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Sustainable Construction Logistics: Analysing Challenges, Solutions, and Critical Success Factors in the Middle Eastern Private Sector

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- **DECLARATION**

I, Abdulla Subhi Najeeb Ruzieh, declare that this thesis was created using my work, except for quotations and citations, which have been properly acknowledged. I declare that no other individuals have submitted this work for research or publication.

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ABSTRACT

Purpose

The construction industry in the Middle East faces significant logistics challenges that negatively impact sustainability, leading to substantial waste, project delays, and cost overruns. However, there is limited understanding of inefficient logistics practices and their consequences within the region. Addressing these challenges is essential for minimising the environmental impact and enhancing competitive advantage. This study focuses on Saudi Arabia, the United Arab Emirates, Jordan, and Palestine, as these countries represent key construction hubs in the Middle East, each facing unique logistical challenges and opportunities for improvement. By examining the causes and consequences of logistics inefficiencies on sustainability within these countries, this study aims to develop a practical model that incorporates logistics challenges, solutions, and critical success factors towards enhancing sustainability.

Design/methodology/approach.

This study follows a sequential explanatory mixed-methods approach within deductive reasoning and a critical realist philosophy. This study begins with a literature review to establish a theoretical foundation and develop a conceptual model. This was followed by semi-structured interviews with 29 construction logistics experts to enhance their understanding, gain industry insights, and identify emerging issues. In the final phase, a quantitative survey was conducted with 422 industry stakeholders to test the proposed model and empirically validate the findings. This approach ensures a rigorous assessment of theoretical assumptions while capturing industry-specific challenges and solutions in construction logistics in the Middle East.

Findings

During the semi-structured interviews, the significance of logistics in Middle Eastern construction was emphasised and challenges were identified, including two unique to the region: sudden labour shortages and unstable conditions. This study revealed that contractors in the Middle East lag in adopting logistics solutions and critical success factors. The conceptual model, developed through literature and interviews, incorporated twenty-three logistics challenges, seven critical success factors, seventeen logistics solutions, and seven sustainability factors. This finding contributes

significantly to construction logistics research by using structural equation modelling (SEM) to examine and validate the theoretical model. The model aims to address logistics challenges by integrating solutions with key success factors to enhance sustainability in the Middle East's construction sector. SEM provides a robust statistical methodology for examining complex variable relationships and evaluating direct and indirect effects while accounting for multiple interactions. Moderation analysis revealed that project country, type, and location influenced relationships between logistics challenges, solutions, and sustainability, highlighting the need for tailored approaches. Additionally, logistics challenges mediate between logistics solutions, critical success factors, and sustainability, underscoring their critical roles in achieving sustainable outcomes in construction projects.

Research Limitations/Implications.

The focus of this research is to improve the logistics of construction, leaving aside the control aspects. A literature review was conducted using a trusted English database that covered publications from 2000 onwards. This study acknowledges that the synthesis of diverse research is challenging. The staff members of contractors in the private sector of the Middle East were targeted for primary data collection. Potential improvements can be achieved by including the perspectives of both clients and donors. In Saudi Arabia, the UAE, Jordan, and Palestine, questionnaires were given face-to-face, but data collection was constrained in Iraq, Syria, and Lebanon due to instability.

Originality/Contribution

This study contributes theoretically by integrating existing frameworks to analyse logistics challenges and their impact on sustainability, emphasising external and regional influences while incorporating solutions and critical success factors. It provides Middle Eastern construction firms with a tailored model to enhance operational sustainability, offering actionable strategies for contractors, engineers, and policymakers. Methodologically, it employs semi-structured interviews for context insights and uses structural equation modelling (SEM) to validate the framework, enabling an evidence-based approach to addressing logistics challenges and promoting sustainability.

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1. Chapter One – Introduction

1.1. Introduction

This chapter provides a review of the construction industry and the justification and significance of this research, including an investigation of the logistics challenges that adversely affect the sustainability of the construction industry in the Middle East. This chapter begins by providing a background for the construction industry, following logistics practices within the industry, and the related consequences. This overview assists in understanding the current logistics practices and challenges that lead to this research question. This chapter details the problem statement, research question, and thesis structure, highlighting the significance of the chapters in achieving their research aim and objectives.

1.2. Research Background

Logistics plays a pivotal role in managing and executing the construction supply chain, involving the planning, coordination, and management of materials, equipment, and workforce to ensure timely delivery and efficient resource allocation (Le et al., 2019; Luong Le and Fredriksson, 2021). Logistics accounts for 15–30 % of the total construction costs and influences 60–80 % of the overall project expenses (Saleh et al., 2023). However, the construction industry faces significant logistical challenges owing to its complex supply chains and multiple stakeholders, which directly affect project timelines, costs, and environmental sustainability (Janne and Rudberg, 2020). Fragmented supply chains involving various suppliers, manufacturers, and distributors make it difficult to coordinate timely deliveries, often leading to delays, material shortages, and oversupply (Dubois et al., 2019). Despite the critical role of logistics, the construction industry has historically underinvested in this area, lacking the necessary understanding and systems to effectively manage logistics (Sundquist et al., 2019; Sundquist et al., 2018). Consequently, construction lags other industries in leveraging logistics for competitive advantage (Saleh et al., 2023).

Sustainability is becoming an increasingly important aspect of construction logistics, driven by pressure to reduce environmental impacts (Janne and Rudberg, 2020). Sustainable logistics practices, such as optimising transportation routes, using eco-friendly materials, and minimising waste, are essential for modern projects. However, the construction industry has been slow to adopt sustainability measures (Le et al., 2021). For instance, a 2019 report revealed that the industry contributes 30 % of the total waste in the Middle East (Brusselaers et al., 2022), which is exacerbated by inefficient logistics practices (Hover Allen et al., 2019; Saleh et al., 2023). Poor logistics practices also lead to financial strain, with businesses experiencing cost overruns of up to 20 per unit, owing to inefficiencies (Guerlain et al., 2019). Low productivity is another critical issue, with reports from England indicating that poor logistics results in a 30 % loss of labour working time and inefficient machinery use (Department for Business Innovation and Skills, 2019). Improving logistics efficiency can help eliminate risks, reduce environmental impacts, and enhance competitive advantage (Behera et al., 2015).

To improve logistics, construction firms must professionalise their operations, focusing on managing information, acquiring resources, and organising materials and machinery according to project needs (Lundesjo, 2015; Luong Le et al., 2021; Katsaliaki et al., 2020). However, construction logistics remains underdeveloped compared to other industries, with challenges related to poor practices, management, and performance (Luong Le et al., 2021; Halldorsson and Vural, 2019). Key issues include low efficiency (Fredriksson et al., 2021), poor management (Ekeskar and Rudberg, 2020), and failure to treat logistics as a vital project component (Sundquist et al., 2018). Enhancing construction logistics performance requires eliminating non-value activities, such as improper labour and material management, and addressing inefficiencies in site practices (Formoso et al., 2002). This can help deliver projects within time, budget, and quality constraints (Donyavi and Flanagan, 2009). Several solutions have been proposed, including consolidation centres (CCs), just-in-time (JIT) principles, outsourcing to third-party logistics (TPL), and adopting the last planner system (LPS) (Hedlund and Telese, 2019; Fredriksson et al., 2021; Luong Le et al., 2021). Some businesses have reduced logistics costs by 20 % through these improvements (Ying et al., 2018).

However, these logistics initiatives often fail to deliver their full potential because of poor understanding and underutilisation (Fredriksson et al., 2021; Gadde and Hulthen, 2018). The industry's tendency to overlook logistics functions and their associated relationships has further hindered progress (Hedlund and Telese, 2019). More effort is needed to fully explore logistics challenges and adopt effective solutions to improve efficiency and sustainability (Fredriksson et al., 2021; Guerlain et al., 2019).

This research aims to explore the logistics challenges affecting sustainability in the construction industry. By gaining an in-depth understanding of logistics practices and identifying solutions and success factors, this study seeks to address these challenges and improve the logistics performance of the industry.

1.3. Problem Statement and Knowledge Gap

The construction industry in the Middle East faces substantial logistics challenges that hinder its sustainability efforts, particularly in the context of rapid urbanisation, large-scale projects, and harsh environmental conditions. Despite significant research on construction logistics, critical gaps that impede the development of sustainable and efficient practices in the region remain. One of the primary issues in existing research is the lack of integration between logistics planning and sustainability. Although numerous studies acknowledge the importance of logistics in achieving sustainability, they often treat it as a peripheral issue rather than a core component of construction project management (Ekeskar and Rudberg, 2020; Sundquist et al., 2018). Research tends to focus on solutions or critical success factors, such as third-party logistics (TPL) and lean approaches (Gadde and Hulthen, 2018; Saleh et al., 2023), but fails to provide a holistic view of the interrelated challenges. This narrow scope limits the ability of these solutions to address the full range of logistics challenges that impede sustainability.

Moreover, current research highlights logistical inefficiencies in construction, including the lack of integrated planning and coordination between stakeholders, inadequate waste management, and inefficient resource utilisation (Janne and Rudberg, 2020; Fredriksson et al., 2021). However, it does not delve deeply into the root causes of these inefficiencies. For instance, while Kotzab et al. (2015) emphasise the need for a clear logistics plan, there is little discussion on the underlying barriers preventing contractors from developing and implementing such plans. Similarly, the limited adoption of innovative logistics technologies has been mentioned (Le et al., 2021), but the reasons behind this reluctance, such as resistance to change, lack of technical knowledge, or inadequate infrastructure, have seldom been explored in depth. The literature also highlights the traditional reliance on non-renewable resources and outdated practices, which significantly increase the industry's environmental impact. While governmental reports and studies emphasize these challenges (Le et al., 2022; Taha, 2019), the proposed solutions, such as green building technologies and waste reduction initiatives, are often implemented in isolation, without fully addressing broader logistics issues. The fragmented nature of these efforts underscores the need for a more integrated systems-level approach that considers logistics as a central component of sustainable construction.

Another significant gap in the literature is the lack of focus on the Middle East's unique context. Most existing research is based on global case studies or focuses on urban projects in developed regions, with little consideration given to the logistical challenges posed by the Middle East's climate, economic conditions, and urbanisation patterns (Brusselaers et al., 2022). This oversight is particularly important given the region's reliance on large-scale infrastructure projects, which require more robust logistics systems to ensure sustainability. Furthermore, research often emphasises the need for improved logistics practices to reduce costs and improve productivity (Gebauer et al., 2013; Hedlund and Telese, 2019), but fails to explore the link between logistics inefficiencies and broader sustainability outcomes. For example, delays caused by poor logistics not only lead to cost overruns but also affect project timelines, customer satisfaction, and the overall reputation of contractors (Le et al., 2022). Thus, the literature benefits from a deeper exploration of how logistics inefficiencies contribute to these negative outcomes and how addressing them could lead to more sustainable construction practices that enhance both economic and social benefits.

Thus, this study is justified by several critical gaps in the existing literature that hinder the development of sustainable logistics practices in the Middle East’s construction industry. First, there is a pressing need for an integrated approach to address logistics challenges, particularly in the context of sustainability. The current research focuses too narrowly on solutions without considering the complex interplay of factors that contribute to logistics inefficiencies. By exploring the root causes of these efficiencies, this study aims to provide a more nuanced understanding of how logistics impact sustainability and what can be done to improve practices in the region. Second, the existing literature lacks sufficient attention to the unique logistical challenges of the Middle East. This study fills this gap by considering the environmental, economic, and social conditions that influence regional logistics. In doing so, it offers tailored solutions that are more likely to succeed in the local context.

Finally, this research contributes to the development of a model for improving construction logistics. By incorporating logistics solutions and critical success factors, it will offer an organised approach to addressing the logistical challenges in the Middle East. This model provides construction contractors with practical tools and strategies to enhance sustainability, improve efficiency, and maintain competitive advantage. The proposed model is constructed through a multi-stage approach that integrates theoretical knowledge and empirical evidence, thereby significantly enhancing research on construction logistics and sustainability in the Middle East. The process commences with a thorough literature review to identify the principal logistics challenges, solutions, and critical success factors (CSFs) pertinent to the construction sector. This foundational knowledge was subsequently supplemented with qualitative data obtained from expert interviews, offering practical, region-perspectives on the logistical obstacles encountered by construction managers in the Middle East. To further enhance the framework, quantitative data were collected via a structured survey from participants across the region. Structural equation modelling (SEM) will be employed to statistically validate the framework, ensuring its accurate representation of real-world logistics operations and sustainability in construction. The value of the model is derived from its thorough context, and empirically validated nature. By synthesising logistics challenges, solutions, and CSFs, this study offers a proper tool uniquely suited to the logistical intricacies of the Middle East. The utilisation of SEM adds analytical rigour, enabling the model to be tested for reliability and precision. Consequently, the model provides actionable insights for construction managers, assisting them in addressing logistics challenges, optimising operations, and improving sustainability, thus making both practical and academic contributions to the field.

1.4. Research Question

According to a previous explanation, the construction sector in the Middle East faces several logistics challenges that adversely impact sustainability. Implementing critical success factors (initiatives) and targeted logistics solutions can effectively address these challenges. Therefore, two research questions were developed to improve the logistics processes in construction.

RQ1: Which logistics challenges in construction in the Middle East affect sustainability?

RQ2: How to address logistics challenges using logistics solutions and critical success factors (Initiatives).

1.5. Research Aim and Objectives

Against these two research questions, this research aims to develop a practical model for addressing logistics challenges in construction in the Middle East using logistics initiatives to enhance sustainability.

Accordingly, the following objectives will assist in achieving this aim:

1. To investigate logistics processes and challenges to identify their impact on sustainability
2. Exploring and understanding construction logistics processes within the context of the Middle East, including challenges and logistics initiatives
3. To identify logistics solutions and critical success factors that could be used to address logistics challenges.
4. Developing a conceptual model for addressing logistics challenges in the Middle East using logistics initiatives.
5. Formulate a practical model that demonstrates actionable insights, practical solutions, and critical success factors to promote sustainable development in the Middle Eastern construction industry by addressing logistics challenges.

1.6. Research Scope

The construction industry plays a crucial role in economic development but faces significant logistical challenges that impact project timelines, costs, and sustainability. This research aims to address logistics challenges within the Middle East's construction industry by exploring effective logistics solutions and identifying critical success factors (CSFs) to enhance sustainability. The focus on the Middle East is due to its unique characteristics, such as extreme climate conditions, emerging regulatory complexities, and frequent supply chain disruptions. Key objectives include identifying the primary logistics challenges in large-scale construction projects, assessing innovative logistics solutions, such as just-in-time (JIT) delivery and lean operations, and determining the critical success factors for implementation. Additionally, this study investigates how these logistics solutions and success factors contribute to sustainable construction practices. This research will develop a model tailored to the Middle Eastern context through literature reviews, interviews, surveys, and data analysis. This model provides actionable insights and strategies for industry professionals and policymakers to improve logistics efficiency and sustainability in regional construction projects.

Nevertheless, the scope of this research is confined to large-scale private-sector construction projects. Smaller construction firms and government-led projects are excluded from the analysis, as these sectors may encounter different logistical and operational dynamics that lie beyond the purview of this study. Furthermore, the research will not address logistical issues pertinent to niche construction markets or highly specialised projects. The objective is to focus on larger commercial and industrial projects that exert a significant regional impact, thereby ensuring that the findings and recommendations are pertinent to major stakeholders in the Middle East construction industry.

1.7. The Research Contribution

This research is expected to contribute to the body of knowledge and the construction industry as follows:

Theoretical Contribution

This research enhances the comprehension of sustainability in construction logistics by merging current logistics theories and frameworks. It offers new perspectives by identifying logistics challenges and illustrating their negative impacts on sustainability. This contributes to theoretical models of construction logistics by highlighting external and regional influences, thereby broadening the understanding of how logistics challenges affect sustainable outcomes. Moreover, this research gives the construction industry a foundation on which to build future research in the fields of construction logistics

Practical Contribution

The proposed model offers construction firms in the Middle East a practical tool for enhancing operational sustainability. It outlines the key logistics challenges, critical success factors, and solutions tailored to regional issues. By providing actionable steps for the Middle Eastern context, the model equips contractors, engineers, and policymakers with strategies to address logistical challenges and improve sustainability.

This contribution is immediately applicable to shaping better logistics practices and fostering more sustainable construction projects in the region.

Methodological Contribution

The research utilises semi-structured interviews with regional experts to gather context-specific insights and applies Structural Equation Modelling (SEM) to quantitatively test and validate the proposed model across a broad stakeholder sample. SEM is a powerful methodology as it assesses causal relationships among multiple variables, providing an understanding of how logistics challenges impact sustainability by testing direct effects as well as mediating and moderating factors. This approach is novel in construction logistics, particularly in the Middle East, where quantitative methodologies such as SEM are underutilised.

1.8. Thesis Structure

Figure 1-1 illustrates the thesis along with the research stages. The structure of this thesis follows a logical progression that ensures a rigorous and coherent approach to investigating logistics challenges in the Middle East construction industry. The sequence of chapters is deliberately designed to align with established research methodologies while allowing for an iterative refinement of the study's framework. This approach ensures that theoretical insights, empirical validation, and practical implications are systematically developed and presented. This thesis begins with the research problem, which forms the foundation of the study. This chapter outlines the key challenges in construction logistics, identifies gaps in the existing knowledge, and defines the objectives and research questions of this study. This stage is critical because it frames the investigation within both practical and theoretical contexts, ensuring that the study addresses a significant and relevant issue. Following the research problem, the methodology chapter is introduced. The placement of this chapter early in the thesis provides a structured roadmap for the study, detailing the research design, data collection techniques, and analytical methods used. Presenting the methodology at this stage ensures that the research process is transparent and robust before engaging in a detailed review of existing literature. Additionally, this approach ensures that the research design is structured around the study’s objectives and problem statement, rather than being overly shaped by existing studies.

The methodology is structured to incorporate a sequential mixed-methods approach, integrating qualitative insights from semi-structured interviews and quantitative validation using Structural Equation Modelling (SEM). By establishing the research design upfront, the study maintains clarity in its approach while allowing subsequent chapters to build upon this methodological foundation. The literature review chapter follows the methodology, providing a theoretical background for the study. This chapter critically examines existing research on construction logistics, identifying key logistics challenges, solutions, critical success factors, and sustainability considerations. The literature review serves two primary purposes: (1) it contextualises the study within prior research, ensuring that the investigation is grounded in established theories and models, and (2) it informs the conceptual model by identifying relevant constructs and relationships. While the methodology is established beforehand, the literature review plays a crucial role in refining the theoretical framework and ensuring that the study's hypotheses and model development are well-supported by existing knowledge. Next, semi-structured interviews are conducted to complement the insights gained from the literature. These interviews with industry experts provide practical perspectives on logistics challenges, solutions, and success factors. The qualitative findings from these interviews are instrumental in shaping the conceptual model, ensuring that it reflects real-world conditions and industry needs. By integrating expert input, the study enhances the validity and applicability of the proposed model, bridging the gap between theory and practice. Building on the literature review and qualitative findings, the conceptual model is then developed. This model represents the hypothesised relationships among logistics challenges, solutions, critical success factors, and sustainability factors. The conceptual model is a crucial output of the study, as it synthesises insights from the literature and interviews to propose a structured framework for understanding logistics dynamics in the construction industry. To validate the conceptual model, the study then moves to quantitative validation, employing Structural Equation Modelling (SEM). This stage involves data collection through a structured questionnaire, followed by statistical analysis to test the relationships between the variables. SEM is chosen due to its ability to assess complex relationships and validate theoretical constructs with empirical data. This validation ensures that the proposed model is statistically sound and generalisable in the context of Middle Eastern construction logistics. Finally, the study culminates in the proposed practical model based on SEM findings. This final framework translates the validated conceptual model into actionable strategies for industry practitioners. The practical model provides guidance on how construction companies can mitigate logistics challenges through effective solutions and critical success factors, ensuring that the research has tangible applications. The thesis concludes with a synthesis of key findings, contributions to both academic knowledge and industry practice, and recommendations for future research. Figure 1-1 provides a view of the research plan, and Figure 1-2 depicts the research process.

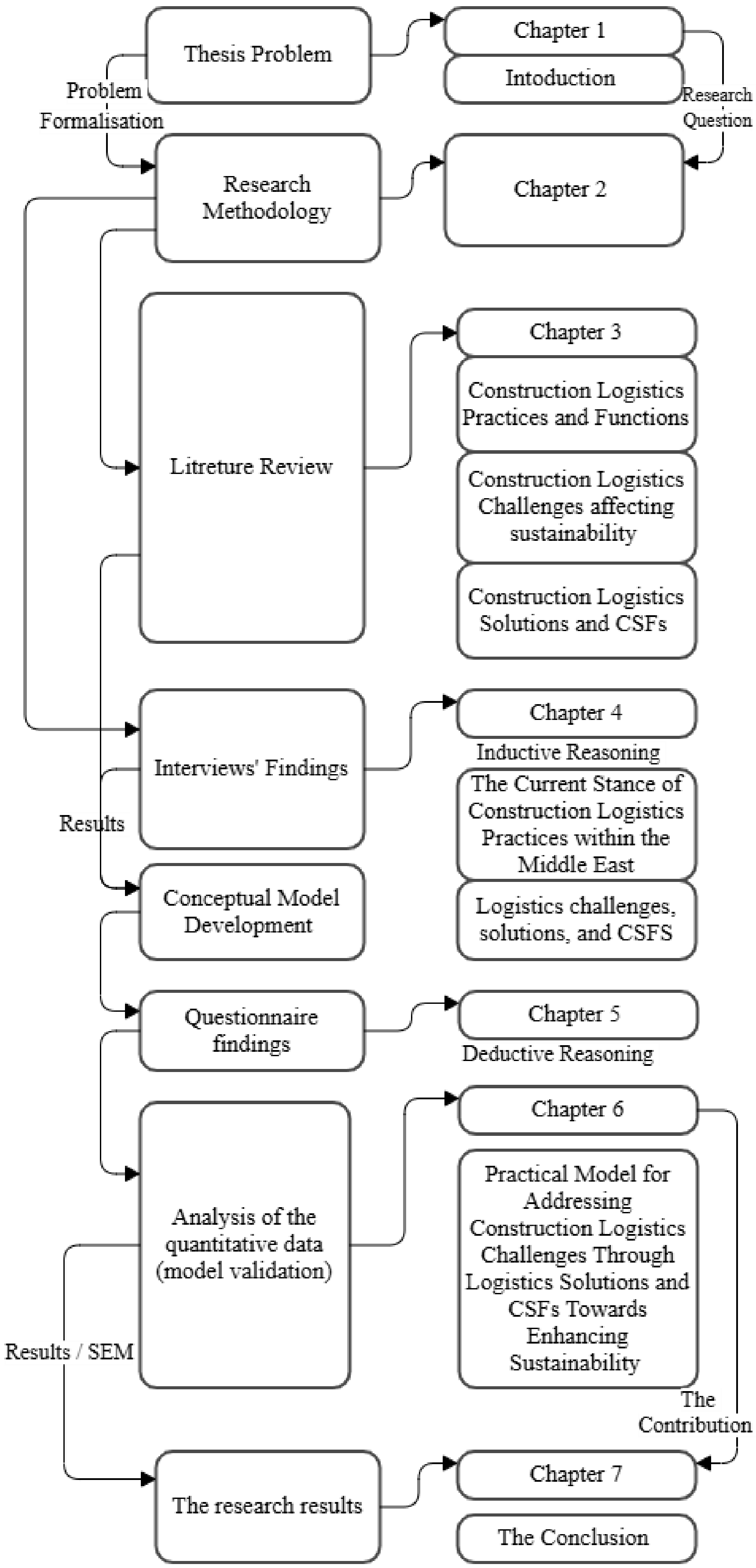

Figure 1-1 Research steps with the related chapters (Created by the Author, 2025)

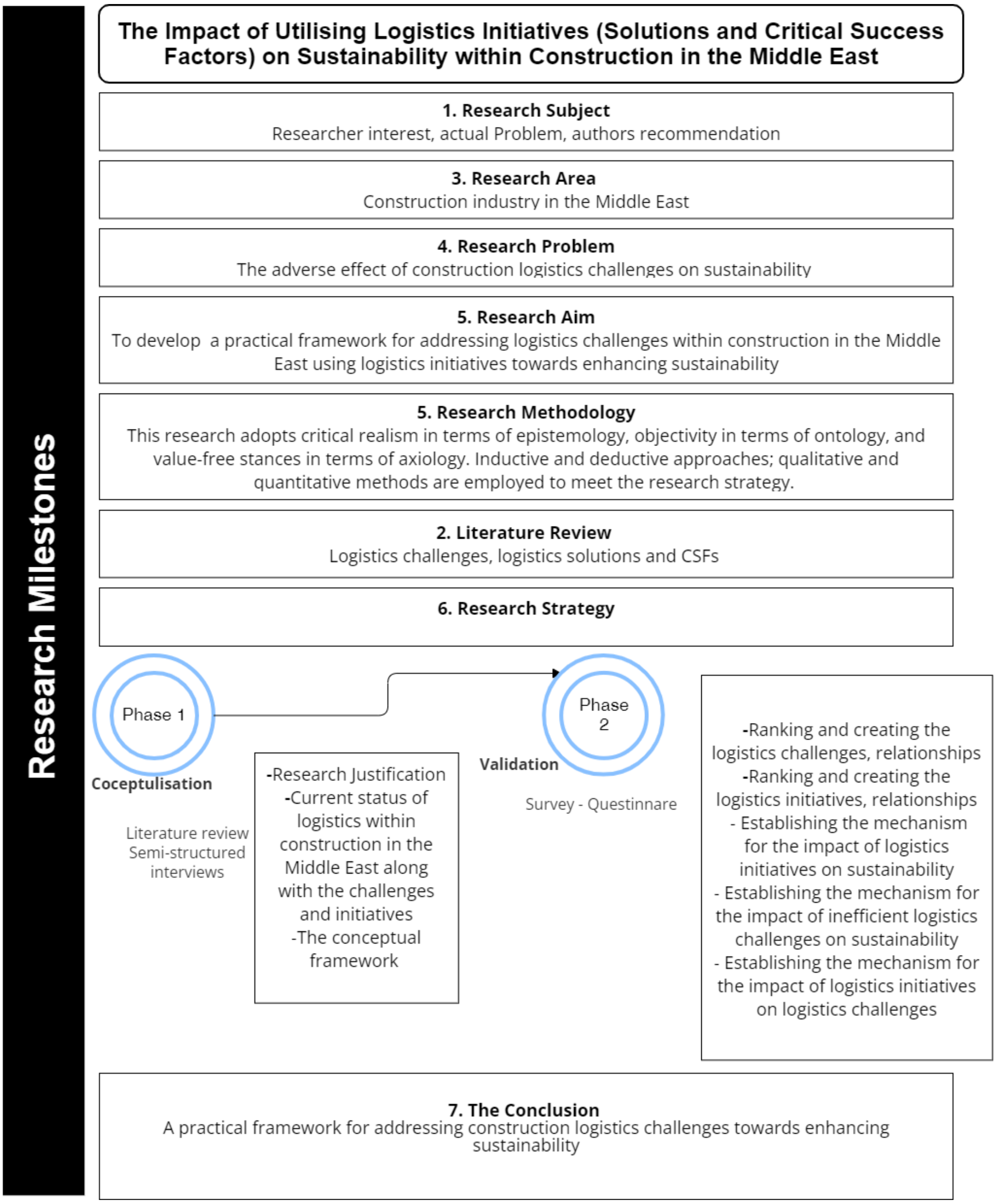

Figure 1-2 The Research Process (Created by the Author, 2025)

2. Chapter Two: Methodology

2.1. Introduction

This chapter begins by identifying and justifying the position of this research as integrated qualitative-quantitative research. Mixed methods are employed to explore the complex features of construction logistics, including enhancing the understanding and facilitating the validation of the proposed outcome. Next, it defines the research design, including the proposed approach for achieving the research aim and objectives. The strategy is then discussed to justify the sampling procedures and respondents' selection. Subsequently, data collection techniques are outlined to address the research objectives. Finally, it identifies and justifies the adopted procedures for analysing and evaluating the data regarding addressing construction logistics challenges towards enhancing sustainability within the Middle East.

