing options influence willingness to adopt new technologies. The results showed a statistically significant effect of economic variables.

5.4.3 Social:

- Company demographics and classification: Social aspects, including company demographics such as classification, size, and experience, greatly influence the perception of barriers and challenges when implementing new technologies. The research highlights differences in perception based on company classification, which are an integral part of strategic planning. Strategic planning in business involves aligning a company's mission, vision, and goals with effective strategies to ensure success. This process applies universally across businesses but is implemented differently based on company size. Company size significantly influences strategic planning implementation. Strategic planning encompasses internal and external factors. Internally, companies control aspects like human resources, technology, logistics, marketing, and procurement. Externally, factors such as market response, competition, labor availability, regulations, and economic conditions are beyond direct control. Larger companies benefit from their size by having greater adaptability to uncontrollable external factors. On both ends of the strategic planning scale, the economies of scale dictate the kinds of strategies a company will implement.

5.4.4 Technological:

Obstacles and challenges: Obstacles and challenges inherent in technology implementation have a clear impact on strategic planning. The research confirms that these challenges are statistically significant and that the strategic planning process requires addressing these technological obstacles.

5.4.5 Environmental:

- Location and demographics of the company: The geographical location of companies operating in Palestine can have a clear impact on the application of technology. Research findings reveal variations in perception based on a company's location, which impacts strategic planning.

5.4.6 Legal:

- Regulations and barriers: Legal factors, such as regulations and barriers, play a pivotal role in shaping the strategic planning process for BIM and lean methods. Understanding the legal framework and resolving legal challenges is indispensable to a successful technology implementation strategy.

5.5 FIVE FORCES

The Five Forces Model is useful for assessing competition, especially for BIM and Lean implementation when considering their role in the construction industry in Palestine. These forces are as the following:

5.5.1 Bargaining power of suppliers:

- The research results indicate that suppliers of BIM and Lean technology solutions have a high degree of influence in the industry. This impact is intricately linked to the barriers and challenges faced by construction companies. Suppliers that effectively address these challenges enjoy a stronger market position, enhancing their bargaining power.

5.5.2. Negotiating power of buyers**:**

In the case of construction companies in Palestine, these entities act as buyers of technological solutions. The research findings confirm that the perceived benefits of implementing BIM and Lean technologies are pivotal. These benefits greatly influence the willingness of construction companies to adopt these innovations. The greater the perceived advantages, the more buyers will be inclined to implement these technologies, thus influencing their bargaining power.

5.5.3. Threat of new entrants:

- The research does not directly address the threat of new arrivals, but it suggests that it may exist. If the Palestinian construction industry remains open to new technologies, it may attract new technology companies. These newcomers will design solutions that suit the needs of the local market.

5.5.4. Threat of alternatives:

- The primary focus of the research is to highlight as well as address the barriers, challenges, and expected benefits relating to BIM and Lean technologies. Although the study does not explicitly address substitutes, it suggests that since these technologies offer significant advantages, the threat of substitutes may diminish. This is due to the increasing importance of BIM and Lean methods in industry, which reduces the feasibility of alternative solutions.

5.5.5. Competitive Rivalry:

Competition in the construction industry depends on its ability to adapt to new technologies. The research findings highlight the important role of barriers and challenges in shaping willingness to implement these technologies. Companies that can effectively overcome these challenges put themselves in a position to gain a competitive advantage in the market. Being aware of the potential benefits and being proactive in implementing technology can strengthen a company's competitive position in this dynamic sector.

5.6 Limitations:

5.6.1. Data Collection Challenges:

- Transportation limitations: The process of collecting questionnaires was hindered by significant transportation challenges. Limited accessibility to certain locations resulted in delays and difficulties in reaching participants, impacting the efficiency of data collection. This is due to the difficult political situation in Palestine.

- Reluctance to Participate: A clear limitation was the reluctance of some participants to answer the questionnaires due to many reasons like the unwillingness or lack of interest in the topic. Despite efforts to explain the significance of the research, concerns about the nature of the data and its conventional nature were expressed by participants, leading to a potential bias in the collected responses.

5.6.2. Conventional Data Perception:

- Perceived Conventional Data: A challenge arose from participants perceiving the data collection methods as conventional. This perception may have influenced the level of engagement and openness in responses. It poses a limitation as it might affect the depth and authenticity of the gathered information.

5.6.3 Political Situation:

- Impact of Political Situation: The political situation in Palestine due to the war on Gaza presented formidable challenges. Restrictions on movement in certain cities affected the ability to collect comprehensive data. Some participants were afraid to respond due to political sensitivities, which in turn limits the scope of data gathered.