2.2. Research Design

Bryman and Bell (2011) suggest that a research design provides overall guidance and a model for collecting and analysing data in the study. To answer the research questions, it is crucial to connect the theory with the collected empirical data (Nachmias and Nachmias, 2008). Selecting a suitable research design affects the type of data collection (Hair et al., 2010). Additionally, designing the research demands several decisions, including the purpose of the study, location, time horizon, and data analysis (Sekaran and Bougie, 2011).

As depicted in Figure 2-1, this study's research design, which examines how logistics initiatives affect sustainability in the Middle Eastern construction sector, commences with the selection of critical realism as its philosophical foundation. The selection of critical realism as a philosophical approach is based on its suitability for addressing the intricate nature of logistics and sustainability in the construction industry. This perspective recognises that while real-world phenomena, such as logistics practices and sustainability outcomes, exist independently of human perception, our comprehension of them is influenced by social and contextual factors. This philosophical stance is particularly appropriate for examining the Middle Eastern context, where construction logistics practices are shaped by socioeconomic, cultural, and regulatory elements. By employing critical realism, researchers can investigate both observable events and underlying mechanisms, offering a thorough understanding of how logistics solutions and critical success factors impact sustainability in the construction sector.

This research adopts a deductive reasoning approach, beginning with established theories in construction logistics and sustainability and exploring any emergent issues within the context of the Middle East. The study starts with a literature review to formulate hypotheses based on existing theoretical frameworks. These hypotheses are then evaluated through data collection and analysis, allowing for validation, refinement, or potential modification of the initial theoretical assumptions. However, the qualitative approach is incorporated to enhance understanding and explore whether additional issues exist beyond those identified in the literature. This methodology ensures that conclusions are derived logically from prior knowledge while accounting for regional variations, thereby improving the applicability of established theories in Middle Eastern construction logistics. Thus, the study's methodology integrates qualitative and quantitative approaches to provide a thorough perspective, employing a sequential explanatory mixed methods design. Initially, in-depth qualitative data were obtained through semi-structured interviews with Middle Eastern construction industry experts, logistics managers, and policymakers. These interviews explored region-specific logistics challenges, solutions, critical success factors (CSFs), and sustainability initiatives, informing the development of a conceptual framework. Semi-structured interviews were selected for their flexibility in probing practices while maintaining a broad investigative structure.

Following the qualitative phase, a quantitative survey was administered to a larger sample of construction professionals to validate the developed framework. This sequential approach allowed the study to first explore logistics-related issues in depth and then test the findings on a broader scale. The questionnaire assessed the perceived effectiveness and impact of various logistics solutions and CSFs on sustainability, utilising a structured format that is amenable to statistical analysis. This mixed-methods approach, grounded in critical realism, ensures that the study not only elucidates nuanced contextual factors influencing logistics and sustainability (through qualitative data) but also examines the generalisability and robustness of these factors (through quantitative data). By integrating qualitative insights into quantitative validation, the research delivers a detailed and empirically valid investigation of how logistics initiatives impact sustainability in the Middle Eastern construction industry.

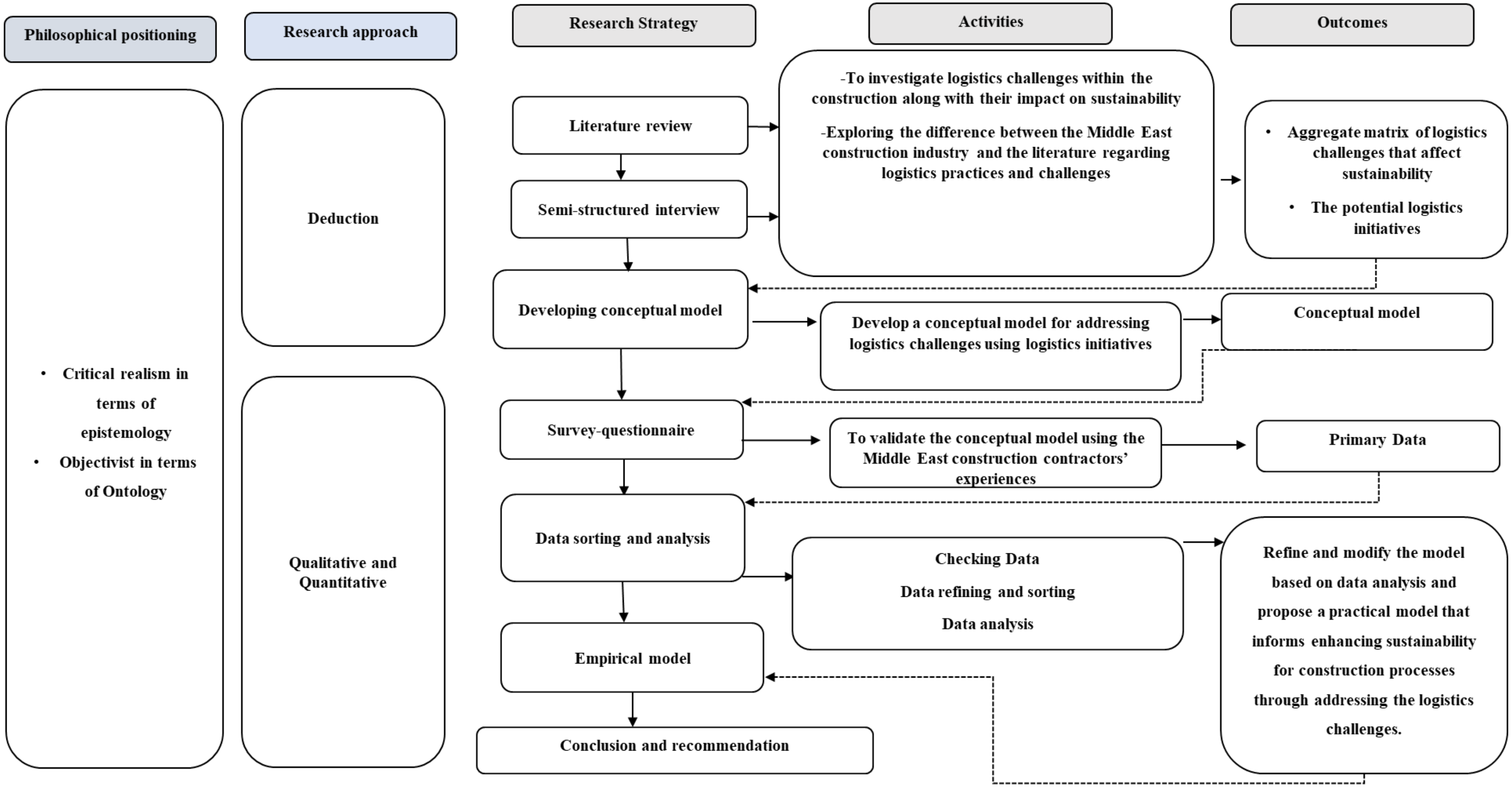

Figure 2-1 The research design (Created by the Author, 2025)

2.3. Research Philosophy

Research philosophy is systematically related to knowledge development (Downward and Mearman, 2007). Ontology and epistemology are regarded as part of this, and their assumptions assist the researcher in establishing consistency between the research strategy and underlying philosophy (Kaushik and Walsh, 2019). Ontology assumptions are related to the nature of reality and how it would be constructed. This assists the researcher in shaping the perception of the object to be investigated (Timans et al., 2019). Epistemological assumptions concern obtaining, presenting, and communicating knowledge to others (Allana and Clark, 2018). Thus, ontology is related to reality, whereas epistemology is related to knowledge. Vidalakis et al. (2011) claimed four philosophical stances for construction logistics: positivism, interpretivism, critical realism, and pragmatism. First, ontological positivism embraces objective reality and the application of the scientific method to explore and identify the relationships among variables. This stance allows existing theories or frameworks to be tested and validated using quantitative techniques including a representative sample (Allana and Clark, 2018). Thus, this stance enhances understanding and provides a trustworthy outcome, as it relies on big quantifiable data but fails to explain the underlying causes of events (Kaushik and Walsh, 2019). Second, interpretivism deals with reality as a subject of people's behaviour and knowledge constructed through interactions. Thus, knowledge is developed by the meaning provided by people by applying a qualitative approach (Sobh and Perry, 2006). Interpretivism rejects the notion that positivists' knowledge is objective and tangible and seeks to investigate and understand social reality from participants' perspectives. It embraces developing a rich and deep understanding, but the generalisation of the outcome seems limited as it relies heavily on respondents' views (Wynn and Williams, 2012). Third, critical realism is built on the idea that reality is formed historically, and individuals construct and reconstruct it. It claims to observe the phenomenon objectively while allowing the researcher's observations and surrounding conditions to shape reality (McEvoy and Richards, 2006). Through critical realism, positivism, and interpretivism, assumptions are acknowledged, establishing an alternative philosophy for the development of knowledge (Kazi, 2003). Critical realism supports the assumption of positivism for the existence of an independent construct that impacts the behaviour of individuals (Kazi, 2003). Additionally, it embraces interpretivism by allowing subject knowledge to form reality. This approach is distinguished from interpretivism and positivism in that it perceives the world as an open system that includes structure, mechanisms, and context (Schiller, 2016). Finally, pragmatic methodological claims that concepts and theories are appropriate if they support actions. Thus, reality concerns pragmatists as practical impacts theories or ideas, and knowledge is valued for supporting actions to be implemented well. However, considering pragmatism in logistics may generate a thrustless outcome, as it relies heavily on relativism and short-term practical issues for developing knowledge while overlooking the existence of fixed principles and concepts (Danermark et al., 2002; Sayer, 1992; Sundquist et al., 2018).

Based on the above explanation and the following investigation of the research conducted on construction logistics, it is concluded that the majority of the research adopted interpretivism facilitated by the qualitative case study approach to understanding logistics aspects and processes relying on case studies (Hedlund and Telese, 2019; Janne and Fredriksson (2021). Alternatively, case studies can be used to examine the introduction of logistics solutions or critical success factors to enhance performance (Guerlain et al. 2019; Janne and Rudberg, 2020). Accordingly, the findings were based on the individual's perspectives with limited generalisation and poor theoretical explanations. Therefore, this research favours adopting critical realism incorporating objective ontology and relative epistemology to achieve the research objectives, including illustrating the mechanism that generates the outcome. This approach facilitates an understanding of the complex features of logistics within the construction and provides a clear insight through a structured approach by explaining the observation through the literature. Logistics within construction is regarded as an objective entity, so this philosophy employs scientific methods to create relationships and define the cause of challenges. Thus, it is critical to inform this objectivity and capture the current issues within construction logistics towards developing and testing hypotheses intended to propose a practical model for addressing logistics challenges. Finally, research in logistics is drying for a generalisation that requires an objective paradigm, which could be achieved by critical realism.

Critical realism is particularly suited to this study, as it allows for exploring underlying mechanisms and causal relationships in the complex, dynamic environment of construction logistics. This philosophical stance supports the investigation of how logistics challenges impact sustainability by considering observable events and underlying structures that may not be immediately apparent. Initially, logistics challenges, such as delays in material deliveries, are identified through data collection, including literature review and interviews. However, critical realism advocates moving beyond these empirical observations to explore the underlying structures. This involves identifying the causes of logistics challenges, such as a lack of expertise and the neglect of logistics functions within construction projects. By examining these factors, a better understanding of their impact on logistics can be developed. Furthermore, the critical realist concept guides the uncovering of deeper mechanisms driving these challenges, such as the poor adoption of logistics solutions, critical success factors, and deficiencies in environmental awareness within the industry. Based on these insights, a model was developed that integrates challenges, logistics solutions, critical success factors, and sustainability factors. This layered approach not only tackles immediate logistics challenges but also promotes long-term, systemic improvements towards sustainability in construction logistics.

2.4. The Research Cycle for Knowledge Development

The ontological stance for critical realism perceives reality at a stratified level, as illustrated in Figure 2-2 (McEvoy and Richards, 2006). This includes the empirical, actual, and real. The empirical shape is part of the actual and is related to information obtained from individuals' perceptions and experiences. The actual represents part of the fundamental actions that occurred, and relevant people might not experience those actions. Finally, reality is expressed by establishing the mechanism of the construct by identifying causal relationships among variables along with hidden causes (Eastwood et al., 2021).

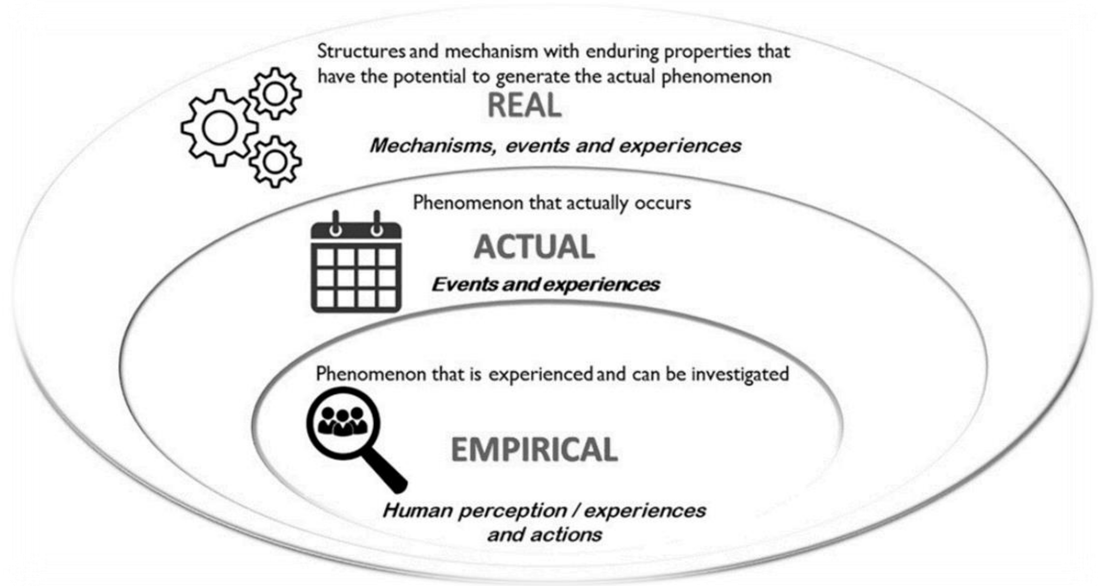

Figure 2-2 Ontological Reality of Critical Realism - The three levels (McEvoy and Richards, 2006).

Scientific approaches are employed through critical realism to develop theories and explanatory models to capture reality (Luong Le et al., 2021). Sayer (2001) proposed two approaches to knowledge development based on the empirical richness of the literature. Emergent approach for exploring theories that lack corresponding empirical application in research. It is started by empirical observation towards the development of theoretical understanding (Manzano, 2016). Conversely, the confirmatory approach started with theory and moved to empirical studies to explore differences, obtain insight into experience, and perform hypothetical testing (Manzano, 2016). The confirmatory approach includes three stages: theory gleaning, refinement, and consolidation (Manzano, 2016). A realist evaluation adopts a confirmatory approach, as its stages offer a robust methodological approach through deduction reasoning comprising theories besides the available observable evidence (Mukumbang et al., 2016).

I. The Initial Phase (Cleaning) / Emergent

This phase assists in developing the initial theorisation for this research. This could be enhanced by identifying the variables and possible relationships between them. Thus, a literature review (SLR) was conducted to identify the current stance of construction logistics, including challenges. The literature is then extended to explore theories and frameworks that can be used to improve performance. Several theories and frameworks were identified and integrated: network theory, resource-based, The A-S-I/A-S-I-F framework, and the green logistics framework. Hence, this assists in identifying critical success factors and solutions. Consequently, the literature data are sorted and analysed to assist in developing the initial conceptual framework.

II. Refining Phase (Constructing)

It is vital to introduce proper data collection procedures to support the development of the framework. This phase is related to theory building and development using multiple adequate research methods. The aspects and variables identified in the initial stage provide the basis for the development of the conceptual model by incorporating the data obtained from the literature with empirical data. This includes utilising semi-structured interviews to enhance understanding, explore additional challenges and practices within the context (The Middle East), and provide further justification for the research.

III. Consolidation Phase (Confirmatory)

This phase is regarded as a second-refining phase towards proposing a fine-tuning model (Danermark et al., 2002). This phase required robust data collection and analytical procedures to obtain reliable and trustworthy results. This was achieved using a survey questionnaire to test and validate the proposed conceptual framework. Then, quantitative analysis methods (discussed in section 2.6) facilitated through Structural Equation Modelling are employed to facilitate archiving validity, reliability, and the best representation of findings (Eastwood et al., 2021). This assists in developing a practical model for enhancing the sustainability of construction logistics processes. However, this process of achieving the research aim informs deduction reasoning (Danermark et al., 2002; Mukumbang et al., 2018). Figure 2-3 illustrates the knowledge development process through the cycle of critical realism for this research.

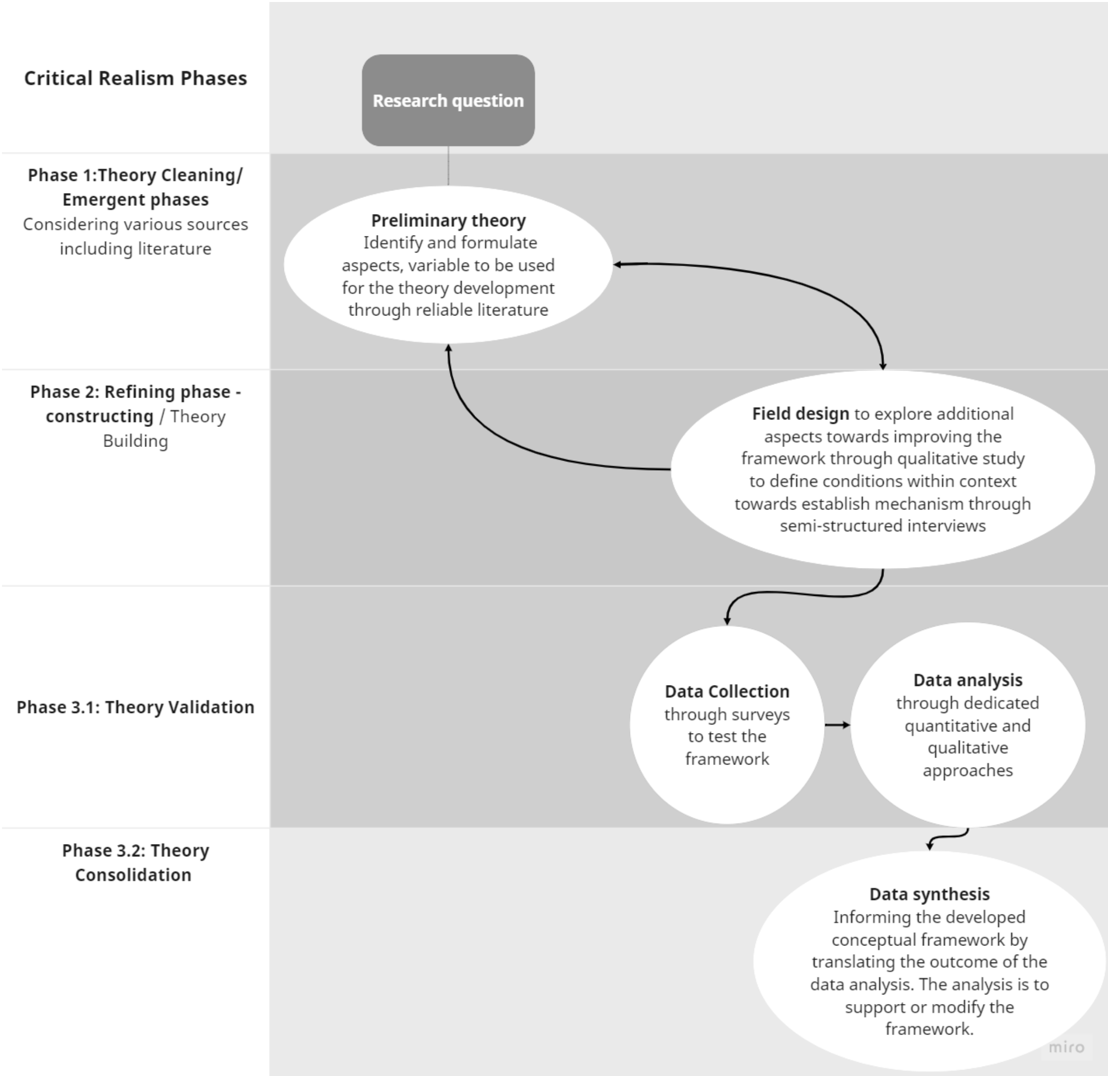

Figure 2-3 illustrates the process of knowledge development through the cycle of critical realism for this research (Mukumbang et al., 2018).

2.5. Deduction Theorizing

Various forms of reasoning and evaluation have been proposed in research, including deduction, induction, and abduction. A deductive approach involves testing established theories or principles under controlled conditions to confirm or refine their applicability (Danermark et al., 2002). Deduction begins with a theoretical framework and systematically applies it to empirical data, ensuring that conclusions logically follow from prior knowledge. In contrast, an inductive approach generates theory through observations or investigations of specific issues (Mukumbang et al., 2018). While abduction incorporates elements of both deduction and induction to explore hidden causes and develop new theoretical insights, the deductive approach remains focused on verifying existing theories rather than generating new ones (Danermark et al., 2002).

Unlike abduction, which begins with empirical findings and seeks plausible theoretical explanations, deduction starts with theory and assesses its validity through empirical testing (Lukka and Modell, 2010). This approach ensures that research findings are grounded in established principles while thoroughly evaluating their applicability in different contexts.

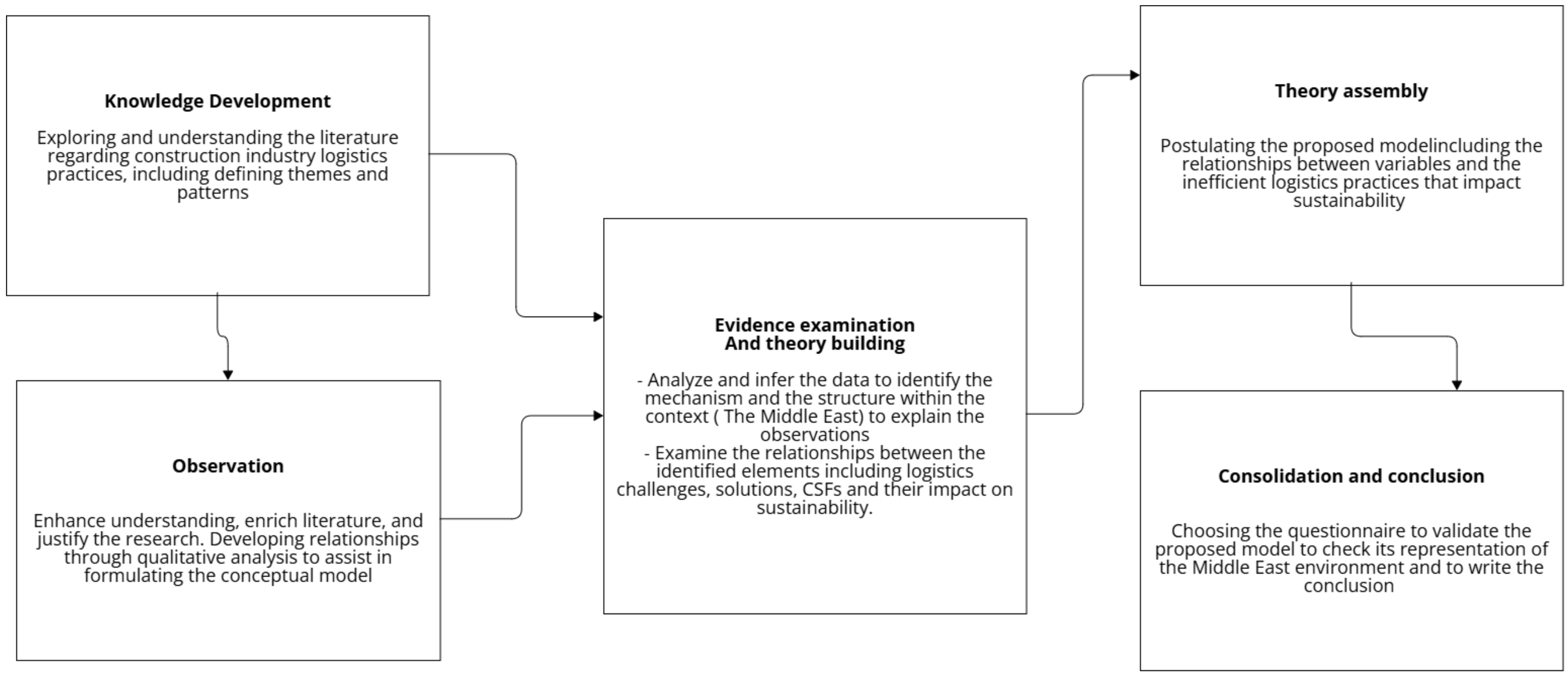

Figure 2-4 The process of knowledge development for this research (Created by the Author, 2025)

A deductive approach is employed in this research, commencing with an established theoretical framework and systematically testing its applicability to logistics and sustainability in the Middle East construction industry. Unlike abduction, which seeks to explore phenomena through individual case examinations without necessarily testing a predefined theory (Thomas, 2010), deduction follows a structured process where hypotheses derived from existing literature are tested against empirical data. This ensures that conclusions are logically drawn from prior knowledge, providing a rigorous evaluation of theoretical constructs (Haig, 2005).

Research on logistics and supply chains, particularly within an ontological critical realism framework, necessitates a multi-method approach to systematically assess interactions among key process elements, including relationships, personnel, and information (Saleh et al., 2023). To achieve this, the study employs both a literature review and semi-structured interviews to identify logistics challenges affecting sustainability, as well as potential logistics solutions and critical success factors (CSFs). This structured approach ensures that findings are grounded in theoretical foundations while allowing empirical insights to refine and validate existing models. By categorising logistics challenges and conceptualising solutions through a sustainable green logistics model, this study systematically examines how logistics functions contribute to inefficiencies. The theoretical underpinnings of logistics management are further reinforced by established management theories (see Chapter 3), which provide valuable principles for adopting CSFs to address challenges and enhance sustainability. This deductive approach enables a structured correlation between logistics challenges and sustainability, determining how logistics solutions and CSFs can mitigate inefficiencies. Following this stage, hypotheses are developed based on the conceptual model, allowing for empirical testing and validation. The results determine whether variables are accepted or rejected, thereby refining the theoretical framework and enhancing its practical applicability. This structured deductive process ensures that the final framework is both theoretically sound and practically relevant, providing a validated approach to improving construction logistics and sustainability in the Middle East

Qualitative Method

The qualitative approach, utilising semi-structured interviews, provides in-depth insights into logistics challenges, solutions, critical success factors (CSFs), and sustainability constructs. This method addresses the research questions by extending beyond superficial observations to offer a thorough understanding of both logistics challenges and their causes, as well as actionable pathways to sustainability. Qualitative methods are employed in critical realism to enhance knowledge and obtain significant information on a research subject. They elicit findings related to a phenomenon that requires examination within its contexts and conditions. Kaplan and Maxwell (2005) posited that qualitative methods become significant when the available knowledge does not provide detailed information about the phenomenon within its dynamic context. Consequently, qualitative methods facilitate capturing the complexity of construction–logistics challenges. They enable an in-depth exploration of different stakeholders' experiences (e.g. contractors, developers, and engineers) and their perceptions of logistics challenges within their operations. The interviews enabled the exploration of the lived experiences of those in the construction industry in the Middle East. However, qualitative strategies would provide additional justification for the research, capturing the narrative of logistics practices within construction in The Middle East. Thus, they facilitate defining the underlying issues and providing significant meaning that shapes causalities. The qualitative methods adopted for this study were as follows:

Literature Review

The literature review seems to be a critical part of this research for several reasons. First, the main parameters of a topic must be captured. Second, determine the available recent knowledge. Third, define any issues that new research may consider for further investigation (Blumberg et al., 2005). Various approaches have been proposed to conduct literature reviews. The choice of methodology depends on the objectives of the review, with different types being suitable for specific goals. These methods can be qualitative, quantitative, or a combination of both, depending on the stage of the review process. The main categories include systematic, semi-systematic, and integrative reviews. Each of these review techniques can offer significant support in addressing specific research questions when applied in the appropriate context (Liberati et al., 2009).

This research employs the systematic literature review (SLR) methodology to identify all empirical evidence that meets the pre-specified inclusion criteria to address the research question (Liberati et al., 2009). This approach encompasses an examination of logistics challenges, solutions, and critical success factors within the construction industry for several reasons. First, the construction industry is inherently complex, necessitating the coordination of various resources such as materials, equipment, and personnel across multiple sites and timelines. This complexity requires an understanding of logistics management to enhance project efficiency. An SLR provides a structured and proper analysis of existing research, facilitating the identification of common logistics challenges and potential gaps in the current practice. Furthermore, research on construction logistics is often fragmented across multiple disciplines, including supply chain management, project management, and transportation. An SLR aids in synthesising these diverse studies, offering a cohesive understanding of the logistics landscape. Construction logistics solutions are evolving with advancements in digital technologies and sustainable practices. By reviewing these solutions, an SLR identifies effective strategies that have been empirically validated. Critical success factors (CSFs) are vital to sustainability and project success, and an SLR identifies these factors across different contexts, providing valuable insights for this research. Moreover, an SLR helps uncover knowledge gaps and conflicting findings in the literature, directing future research towards unresolved issues. Thus, an SLR is essential for developing theoretical knowledge and practical solutions in this research. This research adopted the process suggested by Liberati et al. (2009) and Wong et al. (2013) in conducting the literature review including four phases illustrated in Figure 2-5.

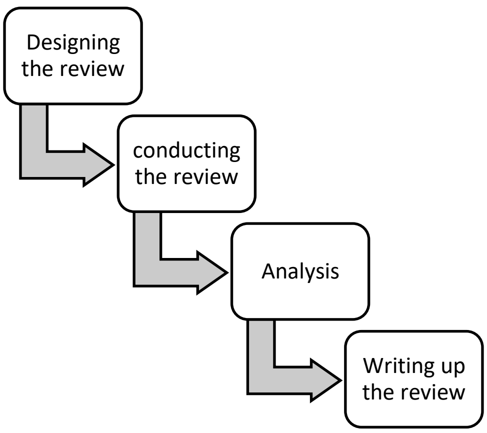

Figure 2-5 The process of conducting a literature review (Created by the Author, 2025)

Phase 1: Designing the Review

Based on the research questions to investigate and synthesize evidence of the effect of logistics challenges on sustainability and how to address them through logistics solutions and CSFS on sustainability a review approach is used; systematic review approach is used. A search strategy for identifying relevant literature was developed. This includes selecting search terms and appropriate databases and deciding on the inclusion and exclusion criteria. This phase consisted of both automatic and manual searches. Both search techniques were used to explore the review content, including additional studies that could provide broader aspects. Reliable databases, including Web of Science, ScienceDirect, and Scopus, were used as the fundamental sources for this study. The listed databases were selected because they are deemed most relevant and offer complete information for the field of logistics (Janne and Fredriksson, 2019; Sundquist et al., 2018). However, to establish boundaries in this study, keywords of interest were searched in the titles and abstracts. Furthermore, a combination of keywords was used in the selected databases to match the identified keywords with published research and relevant literature. The objective was to identify as many relevant articles as possible from the databases. This research focuses on addressing logistics challenges within construction using logistics solutions and critical success factors to enhance sustainability. Thus, identifying relevant keywords include primary keywords such as "construction logistics," "sustainable construction logistics," "construction logistics challenges," "logistics solutions in construction," and "critical success factors in construction logistics." These terms encompass the core aspects of this study. Then, secondary keywords were identified, including "construction supply chain solutions," "green logistics in construction," "just-in-time delivery in construction," "prefabrication in construction logistics," "key success factors in construction logistics," and "sustainable supply chain in construction." Additionally, combining keywords into phrases such as "sustainable construction logistics solutions”, "critical success factors for sustainable construction logistics”, "logistics challenges and solutions in construction”, "enhancing sustainability through construction logistics”, and "construction logistics optimisation for sustainability" helps narrow the focus and improve the relevance of search results. Utilising these keywords in academic databases, structuring the research documents around them, and continuously refining the list based on new findings. A forward and backward search approach was used to trace the collected references for the primary literature. This boosted the fact that the review achieved its aims and answered the proposed research question. Moreover, the second manual search confirmed that the systematic search was relatively complete and indicated if the study missed anything; all these assisted in sorting out the relevant articles. Several inclusion and exclusion criteria were adopted to ensure that all the selected primary literature was pertinent and related to the study. This review entailed collecting related data from journal articles, conference papers, workshops, and book chapters published in English and digital databases from 2000 to 2024, as attention to sustainability in construction logistics is regarded as a new phenomenon. As a result of the peer review process. Still, research articles whose contents did not apply to construction logistics and related productivity issues were excluded. Table 2-1 indicates the criteria for this review.

Table 2-1 The adopted Inclusion / Exclusion Criteria (Created by the Author, 2025)

Included material	**• Available as full text**
	Published between 2000 to 2024
	• Written in English
	• Related to the research objective
	• Published in the selected digital databases
Excluded material	• Full-text not available
	• Outside the search proposed time
	• Containing a non-English manuscript
	• Not related to the research objectives
	• Duplicated studies

Phase 2: Conducting the Review

After defining the purpose, research questions, and approach, the review process began, starting with a pilot test of the search terms and inclusion criteria on a smaller sample. This allowed for adjustments before the main review was conducted. The researcher read the abstracts before moving to full-text articles for the final selection. After gathering the initial literature, the knowledge sources were screened against the inclusion criteria, and their quality was assessed. The following criteria were adopted to assess the quality and accuracy of the primary sources (Kitchenham, 2007).

- Is the topic addressed in the study related to sustainability in the construction industry?
- Is the topic addressed in the paper related to construction logistics?
- Is the research methodology sufficiently described?
- Is the data analysis method accurately evaluated in the article?
- Is the research context clear?
- Are the data collection methodology criteria precisely explained in the paper?

Then, a quick check of references in the selected articles was performed for additional relevant work. However, after reviewing the titles, abstracts, and keywords of the 1495 publications retrieved, the identification step determined which studies were ineligible to be screened. The next stage was dedicated to sorting the 113 papers identified using the exclusion and inclusion criteria. 59 studies were excluded due to the exclusion criteria, which focused on paper characteristics, such as language and full-text availability. The inclusion criteria were focused on the scope of the study, which emphasises the concepts of construction logistics, challenges, and performance. From the primary 54 documents identified in the databases, 40 were the subject of the initial analysis and were found to be appropriate. Figure 2-6 depicts the process for identifying and sorting relevant knowledge sources.

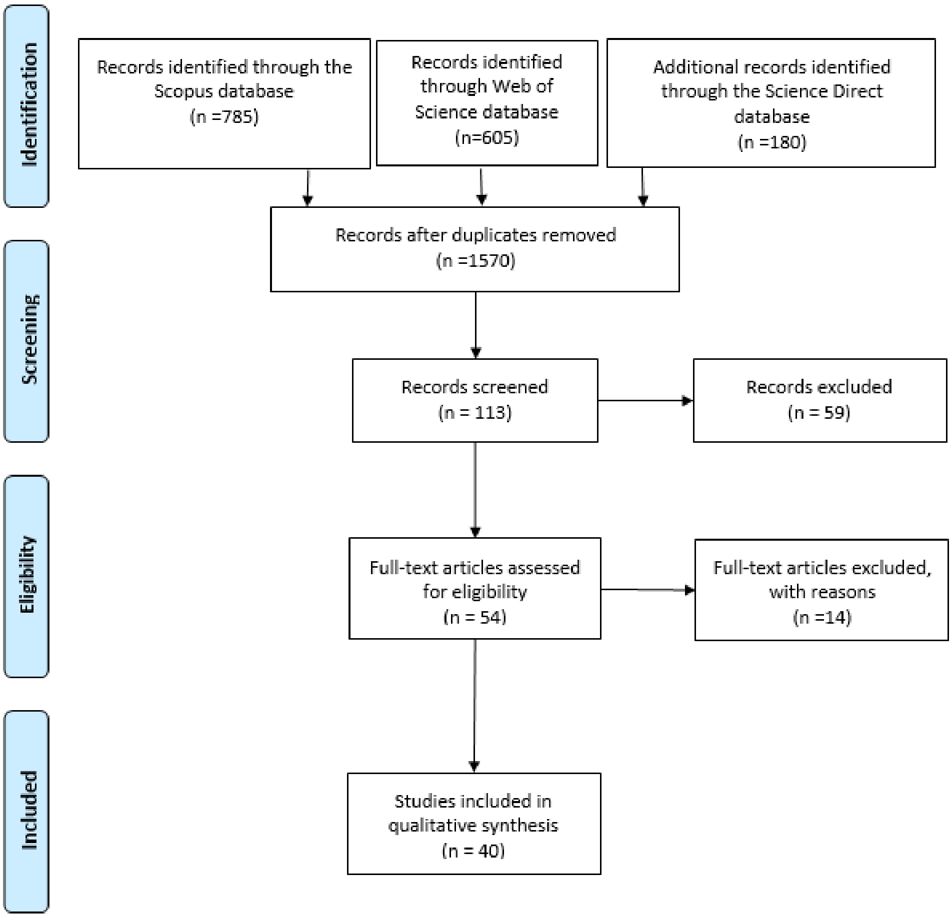

Figure 2-6 PRISMA four-phase that is adopted to select the knowledge sources for this research

Phase 3: The Analysis

Several methods have been proposed for literature review, analysis, and synthesis, as illustrated in Table 2-2. These methods include model synthesis, meta-ethnography synthesis, and thematic analysis (Braun and Clarke, 2006; Clarke and Braun, 2013).

Table 2-2 Methods For analysing the literature review data (Braun and Clarke, 2006; Clarke and Braun, 2013).

Name	Analysis	Role of Theory	Using	Pitfalls
Thematic synthesis	Themes	It may or may not involve theory	An accessible and transparent approach to handling thin and thicker data. Used when there is no theory or framework. It becomes beneficial in developing a framework.	It may be limited to an interpretation.
Modelsynthesis	Framework	To test or generate theory	Accommodates complexity, including representation of theory	Challenging to identify, select, and justify the choice of framework.

Table 2-2 Methods For analysing the literature review data (Braun and Clarke, 2006; Clarke and Braun, 2013). Continued

Name	Analysis	Role of Theory	Using	Pitfalls
Meta-ethnography	First, second, and third-order construct	To generate theory	The primary interpretative synthesis method leads to the creation of descriptive and high order constructs and requires thick and rich data	A complex process requires a highly experienced team, time and resources, and a very deep understanding from all research members to translate findings into action.
Realist synthesis	Theory-driven	Theory development	Realist review is a relatively new strategy for synthesising research with an explanatory rather than judgemental focus. Specifically, it seeks to 'unpack the mechanism' of how complex programs work (or why they fail) in contexts and settings.	The focus of the synthesis is derived from a negotiation between stakeholders and reviewers; therefore, the extent of stakeholder involvement throughout the process is high. A high knowledge of theories is required to explain the causes and effects while synthesising. Focus highly on differences.

However, thematic methods are adopted in this research to achieve the research objective, including exploring, identifying, and categorising the logistics challenges and their impact on sustainability and logistics initiatives (logistics solutions and critical success factors) (Marks and Yardley 2004). The thematic analysis provides the opportunity to code and categorise data into themes. This will produce and present data more effectively and reflect the reality of the data. This method seems useful, as the logistics literature varies from theoretical to case study bases, including deduction and induction approaches (Ghanem et al., 2018). The thematic method allows us to consider and reveal the relationships between variables and concepts (Hatch 2002; Creswell 2003). Through thematic synthesis, themes for logistics challenges are created based on logistics functions; themes for critical success factors are created based on the principles PAT, NT, RBV, and TCA theories; and themes for logistics solutions are proposed based on the Green Logistics Framework, the A-S-I/AS-I-F Framework, the TIMBER Framework, and the IF-TOLD Framework. This would assist in addressing the research question, including summarising, capturing, and depicting logistics challenges and initiatives, along with their impact on sustainability. Consequently, this assists in developing a model of logistics challenges and addressing them using logistics solutions and critical success factors. Thematic analysis and synthesis can be performed using four main approaches, as illustrated in Table 2-3.

Table 2-3 Thematic Analysis and Synthesis Main Approaches (Cruzes and Dyba, 2011)

Approach	**Braun and Clarke (2006)**	**Boyatzis (1998)**	**Attride-Stirling (2001)**	**Thomas and Harden (2008)**
Discipline	Psychology and Social	Social	Health	Social
Coding	Induction and deduction	Quantifying synthesis and deduction mainly	A theoretical model coding	Line-by-line (Grounded theory)

Table 2-3 Thematic Analysis and Synthesis Main Approaches (Cruzes and Dyba, 2011), Continued

Approach	Braun and Clarke (2006)	Boyatzis (1998)	Attride-Stirling (2001)	Thomas and Harden (2008)
Themes	Thematic map	comparing, scoring, scaling, and cluster	Thematic map	Axial coding to generate theory
Trustworthiness	Transparency	Reliability	Not mentioned	Generalizability and Transparency

Based on the research aim and objective, the thematic analysis approach proposed by Braun and Clarke (2006) is adopted, as the logistics discipline lacks a theoretical basis. For instance, applying theoretical principles to create a theme may not capture its characteristics significantly. Moreover, studies on construction logistics have used different words interchangeably with similar meanings. Therefore, deep understanding and research reflection are essential while generating themes. This approach was applied as follows:

Step 1: Familiarization with Data

- **Action**: Gather data on logistics challenges within the construction industry from knowledge sources, such as articles.
- **Goal**: Immerse in the data, read through it carefully, and obtain an overview of logistics and sustainability-related issues in construction.

Step 2: Identify and Apply Predefined Themes (Logistics Functions, Logistics Solutions, CSFs, and Sustainability)

- **Action**: Use the pre-existing logistics functions as themes for logistics challenges, PAT, NT, RBV, and TCA principal themes for CSFs, Green Logistics Framework, A-S-I/AS-I-F Framework, TIMBER Framework, and IF-TOLD Model themes for logistics solutions.

- **Example**:
  - **Planning and Resource Allocation**: Codes related to project planning, scheduling issues, resource distribution, and allocation of manpower or materials.
  - **Communication and Coordination**: Codes related to a breakdown in communication, lack of coordination between teams, or unclear instructions.
  - **Material Management**: Codes for challenges in handling materials, ensuring they arrive on time, or quality control issues.
- **Goal**: Organise the data by assigning sections to the relevant predefined themes to capture the logistics challenges, CSFs, and solutions under each function.

Step 3: Generate Initial Codes

- **Action**: Break down the data into smaller, meaningful units by assigning initial codes related to predefined logistics functions.
- **Example**:
  - For **Planning and Resource Allocation**, code instances where respondents mention delays due to improper scheduling, inefficient allocation of resources, or last-minute changes in plans.
  - For **Communication and Coordination**, code discussions about miscommunication between teams or unclear responsibilities lead to construction delays.
  - For **Material Management**, code complaints about materials arriving late or in poor condition.
- **Goal**: Create a set of codes that accurately capture logistics challenges under each logistics function, CSFs under each theory principal, logistics solutions under the logistics frameworks

Step 4: Review and Refine Themes

- **Action**: Revisit the data to ensure that the coded extracts fit within each logistics function, theory principle, and framework.

- **Example**: Check if all references coded under Transportation fit into Traffic Congestion or Inefficient Routing and see if any challenges do not fit and need new sub-themes.
- **Goal**: Ensure that the predefined themes accurately reflect the challenges, CSFs, and solutions and adjust as necessary.

Step 6: Define and Name Themes

- **Action**: Clearly define each theme and sub-theme, giving it a meaningful name that captures logistics challenges, CSFs, and solutions.
- **Example**:
    - **Planning and resource allocation**: This includes challenges related to improper scheduling and misallocation of manpower or materials, leading to construction delays.
- ***Phase 4: Writing the Review***

In conducting a literature review of this research, encompassing logistical challenges, logistics solutions, and critical success factors for enhancing sustainability within the construction industry, this study presents the significance, motivation, and necessity of the review. The need arises from the increasing emphasis on sustainability in construction, which has resulted in heightened pressure to improve logistical efficiency and mitigate the environmental impacts of construction activities. This review identifies the key logistical challenges that impede sustainability, examines existing logistics solutions, and elucidates the critical success factors essential for sustainable construction logistics. The PRISMA guidelines are adhered to ensure transparency in reporting the methodology for identifying, analysing, synthesising, and reporting the literature. This review provides a proper analysis of how logistics in the construction industry impacts sustainability goals. Additionally, it presents a conceptual model categorising the logistical challenges, solutions, and success factors and proposes an agenda for future research to address knowledge gaps and further enhance sustainability in construction logistics. This approach ensures that the review is structured to contribute substantive insights to the field while maintaining methodological rigour and clarity.

Semi-Structured Interviews

Research interviews can be categorised into three components: structured interviews, unstructured interviews, and semi-structured interviews (Ghanem et al., 2018). The differences between these types were based on the designation of the questions. For instance, a structured interview is based on planned questions that the researcher has a clear and sufficient understanding of. Conversely, unstructured interviews are based on unplanned questions in which the researcher is interested in in-depth information using their own words. Thus, unstructured interviews are significant in interpretive research, while structured interviews are used in positivism (Creswell, 2003). Cruzes and Dyba (2011) claimed that researchers consider using structured interviews to enhance the reliability and validity of their findings. However, this method limits the flexibility of the discussion. On the other hand, unstructured interviews require sufficient caution to maintain a discussion of issues and reduce biases. As a result, a semi-structured interview was used to overcome the pitfalls of the previous methods and achieve the best outcomes. The discussion through the semi-structured interview was based on prepared questions while allowing discussion of any emerging points. However, this would collect valuable and meaningful information (Fellow and Liu, 2008). The semi-structured interview is regarded as a powerful and appropriate method to collect information for this research to capture logistics status within The Middle East. In this research, participants will be chosen based on their experience, knowledge, and contribution to construction logistics within The Middle East. This method assists in achieving the research's second objective, as it will enhance the understanding of the current logistics challenges and their consequences. A purposive sampling strategy was employed. This methodology was selected to ensure the inclusion of participants with relevant expertise in construction logistics and sustainability. The sample comprised 29 participants, including project managers, logistics coordinators, sustainability officers, and site supervisors from various construction companies actively engaged in sustainable projects. These individuals were selected based on their experience and involvement in construction projects that prioritised sustainable practices.