5.6.4 Reliability and Generalizability:

- Reliability Concerns: The above-mentioned challenges in relation to data collection, combined with the constrained sample size, lead to many concerns about the reliability of the results. The limited number of responses affects the diversification of perspectives within the Palestinian construction industry. Besides, it influenced the depth of the collected data.

5.6.5 Implications for Thesis Quality:

- Need for Additional Data: The challenges faced during data collection confirm the need for additional data to enhance the quality and reliability of the thesis. A larger, more diverse dataset would contribute to a more comprehensive understanding of the impact of strategic planning, BIM adoption, and lean principles in the Palestinian construction industry.

5.7. Conclusions

Investigating the strategies used in the Palestinian construction context, as a very unique way of work in the industry phase, and analyzing it according to the BIM and lean aspects, is a tough job due to the unique nature of the subject. There are numerous attitudes towards BIM and as well as lean; mostly argue that they are practically beneficial in many different aspects for the local companies and industries. The researcher strongly believes that the implementation of such strategies adds value to the overall work since these strategies are vital part of the work. As a main conclusion of this thesis, the researcher concluded that BIM and lean, as two contemporary ideas of work in construction, have the possibility to integrate and work with each other and with other ways of work. They would bring different advantages to the construction.

This study examined the factors that affect BIM and Lean implementation in Palestinian construction. The research shows that these methods are hindered by a lack of awareness and understanding of their benefits, limited access to technology and software, inadequate training and education, and resistance to change. The study also found that BIM and Lean methods improve project outcomes, stakeholder collaboration, productivity, efficiency, waste reduction, and cost savings.

Furthermore, the study has indicated that company demographics and readiness are crucial factors to ensure the successful implementation of BIM and Lean methods in the construction industry of Palestine. The research findings suggest that larger companies with more experience in the construction industry are willing to adopt these methods, while smaller companies are more hesitant due to many challenges like resources’ constraints and limited knowledge in the field.

To conclude, the study sheds light on BIM and Lean implementation in the Palestinian construction industry. Industry stakeholders, policymakers, and academics can use these insights to understand the main factors that affect the successful adoption of these methods. By using these insights, organizations can create strategies to overcome barriers, maximize benefits, and improve construction project outcomes, cost-effectiveness, and efficiency.

5.8 Recommendations

This study made recommendations to improve BIM and lean implementation in construction projects. Based on the study's findings, the researcher has formulated a set of comprehensive recommendations to address the perceived obstacles and challenges faced by individuals in the construction industry. These recommendations are as the following:

W. Conducting training for the staff must be done in in order to meet the specific needs of the individuals, highlighting the potential gains from these methods to motivate individuals to adopt them. Cooperation between co-workers in the same company has been identified as an effective way to share best practices and find solutions to common issues. This results in exchanging experiences and learning new skills from others and trying to find practical solutions to challenges they may face.

Supportive strategies that facilitate the use of BIM and lean methods in construction projects are essential in this regard. Calling for the importance of adopting such policies can help to overcome the various barriers that prevent the adoption of these methods. By providing a conducive environment, individuals can be encouraged to adopt BIM and lean methods, leading to significant improvements in the construction industry.

Regular following up and monitoring are crucial in tracking changes in barriers, benefits, and company demographics. Action plans or follow up plans are very important identifying the areas that need improvement and ensure that the adoption of BIM and lean methods is potential in the long run. By monitoring the progress, individuals can be held accountable, and corrective measures can be taken when necessary.

These recommendations are vital to overcome the challenges faced in the adoption and implementation of BIM and lean methods in construction projects. By incorporating these suggestions, the efficiency of the construction industry will be enhanced, waste will be reduced, and productivity will be improved.

5.9 Future research

For the purpose of future research, it would be advantageous to investigate the longitudinal effects of strategic planning on the implementation of technology within the construction industry of Palestine. This research would allow for the identification of potential barriers that may arise when considering implementation of such approaches, as well as provide a better understanding of the impact that strategic planning has on the process of implementation of technology. It is also possible that the research will investigate the difficulties that face different types of construction companies in Palestine. These types include small-scale businesses and large corporations.

In addition to this, the researcher suggests to conduct various scientific research in order to investigate the effectiveness of the recommendations highlighted in the current study, as this could provide industry stakeholders with interesting and useful information. In order to gain a better understanding of successful and unsuccessful approaches, it is possible to gain a better understanding of the effectiveness of strategies that have already been implemented. This knowledge can then be used to come up with good decisions in the future. Ultimately, this type of research has the potential to improve the overall professionality and efficiency of technology implementation within the construction industry, which will bring benefit to all stakeholders across the board.