To recruit participants, industry networks were utilised, and invitations were extended to professionals recognised for their expertise in logistics and sustainability. Snowball sampling was also implemented, wherein participants recommended other individuals with comparable qualifications and experience. The interviews were conducted in a semi-structured format, allowing for flexibility in exploring diverse logistical challenges and solutions while adhering to a core set of predefined questions. Data collection occurred over eight weeks, with interviews conducted both in person and via video conferencing to accommodate participants' schedules. Each interview lasted for 45–60 minutes. All interviews were audio-recorded with the participant's consent and subsequently transcribed verbatim to ensure accuracy in data analysis. Field notes were compiled during interviews to capture non-verbal cues and contextual insights. This approach facilitated a rich, in-depth exploration of logistical challenges and sustainability efforts within the construction industry. For confidentiality, the interview will be kept anonymous, and you will receive an invitation letter and consent form to sign. However, participation in the interview will be optional, and the interviewee will be free to withdraw at any stage. The interview data were analysed using Braun and Clarke’s thematic approach. For example, the six steps generate a clear and robust outcome. However, the themes generated from the literature are used to analyse the data, and the available findings seem relevant.

2.6. Quantitative Method

Quantitative methods are regarded as essential in critical realism because they provide robust and reliable findings (McEvoy and Richards, 2006). Using the quantitative method in critical realist research is claimed to enhance the legitimacy of proposed solutions by informing the developed theory through statistical interpretation (Zachariadis et al., 2013). This includes adopting proper data collection procedures and a suitable analysis process to meet the research objectives (Ron, 2002; Westhorp, 2014). Consequently, choosing the research sample carefully is vital, as the research results will depend on it (Rowley, 2014). It may be difficult or impossible to ask everyone who can provide a valuable response to the questionnaire. However, the population includes every member of the group in which a researcher is interested. Generally, a representative sample should be chosen from the population. In addition, the sample was considered a division of the population to complete a questionnaire (Rowley, 2014). In addition, respondents were considered a division of the sample that completed the questionnaire and returned it (Rowley, 2014). Sample selection can be performed using different approaches, including probability and nonprobability approaches. These methods can be conducted through several techniques, as elaborated in Table 5 (Baker and Foy, 2008).

Generally, social science depends on a nonprobability approach for several reasons. First, building a frame for the proposed respondents is challenging, as some might be unavailable due to a specific organisational issue. Second, researchers may have no clear vision of the most important stakeholders that should be involved in the questionnaires (Bryman and Bell, 2011). Therefore, this research favours adopting a nonprobability purposive method as the main contractors' actors in the construction industry in the Middle East are the foreman, junior engineer, senior engineer, project manager, and contractor representative. In addition, in the Middle East, the role of logistics management may vary depending on project size and type.

Rowley (2014) posited that the nature of the research, population variability, and analysis type determine the questionnaire's length and sample size. However, Rowley (2014) noted that there is no specific text providing definitive guidelines for researchers to determine the sample size and format. The questionnaire designed for this study adhered to the guidelines proposed by Rowley (2014), ensuring clarity, relevance, and effective data collection. The questionnaire was structured to facilitate participants' provision of quantitative responses, enabling validation of logistical challenges, logistics solutions, and critical success factors for enhancing sustainability in the construction industry. Following Rowley's approach, the questionnaire incorporated closed-ended questions to gather demographic information and general insights into participants' roles in construction logistics and sustainability initiatives. This was followed by a series of Likert-scale questions that assessed participants' perceptions of common logistical challenges, CSFs, logistics solutions, and sustainability factors. The questionnaire was carefully designed to eliminate leading questions and ensure alignment with the study's objectives. A pilot test involving ten industry professionals was conducted to refine the wording and structure, ensuring clarity and ease of understanding. A total of 503 questionnaires were distributed, but after a thorough refinement process, 81 were excluded due to incomplete responses and unreliable answers. Consequently, 422 fully completed and reliable questionnaires were considered for analysis, providing a diverse range of perspectives on logistical challenges and sustainability practices in the construction industry. To ensure representativeness, participants were selected from companies of different sizes and various types of construction projects, including commercial, residential, and infrastructure.

Data Collection

The maximisation of the response rate is a priority for researchers. However, this could be enhanced by choosing the most appropriate method for data collection, including distributing questionnaires (Lee and Lings, 2008). However, several methods can be used for data collection, including mail, email, internet, telephone, and paper-based (Lee and Lings, 2008). However, the primary consideration in determining the best way is the respondents' time, experience, and work field (Bryman and Bell, 2011). Therefore, the paper-based method and online method (Microsoft form method) are adopted in this research to enhance the response rate and increase the flexibility for participation.

Data Analysis

The interview data analysis begins by considering the pre-established themes based on the literature review analysis for logistics challenges, logistics solutions, and CSFs, such as material management, lean, collaborating with suppliers, and technology integration. After conducting the interviews, the recordings were transcribed and familiarised by reading the transcripts. While reviewing, coding is applied to interesting ideas and repeated patterns related to predefined themes. Then, the highlighted codes are assigned to the themes. Once the deductive thematic analysis of interview data is completed, structural equation modelling (SEM) is used to validate the findings by quantitatively testing the relationships between logistics challenges, proposed solutions, and critical success factors. SEM allows the assessment of the complex, interrelated relationships between variables identified during thematic analysis, such as logistics challenges, logistics solutions, CSFs, and sustainability outcomes.

The quantitative data collected through questionnaires were analysed in two different stages for this research. In the initial phase, SPSS 18.02 was employed for descriptive statistics and preliminary data analysis (see Chapter 4) of the mean and standard deviation. In the second stage (Chapters 4 and 5), Structural Equation Modelling (SEM) was utilised to test and examine the relationships among variables in the proposed conceptual model. SEM, referred to as path analysis, analysis of covariance structure, and simultaneous equation models, is employed to test and examine the hypothesised relationships between variables in the conceptual model. SEM is regarded as an updated version of multivariate analysis. A set of hypotheses can be tested simultaneously using multiple independent and dependent variables (Gefen et al., 2000). Hair et al. (2010) claimed that SEM is a multivariate method that combines the elements of factor analysis and multiple regression to estimate various relationships simultaneously. SEM assists in testing the interrelated hypotheses through single analysis to facilitate the development of concepts and theories (Gefen et al., 2000). SEM assists in assessing and achieving a model's fit with the collected data (Yuan, 2005). In addition, they can effectively handle complex mathematical models. The reasons for selecting SEM as the primary analysis technique in this research are as follows:

- Structural equation modelling is more appropriate than other statistical techniques when the model includes several exogenous (independent) variables and endogenous (dependent) variables with interconnected relationships (Tabachnick and Fidell, 2000). This research includes several variables (constructs), including logistics challenges, CSFs, logistics solutions, and sustainability factors. These variables seem to be affected by each other simultaneously. In this situation, the model undergoes simultaneous testing. When utilising first-generation statistical tools, it is necessary to conduct multiple analyses.
- The proposed conceptual model aims to understand the effect of logistics challenges on sustainability and the promises of CSFs and logistics solutions in the context of the Middle East, which is considered a complex model. Therefore, testing complex modelling requires the use of SEM, which is more valuable than first-generation statistical tools (Gefen et al., 2000).
- The proposed research model, which employs a confirmatory modelling strategy (Tabachnick and Fidell, 2000), will be used to test a set of hypothesised relationships within the constructs of this research (Tabachnick and Fidell, 2000).

According to Hair et al. (2010), the SEM analysis process has six stages (see Figure 2-7): defining specific constructs, developing the measurement model, designing the study to create empirical results, assessing the validity of the measurement model, specifying the structural model, and assessing the validity of the structural model (Hair et al. 2010). The measurement model typically covers the first four stages, whereas the structural model covers the last two stages. Chapters 5 and 6 provide a detailed discussion of the use of these six stages in the SEM. There are two extended families of SEM. Covariance-based modelling with software such as LISREL, AMOS, and EQS). Variance-based modelling – partial least squares (PLS) (Gefen et al., 2000). Covariance-based SEM is the best option when the main objective of research is to test and confirm theories. However, PLS-SEM is better suited for theory development and predictions (Hair et al. 2010). A covariance-based SEM approach is used to analyse and examine the proposed conceptual model in the current research using the Analysis of Moment Structures (AMOS 21.0). This research follows Hair's (2010) guidelines for assessing the structural model using a two-pronged approach (first using the measurement model and then the structural model).

Through SEM, model validation is achieved through several statistical tests, including goodness-of-fit principles to ensure the robustness of the proposed framework. This includes the measured value of the Goodness-of-Fit Index (GFI), the Root Mean Square Error of Approximation (RMSEA), and the Comparative Fit Index (CFI). Still, these statistical measures could be calculated using SPSS and AMOS software. The SEM in this research is explained in detail in the following chapters.

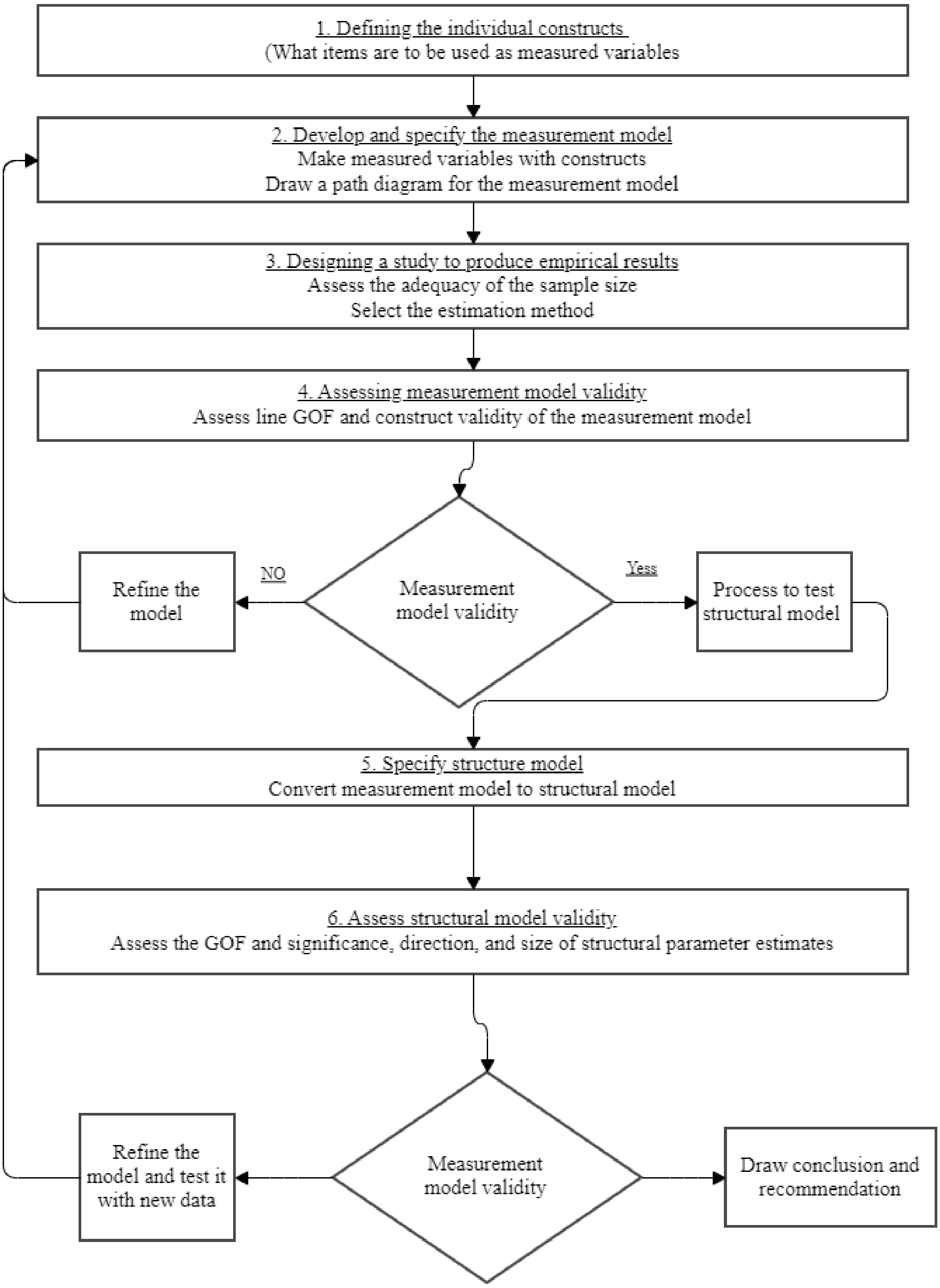

Figure 2-7 The six-phase process for SEM utilised in this research (Hair et al., 2010)

2.7. Ethical Issues

This research will abide by BCU regulations (codes of conduct) for academic research. Therefore, this research will enhance the adoption of best practices and respect ethical and legal requirements. The research and data collection activities will be monitored by the director of the study and supervisory team. The researcher will be responsible for obtaining consent from the participants through a predefined BCU form. However, these forms include all critical issues for respondents, including information, confidentiality, anonymity, and time. The respondents will receive an access request via email or hand to check their interest and availability to share with this research. Hence, the respondents will have sufficient time (not less than seven days) to respond to this request. Therefore, consent was obtained from the participants before entering the research. Through this phase, the participant will obtain all information regarding the research through the participation information sheet form. They had the right to ask for any unclear information from the researcher. Moreover, respondents could discuss this information with others if they wished. Sometimes, a participant may not understand English, so an official Arabic-translated form will be available for any participant. Still, the participant was free to withdraw from this research process at any time without any consequences. Finally, obtaining written consent is a priority; otherwise, recording consent will occur for people who may have issues preventing them from writing, such as disability. However, approval from the participant will be obtained before recording, ensuring that the data will be kept secure and confidential. Finally, ethical approval was obtained from the BCU before data collection started.

2.8. Limitations of The Chosen Methodologies and How They Were Mitigated.

The selected research approach, which integrates qualitative and quantitative methods within a critical realist philosophy, acknowledges certain limitations but implements strategies to address them. While qualitative techniques, such as semi-structured interviews, may introduce subjective elements and potential biases due to their reliance on individual experiences, these issues are mitigated through data triangulation. This involves interviewing a diverse range of stakeholders across the Middle East, including construction managers, logistics experts, and engineers, to capture a broad spectrum of perspectives and minimise individual bias. A semi-structured interview guide was employed to ensure consistency while allowing for in-depth exploration of topics.

To address the limited generalisability of qualitative research due to smaller sample sizes, this study incorporates a quantitative survey based on qualitative findings. This survey was distributed to a larger sample to validate and generalise the initial insights. However, surveys can be subject to design weaknesses, such as imprecisely phrased questions or respondent misinterpretation, potentially leading to unreliable responses. To counter this, pilot testing was conducted to refine the survey questions and enhance clarity. Additionally, although surveys may struggle to capture the full contextual complexity of logistics and sustainability challenges, the preceding qualitative phase ensures that the survey is grounded in the realities of the Middle Eastern construction industry. The integration of qualitative and quantitative data in mixed-methods research can be time-intensive and complex. This challenge is addressed through a sequential design, where qualitative data inform the development of the conceptual framework, which is then validated by quantitative methods. An abductive reasoning process, alternating between theory and empirical data, facilitates the coherent integration of insights from both methods. Through careful design choices and mitigation strategies, this study maintains both depth and breadth, yielding robust, credible, and contextually relevant findings on how logistics solutions and CSFs address challenges and impact sustainability in the Middle Eastern construction sector.

2.9. Summary of the Adopted Methodology

This research analytically examines the relationships between sustainability, logistics challenges, CSFs, and solutions in Middle Eastern construction. Critical realism helps recognise the deeper mechanisms influencing logistics processes and their sustainability impacts (Objective 1). Through a literature review and semi-structured interviews, the study explores region-specific logistics practices and challenges shaped by local factors, identifying their effects on sustainability, and examining local mitigation initiatives (Objective 2). The qualitative phase is crucial for addressing the objectives and ensuring the investigation of the logistics challenges and their impact on sustainability in the Middle Eastern context. Objective 3 employs a dual-method approach: interviews provide insights into existing logistics solutions and critical success factors (CSFs), whereas a quantitative survey validates them on a larger scale. This objective identifies logistics initiatives to effectively address challenges. The study incorporates themes from the Green Logistics Framework, emphasising environmental impact reduction, and frameworks such as A-S-I/AS-I-F (Avoid, Shift, Improve), TIMBER, and IF-TOLD, which aim to optimise resource use and reduce inefficiencies. Principal-agent theory (PAT), Network Theory (NT), Resource-Based View (RBV), and Transaction Cost Analysis (TCA) are applied to identify CSFs, offering an understanding of logistics and sustainability. PAT addresses stakeholder conflicts by identifying CSFs such as trust, transparency, and communication to align objectives towards sustainability. NT highlights collaboration and coordination across the logistics network, with CSFs such as information sharing and partnerships to improve efficiency. The RBV focuses on internal resource management, identifying technological capabilities, skilled labour, and sustainable materials as key CSFs. TCA emphasises reducing transaction costs, with CSFs such as efficient procurement, contract management, and risk reduction for cost-effective and sustainable logistics solutions. Together, these theories and frameworks offer a multidimensional approach to enhancing sustainability in construction logistics by addressing relational and operational factors and providing actionable insights and tailored solutions. Objective 4 aims to develop a conceptual model to address logistics challenges using solutions and CSFs that are inherently tied to the abductive approach. By iterating between qualitative data (interviews) and theoretical constructs (literature), this study creates a model reflecting both theoretical insights and empirical realities. This model addresses Middle Eastern logistics challenges by incorporating solutions and CSFs identified in the qualitative phase. For Objective 5, a quantitative survey will validate the framework, with Structural Equation Modelling (SEM) testing relationships between challenges, solutions, CSFs, and sustainability outcomes. This validation resulted in a practical model with actionable insights, solutions, and critical success factors.

3. Chapter Three: Literature Review

3.1. Introduction

This chapter explains the construction industry and logistics practices and highlights the theoretical underpinning of inefficient construction logistics practices. In this chapter, the functions of construction logistics are investigated and defined to assist in understanding the research subject. This research opted for an SLR to comprehend trends and identify gaps in the scientific literature. Unlike traditional or narrative literature reviews, an SLR uses a more detailed and standardised approach to review literature in a particular domain. We followed the instructions outlined by Kitchenham (2007).

The inclusion and exclusion criteria were applied to ensure that only relevant papers were chosen for further analysis after establishing the research search methods and information sources. Papers published between 2000 and 2024 were selected to include various studies. The most representative papers related to the study were chosen for further analysis, which included only peer-reviewed academic journals and conference papers written in English. The search process resulted in the identification and selection of 37 papers. The references of all 37 initially selected papers were reviewed using a snowball technique to ensure complete coverage of relevant literature. This approach resulted in the identification and further selection of 3 additional papers. The SLR could use 40 papers. A complete evaluation of the results obtained from the SLR is provided in the following sections. This research provides valuable knowledge gained through the SLR and its robust approach by examining this methodology's key findings, insights, and conclusions.

3.2. Distribution of Papers Across Countries

Figure 3-1 illustrates that the papers selected for this study exhibited a broad geographic distribution. China contributed the most significantly to the 40 papers selected for this study, indicating its strong research focus on construction logistics. Several other countries, including the UK, India, the USA, and Hong Kong, have also made significant contributions to publications related to logistics within the construction industry. This distribution suggests that construction logistics is a globally relevant topic, with research concentrated in regions experiencing rapid urbanisation and large-scale infrastructure projects.

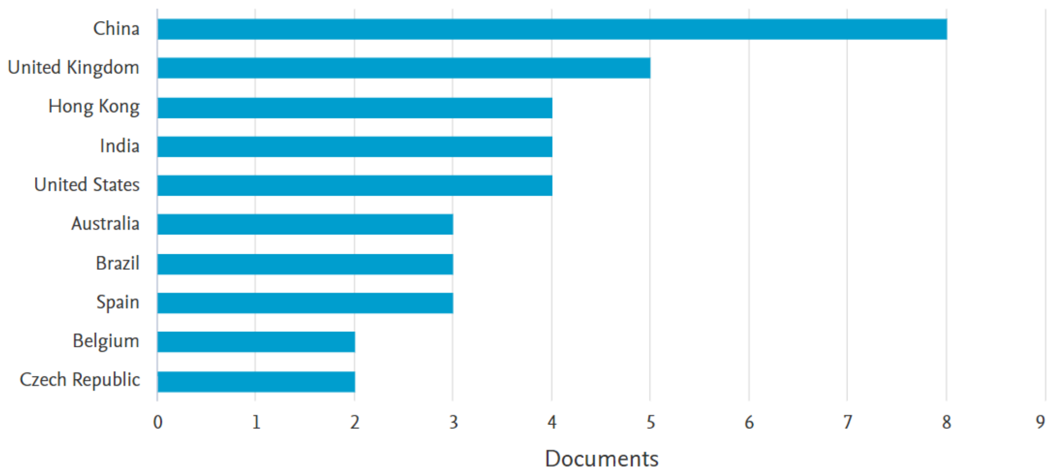

Figure 3-1 Geographical distribution of selected papers (Created by the Author, 2025)

3.3. Distribution of Papers Across the Years

Figure 3-2 illustrates papers related to construction logistics over the years of publication. There seems to be increasing interest in logistics research in the construction industry. This means that construction logistics research is attracting attention from several authors and stakeholders towards enhancing performance and gaining competitive advantages (Loung et al., 2022). Consequently, the increasing complexity, scales, and demands of prevailing projects, combined with technological spreads and sustainability objectives, drive the demand for enduring research for construction logistics (Saleh et al., 2023)

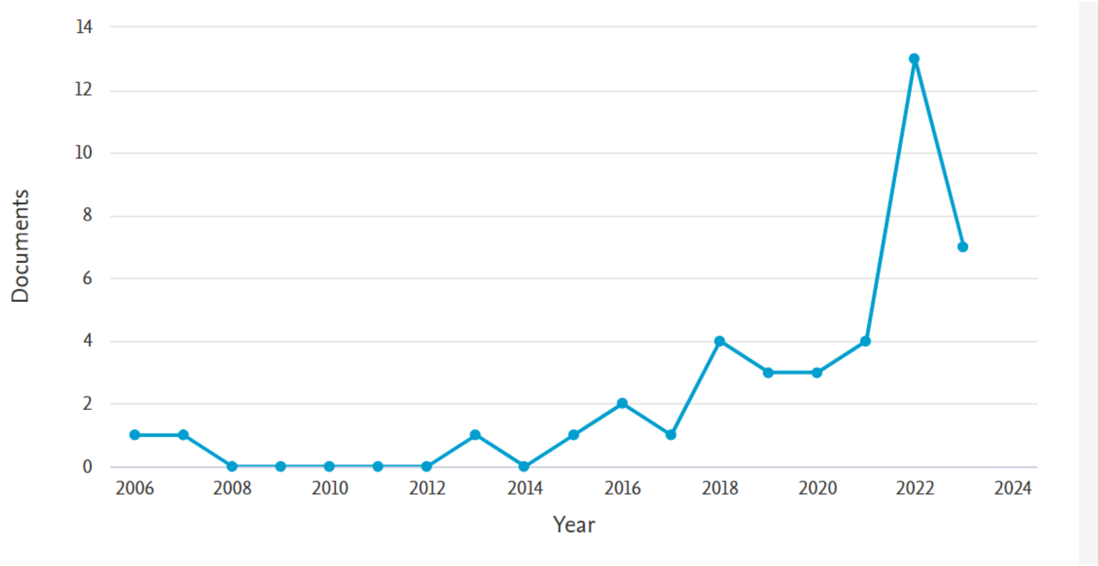

Figure 3-2 Number of papers per year (Created by the Author, 2025)

3.4. Logistics Functions within the Construction Industry

The logistics practices identified from the selected publications were further categorised into nine primary constructs to facilitate easy identification and simplify their understanding. As highlighted in Table 3-1, the categorisation was performed following extant studies. For example, Dey (2001) revealed that logistics functions and practices in construction can be categorised into planning and resource allocation, transportation, inventory and warehousing management, reverse logistics, and waste management. On the other hand, Ameh et al. (2010) disclosed that logistics functions can be categorised into planning, including resource allocation, inventory and warehousing management, material management, reverse logistics, and safety management. Ghanem et al. (2018) argued that logistics functions can only be categorised into transportation, reverse logistics, waste management, and security. Another interesting finding from extant studies disclosed how Hedlund and Telese (2019) identified logistics functions as an essential part of construction activities that integrate material management with the construction processes, including receiving and storing materials and shipping them to construction sites and reverse activities. Similarly, Fredriksson et al. (2021) stressed that logistics functions are gaining considerable attention in the global construction economy owing to their ability to substantially save cost and energy. Increase material efficiency and use and minimise environmental impact in construction through efficient practices. Ekeskar and Rudberg (2020) concluded that logistics functions are significant in construction projects.

Similarly, Saleh et al. (2024) noted that logistics functions are the main obstacles to ensuring sustainable construction projects that promote efficient energy use. In essence, logistics involve accurate coordination between the client and the developers, who discuss the project life to enhance project delivery (Sundquist et al., 2018). To simplify the categorisation of the different logistics functions in Table 8, a thematic analysis was applied to synthesise the researchers' findings and gain an understanding of these practices.

Related practices were merged to avoid unnecessary repetition or a long extension of the categorisation. For example, all the scheduling, arrangements, and organising activities were integrated into the planning and resource allocations. This decision was influenced by the conclusions of Le et al. (2021), who established that planning and resource allocation encompasses layouts, scheduling, equipment, and labour allocation. Furthermore, all activities related to procurement, warehousing practices, inventory control, stock level, and replenishment constructs were merged into inventory and warehousing management. Ekeskar and Rudberg (2020) pointed out that the inventory and warehousing management function involved designing efficient storage layouts, which aligns with this decision while ensuring the safe and organised handling of materials by implementing appropriate storage solutions. Following a systemic review of extant studies and the implementation of the thematic approach, nine logistics functions were developed: planning, procurement resource allocation, transportation, inventory and warehousing management, material management, communication and coordination, and reverse logistics.

Table 3-1 Logistic functions within the construction

	Primary					
Author	**Planning including resource allocation**	**Transportation**	**Inventory and warehousing management**	**Material management**	**Communication and coordination**	**Reverse logistics**
Dey (2001)		×		×	×	
Navon and Berkovich (2004)			×		×	×
Kasim et al., (2005)	×			×		
Moura et al. (2007)			×		×	×
Le-Hoai et al. (2008)	×	×			×	
Sohrab and Donyavi (2009)			×		×	×
Ameh et al. (2010)	×					
Patel and Vyas (2011)		×		×	×	
Lindholm and Behrends (2012)			×			
Lindholm and Behrends (2012)						×
Thunberg et al. (2014)		×				
(McKinnon, 2015)	×					
Ahmed (2017)				×	×	×
Shigute and Nasirian (2014)						×
Ghanem et al. (2018)				×		
Ekeskar and Rudberg (2016)			×			×
Sundquist et al. (2018)	×	×		×	×	
Kock and Hadaya (2018)						×
Thunberg and Fredriksson (2018)			×			
Janne and Fredriksson (2019)						
Hedlund and Telese (2019)			×		×	×
Schuldt, and Carvalho (2020)						
Centobelli et al. (2020)						
Fredriksson et al. (2021)	×				×	
Luong Le et al. (2021)	×	×	×	×	×	
Arvianto et al. (2021)						
Janne and Fredriksson (2021)	×	×				
Ekeskar and Rudberg (2020)			×		×	×

Table 3-1 Logistic functions within the construction, Continued

Author	**Planning including resource allocation**	**Transportation**	**Inventory and warehousing management**	**Material management**	**Communication and coordination**	**Reverse logistics**
Chawatheet al. (2023)			×		×	
Pivaa (2024)	×	×			×	
Luong Le et al., (2024)	×					
(Lam et al. (2024)	×	×				
Vrijhoef (2020)						
Janne and Rudberg (2020)		×		×	×	
Rad et al. (2022)						
Le and Nguyen (2022)		×				
Balasubramaniana and Shuklab (2017)						
Fredriksson and Huge (2022)			×	×	×	×
Le and Nguyen (2023)						×
Le and Nguyen (2023)	×			×		

3.5. Construction Logistics Challenges within the Logistics Functions

Planning and Resource Allocation

Numerous studies have highlighted the significance of the planning function in construction logistics in achieving the project's goals (Ying et al., 2018; Halldorsson and Vural, 2019). Planning includes identifying, sorting, and scheduling resources available at the right time according to project specifications and quality (Janne and Fredriksson, 2019). However, the planning function of logistics must be coordinated and integrated with construction schedules (Halldorsson et al., 2015). During construction, several factors affect logistics planning efficiency. First, poor coordination between logistics and construction activities is a primary factor for logistics inefficiency. For instance, significant waiting for labour and equipment occurs due to poor coordination and information sharing between logistics and construction schedules (Linden and Josephson, 2013). Second, poor logistics planning leads to several disturbances among construction resources when they are delivered without complying with construction schedules (Heaslip and Kovacs, 2019). Third, the lack of supervision of logistics functions by experienced staff is claimed to be an additional factor that causes inefficiency. This includes unclear responsibilities and poor handling of logistics practices (Ghanem et al., 2018). Logistics supervision is essential to monitor and control the progress of logistics, as this adversely affects the progress of construction activities, including resource allocation (Lundesjo, 2015). Fourth, it is noted that poor work plans and bad layouts are regarded as consequences of the previous factors. For instance, employing inexperienced staff leads to duplication and the generation of a flawed plan (Sundquist et al., 2018).

Transportation

Transportation entails moving materials from a storage area (for example, suppliers, material providers, warehouses, and subcontractors) to their destination (construction site) by an appropriate and acceptable mode of transport (Ying et al., 2018). Transportation in construction accounts for 10 to 20 % of the total project costs. The construction logistics process depends highly on transportation as a material, and numerous resource movements depend on it (Halldorsson and Vural, 2019). Transportation during construction is classified as offsite or onsite. Offsite transportation implies a system for keeping and transferring material and the required resources to the storage area for the construction project (Janne and Fredriksson, 2019).

Conversely, on-site transportation relates to moving material from storage areas to the construction activity location (Ekeskar and Rudberg, 2016). Various factors must be considered for efficient transportation planning, including defining transport size and route type, the schedule of construction activities, handling requirements, and the required number of vehicles (Fredriksson et al., 2021). Several challenges have been noticed in construction related to transportation functions that affect efficiency in terms of productivity, such as relying on poor vehicles and poor planning for routing (Selviaridis and Norrman, 2015). This causes delays in the availability of materials and resources at the right time and with the required quality (Halldorsson et al., 2015). Significant transportation logistics challenges include using improper vehicles in transportation, which contributes to several problems that cause inefficiency (Fredriksson et al., 2021; Guerlain et al., 2019). This creates several sub-challenges.

Using an inappropriate vehicle might destroy such materials, neither delivering low-quality material nor at the wrong time (Fredriksson and Jonsson, 2009).

Inventory and Warehousing Management.

Inventory and warehousing management are related to storing and maintaining materials and products that are qualified and available at the right time. Construction businesses try to maintain a sufficient inventory of materials and resources to run their construction processes smoothly (Ekeskar and Rudberg, 2016). Construction materials are divided into two categories: materials that cannot be stored and materials that can be stored (Ghanem et al., 2018). The materials that can be stored require proper planning to avoid any disruptions in the construction processes and fluctuations in quantity or price (Luong Le et al., 2021). Good inventory management implies planning, procuring, receiving, sorting, keeping, and monitoring resources to be available according to construction schedules (Janne and Rudberg, 2020). The main challenge affecting construction productivity related to inventory management is inappropriate material availability (Sundquist et al., 2018). This is caused by incorrect estimation, unreliable receiving, bad storing, reliance on inexperienced staff for material estimation, using poor material for material handling, and adopting inadequate distribution procedures (Luong Le et al., 2021; Fredriksson et al., 2021; Guerlain et al., 2019).

Material Management

Material management in construction logistics is critical because it is directly linked to minimising waste, improving productivity, and reducing costs (Brag, 2011). Material management can be defined as the activities and tasks followed to deliver the required material with the required quality at the right time and competitive price (Kasim, 2008). Generally, construction materials are expensive, large, and delivered in bulk to sites. For instance, the construction material cost contributes to approximately 60 % of the total project cost (Josephson et al., 2008). Poor material management practices in construction projects cause material shortages, colossal waste, and loss of productivity. For instance, poor material management regarding inadequate distribution procedures and inappropriate equipment handling contribute to approximately 40 % of workers' time loss (Kasim, 2008). Several challenges are encountered in construction material management, including relying on negotiation rather than collaboration for material acquisition. For instance, numerous construction contractors create deals based on prices rather than the quality of services. Hence, this may contribute to dealing with unreliable businesses, resulting in late and inadequate delivery (Morris and Pinto, 2007). Second, material management requires proper forecasting of resource quantities to avoid fluctuations in quantities and prices. Third, several construction businesses experienced significant losses due to using inappropriate material storage and handling methods. Hence, these losses affect the construction process and cause disruptions and delays (Fredriksson et al., 2021). Abdul-Rahman et al. (2006) stated that paper-based methods and inexperienced staff are the main challenges in this process. This may lead to problems such as redundancy and bad or wrong deals. However, this may contribute to productivity losses and cost overruns (Abdul-Rahman et al., 2006).

Communication and Coordination

Construction logistics procedures must be completed precisely in the context of communication, coordination, and information exchange to prevent delays (Fredriksson et al., 2021). The means of communication in construction logistics include sharing knowledge and information, establishing coordination, and receiving or sending instructions (Janne and Fredriksson 2021). However, this can be achieved by phone, in person, or online (Johnston and Clark, 2005). This function serves as a link connecting all construction phases and actors. Clear, recorded, and detailed statements are essential to avoid misunderstandings and conflicts (Ekeskar and Rudberg, 2020). Several authors have claimed that poor and prolonged communication between construction stakeholders is one of the main features of logistics inefficiency (Fredriksson et al., 2021; Guerlain et al., 2019). For instance, efficient logistics should include a proper and reliable communication system to facilitate information transfer among all parties (Janne and Fredriksson, 2021). Several challenges related to this function have been noticed in construction, contributing to logistics inefficiency. These challenges include, first, not defining a proper communication matrix between parties. For instance, several connections were incorrectly made by the wrong staff. This generates misunderstandings, disturbances, and decision delays (Hedlund and Telese, 2019). Second, some construction businesses overlook the effect of suppliers on logistics and construction activities. For instance, suppliers and material providers significantly affect the construction supply chain, as construction activities depend mainly on their operation for materials and resources (Ghanem et al., 2018). Hence, the logistics function would not be appropriately executed without coordination to check their capabilities for the assigned tasks (Sundquist et al., 2018).

Reverse Logistics (RL)

Reverse logistics is regarded as an essential aspect of construction logistics. Its activities have expressed the process of defining, sorting, and returning or changing unqualified materials or resources delivered to sites (Ghanem et al., 2018). The construction industry has been criticised for poorly implementing effective RL systems (Hedlund and Telese, 2019). For instance, numerous construction stakeholders have stated that they do not consider RL systems in their operations (Janne and Rudberg (2020). Hence, there is a significant weakness in the management of unqualified resources. Hosseini et al. (2014) argued that construction businesses are less concerned with this factor because of the associated cost of the material return, including labour and transportation costs (Fredriksson et al., 2021). Even so, this issue becomes vital for specific materials. For instance, a construction project contains costly and unique materials (Ekeskar and Rudberg, 2020). Any deficiencies in their quality would affect the construction processes. Therefore, having a reliable and proper RL system becomes essential to returning these materials and bringing them to a qualified level while ensuring the streamlining of the construction process (Sundquist et al., 2018). Table 3-2 summarises the logistics challenges affecting sustainability within the construction industry and the logistics function.

Table 3-2 Logistics challenges affecting sustainability and logistics functions within the construction industry

Logistics function (Theme)	Challenges	Authors																																							
		Dey (2001)	Navon and Berkovich (2004)	Kasim et al., (2005)	Moura et al., (2007)	Le-Hoai et al. (2008)	Sohrab Donyavi (2009)	Ameh et al. (2010)	Patel and Vyas (2011)	Lindholm and Behrends (2012)	Lindholm and Behrends (2012)	Thunberg et al. (2014)	(McKinnon, 2015)	Ahmed (2017)	Shigute and Nasirian (2014)	Ghanem et al. (2018)	Ekeskar and Rudberg (2016)	Sundquist et al. (2018)	Kock and Hadaya (2018)	(Thunberg and Fredriksson, 2018)	Janne and Fredriksson (2019)	Hedlund and Telese (2019)	Schuldt, & Carvalho, 2020;	Centobelli et al. (2020)	Fredriksson et al. (2021)	Luong Le et al. (2021)	Arvianto et al., 2021	Janne and Fredriksson (2021)	Ekeskar and Rudberg (2020)	Vrijhoef, 2020)	Janne and Rudberg (2020)	Rad et al., 2022	Le & Nguyen, 2022	Balasubramaniana and Shuklab, 2017	Fredriksson and Huge, 2022	Le and Nguyen, 2023	Le and Nguyen (2023)	Chawathe et al. (2023)	Pivaa, 2024	Luong Le et al., 2024	(Lam et al., 2024),
Planning and resources allocation	A lack of expertise (or knowledge) in construction logistics			×	×	×		×	×				×			×	×	×							×	×		×	×								×		×		
Communication and coordination	lack of coordination and integration with suppliers	×				×			×			×						×								×		×			×		×						×		×
Planning and resources allocation	Inadequate planning for logistics processes, including resource management	×	×		×		×			×				×			×			×		×			×	×		×	×						×			×			
Planning and resources allocation	Management's insufficient commitment to on-site logistics operations	×		×		×			×					×		×		×								×			×		×				×		×				
Material management	Neglecting the understanding of quality in purchasing processes	×	×		×	×	×		×					×				×				×			×	×			×		×				×			×	×		
Planning and resources allocation	Inadequate alignment between construction schedules and logistics practices		×		×		×				×			×	×		×		×			×							×						×	×					
Communication and coordination	Inadequate communication among internal parties	×	×	×				×	×					×				×							×			×	×		×							×	×		
Communication and coordination	Ineffective coordination among internal parties							×	×					×		×		×													×				×		×		×		
Planning and resources allocation	Inefficient site layout				×	×		×				×			×		×	×				×			×			×			×		×			×		×	×		×
Material management	waste of materials due to inefficient material handling	×		×		×			×					×		×		×		×						×			×						×				×		
Planning and resources allocation	Poor material identification and estimation				×			×				×		×	×		×								×			×	×				×		×	×		×			×
Transportation	lack of real-time tracking of fleet and equipment used in construction logistics	×				×	×		×					×				×		×		×				×			×						×				×		
Planning and resources allocation	Ineffective monitoring and control of logistics activities			×			×			×		×			×	×						×						×	×				×			×	×				×
Communication and coordination	Delays in decision-making by the consultant engineer	×	×	×				×	×					×		×									×	×			×		×				×		×				
Communication and coordination	Ambiguity in logistics responsibilities for the construction team					×	×	×										×			×				×						×								×		
Transportation	The use of inappropriate types of vehicles in transportation	×		×	×		×									×	×		×			×				×			×								×	×			
Material management	The fluctuating prices of construction materials and components					×		×			×			×			×	×							×				×		×				×			×	×		
Material management	Duplication and errors caused by excessive paperwork	×				×	×		×					×				×				×				×									×				×		
Inventory and warehouse management	Accuracy of goods (orders) received from suppliers			×			×					×			×	×						×		×				×	×				×			×	×				×
Inventory and warehouse management	Inaccurate inventory records	×	×	×				×	×					×		×			×							×					×				×		×				
Reverse logistics	Inefficient management of the return process for purchased materials		×		×	×	×							×			×					×		×					×						×			×			

3.6. Sustainability within Construction Logistics

UNEP defines a sustainable economy as achieving enhanced human well-being and social equity, significantly reducing environmental risks and ecological scarcity. Essentially, a sustainable economy is characterised by being low-carbon, resource-efficient, and socially inclusive (Fazio and Brink, 2012). On the other hand, the OECD Green Growth Report describes sustainable growth as promoting economic development while ensuring that natural assets continue to provide the necessary resources and environmental services for well-being (OECD, 2011). Sustainability in construction logistics is a significant shift in how the industry approaches minimising environmental impact, promoting social responsibility, and ensuring economic viability (Dhawan et al., 2022). Over the years, the construction sector has become more recognised for its significant environmental impact, from resource extraction to transportation and waste generation (Jones et al., 2021). The integration of eco-friendly practices and innovative technologies has led to the prominence of sustainable construction logistics (Guerlain et al., 2019b). Green transportation modes, such as electric or hybrid vehicles, should be adopted to reduce the emissions associated with the movement of materials and equipment. In addition, applying effective route planning and logistics management systems aids in enhancing delivery schedules and minimising fuel consumption and traffic (Riazi et al., 2020). Furthermore, the emphasis on sourcing sustainable materials and minimising waste contributes to the overall environmental sustainability of the industry (Dhawan et al., 2022). Sustainable construction logistics requires socially responsible practices, including fair labour conditions and community engagement (UNEP, 2020). As sustainability becomes more important to stakeholders, the construction industry continues to develop, encouraging a more environmentally friendly and socially responsible approach to logistics (UNEP, 2020). The environment is not the only benefit of this ongoing development, as it also aligns with broader universal programs aimed at achieving sustainable development goals (Riazi et al., 2020).

To tackle sustainability challenges in the construction sector, it is crucial to comprehend relevant indicators. Construction projects typically use specific indicators to gauge their success (Khan and Lockhart, 2019). Sustainable logistics management integrates sustainability goals from the management of construction companies, external stakeholders, suppliers, and customers (Silva 2019). Achieving environmental, social, and economic goals throughout the construction supply chain is essential for sustainability (Silva, 2019). A valuable approach is product life-cycle analysis, which reveals the environmental impact from design to product or building utilisation (Riazi et al., 2020). The criteria for selecting construction material suppliers, including environmental considerations, should align with strategic objectives, policies, and regulatory standards (Dhawan et al., 2022). Construction businesses may choose suppliers based on environmental criteria for performance monitoring or set policies for supplier compliance (Dhawan et al., 2022). Sustainable logistics management research often centres on the Triple Bottom Line pillars (environmental, economic, and social), as defined by the Brundtland Report. Dani et al. (2022) extensively explored these pillars' tools for assessing construction company sustainability based on the Triple Bottom Line. They claimed that understanding the relevant indicators is crucial for addressing construction sustainability. Table 3-3 presents the identified pillars based on the views of numerous authors and related indicators.

Table 3-3 Sustainable factors

Factors	Hedlund and Telese (2019)	Fredriksson et al. (2021)	Luong Le et al. 2021	Janne and Fredriksson (2021)	Ekeskar and Rudberg (2020)	Dani et al. (2022)	(Dhawan et al., 2022).	(Khan and Lockhart, 2019)
Enhancing Labour productivity	x		x	x	x			x
Minimise greenhouse gas emissions	x		x			x		
Reduce the Total cost of completing a project.		x			x			x
Improve resource efficiency		x		x		x		x
Reduce waste	x		x		x		x	
Increase well-being		x		x	x	x		x
Enhancing technology adoption	x		x				x	x

3.7. Enhancing Sustainability in Construction Logistics

Integrating theories and frameworks that address environmental, social, and economic aspects is necessary to enhance sustainability in construction logistics (Jones et al., 2021). Resource efficiency, waste reduction, and cost reduction are prioritised in theoretical approaches from logistics theories such as network theory and transaction cost theory (Dhawan et al., 2022). Logistics theory focuses on explaining fundamental principles and predicting behaviours, while frameworks provide a structured model for organising and analysing information related to logistics processes (Dani et al.,2022). Theory and model can work together to enhance the understanding of underlying principles, and frameworks can provide practical structures for applying those principles in real-world logistics scenarios (Silva, 2019). Critical success factors are highlighted in theoretical concepts by identifying key elements or principles that contribute to the success of logistics operations (Dhawan et al., 2022). For instance, theories such as network theory or transaction cost theory may identify critical success factors, including minimising waste, optimising processes, and identifying and addressing bottlenecks (Dani et al., 2022). Conversely, frameworks in logistics are often utilised as practical tools or structures for implementing solutions. These frameworks provide a proper approach to organising, analysing, and addressing logistics challenges. For instance, the Green Logistics Model and TIMBER Model offer practical advice to enhance safety and reduce the environmental impact of construction logistics processes. Construction businesses can undertake critical activities, such as reducing vehicle emissions, mitigating traffic congestion, and enhancing productivity, by implementing the principles of these frameworks (Chatziioannou et al., 2020). However, integrating theories and frameworks assists construction logistics in moving beyond compliance with protocols, actively contributing to sustainability aims and promoting a more socially responsible and environmentally conscious approach to construction activities (Dani et al.,2022).

3.7.1. Logistics Solutions

Organisations use logistics solutions to address and overcome logistics challenges through strategies, tactics, technologies, and processes (Dhawan et al., 2022). Organisations implement logistics solutions to address logistics challenges (Alashwal and Fong, 2015). The solutions comprise a mix of strategies and actions designed to mitigate or eliminate challenges (Dani et al.,2022). To overcome these challenges, it is crucial to implement logistics solutions. Efficient and sustainable logistics practices can be attained by adopting the solutions elaborated in Table 3-4. Hence, each solution is related to a specific issue as indicated in the definition column. However, integrating the identified solutions would have significant value, including improving productivity and reducing delays and costs (Le et al., 2021). Four foundational frameworks involved several logistics solutions for enhancing sustainability: the Green Logistics Framework, A-S-I/AS-I-F Framework, TIMBER Framework, and IF-TOLD Framework. Understanding and discussing these frameworks is crucial for aligning their dimensions with the logistics challenges that present opportunities for sustainability.

Table 3-4 Logistics solutions are identified through frameworks (McKinnon, 2018).

Framework	Description	The Logistics Solutions
Green Logistics Framework	This was developed specifically for greening logistics operations. It focuses on minimising the environmental impact of logistics and supply chain operations.	• Adopting Lean principles as follows: ✓ Implementing the Kanban system to assist in managing inventory levels, production, and logistics flow. It guarantees that materials are replenished only when necessary, minimising waste and improving efficiency (Hedlund and Telese, 2019). ✓ By implementing the Last Planner System (LPS), which involves collaborative planning and reliable commitments, project schedules can be more predictable, and waste can be reduced (Luong Le et al. (2021) ✓ Implementing Just-in-time (JIT) to

Table 3-5 Logistics solutions identified through frameworks (McKinnon, 2018), Continued

Framework	Description	The Logistics Solutions
Green Logistics Framework	This was developed specifically for greening logistics operations. It focuses on minimising the environmental impact of logistics and supply chain operations.	✓ reduce excess inventory, minimising the need for storage and transportation and decreasing overall environmental impact. Furthermore, arranging deliveries to the construction site to satisfy the project's current requirements reduces on-site storage and handling (Fredriksson et al., 2021). ✓ The utilisation of real-time visibility tools to identify inefficiencies and opportunities for improvement (Janne and Fredriksson, 2021) ✓ Applying lean design principles in construction projects (Ekeskar and Rudberg, 2020; Janne and Rudberg, 2020). ✓ Using Value Stream Mapping to assist in identifying and eliminating non-value-added activities (Fredriksson et al., 2021). ✓ Applying the Kaizen principle (Continuous Improvement) (Taha, 2019) ✓ Implementing Poka-Yoke (Error-prevention) (Taha, 2019)

Table 3-5 Logistics solutions identified through frameworks (McKinnon, 2018), Continued

Framework	Description	The Logistics Solutions
Green Logistics Framework	The was developed specifically for greening logistics operations. It focuses on minimising the environmental impact of logistics and supply chain operations.	✓ Optimized transportation routes and Use of energy-efficient vehicles. Consider the Modal Shift, which promotes using more environmentally friendly transport modes, such as rail, which generally have a lower carbon footprint (McKinnon, 2018). ✓ Conducting a regular on-site visit (Gemba Walks) (Schipper et al., 2009). ✓ Applying the 5S Methodology for organising and maintaining a clean, efficient workspace. This approach can be applied to logistics to improve visibility, safety, and overall organisation (Janne and Fredriksson, 2021). ✓ Applying ABC (Pareto) analysis for inventory management. ✓ Implementing the Andon system to enable quick response to issues or challenges that occur while improving communication and coordination (Luong Le et al., 2021)

Table 3-5 Logistics solutions identified through frameworks (McKinnon, 2018), Continued

Framework	Description	The Logistics Solutions
Green Logistics Framework	This was developed specifically for greening logistics operations. It focuses on minimising the environmental impact of logistics and supply chain operations.	✓ Participate in associations, non-profit activities, and events (Janne and Fredriksson, 2021), ✓ Adopt proper information systems and modelling tools such as BIM and CAD (Taha, 2019). • Implement logistic centres to reduce congestion and disruption in the construction process. • Utilizing project management tools and procedures. • Logistics outsourcing, such as turning to Third-party logistics (TPL). TPL is a logistics firm that serves as a governance structure for controlling, monitoring, and managing labour, material, and information. The functions of TPL could be summarised as follows: o Building clear relations between the supply chains and activities carried out in and off-site while defining responsibilities. o Improve logistics and information sharing. o Improve supply chain structure. o Improve supply chain visibility and reliability. o Access to new and competitive opportunities (Fredriksson et al., 2021; Luong Le et al., 2021).