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Appendices

Appendix A Questionnaire (English Version)

Arab American University

Ramallah Site

Arab American University

Ramallah website

Arab American University

Master in Strategic Planning and fundraising

Thesis Title:

Strategic Planning to Improve the Construction Industry in Palestine: Towards Lean Construction and BIM in Palestine.

SPRING 2023

Wissam Younis Sbeih

Thank you for participating in our survey on strategic planning to improve the Palestinian

construction industry. This study aims to identify the obstacles and challenges faced by the engineering and contracting industry in Palestine in terms of adopting building information modeling(BIM) and lean technologies(LEAN) in addition to companies' readiness to adopt , .them

This study aims to study the impact of strategic planning processes on the adoption of building information modeling and lean technologies and to develop a conceptual framework for integrating strategic planning and adoption in the engineering and contracting sector. Your participation in this survey is essential to achieving our research goals, and we appreciate your .candid responses

Your responses will be kept strictly confidential and used for research purposes only. We expect your participation and value your contribution to our research. We appreciate your cooperation.

Researcher: Wissam Sbeih

General information

Please check (x) the box that applies to you:

1) Gender: □ Male □ Female

2) Academic qualification: □ Diploma or less □ Bachelor's degree □ Postgraduate studies

3) The nature of your work in the company: □ General Manager □ Construction Engineer □ Office Engineer □ Site Engineer □ Other

4) Company classification in the field of buildings - contracting:

First, second, third, fourth, fifth-degree

Contracting □ □ □ □ □

4) Company classification in the field of engineering - (company/office):

Consultant grade, first, second, third

Engineering □ □ □ □

5) The governorate in which the company is located:

□ Jenin □ Tulkarm □ Nablus □ Ramallah and Al-Bireh □ Jerusalem □ Hebron □ Bethlehem □ Salfit □ Qalqilya □ Jericho □ Tubas.

6) Number of employees in the company:

□ From 1-9 □ From 10-19 □ From 20-50 □ More than 50

7) Number of years of company experience in its field of work:

¨ Less than 5 years ¨ 5-15 years □ More than 15 years

8) Does your company use building information modeling (BIM) and lean technologies in designing or implementing projects?

¨ Currently in use ¨ No plans to use it currently ¨ Plans to use it within twelve months

¨ Planning to use it within more than twelve months ¨ Not sure

10) The average number of contract employees working in the company is: □ Less than 5 □ 6-10 □ More than

Second: Please put a tick(x) in the box that corresponds to the current status of your :company in front of each of the following paragraphs

Part One: Obstacles and Challenges Implementing these techniques is essential to enhance productivity ,And improve project results. However it is necessary to identify and address the barriers and challenges that hinder its widespreadadoption This part aims to gain valuable knowledge and insights that can guide the development of strategies to overcome these obstacles and facilitate the successful implementation of BIM models and Lean Technologies in .engineering and construction in Palestine					
Paragraph	**Strongly opposed**	**opposed**	**neutral**	**Agree**	**Strongly Agree**
Obstacles and challenges					
1. The lack of **government support** is an obstacle to the adoption ofbuilding information modeling - BIM and lean technologies in the engineering and .construction industry in Palestine					
2. The lack of supportive **government policies** is an obstacle to the adoption of building) information modelingBIM)) and lean LEAN) techniques in engineering and .contracting companies in Palestine					
3. The lack of **awareness of the benefits of** building information modeling - BIM and lean technologies - is an obstacle to their adoption in the engineering and construction industry in .Palestine					
4. The lack of **technical expertise** is an obstacle to the adoption of building information					

) modelingBIM) and lean technologies in the engineering and construction industry in .Palestine					
5. The **high cost** of implementation is an obstacle to the adoption of building information) modelingBIM) and lean technologies in the engineering and construction industry in .Palestine					
6. The lack of **interoperability** with existing systems is an obstacle to the adoption of) building information modelingBIM) and lean technologies in the engineering and .construction industry in Palestine					
7. That lack**of standardization** is an obstacle to the adoption of building information modeling)BIM) and lean technologies in the engineering and construction industry in Palestine.					
8. Resistance **to change** is an obstacle to the) adoption of building information modeling BIM) and lean technology in the engineering .and construction industry in Palestine					
9. Lack of **access to the necessary software and hardware** is an obstacle to the adoption of) building information modelingBIM) and lean technologies in the engineering and .construction industry in Palestine					
10. The lack of **cooperation between companies** is an obstacle to the adoption ofbuilding information modeling - BIM and lean					

technologies in the engineering and .construction industry in Palestine					
11. **Institutional culture** is a barrier to the use of building information modeling - BIM and lean technologies in the engineering and .construction industry in Palestine					
12. The lack **of understanding of building - information modeling techniques** BIM and - lean techniquesLEAN is an obstacle to their adoption in engineering and contracting .companies in Palestine					
13. The lack **of staff trained** inbuilding information modeling - BIM and lean techniques - is an obstacle to their adoption in engineering and contracting companies in .Palestine					