Table 3-5 Logistics solutions identified through frameworks (McKinnon, 2018), Continued

Framework	Description	The Logistics Solutions
The A-S-I/A-S-I-F Framework	Avoid-Shift-Improve (A-S-I) was first developed in Germany in 1991. The term was first published in a 1994 report by the German Parliament's Commission. The related principles are as follows	***Avoid or reduce*** the need to improve the transportation system's efficiency. Integrating land-use and transport demand management is a way to achieve this. ***Shift/Maintain*** instruments to enhance the efficiency of individual trips. Shifting from the most energy-consuming and polluting transport mode to more environmentally friendly modes significantly address the challenges of transport systems. ***Improve*** the focus on vehicle and fuel efficiency and enhance transportation's operational efficiency. Additionally, improving the energy sources required for their operation is key, with an inclination towards introducing renewable energy into the transport sector.
The TIMBER Framework	When formulating a logistics decarbonisation strategy, logistics operations must consider factors irrelevant to the organisation. The factors, acronymised as "TIMBER," are as follows.	**Technology adoption**: Advancements in technology encompass transportation, warehouse technology, and materials handling. **Infrastructure** is largely focused on transport infrastructure, encompassing networks and terminals for all primary transport modes. **Continuous improvement of behaviour** for employees through training and certification programs. **Energy** encompasses the process of producing power, the availability of alternative fuels, and the carbon impact of the fuels used.

Table 3-5 Logistics solutions identified through frameworks (McKinnon, 2018), Continued

Framework	Description	The Logistics Solutions
The IF-TOLD Framework	This model is like the Green Logistics Framework, and its principles are as follows.	• involves technologies for operations and infrastructure. • Proper management of operational practices. • Implementing a warehousing or consolidation centre along with a logistics centre to achieve efficiency in inventory operations. The operations through it imply the consolidation of materials required for construction activities. The main advantages of CC are receiving, checking, sorting the material, and consolidating them to be ready for delivery to the construction site according to the execution schedule and contractor needs. Hence this would enhance material visibility, keep material properly, and reduce disturbance in the construction site by managing the deliveries.

However, in terms of addressing logistics challenges to improve sustainability, the green model is the most overarching among the four mentioned above. Minimum attribute specificity makes it flexible and adaptable to circumscribe more than one sustainability dimension within each of its attributes, at the same time associating more than one attribute with a particular dimension of the other frameworks, resulting in a multidimensional application matrix. Based on an integration of the four frameworks, a solution for addressing logistics challenges should include four focus areas: lean solution, utilisation of TPL, utilisation of project management tools and procedures, and implementation of a logistics centre. This solution is illustrated in Figure 3-3.

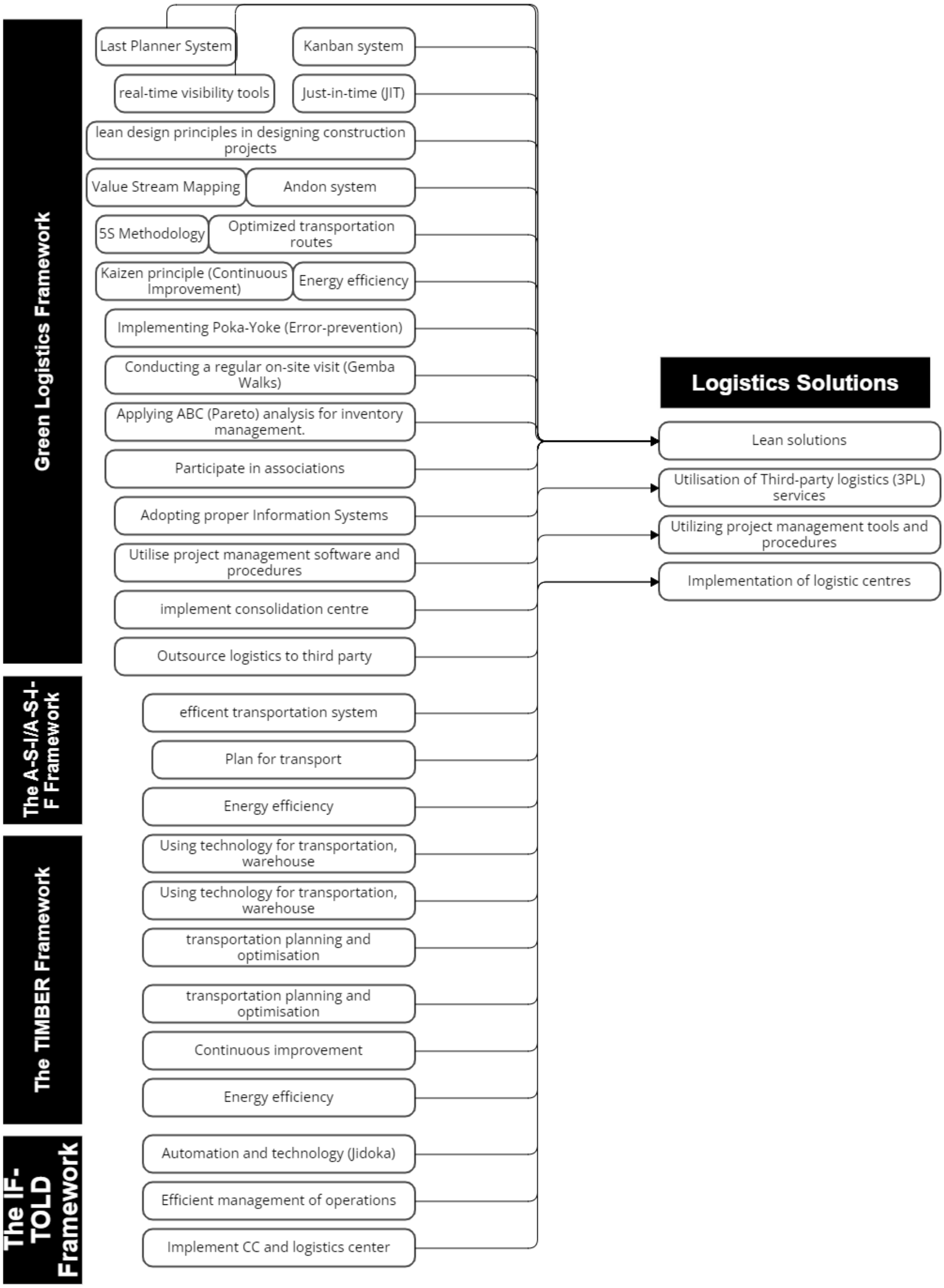

Figure 3-3 Logistics solutions proposed by logistics improvement frameworks (Created by the Author, 2025)

3.7.2. The Critical Susses Factors (C.S. Fs)

In the domain of construction logistics, a critical success factor (CSF) constitutes an element that influences the efficacy and sustainability of logistics operations within construction projects (Janne and Rudberg, 2020). These factors denote vital conditions or actions that must be proficiently managed to ensure the efficient movement of materials, timely deliveries, and optimal resource utilisation while simultaneously minimising waste and mitigating environmental impact. Enhancing efficiency in construction logistics involves refining processes, reducing delays, and fostering collaboration among stakeholders (Manuj et al., 2013). Concurrently, sustainability emphasises the adoption of environmentally friendly practices, reduction of carbon emissions, and compliance with environmental regulations (Rudberg and Olhager, 2003). Several authors have highlighted elements and recommendations for enhancing the sustainability and performance of construction logistics, and these recommendations are claimed to be critical success factors (Davis and Spekman, 2004, 2008; Miemczyk et al., 2016). This theory is often linked to critical success factors, which highlight the essential elements or principles of the success of logistics operations. Critical success factors, such as reducing delays, optimising processes, and addressing bottlenecks, can be identified by theories such as network theory or resource-based theory (Davis and Spekman, 2004). C.S. Fs are regarded as elements to be implemented within businesses to enhance the achievement of desired outcomes (Manuj et al., 2013). However, the proper integration of CSFs with business activities would generate a significant outcome and meaningful values (Khan et al., 2022). In the construction logistics environment, CSFs serve as a guide for implementing and monitoring adopted logistics solutions. Moreover, CSFs are recommended to be within logistics practices and processes to facilitate the achievement of business goals (Hedlund and Telese, 2019; Fredriksson et al., 2021; Luong Le et al., 2021). Hence, this supports the functioning of the logistics solution (Janne and Rudberg, 2020). Thus, achieving success in logistics and supply chain management requires the use of logistics critical success factors, which are key elements or drivers (Dhawan et al., 2022). Logistics CSFs have been developed and managed through the effective implementation of logistics solutions (Taha, 2019). Construction logistics and supply chains include several businesses and the flow of information, goods, and materials to satisfy clients' needs (Handfield and Nichols, 2002). However, a supply chain is considered a meta-organisation with numerous processes. It is also considered a borderless business (Picot et al., 2001), value net (Bovet and Martha, 2000), virtual supply chain (Chandrashekar and Schary, 1999), interactive firm (Johansen and Riis, 2005), a multi-organisation coordinated network (Rudberg and Olhager, 2003), and extended enterprise (Davis and Spekman, 2004; Boardman and Clegg, 2001).

Management refers to improving profitability by adopting reliable management of inter-organizational processes and relationships (Rudberg and Olhager, 2003).

Several theories can be used to enhance the sustainability of construction logistics and supply chains. These theories include. principal-agent theory (PAT), transaction cost analysis (TCA), resource-based view (RBV), and network theory (Manuj et al., 2013; Treiblmaier, 2018). The application of these theories towards improvement depends on the challenges to be addressed. For instance, positivist agent theory (PAT) focuses on the aspects of contracting between stakeholders and highlights the importance of achieving transparency and visibility in practice. PAT also promotes positive aspects within organisations and their agents. TCA was developed in economics and has been utilised in various areas, such as business and organizational studies. Optimising transactions and reducing costs associated with sustainability initiatives can be achieved by adapting TCA principles in the context of construction logistics and sustainability. The RBV approach to logistics management considers a firm's core resources and capabilities as sources of competitive advantage. Although RBV theory is commonly used for business strategy, its principles can also be utilised to enhance sustainability and improve construction logistics. Finally, network theory (NT) is claimed to be used to optimise processes, improve efficiency, and reduce environmental impacts in construction logistics, which has the potential to improve sustainability. NT is related to improving the management of information and practices by focusing on the relationships within networks to achieve smooth operations (Manuj et al., 2013; Davis and Spekman, 2004; Miemczyk et al., 2016; Treiblmaier, 2018). Table 3-5 depicts the main features of the four theories, considering several aspects.

Table 3-5 Comparison of PAT, TCA, RBV, and NT theories (Madhok, 2002; Hertz and Alfredsson, 2003; Halldorsson, 2007; Treiblmaier, 2018)

Aspects	Theory			
	PAT	**TCA**	**RBV**	**NT**
Primary focus of analysis	incentives and contracts	Transaction attributes	Resource attributes	Inter-organizational relations
Function of relationships	Efficient contract for relations (control, rights, and ownership)	Market failure	Access to integral and complementary resources	Access to several heterogeneous resources

Table 3-5 Comparison of PAT, TCA, RBV, and NT theories (Madhok, 2002; Hertz and Alfredsson, 2003; Halldorsson, 2007; Treiblmaier, 2018), Continued

Aspects	**Theory**			
	PAT	**TCA**	**RBV**	**NT**
Principals	• Identify and leverage the strengths of individuals and teams. • Empowerment of staff • Enhancing learning and development • Provide positive leadership. • Foster trust and Collaboration • Providing Positive Feedback	• Proper Monitoring • Proper planning and defining clear objectives. • Risk management. • Efficient information systems and technology • Standardization and Certification • Continuous Improvement	• Identification and estimation of resources • Integration of Technologies • Knowledge transfer and staff development • Strategic alliances and collaborations • Risk management and flexibility and Adaptability. • Continuous Improvement	• Optimization of transportation routes • Collaborate with stakeholders. • Resource allocation and load balancing • Resilience and risk management • Real-time monitoring and data analytics • Encourage the sharing of information. • Implement proper technologies. • Continuous improvement

All four theories mentioned above for logistics improvement provide significant insights and valuable points that can be implemented to improve sustainability. The principles identified by these theories have specific dimensions. Associating more than one attribute with a particular dimension of other theories leads to a multidimensional application matrix. Thus, based on an integration of the four theories, a critical success factor space consisting of eleven focus areas emerges: accurate demand forecasting and planning, efficient transportation and delivery management, effective inventory management, proper information flow, compliance with safety, environmental and regulations, effective risk management, integration of technology, efficient resource allocation, collaboration with suppliers, adequate training and skill development, and strong commitment and support from top management. Figure 3-4 depicts the attributes of the identified theories and the associated dimensions, which are critical success factors. The following illustrates CSFs in detail and their contribution to sustainability.

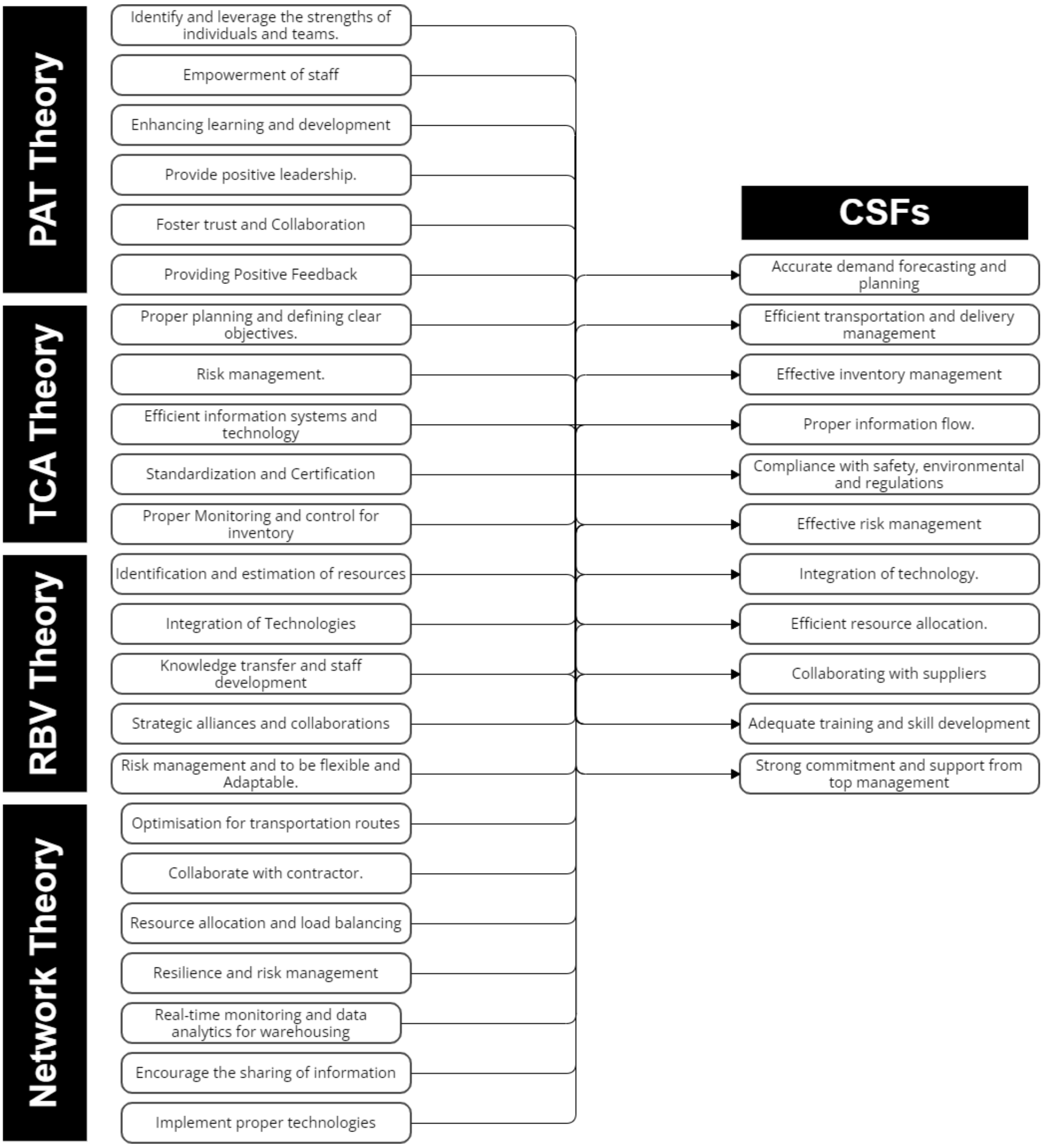

Figure 3-4 The logistics critical success factors are based on PAT, TCA, BRV, and Network theories (Created by the Author, 2025).

The subsequent analysis examines eleven critical success factors (CSFs), investigating their strategic management through these theoretical bases to enhance sustainability in construction projects.

3.7.2.1. *Accurate Demand Forecasting and Planning*

Accurate demand prediction and scheduling are essential for aligning the objectives of construction companies (principals) with those of vendors and subcontractors (agents). Principal-agent theory (PAT) emphasises the necessity of minimising information asymmetry between these entities to address challenges such as moral hazard and adverse selection (Manuj et al., 2013). When demand is accurately anticipated, agents are less likely to engage in opportunistic behaviour such as excessive ordering or insufficient material delivery. This alignment minimises the probability of setbacks and inefficiencies, thereby promoting optimal resource utilisation. Furthermore, Transaction Cost Analysis (TCA) indicates that precise forecasting reduces the need for frequent contract revisions, as project requirements are better understood from the outset (Davis and Spekman, 2004). By reducing these transaction costs, firms can focus on achieving sustainability objectives without being impeded by administrative barriers. From a Resource-Based View (RBV) perspective, demand forecasting represents a critical capability that enables companies to allocate resources effectively, ensuring that materials are procured and utilised as required, thereby minimising waste and excess inventory (Miemczyk et al., 2016). Network Theory further underscores the significance of collaboration in demand forecasting, as sharing accurate demand data with suppliers facilitates improved coordination of deliveries, reducing delays, and promoting sustainability throughout the supply chain (Treiblmaier, 2018). In conclusion, accurate demand forecasting aligns objectives, reduces waste, and facilitates sustainable resource utilisation across the construction network.

3.7.2.2. *Efficient Transportation and Delivery Management*

Efficient transportation and delivery play crucial roles in the construction supply chain, significantly affecting project sustainability. Principal-agent theory (PAT) posits that establishing explicit performance objectives and aligning incentives for logistics providers can mitigate agency problems, such as inefficient or late deliveries (Manuj et al., 2013). This approach ensures that logistics agents operate in the principal's best interests by enhancing route efficiency and reducing delivery times, which not only minimises project delays but also decreases carbon emissions and fuel consumption. Transaction Cost Analysis (TCA) further underscores the importance of streamlined transportation in cost reduction, as optimised logistics decrease expenses related to fuel consumption, vehicle maintenance, and driver time (Davis and Spekman, 2004). These cost savings can be reallocated to more sustainable practices, such as the implementation of electric vehicles or alternative fuel sources. From a Resource-Based View (RBV) perspective, efficient transportation becomes an asset, enhancing a company's competitive advantage by reducing environmental impact while maintaining project schedules (Miemczyk et al., 2016). Moreover, Network Theory emphasises the significance of supply chain collaboration in achieving transportation efficiency. By synchronising delivery schedules with suppliers and other stakeholders, companies can consolidate shipments, decrease the number of required trips, and minimise their overall environmental impact (Treiblmaier, 2018). Consequently, effective transportation management reduces costs and supports the sustainability objectives of the entire construction supply chain.

3.7.2.3. Effective Inventory Management

Effective inventory management is regarded as essential for the completion of construction projects, mitigating waste, and preventing delays. Principal-agent theory (PAT) underscores the necessity for rigorous oversight in inventory control, as principals must supervise agents (suppliers) to prevent both excess and insufficient material stocks, which can impede project progress (Manuj et al., 2013). Maintaining optimal inventory levels is crucial for minimising material waste, a critical aspect of sustainability initiatives. Transaction Cost Analysis (TCA) indicates that by maintaining appropriate inventory levels, firms can avoid significant transaction costs associated with expedited orders or excess storage (Davis and Spekman, 2004). These expenses frequently result from inadequate planning and communication and can be mitigated through efficient inventory control methods. From a Resource-Based View (RBV), proficient inventory management is a vital capability that enables companies to optimise their resources, reduce waste, and enhance overall sustainability (Miemczyk et al., 2016). Furthermore, Network Theory emphasises the importance of inventory information exchange across the supply chain to balance supply and demand. By synchronising inventory practices with suppliers, construction firms can ensure timely material availability, thereby reducing overproduction and material waste (Treiblmaier, 2018). This collaborative approach fosters sustainable inventory management, diminishing the environmental impact of surplus stock or last-minute deliveries.

3.7.2.4. Proper Information Flow

The effective flow of information plays a crucial role in aligning all parties involved in the construction supply chain with a project's sustainability goals. Principal-agent theory (PAT) emphasises the necessity of minimising information asymmetries between principals and agents to reduce the likelihood of opportunistic behaviour (Manuj et al., 2013). When both parties have access to accurate and current information, they can make informed decisions that promote sustainability, such as selecting the most environmentally friendly materials or optimising schedules for efficient resource utilisation. Transaction Cost Analysis (TCA) demonstrates that streamlined information flow diminishes the need for costly contract monitoring and enforcement, thereby simplifying the construction process and reducing transaction costs (Davis and Spekman, 2004). By enhancing communication, organisations can avoid misinterpretations or miscommunication that might result in project delays or environmental inefficiencies. From a Resource-Based View (RBV) perspective, information is considered an asset that can be utilised to enhance decision-making and improve project outcomes (Miemczyk et al., 2016). Organisations that effectively manage information flow can allocate resources more efficiently, minimise waste, and prioritise sustainability throughout the project. Network Theory further suggests that open information sharing across the supply chain fosters trust and cooperation, enabling all stakeholders to collaborate towards common sustainability objectives (Treiblmaier, 2018). Network-wide transparency is essential for ensuring alignment among all parties, reducing inefficiencies, and promoting sustainable practices throughout the construction supply chain.

3.7.2.5. Compliance with Safety, Environmental, and Regulatory Requirements

Adherence to safety, environmental, and regulatory standards is crucial for construction sustainability. According to the principal-agent theory (PAT), it is imperative for principals to closely monitor agents to ensure regulatory compliance, as violations can result in penalties, project delays, and reputational damage (Manuj et al., 2013). By aligning agent incentives with compliance objectives, principals can mitigate noncompliance risks and prioritise sustainability throughout projects. Transaction Cost Analysis (TCA) corroborates this notion by emphasising the expenses associated with noncompliance, such as legal costs or penalties, and positing that mitigating these risks through compliance can reduce transaction costs and enhance project outcomes (Davis and Spekman, 2004). From a Resource-Based View (RBV) perspective, meeting environmental and safety regulations is a critical asset that enhances a company's reputation and competitive advantage, as clients and stakeholders increasingly value sustainability (Miemczyk et al., 2016). Organisations that consistently meet or exceed regulatory requirements are better positioned to attract clients and maintain long-term business relationships. Network Theory underscores the significance of collaboration in ensuring compliance across the supply chain, as companies must cooperate closely with suppliers and subcontractors to ensure that all parties adhere to the necessary standards (Treiblmaier, 2018). This collaborative approach not only mitigates noncompliance risks but also fosters a sustainability-focused culture throughout the construction network.