Part Two. Preparedness and strategic planning to adopt new technologies

This part aims to study the extent of readiness to adopt these technologies and the benefits resulting from them and to study the necessary needs such as lack of awareness, technical expertise, and investment capital that hinder the widespread adoption of BIM and Lean technologies in the AEC industry in Palestine.

Paragraph	**Strongly opposed**	**opposed**	**neutral**	**OK**	**Strongly Agree**
Preparedness and strategic planning to adopt new technologies					
1. We are ready **to invest in**building information modeling - BIM and lean technologies for your engineering and contracting business in .Palestine					

2. We believe that having **a strategic plan** for building information modeling - BIM and adopting lean technologies is important for the adoption of engineering and contracting .companies in Palestine					
3. We believe that a strategic plan should **include goals and objectives** Help withthe adoption of) Building information modeling BIM) and adopting lean technology in the electronics .industry in Palestine					
4. We believe that the strategic plan must include **a timetable** to help adopt building information modeling and lean technologies in the .electronics industry in Palestine					
5. We believe that a strategic plan should include **abudget** It helps in adopting Building) Information ModelingBIM and adopting (lean technology in the electronics industry .(engineering and contracting) in Palestine					
6. We believe that the strategic plan must include **performance measures to measure** the success ofbuilding information modeling - BIM and the adoption of lean technologies in the engineering and contracting industry in .Palestine					
7. We believethat sharing **Stakeholders** in the strategic planning process may increase the success of BIM adoption and the adoption of lean technologies in the engineering and contracting industry inPalestine.					

8. We believe that **providing training and support to employees** is important for the successful adoption ofBIM and LEAN technologies in the engineering and .contracting industry in Palestine					
9. We believe that partnering with technology **providers and vendors** can help adoptBIM and LEAN technologies in the engineering and .contracting industry in Palestine					
Part Three: Benefits expected fromthe adoption of BIM andLean techniques in the engineering and .contracting industry in Palestine This section is dedicated to measuring the extent of the desired benefits you see as a result of adopting**BIM andLean .techniques in** the engineering and contracting industry in Palestine					
Paragraph	**Strongly opposed**	**opposed**	**neutral**	**OK**	**Strongly Agree**
Benefits of adoptionof BIM andLean technologies					
1. We believe inbuilding information modeling - BIM and LEAN **A mission to remain competitive** in the engineering and .construction industry in Palestine					
2. We believethat embracing BIM and lean It will lead to **improving the efficiency and productivity** of the engineering and .construction industry in Palestine					
3. We believe in embracingBIM and leading to the **improvement Quality of engineering .and contracting projects** in Palestine					
4. We believe in adopting Building Information Modeling - BIM - and Lean Technologies					

LEAN It will lead to **improved cooperation and communication** between stakeholders in the engineering and construction industry in .Palestine					
5. We believe in adopting building information modeling - BIM and LEAN technologies It will lead to **improving the accuracy and speed of** project delivery in the engineering .and construction industry in Palestine					
6. We believe that adopting building information modeling - BIM and lean technologies - will increase the potential **for innovation** in the engineering and contracting industry in .Palestine					
7. We believe that adopting building information modeling - BIM and lean technologies - will increase **new job opportunities** in the engineering and contracting industry in .Palestine					
8. We believe in adopting building information modeling - BIM and LEAN technologies It will lead to **improving the sustainability and environmental impact** of engineering and .contracting projects in Palestine					
9. We believe in adopting building information modeling - BIM and LEAN technologies It leads to **improving the safety and health of workers** in the engineering and contracting .industry in Palestine					

10. We believe that engineering and contracting companies in Palestine are **aware of the potential benefits** of building information) modelingBIM) .and lean technologies					
11. We believe that engineering and contracting companies in Palestine **use** building) information modelingBIM)) and lean LEAN) techniques .in their projects					
12. We believe that engineering and contracting companies in Palestine **are actively seeking to adopt** building information modeling - techniquesBIM and lean techniques - in their .work					
13. We believe that engineering and contracting companies in Palestine **are ready to invest** in the resources necessary to adopt building) information modelingBIM) and lean .technologies					

Appendix B Questionnaire (Arabic Version)

Arab American University

Ramallah Site

الجامعـــة العربيـــة الأمريكيـــة

موقع رام الله

الجامعة العربية الامريكية

ماجستير في التخطيط الاستراتيجي وجمع التبرعات

عنوان الرسالة:

التخطيط الاستراتيجي لتحسين صناعة البناء والتشييد في فلسطين: نحو البناء المرن ونمذجة معلومات البناء في فلسطين.