3.7.2.6. Effective Risk Management

Risk management is critical in the construction industry because unforeseen challenges can lead to significant project delays, budget overruns, and unsustainable practices. Principal-agent theory (PAT) posits that effective risk management aligns the interests of principals and agents, thereby reducing the likelihood of project risks that could compromise sustainability (Manuj et al., 2013). By synchronising risk management approaches, both parties can collaborate to anticipate potential issues and mitigate their impact on project schedules and resources. Transaction cost analysis (TCA) indicates that proactive risk management reduces the transaction costs associated with unforeseen events, such as delays or material shortages, which can disrupt the construction process and result in unsustainable practices (Davis and Spekman, 2004). Through efficient risk management, organisations can maintain project momentum, thus minimising the need for costly modifications. The resource-based view (RBV) considers risk management as a core capability that enables firms to address uncertainties and maintain sustainability as a priority, even when confronted with challenges (Miemczyk et al., 2016). Network Theory proposes that risk management should be a collaborative effort across the supply chain, with all stakeholders sharing the responsibility of identifying and mitigating risks (Treiblmaier, 2018). This cooperative approach ensures more effective risk management, reduces the probability of project disruptions, and promotes sustainability.

3.7.2.7. Integration of Technology

In construction projects, the incorporation of technology is essential for providing tools and systems that can significantly enhance sustainability. According to Principal-Agent Theory (PAT), the integration of technology enables principals to minimise information asymmetry and grant agents access to up-to-date information, leading to improved decision-making processes (Manuj et al., 2013). An exemplification of this is the utilisation of building information modelling (BIM) systems, which allow all parties involved to view project schedules, resource requirements, and potential obstacles, ensuring more efficient and sustainable project execution. Transaction Cost Analysis (TCA) emphasises that technology reduces coordination expenses by enhancing communication and collaboration among project participants, thus decreasing transaction costs (Davis and Spekman, 2004). For instance, automated systems can diminish the need for manual supervision and enable more effective management of project resources. From a Resource-Based View (RBV) standpoint, technology is considered an asset that allows companies to enhance processes, minimise waste, and improve sustainability outcomes (Miemczyk et al., 2016). Organisations that invest in technology can differentiate themselves by demonstrating their commitment to efficiency and environmental stewardship. Network Theory underscores that the integration of technology strengthens connections throughout the supply chain, enabling seamless communication and collaboration among stakeholders (Treiblmaier, 2018).

3.7.2.8. Efficient Resource Allocation

Sustainable construction projects are contingent on the effective distribution of resources. The optimal utilisation of materials, workforce, and equipment contributes to waste reduction, energy conservation, and enhanced cost efficiency. According to principal-agent theory (PAT), principals must monitor agents' resource allocation to prevent inefficient use and waste stemming from poor management (Manuj et al., 2013). For instance, without adequate supervision, subcontractors might over-utilise materials, resulting in unnecessary expenditure and environmental detriment. Appropriate oversight ensures that agents adhere to sustainability objectives by utilising only essential resources for project completion. Transaction Cost Analysis (TCA) corroborates that efficient resource allocation minimises transaction costs by reducing the necessity for contract revisions or urgent procurement due to resource misallocation (Davis and Spekman, 2004). Through effective resource planning, construction companies can avert costly delays or rushed adjustments that often lead to unsustainable practices, such as expedited shipping or excessive material orders. The resource-based View (RBV) posits that proficient resource allocation is a vital capability that provides firms with a competitive advantage by maximising resource utility while minimising waste (Miemczyk et al., 2016). Companies excelling in resource allocation can distinguish themselves by completing projects on schedule and within the budget while reducing environmental impact. Network Theory emphasises the significance of supply chain coordination in achieving efficient resource allocation. By collaborating closely with suppliers and subcontractors, firms can ensure timely delivery and utilisation of materials and labour, minimising idle time, overstocking, and resource mismanagement (Treiblmaier, 2018). This coordination is vital for smooth project execution and meeting sustainability goals through optimal resource utilisation.

3.7.2.9. Collaborating with Suppliers

Collaboration with suppliers is imperative for enhancing sustainability in construction projects. Suppliers play a critical role in providing the requisite materials and services for project completion, and robust partnerships can improve sustainability. According to the principal-agent theory (PAT), fostering strong supplier relationships enables principals to mitigate risks associated with opportunistic behaviours, such as the provision of substandard materials or inflated service charges (Manuj et al., 2013). Establishing enduring, trust-based relationships motivate suppliers to prioritise project interests and deliver high-quality, sustainability-compliant materials. Transaction Cost Analysis (TCA) demonstrates that supplier collaboration reduces expenses related to contract negotiation and enforcement, as long-standing partnerships often result in more informal agreements and better-aligned objectives (Davis and Spekman, 2004). This reduction in transaction costs facilitates the reallocation of resources towards sustainable practices. From a Resource-Based View (RBV) perspective, supplier collaboration enables firms to leverage their partners' unique competencies and knowledge, enhancing their capacity to execute sustainable projects (Miemczyk et al., 2016). Suppliers frequently possess specialised expertise in sustainable materials and construction methodologies, and close collaboration allows firms to utilise this knowledge to improve their sustainability performance. Network Theory emphasises that strong supplier relationships promote greater supply chain coordination, enabling firms to synchronise their efforts and achieve shared sustainability objectives (Treiblmaier, 2018). Through close supplier collaboration, construction firms can ensure timely delivery of materials that meet environmental standards and are utilised efficiently, contributing to overall project sustainability.

3.7.2.10. Adequate Training and Skill Development

It is imperative to invest in training and skill enhancement to create a workforce that can execute sustainable construction projects. According to principal-agent theory (PAT), principals must ensure that agents (such as subcontractors or employees) receive adequate training to align their capabilities with the project's sustainability objectives (Manuj et al., 2013). Without proper instruction, agents may lack the expertise required to implement environmentally conscious practices, resulting in inefficiencies or failure to meet environmental standards. Training equips all stakeholders to make informed decisions that support a project's sustainability goals. Transaction Cost Analysis (TCA) also underscores the cost-reduction potential of training, as skilled agents are less susceptible to making costly errors or requiring constant supervision (Davis and Spekman, 2004). This reduction in oversight not only decreases transaction costs but also enhances project execution efficiency. From a Resource-Based View (RBV) perspective, training and skill development are critical resources that enhance a company's capacity to innovate and implement sustainable practices (Miemczyk et al., 2016). A skilled workforce is better positioned to identify opportunities for improving sustainability, such as optimising material usage, minimising waste, or implementing energy-efficient construction techniques. Network Theory emphasises the significance of knowledge dissemination across the supply chain, as well-trained teams can collaborate more effectively with suppliers, contractors, and other stakeholders to achieve common sustainability objectives (Treiblmaier, 2018). By prioritising training, construction firms can ensure that their workforce is not only proficient in sustainable practices but also capable of working collaboratively to implement them throughout the project.

3.7.2.11. Strong Commitment and Support from Top Management

The efficacy of sustainability initiatives in construction projects is contingent on the commitment and support of senior leadership. According to principal-agent theory (PAT), when executives demonstrate a strong commitment to sustainability, they establish clear expectations for their subordinates, aligning their actions with the organisation's environmental objectives (Manuj et al., 2013). Upper management plays a crucial role in developing policies, incentives, and oversight mechanisms that ensure that all parties involved prioritise sustainability throughout the project. In the absence of this commitment, employees may not accord sufficient importance to sustainability, resulting in suboptimal practices that undermine an organisation's environmental goals. Transaction Cost Analysis (TCA) corroborates the notion that strong leadership reduces expenses associated with monitoring and enforcing sustainability practices as sustainable practices become integrated into the organisation's operations (Davis and Spekman, 2004). When sustainability is a top priority, fewer resources are required to ensure compliance, as employees are inherently motivated to meet these objectives. From a resource-based View (RBV) perspective, executive support is a critical asset that drives an organisation's capacity to implement sustainable practices and gain a competitive advantage (Miemczyk et al., 2016). Organisations with strong sustainability leadership are more likely to innovate, adopt cutting-edge technologies, and form partnerships that enhance their sustainability performance. Network Theory further emphasises that executive commitment strengthens relationships across the supply chain, as suppliers, contractors, and other partners are more inclined to align with the organisation's sustainability goals when they observe strong leadership from the top (Treiblmaier, 2018). By exhibiting a clear dedication to sustainability, senior management establishes the foundation for the entire project, ensuring that all stakeholders are united and working towards the shared goal of minimising environmental impact and promoting sustainability.

The Literature Outcome

The literature review identifies logistics challenges, solutions, and CSFs. In addition, the sustainability dimensions within the construction are highlighted. However, logistics challenges are identified and themed to logistics functions within the construction industry. Furthermore, logistics solutions are claimed to address these challenges while facilitating the adoption of CSFs. Logistics solutions are identified based on four foundational frameworks: the Green Logistics Framework, A-S-I/AS-I-F Framework, TIMBER Framework, and IF-TOLD Framework. These frameworks specify structured methods that address numerous logistics and supply chain aspects. For instance, the Green Logistics model assists firms in designing and implementing logistics processes that balance economic and environmental objectives. On the other hand, CSFs are formulated based on integrating the four theories, PAT, NT, RBV, and TCA. The theories discussed provide insights into the fundamental principles and dynamics that impact the efficiency and effectiveness of logistics operations. For instance, understanding and aligning stakeholder priorities is emphasised in RBV while ensuring that logistics strategies comply with organizational goals and stakeholder expectations.

4. Chapter Four: Qualitative Research / Understanding the Problem and Hypothesis Development

4.1. Introduction

This chapter explores the qualitative research approach used to understand the problem and enhancing in develop the study’s hypotheses. It provides an in-depth analysis of logistics challenges in the Middle Eastern construction industry by leveraging expert insights through semi-structured interviews. This qualitative phase assists in identifying key variables, refining theoretical assumptions, and ensuring the proposed model aligns with real-world industry dynamics. By integrating expert perspectives, the study establishes a basis for hypothesis development, which is later tested quantitatively using structural equation modelling (SEM).

4.2. Exploratory Interviews

Qualitative studies play a crucial role in this research by examining intricate situation-explicit phenomena. This approach enables the elucidation of patterns, constructs, and underlying factors that are not readily apparent or adequately addressed in the extant literature. The qualitative study employed semi-structured interviews to investigate logistics challenges, practices, and solutions in the Middle East construction industry. By engaging with diverse participants from various construction projects, the qualitative method provides a nuanced understanding of logistics dynamics across different projects, organisations, and locations. The selection of a qualitative study was essential because of the highly context-dependent nature of logistics challenges in the construction sector, which can vary significantly between projects and organisations. A rigid quantitative approach would have been insufficient to explore these complexities. Qualitative research allows for unrestricted exploration, revealing insights into how logistics practices differ based on factors such as project scale, contractor involvement, and regional customs. This method offers the necessary depth to reveal latent causes and emerging challenges, which can then be formulated as hypotheses. These hypotheses were subsequently tested quantitatively, rendering the qualitative study a vital initial step in comprehending the problem and guiding further research.

The interview data were analysed using Braun and Clarke's (2006) thematic approach. This includes understanding the transcripts, searching for codes, and defining and refining themes. For instance, the process for this study started by understanding the transcripts through several readings, and then line-by-line coding was employed to highlight the codes. Finally, the identified logistics challenges are assigned to pro-identified themes. The current logistics practices are investigated along with the emergent challenges, hidden causes, and adopted methods and techniques to address challenges and enhance sustainability. The chosen interviewees had different roles in capturing the research subject from various corners. Therefore, the interview processes were initiated after identifying the main actors within the construction project who were related to or responsible for logistics practices. All interviews were conducted with actors who had sufficient experience in construction logistics and had a direct impact on logistics practices. It seems that most of the interviewees had significant experience in different construction projects ranging from small to large, including buildings, roads, and infrastructure, which reinforces the reliability of the findings. Logistics' role is observed to vary from one construction company to another and from one project to another in the Middle East. For instance, a contractor representative may be responsible for logistics management, whereas, in other companies, the site or office engineer may be responsible for logistics management. Consequently, this is influenced by the contractor's number of staff members and experience. Furthermore, it has been observed that subcontractors handle their logistics activities independently from the main contractor and other stakeholders. Between May 2023 and Dec 2023, twenty-nine interviews were conducted with several participants in the Middle East, including academics, engineers, contractor representatives, and suppliers, as depicted in Table 4-1. The interviews continued until saturation because the interviewees did not generate any more valuable information.

Table 4-1 Interviewees list

#	CODE	ROLE OF INTERVIEWEES	EXPERIENCE
1	**A**	Contractor's Representative	More than 15 years
2	**B**	Project Manager	12 years
3	**C**	Senior Site Engineer	15 years
4	**D**	Logistics Manager	12 years
5	**E**	Logistics Manager	15 years
6	**F**	Project Manager	21 years
7	**G**	Contractor's Representative	18 years
8	**H**	Project Engineer	10 years
9	**I**	Senior Office Engineer	10 years
10	**J**	Project Manager	20 years
11	**K**	Construction Manager	More than 15 years
12	**L**	Contractor's Representative	13 years
13	**M**	Project Manager	10 years
14	**N**	Senior Site Engineer	18 years
15	**O**	Logistics Manager	8 years
16	**P**	Logistics Manager	11 years
17	**Q**	Project Manager	17 years
18	**R**	Contractor's Representative	8 years
19	**S**	Supplier of construction material	20 years
20	**T**	Supplier of construction material and owner of Block Factory	25 years
21	**J**	Construction Manager	12 years
22	**V**	Logistics Manager	12 years
23	**W**	Logistics Manager	15 years
24	**X**	Project Manager	12 years
25	**Y**	Contractor's Representative	More than 18 years
26	**Z**	Project Engineer	21 years
27	**AA**	Senior Office Engineer	18 years
28	**BB**	Project Manager	8 years
29	**CC**	PhD in Construction Logistics	6 years

The selection criteria for the participants were based on their experience and knowledge of construction logistics to contribute to this research significantly. After obtaining consent from each respondent, the interview process began. All interview data were securely encrypted, and personal information was kept anonymous. The interviews were conducted to investigate current logistics practices to improve understanding and provide additional justification for the research based on respondents' perceptions, which enriches the literature findings. The interviews lasted around an hour per respondent and included five questions. The findings of the interviews were validated based on credibility by sharing the outcome with respondents to validate interpretations and ensure accuracy and transferability by offering descriptions of the context, contributors, and data collection methods to allow the readers to assess applicability to different contexts; dependability, including maintaining records of the research procedure, including data collection, analysis, and interpretations, to allow for replication and scrutiny; and conformability, by discussing interpretations and outcomes with colleagues to minimise bias and subjectivity. Finally, the outcomes offer valuable information about logistics practices in construction in The Middle East.

4.2.1. Perception Regarding Logistics Practices within Construction in the Middle East

According to several interviewees, the logistics of the construction industry in the Middle East are poorly understood and have received little attention. For instance, respondent B said,

"*Very few people working in the construction industry understand logistics and supply chain management and the related application in construction".*

additionally. they argued that numerous construction actors do not have sufficient experience and knowledge of logistics and related processes, contributing to the project's success as indicated by Respondent C

"*Construction industry people have little knowledge and experience in logistics and supply chain management*".

The research indicates that many construction professionals have a limited understanding of logistics, resulting in its underuse and minimal incorporation of effective logistics strategies into project management. Interviewees pointed out that construction stakeholders often lack expertise in logistics and supply chain management, which directly affects project outcomes, especially in terms of resource management and cost efficiency. This suggests that while some contractors may recognise the importance of logistics in handling materials, they frequently overlook its broader potential to optimise the utilisation of all resources, including the workforce, machinery, and time, throughout the construction process.

Furthermore, they fail to recognise the roles and responsibilities of logistics and supply chain management. Some interviewees, such as F, argued

"*We consider logistics and SCM for material monitoring and coordinating and we neglect logistics and SCM to integrate all resources".*

This suggests that while some construction contractors grasp the concepts of material management logistics, they often overlook the importance of resource coordination and optimisation for cost reduction. According to Interviewees K and J, logistics and SCM research in the Middle Eastern construction sector receive minimal attention, with most academic institutions failing to offer logistics courses that would provide students with knowledge in this field. For example, most educational programs, including those for engineering students, lack content related to this discipline or its essential practices. The scarcity of logistics and SCM courses in engineering and construction curricula points to a widespread issue that hinders the development of industry-wide expertise in this area. This education gap has far-reaching consequences for an industry's capacity to enhance supply chain efficiency and implement sustainable practices.

4.2.2. Interviewees' Experience in Logistics within Construction in the Middle East

The roles and responsibilities of staff working in construction logistics in the Middle East can be summarised into three main tasks: first, preparing a list of required resources and materials and specifying quantities and qualities to be procured, as indicated by respondent C:

"*My job was to prepare the lists for suppliers and material providers*"

Second, liaising with suppliers to obtain proposals that include potential alternatives to secure the best quality at competitive prices, as specified by respondent E:

"We seek alternatives to achieve the best quality and prices"

The third is monitoring and coordinating deliveries. However, several respondents highlighted that working in construction logistics is often perceived as a complex and stressful task, mainly due to a lack of commitment from key parties and inadequate logistics knowledge, as elaborated by respondent Q:

"*The challenge I experience is my lack of coordination and communication for example, contractor or subcontractor staff depend on each other to monitor or estimate the material*"

Logistics operations in construction are often managed reactively without adequate planning. According to respondents M and F, logistics are frequently considered a secondary priority in the construction process, leading to inefficiencies. This observation directly addresses the research question by highlighting the key challenges and inefficiencies in logistics management within the Middle Eastern construction industry, which significantly impacts sustainability. A detailed description of logistics responsibilities, such as creating resource inventories, communicating with suppliers, and managing deliveries, exposes gaps in the comprehension and implementation of logistics tasks, as noted by several respondents. Their comments emphasised the lack of synchronisation, poor communication, and reactive logistics practices, which are identified as major obstacles to effective project management. These inefficiencies indicate deeper systemic problems, including a lack of qualified personnel and inadequate planning, underscoring the necessity for a more proactive and organised approach to construction logistics. The insights from respondents regarding the perception of logistics as a secondary concern provide crucial evidence that logistics are not fully integrated into construction processes, thereby hindering project efficiency and sustainability. The observation that logistics activities are often reactive rather than pre-planned reflects a significant operational weakness aligned with the research goal of identifying logistics solutions and CSFs to enhance sustainability.

4.2.3. Logistics Problems and Challenges within the Middle East Construction Industry

This section provides a crucial understanding of the challenges affecting logistics performance in Middle Eastern construction projects. The findings not only underscore major inefficiencies in supply chain and logistics management but also reveal region challenges that set the Middle East apart from other areas, as explored in the literature analysis.

- *Planning and Resource Allocation*

The participants identified the lack of synchronisation between logistics and construction operations as the main concern, which significantly affects the effectiveness of logistics management. According to respondent A: *"The difficulty I face is the poor construction staff and the bad coordination between stakeholders."* According to respondent J, this absence of coordination leads to significant losses in time and efficiency.: *"Several construction contractors in the Middle East deal with logistics daily not creating or generating coordinated logistics plans with the construction activities plan. As a result, we are facing significant productivity losses."* Although existing research often examines the coordination challenges between logistics and operations in construction, this issue appears particularly acute in the Middle East. The region's construction industry is characterised by a highly fragmented structure, with numerous subcontractors employing their unique systems and processes. This fragmentation introduces additional layers of complexity in logistics planning and resource allocation, resulting in inefficiencies that are not as thoroughly documented in other parts of the world.

Additionally, the comment from respondent J regarding inadequate planning for obtaining resources further highlights this problem.: *"Poor planning for resource acquisition is the other reason for delays and troubles. For instance, several construction projects create schedules for construction activities, but they do not create any logistics plan for the required resources that need to be available at a specific time along with very limited supervision."* This highlights the reactive approach to logistics management in Middle Eastern countries, where logistics are often treated as an afterthought to construction projects. By contrast, more advanced regions incorporate logistics planning from the outset and integrate it into the initial project phases.

- *Transportation*

In the Middle East, significant challenges related to transportation inefficiencies have been identified. Respondents X and Z pointed out that the use of outdated and unreliable vehicles resulted in delays in material and resource deliveries. Furthermore, respondents P, J, and E emphasized the absence of systems for tracking and monitoring.: *"A poor tracking system and improper types of vehicles used in transportation are among the primary challenges."* Unlike the global best practices described in the literature, which utilise cutting-edge logistical tracking technologies and efficient vehicle management systems, the outdated transportation infrastructure of the Middle East hinders productivity. Transportation delays compound time and cost inefficiencies, leading to poor project implementation and high expenses. These issues are less common in regions that have adopted modern logistics.

- *Inventory and Warehouse Management*

A contractor representative with extensive experience spanning over 15 years points out that the Middle East also faces significant challenges in managing inventory effectively.: *"The practice of inventory management seems to be weak with unreliable practices. Several contractors rely on weak people to manage inventory resulting in poor availability of qualified materials and resources."* The shortage of qualified workers and inadequate inventory control systems result in poor tracking of materials, causing supply shortages, project delays, and resource waste. Although existing research has discussed inventory management issues in construction, the Middle East seems to be facing more severe problems in this area. This situation also highlights a broader skills gap in the region, where logistics and supply chain management professionals may not have access to the same level of education or tools as their counterparts in more economically advanced countries.

- *Material Management*

Ineffective material management poses a substantial challenge in the Middle East. As stated by respondent K: *"Some contractors rely on undetailed and inappropriate design drawings or specifications for material estimation and use inappropriate methods for material handling. Wrong material was delivered due to poor quality checks, severe fluctuation of material prices in the market due to weak agreements, and forming agreements based on negotiation, not collaboration."* The absence of cooperative efforts in acquiring materials and the tendency to rely on negotiations rather than long-term strategic alliances contribute to price instability and inefficient use of resources. While scholarly research generally endorses collaboration and partnership formation as optimal practices for managing materials, these strategic relationships appear to be underutilised in the Middle East. Moreover, a senior site engineer pointed out that imprecise material estimations and redundancies resulting from poor communication and excessive documentation are additional hurdles that compound resource inefficiencies.

- *Communication and Coordination*

Respondent W emphasised poor communication and collaboration among the involved parties. *"Several construction projects in the Middle East face difficulties due to weak communication and coordination."* This leads to confusion, redundancy, and setbacks. Research highlights the necessity of robust communication structures and interparty coordination in logistics management; however, this appears to be a notable deficiency in the Middle East. The region's construction projects are characterised by fragmentation, involving numerous subcontractors and poorly defined responsibilities. This complexity hinders the implementation of effective communication systems, in contrast to the more unified and cooperative approaches observed in other parts of the world.

- *Reverse Logistics (RL)*

According to a logistics manager, the construction industry in the Middle East largely overlooks reverse logistics (RL) *"Construction businesses are less concerned with resources returning and reversing processes due to the associated cost of the material return, including labour and transportation costs."* Unlike the more sustainable approaches emphasised in research, in which RL is utilised to reduce waste and enhance resource efficiency, the cost-centric mindset of contractors in the Middle East hinders the implementation of RL strategies. The region's emphasis on immediate financial savings rather than long-term environmental responsibility stands entirely in contrast to global industry standards, where RL is increasingly incorporated into construction supply chains to enhance sustainability.

- *Sudden Labor Shortages and Unstable Conditions*

The Middle Eastern region faces a unique obstacle in the form of abrupt workforce shortages and shutdowns resulting from volatile circumstances. This problem, which has not been extensively examined in scholarly studies, poses a significant threat to logistical operations in this area. Fluctuations in political circumstances, safety issues, and changes in regulations can result in unforeseen disruptions, affecting the availability of workers and causing project schedules to decline. This regional challenge sets the Middle East apart from more stable economies where such risks are typically less pronounced.

4.2.4. Perspective Regarding the Root Causes and Consequences of Logistics Challenges and Their Impact on Sustainability

This section highlights key problems that contribute to logistical difficulties in the Middle Eastern construction sector, particularly focusing on decreased productivity, budget overruns, and effects on sustainability. To contextualise these challenges within the broader model sustainability and critical realism methodology, we can examine the fundamental causes and effects to comprehend how this study informs the theoretical structure as follows:

4.2.4.1. Root Causes of Logistical Challenges

- **Unreliable Practices**: The construction sector struggles with a lack of consistency in its planning and implementation processes as highlighted by Respondent A

"*The main cause for inefficient logistics practices are unreliable practices, poor management commitment, and not considering logistics as a primary part of the construction activity*"

This unpredictability often arises from the absence of uniform procedures or guidelines for overseeing logistics within the construction supply chain management (SCM) as indicated by Respondent E

"*Several construction contractors in the Middle East deal with logistics on a daily basis not creating or generating logistics plans as the construction activities plan*"

In the ever-changing landscape of construction, where materials and workforce are in constant flux, unreliable methods result in project setbacks, the need for corrections, and escalating expenses.

- **Poor Management Commitment**: The interviews highlight that executives often undervalue the importance of logistics in construction projects while assigning a very limited budget to its operations as Respondent F quotes

"Poor top management commitment to employ logistics properly including assigning logistics-experienced people to conduct logistics functions."