وسام يونس صبيح

ربيع 2023

شكرا لك على المشاركة في استطلاعنا حول التخطيط الاستراتيجي لتحسين صناعة البناء الفلسطينية. تهدف هذه الدراسة إلى تحديد العوائق والتحديات التي تواجهها صناعة الهندسة و المقاولات في فلسطين من حيث تبني نمذجة معلومات المباني BIM والتقنيات الخالية من الهدر LEAN ، بالإضافة إلى استعداد الشركات لاعتمادها.

تهدف هذه الدراسة الى دراسة تأثير عمليات التخطيط الاستراتيجي على اعتماد نمذجة معلومات المباني والتقنيات الخالية من الهدر وتطوير إطار مفاهيمي لدمج التخطيط الاستراتيجي واعتمادها في قطاع الهندسة و المقاولات. إن مشاركتكم في هذا الاستطلاع ضرورية لتحقيق أهدافنا البحثية، ونحن نقدر ردودكم الصريحة.

سيتم الاحتفاظ بردودك بسرية تامة واستخدامها لأغراض البحث فقط. نتوقع مشاركتك ونقدر مساهمتك في بحثنا. نحن نقدر تعاونكم.

الباحث: وسام صبيح

أولاً: معلومات عامة

يرجى وضع إشارة (x) في المربع الذي ينطبق عليك:

1) **الجنس:** ☐ذكر ☐ انثى

2) **المؤهل العلمي:** ☐ دبلوم او اقل ☐ بكالوريوس ☐ دراسات عليا

3) **طبيعة عملك في الشركة:** ☐مدير العام ☐ مهندس الانشاءات ☐ مهندس مكتب ☐ مهندس موقع ☐ غير ذلك

4) **تصنيف الشركة في مجال الابنية - مقاولات :**

الدرجة	**الاولى**	**الثانية**	**الثالثة**	**الرابعة**	**الخامسة**
مقاولات	☐	☐	☐	☐	☐

4) **تصنيف الشركة في مجال الهندسة - (شركة/ مكتب):**

الدرجة	**استشاري**	**اولى**	**ثانية**	**ثالثة**
هندسة	☐	☐	☐	☐

5) **المحافظة التي تتواجد فيها الشـركة:** ☐ جنين ☐ طولكرم ☐ نابلس ☐ رام الله والبيرة ☐ القدس ☐ الخليل ☐ بيت لحم ☐ سلفيت ☐ قلقيلية ☐ اريحا ☐ طوباس.

6) **عدد الموظفين في الشركة:** ☐ من 1-9 ☐من 10-19 ☐ من 20-50 ☐اكثر من50

7) **عدد سنوات خبرة الشركة في مجال عملها:** ☐أقل من 5سنوات ☐ من 5-15سنة ☐ اكثرمن15 سنة

8) **هل تستخدم شركتك نمذجة المباني معلوماتيًا - BIM والتقنيات الخالية من الهدر - LEAN في تصميم او تنفيذ المشاريع ؟**

☐ تستخدم حاليا ☐ لا يوجد خطط لاستخدامها حاليا ☐ تخطط لاستخدامها خلال اثنا عشر شهرا ☐ تخطط لاستخدامها خلال اكثر من اثنا عشر شهرا ☐ غير متأكد

10) **متوسط عدد موظفي العقود العاملين في الشركة هو:** ☐ اقل من 5 ☐من 6-10 ☐اكثر من1

ثانياً: يرجى وضع إشارة (x) في المربع الذي يتفق مع الوضع الحالي لشركتكم أمام كل فقرة من الفقرات الآتية

الجزء الأول: العوائق والتحديات

يعد تنفيذ هذه التقنيات أمرًا ضـــروريًا لتعزيز الإنتاجية وتحســين نتائج المشـــروع. ومع ذلك ، فمن الضـــروري تحديد ومعالجة العوائق والتحديات التي تعيق تبنيها على نطاق واســع يهدف هذا الجزء الى اكتســـاب المعرفة والرؤى القيمة التي يمكن أن توجه تطوير الاستراتيجيات للتغلب على هذه العقبات وتسهيل التنفيذ الناجح لنماذج BIM و Lean Technologies في الهندسة والبناء في فلسطين

الفقرة	**معارض بشدة**	**معارض**	**محايد**	**موافق**	**موافق بشدة**
العوائق والتحديات					
14. أن الافتقار إلى **الدعم الحكومي** تعد عائقًا أمام تبني نمذجة المباني معلوماتيًا - BIM والتقنيات الخالية من الهدر - LEAN في صناعة الهندسة والبناء في فلسطين.					
15. أن الافتقار إلى **السياسات الحكومية** الداعمة هو عائق أمام تبني تقنيات نمذجة المباني معلوماتيًا - BIM والتقنيات الخالية من الهدر - LEAN في شركات الهندسة و المقاولات في فلسطين					
16. أن نقص **الوعي بفوائد** نمذجة المباني معلوماتيًا - BIM والتقنيات الخالية من الهدر - LEAN هو عائق أمام تبنيها في صناعة الهندسة والبناء في فلسطين.					
17. أن الافتقار إلى **الخبرة الفنية** تعد عائقًا أمام تبني نماذج نمذجة المباني معلوماتيًا - BIM والتقنيات الخالية من الهدر - LEAN في صناعة الهندسة والبناء في فلسطين.					
18. أن **التكلفة المرتفعة** للتنفيذ تعد عائقًا أمام تبني نماذج نمذجة المباني معلوماتيًا - BIM والتقنيات الخالية من الهدر - LEAN في صناعة الهندسة والبناء في فلسطين.					
19. أن الافتقار إلى **إمكانية التشـــغيل البيني** مع الأنظمة الحالية تعد عائقًا أمام اعتماد نمذجة المباني معلوماتيًا - BIM والتقنيات الخالية من الهدر - LEAN في صـــناعة الهندســـة والبناء في فلسطين.					

20. أن الافتقار إلى **التقييس - standardization** تعد عائقًا أمام اعتماد نماذج نمذجة المباني معلوماتيًا - BIM والتقنيات الخالية من الهدر - LEAN في صناعة الهندسة والبناء في فلسطين.					
21. أن **مقاومة التغيير** تعد عائقًا أمام تبني نماذج نمذجة المباني معلوماتيًا - BIM والتقنية الخالية من الهدر في صناعة الهندسة والبناء في فلسطين.					
22. أن الافتقار إلى **الوصول إلى البرامج والأجهزة الضرورية** تعد عائقًا أمام اعتماد نمذجة المباني معلوماتيًا - BIM والتقنيات الخالية من الهدر - LEAN في صناعة الهندسة والبناء في فلسطين.					
23. أن الافتقار إلى **التعاون بين الشركات** تعد عائقًا أمام اعتماد نمذجة المباني معلوماتيًا - BIM والتقنيات الخالية من الهدر - LEAN في صناعة الهندسة والبناء في فلسطين.					
24. أن **الثقافة المؤسسية** تعد حاجزًا أمام استخدام نمذجة المباني معلوماتيًا - BIM والتقنيات الخالية من الهدر - LEAN في صناعة الهندسة والبناء في فلسطين.					
25. أن عدم **فهم تقنيات** نمذجة المباني معلوماتيًا - BIM والتقنيات الخالية من الهدر - LEAN هو عائق أمام تبنيها في شركات الهندسة و المقاولات في فلسطين.					
26. أن عدم **توفر الموظفين المدربين** على نمذجة المباني معلوماتيًا - BIM والتقنيات الخالية من الهدر - LEAN هو عائق أمام تبنيها في شركات الهندسة و المقاولات في فلسطين.					
الجزء الثاني. الاستعداد والتخطيط الاستراتيجي لتبني التقنيات الجديدة يهدف هذا الجزء الى دراسة مدى الاستعداد لتبني هذه التقنيات و الفوائد المترتبة عليها ، و دراسة الاحتياجات اللازمة مثل: نقص الوعي والخبرة الفنية ورأس المال الاستثماري التي تعيق التبني الواسع النطاق لتقنيات BIM و Lean في صناعة AEC في فلسطين.					
الفقرة	**معارض بشدة**	**معارض**	**محايد**	**موافق**	**موافق بشدة**
الاستعداد والتخطيط الاستراتيجي لتبني التقنيات الجديدة					

					10. نحن على على استعداد **للاستثمار في نمذجة** المباني معلوماتيًا - BIM والتقنيات الخالية من الهدر - LEAN لأعمالك في الهندسة و المقاولات في فلسطين.
					11. نحن نعتقد أن وجود **خطة إستراتيجية** لنماذج نمذجة المباني معلوماتيًا - BIM وتبني التقنيات الخالية من الهدر أمر مهم لتبني شركات الهندسة و المقاولات في فلسطين.
					12. نحن نعتقد أن الخطة الإستراتيجية يجب أن **تتضمن أهدافًا وغايات** تساعد في تبني نمذجة معلومات البناء (BIM) واعتماد التكنولوجيا الخالية من الهدر في صناعة الإلكترونيات في فلسطين.
					13. نحن نعتقد أن الخطة الإستراتيجية يجب أن تتضمن **جدولاً زمنياً** تساعد في تبني نمذجة معلومات البناء والتقنيات الخالية من الهدر في صناعة الإلكترونيات في فلسطين.
					14. نحن نعتقد أن الخطة الإستراتيجية يجب أن تتضمن **ميزانية** تساعد في تبني نمذجة معلومات البناء (BIM) واعتماد التكنولوجيا الخالية من الهدر في صناعة الإلكترونيات (الهندسة و المقاولات) في فلسطين.
					15. نحن نعتقد أن الخطة الإستراتيجية يجب أن تتضمن **مقاييس أداء لقياس** نجاح نمذجة المباني معلوماتيًا - BIM وتبني التقنيات الخالية من الهدر في صناعة الهندسة و المقاولات في فلسطين.
					16. نحن نعتقد أن مشاركة **أصحاب المصلحة** في عملية التخطيط الاستراتيجي قد يزيد من نجاح تبني نمذجة المباني معلوماتيًا - BIM وتبني التقنيات الخالية من الهدر في صناعة الهندسة و المقاولات في فلسطين.
					17. نحن نعتقد أن **توفير التدريب والدعم للموظفين** أمر مهم للتبني الناجح لنماذج نمذجة المباني معلوماتيًا - BIM والتقنيات الخالية من الهدر - LEAN في صناعة الهندسة و المقاولات في فلسطين.
					18. نحن نعتقد أن **الشراكة مع مزودي التكنولوجيا والبائعين** يمكن أن تساعد في تبني نمذجة المباني معلوماتيًا - BIM والتقنيات

الفقرة	معارض بشدة	معارض	محايد	موافق	موافق بشدة
الخالية من الهدر - LEAN في صناعة الهندسة و المقاولات في فلسطين.					
الجزء الثالث: الفوائد المرجوة من تبني تقنيات BIM و Lean في صناعة الهندسة و المقاولات في فلسطين. هذا القسم مخصص لقياس مدى ما ترونه من فوائد مرجوة كنتيجة لتبني **تقنيات BIM و Lean في** صناعة الهندسة و المقاولات في فلسطين.					
الفقرة	**معارض بشدة**	**معارض**	**محايد**	**موافق**	**موافق بشدة**
الفوائد المرجوة من تبني تقنيات BIM و Lean					
14.نحن نعتقد أن نمذجة المباني معلوماتيًا - BIM والتقنيات الخالية من الهدر - LEAN **مهمة للبقاء في المنافسة** في صناعة الهندسة والبناء في فلسطين.					
15.نحن نعتقد أن تبني تقنيات نمذجة المباني معلوماتيًا - BIM والتقنيات الخالية من الهدر - LEAN سوف يؤدي الى **تحسين كفاءة وإنتاجية** صناعة الهندسة والبناء في فلسطين.					
16.نحن نعتقد أن تبني تقنيات نمذجة المباني معلوماتيًا - BIM والتقنيات الخالية من الهدر - LEAN يؤدي الى **تحسين جودة مشاريع** الهندسة و المقاولات في فلسطين.					
17.نحن نعتقد أن اعتماد نمذجة المباني معلوماتيًا - BIM والتقنيات الخالية من الهدر - LEAN سوف يؤدي الى **تحسين التعاون والتواصل** بين أصحاب المصلحة في صناعة الهندسة والبناء في فلسطين.					
18.نحن نعتقد أن تبني تقنيات نمذجة المباني معلوماتيًا - BIM والتقنيات الخالية من الهدر - LEAN سوف يؤدي الى **تحسين دقة وسرعة تسليم** المشاريع في صناعة الهندسة والبناء في فلسطين.					
19.نحن نعتقد أن اعتماد نمذجة المباني معلوماتيًا - BIM والتقنيات الخالية من الهدر - LEAN سيزيد من إمكانات **الابتكار** في صناعة الهندسة و المقاولات في فلسطين.					

20.نحن نعتقد أن اعتماد نمذجة المباني معلوماتيًا - BIM والتقنيات الخالية من الهدر - LEAN سيزيد من **فرص العمل الجديدة** في صناعة الهندسة و المقاولات في فلسطين.					
21.نحن نعتقد أن تبني تقنيات نمذجة المباني معلوماتيًا - BIM والتقنيات الخالية من الهدر - LEAN سوف يؤدي الى **تحسين الاستدامة والأثر البيئي** لمشاريع الهندسة و المقاولات في فلسطين.					
22.نحن نعتقد أن تبني تقنيات نمذجة المباني معلوماتيًا - BIM والتقنيات الخالية من الهدر - LEAN يؤدي الى **تحسين سلامة وصحة العاملين** في صناعة الهندسة و المقاولات في فلسطين.					
23.نحن نعتقد أن شركات الهندسة و المقاولات في فلسطين على **دراية بالفوائد المحتملة** لنماذج نمذجة المباني معلوماتيًا - BIM والتقنيات الخالية من الهدر.					
24.نحن نعتقد أن شركات الهندسة و المقاولات في فلسطين **تستخدم تقنيات** نمذجة المباني معلوماتيًا - BIM والتقنيات الخالية من الهدر - LEAN في مشاريعها.					
25.نحن نعتقد أن شركات الهندسة و المقاولات في فلسطين **تسعى بنشاط لتبني** تقنيات نمذجة المباني معلوماتيًا - BIM والتقنيات الخالية من الهدر - LEAN في أعمالها.					
26.نحن نعتقد أن شركات الهندسة و المقاولات في فلسطين **مستعدة للاستثمار** في الموارد اللازمة لاعتماد تقنيات نمذجة المباني معلوماتيًا - BIM والتقنيات الخالية من الهدر.					

الملخص

في فلسطين، يشهد قطاع البناء تحولًا هامًا نتيجة لاعتماد تقنيات متقدمة مثل البناء الخالي من الهدر/ الانسيابي (lean)ونمذجة معلومات البناء (BIM). يهدف هذا البحث إلى استكشاف إمكانية تطبيق هذه الأساليب المبتكرة في القطاع الفلسطيني للبناء، وإنشاء إطار تصوري استراتيجي لتنفيذها.

تركز الدراسة في بدايتها على دور البناء الانسيابي في تحسين القيمة، وتلبية متطلبات العملاء، والتخلص من الهدر. بالإضافة إلى ذلك، تقدم نمذجة معلومات البناء نهجًا ذكيًا لتصميم وتشغيل المباني. ومع ذلك، يواجه تنفيذ هذه التقنيات في فلسطين تحديات مثل الرأسمال المحدود، ونقص المهارات، ومخاوف التكلفة، وقلة المعرفة في هذه التكنولوجيا إضافة الى الوضع السياسي السيء في فلسطين

لمواجهة هذه التحديات، تم إجراء استبيان يتضمن 150 عينة بين محترفي البناء والمسؤولين الحكوميين والمعنيين لتحليل بشكل شامل التحديات التي تواجه تنفيذ التكنولوجيات في فلسطين، بما في ذلك الرأسمال المحدود، ونقص المهارات، ومخاوف التكلفة، والعوامل الثقافية. يقوم التحليل بتوجيه استراتيجيات مستهدفة لبناء القدرات، بهدف ضمان تجهيز القوى العاملة بشكل جيد للاستفادة من إمكانيات البناء الخالي من الهدر ونمذجة معلومات البناء.

تشير التحليلات الإحصائية باستخدام SPSS و smartpls إلى أن العقبات المتصورة تفسر جزءًا كبيرًا من التباين في التخطيط الاستراتيجي لتكامل البناء الخالي من الهدر و ونمذجة معلومات البناء. بالإضافة إلى ذلك، يُلاحظ تأثير كبير للفوائد المتوقعة على رغبة تنفيذ هذه التقنيات، حيث تلعب الفوائد المتصورة دورًا هاماً.

أهداف هذه الدراسة تتناول تحديد الحواجز والتحديات أمام تنفيذ نمذجة معلومات البناء والبناء الخالي من الهدر ، وتقييم جاهزية فلسطين لتنفيذ هذه التقنيات، وفحص تأثير التخطيط الاستراتيجي على تنفيذها، وتطوير إطار استراتيجي يربط بين التخطيط الاستراتيجي وتنفيذ التكنولوجيا.

كما انه تكمن أهمية هذا البحث في إمكانيته لتحول قطاع البناء في فلسطين من خلال تحسين كفاءة المشاريع، وتقليل الهدر، ورفع جودة البناء. تهدف الدراسة إلى معالجة التحديات، واقتراح الحلول، والاستفادة منها من قبل المهندسين والمقاولين والحكومات على حد سواء.