Logistics, which encompasses the coordination of materials, equipment, and workforce, can lead to substantial inefficiencies if not given proper attention. When top-level management fails to recognise logistics as a crucial component of project success, it results in ineffective resource distribution, ultimately compromising overall project efficiency.

- **Lack of Logistics as a Primary Activity and Undervalue of its Effect**: In contrast to some sectors where logistics is seamlessly integrated, the construction industry is often treated as a secondary role as Respondent H claimed

"They are dealing with logistics as a minor and secondary part with poor planning and this is the problem"

And Respondent M mentioned

"The project's stakeholders are unaware of how logistics affect project costs"

This approach results in reactive problem-solving rather than proactive planning, necessitating teams to address challenges as they arise instead of anticipating and mitigating them.

- **Lack of Expertise and Skilled Personnel**: A persistent challenge is the lack of experienced logistics officers and supply chain management professionals. The reliance on weak, less skilled personnel mentioned by several respondents, such as G and I, compounds operational inefficiencies, as these individuals often lack the necessary expertise and decision-making capabilities to optimise logistics operations. Furthermore, their limited experience may hinder their ability to effectively coordinate intricate supply chain functions, resulting in disjointed and piecemeal problem-solving approaches.

4.2.4.2. Consequences of Inefficient Logistics Practices

- **Productivity Losses**: Inefficiencies in logistics, such as idle time resulting from waiting for workers, materials, or equipment, contribute to direct on-site time wastage. The Middle Eastern construction sector has already experienced productivity challenges, and these logistical deficiencies exacerbate the situation, leading to weak schedule delays and budget overruns. This is elaborated by respondent J as:

"*Due to the identified logistics challenges, we are facing huge productivity losses in terms of material and resource availability such as workers, information, data, equipment and labour*"

- **Cost Overruns**: Poor management of logistics leads to obstructions that increase expenses as indicated by respondent R

"*Thus, this is why logistics inefficiency adversely affects productivity and causes cost overruns*."

Through prolonged project durations and higher costs for labour and materials. For instance, when supplies are not delivered on time or sent to incorrect sites, construction firms must bear the financial burden of placing new orders or rearranging work crews, putting additional strain on the project's budget.

- **Environmental Impact and Sustainability:** The concept of sustainability in construction extends beyond the utilisation of eco-friendly materials and energy-conserving designs. It also involves the optimal utilisation of resources, such as time, workforce, and building materials. Ineffective logistics management compromises sustainability in several ways. For instance, the construction sector is a significant source of carbon emissions, and logistical inefficiencies such as unnecessary material transportation, equipment idling due to delays, and increased waste from disorganised supply chains further exacerbate these sustainability challenges. This is highlighted by respondent Z as

"Poor *monitoring and control cause transportation delays and emissions*"

Consequently, enhancing logistics efficiency directly contributes to reducing the industry's carbon footprint.

- **Disruption of Project Flow**: Respondent X noted

"*Many construction projects in the Middle East face delays and disruption in schedules due to inefficient logistics coordination and practices*"

The disjointed management of logistics by various stakeholders often leads to workflow interruptions, commonly resulting in material shortages or improper equipment allocation. This lack of coordination contributes to project setbacks and intensifies the challenges associated with overseeing large-scale construction activities, especially in the Middle Eastern regions where massive projects are common. However, delays or disruptions often cause materials to be ordered prematurely or in excess, thereby increasing waste.

4.2.5. Methods and Solutions Used to Address Logistics Challenges to Enhance Sustainability.

The interviews stressed the significance of effective logistics management in cutting expenses and eliminating inefficiencies related to time and finances. Various strategies have been implemented within the Middle East construction industry to maximise resource utilisation and reduce waste, such as outsourcing, implementing state-of-the-art technologies, and enhancing communication. Several respondents noted, such as A, B, and F, that multiple techniques and methodologies are utilised to boost logistics efficiency and address challenges, with the primary objectives of enhancing productivity and sustainability. The organisation acknowledges that, in the Middle Eastern construction sector, cost overruns and project delays are prevalent owing to poor resource estimation and management. To address these challenges, the participants' answers highlight several solutions and critical success factors, providing valuable insights into strategies and crucial areas for improving logistics performance.

- *Importance of Logistics and Supply Chain Management (SCM)*

Throughout the interviews, a recurring theme was the increasing significance of logistics and supply chain management (SCM) in construction projects. The interviewee repeatedly stressed the crucial part that logistics play in controlling expenses and reducing project delays. According to their observations, "*logistics and SCM contribute to a significant amount of project cost*" and improving these operations can have substantial impacts on overall project efficiency. The emphasis on logistics signifies a larger trend in the construction sector, where logistics are increasingly recognised as a crucial element for project achievement.

- *Collaboration and Communication*

A significant focus is placed on the importance of teamwork and interaction among the different parties involved. The person interviewed stressed the significance of team gatherings held daily and ongoing sessions for providing feedback, noting that *"holding continuous daily group meetings"* assists in enhancing visibility and coordination across teams. This approach fosters *"open communication"* This approach fosters a more cohesive work setting, allowing for quick and cooperative resolution of operational challenges. In addition, the implementation of communication matrices and plans enhances teamwork and coordination.

- *Technological Integration*

The interviewees emphasised the crucial role of technological integration in logistics. They discuss the implementation of systems for tracking materials and the adoption of tools such as the Last Planner System (LPS) for planning resources and materials. The goal of these technological innovations is to improve visibility and efficiency while simultaneously tackling common operational issues, such as material shortages and ineffective oversight. The implementation of Kanban cards and LPS indicates a growing trend towards utilising data-oriented, tech-enabled approaches for resource planning and tracking. Respondent K explains, *"We introduce Kanban cards to enhance resource planning"*, indicating a shift towards more responsive project management techniques.

- *Outsourcing*

The utilisation of third-party logistics providers has become a strategic method for handling complex projects. According to Respondent O, the company, when dealing with exceptional or large-scale initiatives, *"considers third-party logistics to handle logistics activities"*. This demonstrates the utilisation and deployment of outside expertise to optimise operations, enhance resource management, and facilitate the seamless implementation of intricate logistical processes. Additionally, collaboration with *"experts and professionals"* is emphasised as a crucial strategy for success, highlighting the importance of leveraging proper knowledge and experience in logistics management.

- *Material Management*

In the construction sector, a persistent operational issue involves managing supply chain disruptions and the price volatility of building materials. Respondent Q mentions the construction of a *"central warehouse"* to mitigate material deficiencies and improve management. Warehousing supports the management of variations in material supply, facilitates improved inventory control, and minimises disruptions caused by unexpected shortages. The construction of storage facilities and distribution hubs demonstrates a proactive strategy in logistics management designed to enhance the flow of materials and prevent project delays. This concept shows how advanced systems for managing materials can substantially influence project flows and expenses.

- *Training and Staff Development*

Interviewee Z emphasizes the critical nature of ongoing education and the necessity to *"employ logistics officers"* to enhance logistics management. Regular training is crucial to keep employees up to date with the newest logistics methods and tools. By equipping staff with the right skills and knowledge, organisations can improve their handling of logistics operations. Interviewee AA points out that their logistics approach incorporates "*continuous feedback and training"* underscoring the importance of maintaining a flexible and well-informed workforce.

- *Management Commitment and Planning*

The interview with BB highlights the critical role of management's dedication in enhancing logistics efficiency. According to the interviewee, the initial step in tackling logistical issues is securing *"management commitment"*. They emphasise the importance of conducting meetings with managers to ensure that they grasp the significance of logistics in cost reduction and delay prevention. This implies that improvements in logistics must be initiated by upper management. In addition, strategic planning plays a vital role, with an emphasis on creating thorough logistics plans that are seamlessly integrated with construction schedules. By developing plans that incorporate both resources and construction activities, logistics become an essential component of the overall project implementation, facilitating smoother coordination and minimising unexpected issues throughout the project's duration.

- *Cost Reduction and Efficiency*

The interviewee repeatedly highlights how effective logistics management can " minimise expenses" and "eradicate time and monetary inefficiencies". Various strategies, including outsourcing, embracing new technologies, and enhancing communication, have been implemented to maximise resource utilisation and eliminate inefficiencies. The interviewee notes that ‘multiple approaches and strategies’ are utilised to ‘boost logistics efficiency’ and ‘tackle logistics obstacles’, all aimed at achieving greater productivity. The organisation also acknowledges that budget overruns and schedule delays are prevalent in the Middle Eastern construction sector owing to poor resource estimation and management. To address these issues, companies are actively implementing improved logistics practices.

Still, the interview data and their analysis are available in Appendix 11.

4.3. Summary and How the Interviews Inform the Research Question and Research Methodology

Critical realism is a philosophical model that aims to elucidate and comprehend the underlying causes of observable phenomena. In the construction industry, logistical challenges are not merely superficial issues but are deeply rooted in structural, cultural, and organizational practices. This perspective facilitates a more in-depth analysis of the complexities of logistical inefficiencies in the construction sector. This research enhances the critical realism methodology in several ways. First, it emphasises the identification of root causes by examining fundamental issues such as insufficient management commitment, lack of skilled labour, and fragmented stakeholder and subcontractor management. The interviews revealed that logistical inefficiencies originate from the industry's organizational structure and cultural norms rather than solely from poor day-to-day management. Notably, this study identifies two challenges distinctive to the Middle East: unexpected labour shortages and project shutdowns due to unstable conditions. These issues are crucial as they not only exacerbate existing logistical inefficiencies but also introduce unpredictable elements that are difficult to address. Sudden workforce shortages can disrupt entire supply chains, delay project schedules, and create inefficiencies in resource allocation. Similarly, project closures due to unstable political or economic situations result in abrupt operational halts, rendering long-term planning and execution exceptionally challenging. The instability introduced by these factors adds regional complexity unique to the Middle East, and addressing these challenges necessitates solutions that account for this unpredictability. Second, the interviews provide context by focusing on the Middle Eastern construction industry, which is distinctive because of its emphasis on large-scale projects, complex supply chains, and diverse workforces. By considering the region-context, the interviews offer insights into how local practices, governance, and market conditions contribute to logistical challenges, aligning with critical realism's emphasis on understanding phenomena within their contexts. Finally, the study promotes informed action and change. Uncovering the deep-rooted causes of logistical inefficiencies indicates the systemic changes that address these issues through logistics solutions and CSFs.

5. Chapter Five: Conceptualisation and Model Development

5.1. Introduction

This chapter presents a theoretical model that examines the interrelationships between logistical challenges, solutions, critical success factors (CSFs), and sustainability in the construction sector. An approach to examining sustainability in construction can be achieved by integrating the principal-agent theory, transaction cost analysis, resource-based view, and network theory. This model elucidates how logistics challenges, solutions, and Critical Success Factors (CSFs) influence sustainable logistics within the construction industry. These theoretical perspectives underscore the importance of aligning stakeholder objectives, minimising transaction costs, optimising internal resources, and strengthening network connections to achieve sustainability. For instance, principal-agent theory (PAT) addresses conflicts stemming from information asymmetries among stakeholders, a prevalent issue in construction logistics. This theory elucidates how divergent objectives between parties such as contractors and clients can result in logistical inefficiencies, delays, and increased costs (Le et al. 2022). By contributing to the framework, PAT illuminates how logistics solutions can mitigate misalignment through transparency mechanisms. For instance, Li and Tan (2022) demonstrated that Building Information Modelling (BIM) enhances information exchange across construction teams, thereby reducing delays caused by inadequate communication. Similarly, Zhao et al. (2023) ascertained technological solutions, such as tracking tools, to minimise costs through transparent, immutable records. These findings suggest that incorporating PAT into the model guides the development of logistics solutions to enhance accountability and coordination, resulting in long-term improvements in resource allocation and stakeholder alignment (Rad et al. 2022).

Moreover, Transaction Cost Analysis (TCA) plays a pivotal role in this model by addressing economic inefficiencies associated with logistical operations. TCA aims to identify and mitigate transaction costs in construction logistics that are frequently attributable to transport delays, demand fluctuations, and regulatory challenges (Taha, 2017). By incorporating TCA, the model emphasises the necessity of logistics solutions that enhance efficiency and minimise waste. Studies conducted by Sun et al. (2022) on the Last Planner System (LPS) and lean methodologies corroborate TCA's efficacy of TCA in mitigating logistical inefficiencies and fostering sustainable outcomes, demonstrating that these practices decrease transaction costs by reducing material waste and enhancing project schedules. Additionally, Lee and Park (2023) emphasised that collaborative procurement strategies lower regulatory and compliance expenses, highlighting the broader influence of TCA on logistical cost reductions. Consequently, TCA informs the model by emphasising the significance of logistics solutions that address cost-efficiency, optimise resource utilisation, and improve environmental sustainability, enabling organisations to achieve continuous enhancement in operational effectiveness (Kim et al., 2023).

The Resource-Based View (RBV) plays a crucial role in this framework, emphasising the utilisation of distinctive resources and capabilities to achieve competitive advantages and promote sustainability in logistics. The RBV posits that a firm's internal assets, such as effective leadership, advanced technology, and operational expertise, are essential for overcoming logistical challenges and enhancing sustainable practices (Barney 1991). By incorporating the RBV, the model encourages construction firms to develop logistics strategies that leverage these unique assets. Wang and Chen (2023) demonstrated that investment in real-time tracking systems minimises waste by optimising material flows, corroborating the RBV concept that resource-driven approaches yield sustained efficiency improvements. Furthermore, Kumar et al. (2023) revealed that organisations with personnel trained in environmentally friendly logistics methods were able to significantly reduce emissions, indicating that human resources are as critical as technological assets for sustainability. The integration of the RBV within this model directs firms to identify and leverage their distinctive resources to foster continuous improvements in logistical efficiency and environmental performance. Finally, Network Theory augments this model by emphasising the importance of interconnected relationships and collaborative networks in construction logistics. The construction industry requires robust cooperation among suppliers, contractors, and regulatory entities for effective logistics management. As Network Theory posits, well-integrated networks enhance resource-sharing, responsiveness, and adaptability (Powell, 1990). By incorporating Network Theory, the model addresses sustainability from a relational perspective by fostering collaboration and resilience. Johnson and Andersson (2023) revealed that projects with well-established supplier networks encountered fewer material delays and improved resource utilisation, resulting in waste reduction. Similarly, Smith and Patel (2023) noted that collaborations with third-party logistics providers enhanced project sustainability by optimising delivery schedules and minimising emissions through efficient routing. These studies underscore the significance of Network Theory within this framework, demonstrating that robust logistics networks yield sustainable improvements in both operational and environmental performance. Consequently, Network Theory informs the framework's focus on collaboration, ensuring that organisations maintain logistical enhancements through dependable partnerships and adaptive networks (Janne and Fredriksson, 2021). The conceptual model developed by this study (depicted in Figure 5-1) integrates logistics challenges, solutions, critical success factors (CSFs), and sustainability in the construction industry. This model provides an understanding of how logistics challenges affect sustainability and how logistics solutions and CSFs can mitigate these challenges. The principles of these theories inform the formulation of relationships among constructs and support the development of the following hypotheses.

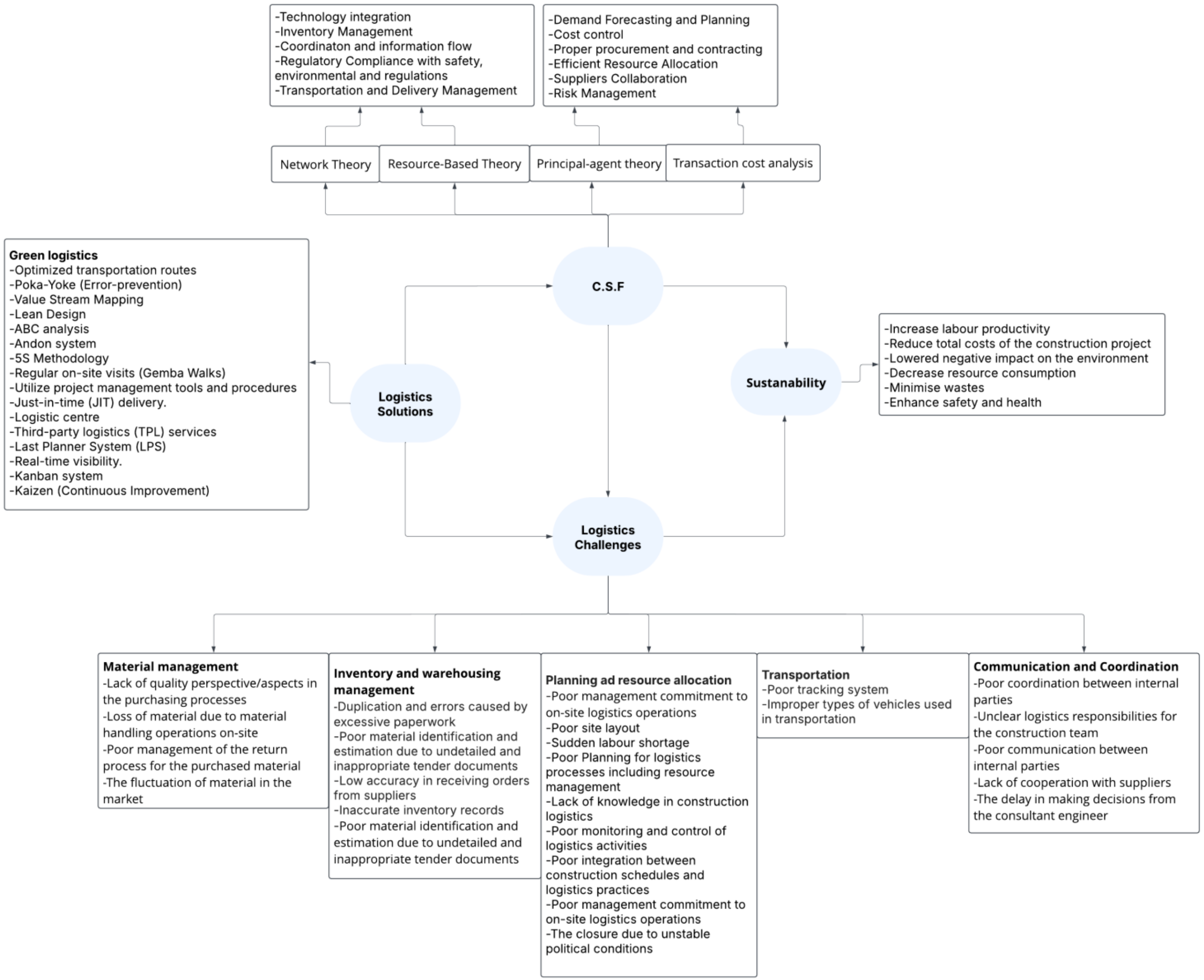

Figure 5-1 The conceptual model (Created by the Author, 2025)

5.2. Logistics Solutions and Sustainability

Integrating Network Theory and Transaction Cost Theory (TCA) provides a basis for understanding the relationship between logistics solutions and sustainability outcomes in the construction sector. Network Theory posits that the effectiveness of logistics solutions depends primarily on the quality of relationships and collaborations among supply chain participants. Efficient logistics solutions enhance these networks and promote communication and cooperation, which are essential for sustainable practices (Janne and Rudberg 2020). For instance, Rad et al. (2022) demonstrated that strong inter-organisational ties improve the implementation of just-in-time (JIT) methods, leading to significant reductions in material waste and improved resource efficiency. Moreover, Balasubramanian and Shuklab (2017) argued that collaborative logistics strategies, such as shared transport and storage, can significantly reduce carbon emissions associated with construction logistics. These approaches not only optimise resource allocation but also establish a sustainable logistics model that contributes to broader environmental goals. This perspective is supported by Le and Nguyen (2022), who emphasise that advanced logistics solutions, including third-party logistics (3PL) and real-time tracking systems, enable construction firms to enhance supply chain activity coordination and improve material flow, thereby reducing lead times and resource consumption. Conversely, Transaction Cost Theory highlights the importance of minimising the costs associated with supply chain inefficiencies. Effective logistics practices can significantly reduce transaction costs related to delays and miscommunication, a point emphasised by Fredriksson and Huge (2022). The implementation of logistics solutions that promote sustainability aligns with the firms' objectives of reducing operational costs while maximising value. For instance, Le et al. (2024) showed that construction companies adopting digital technologies in logistics processes observe a notable improvement in operational efficiency, resulting in lower costs and improved sustainability outcomes. Furthermore, the research of Le and Nguyen (2023) suggests that incorporating innovative technologies into logistics such as automation and data analytics—not only enhances transparency within the supply chain but also drives accountability among stakeholders. Such technological advancements facilitate better demand forecasting and inventory management, which are crucial for minimising waste and reducing environmental impact. Chawathe et al. (2023) further support this notion, suggesting that technology integration fosters an environment where sustainable practices can thrive. While the advantages of integrating logistics solutions for sustainability are evident, it is important to critically evaluate potential limitations. Some studies, such as that by Lam et al. (2024), indicate that the initial investment and ongoing maintenance costs associated with advanced logistics technologies can be a barrier for smaller construction firms. This highlights the need for a balanced approach that considers both economic implications and the potential for sustainable outcomes. Consequently, we propose the following hypothesis:

H1: Logistics solutions have a direct, positive effect on sustainability in the construction industry. (LS -> SF)

5.3. Critical Success Factors (CSFs) and Sustainability

Resource-Based Theory (RBT) and principal-agent theory (PAT) provide conceptual foundations for assessing the influence of Critical Success Factors (CSFs) on sustainability outcomes in the construction industry. RBT posits that organisations can attain a competitive advantage through the effective utilisation of unique resources and capabilities, such as strategic project management and stakeholder engagement (Le and Nguyen, 2022). Within this context, crucial CSFs, including strong leadership, effective communication systems, and robust supplier relationships, are instrumental in enhancing the capacity of construction firms to implement environmentally sustainable practices. For instance, capable leadership can foster a sustainability-oriented organisational culture, encouraging teams to prioritise eco-conscious methodologies (Fredriksson and Huge, 2022). Furthermore, effective communication systems ensure that all stakeholders are aligned with sustainability objectives, promoting transparency and accountability throughout the project implementation. This alignment is crucial, as Rad et al. (2022) emphasise that clear communication channels can significantly enhance collaborative efforts, which are essential for the adoption of sustainable practices. The role of technology in facilitating communication, such as project management software and collaborative platforms, is significant because it enhances information sharing and coordination among stakeholders. Conversely, PAT elucidates the intricacies of stakeholder interactions, particularly between management and employees or suppliers, which can considerably affect the adoption of sustainable practices. This theory underscores the potential conflicts of interest and information asymmetries that may arise between parties (Chawathe et al., 2023). When CSFs are effectively managed, for instance, through the implementation of sustainability performance incentives, they can help align the interests of various stakeholders and foster collaborative efforts towards sustainability. The use of performance-based contracts serves as a practical illustration that motivates suppliers to achieve sustainability targets, thereby improving overall project sustainability (Le et al., 2024). Furthermore, Le and Nguyen (2023) contended that firms proficient in managing their critical success factors are better equipped to navigate the complexities of sustainability. By integrating RBT and PAT, organisations can develop an approach that not only leverages their unique resources but also addresses potential stakeholder conflicts, ultimately leading to enhanced sustainability outcomes. This link between CSFs and sustainability implies that a strategic focus on these factors is crucial for construction firms that aim to improve their environmental performance. Consequently, we propose the following hypotheses:

H2: Critical success factors positively influence sustainability in the construction industry. (CSF -> SF)

5.4. Logistics Challenges and Sustainability

The impact of logistical challenges on construction project sustainability can be effectively examined through the lens of Principal-Agent Theory (PAT). This theory suggests that even minor logistical inefficiencies or disruptions may lead to unforeseen and detrimental effects on sustainability outcomes (Fredriksson and Huge, 2022). For instance, logistical issues that cause material delivery delays can result in increased resource waste and project schedule disruptions, ultimately compromising the overall sustainability of construction endeavours. This concept aligns with the findings of Le and Nguyen (2023), who posit that logistics management efficacy is directly linked to sustainability performance, emphasising the importance of addressing inefficiencies to achieve the desired sustainability goals. By comprehending the potential adverse consequences of logistical obstacles, project managers can implement proactive measures to mitigate their impacts, thus supporting sustainability initiatives. PAT further elucidates the interactions between various logistics stakeholders, particularly how conflicting interests can generate challenges that negatively affect sustainability. For instance, a contractor might prioritise short-term cost reductions, while a supplier may emphasise adherence to sustainable practices, resulting in misaligned objectives and subsequent inefficiencies (Chawathe et al., 2023). When logistical issues arise, such as resource shortages or delivery delays, these misalignments can exacerbate sustainability problems, underscoring the necessity of aligning stakeholder incentives to foster cooperation and enhance project sustainability. Moreover, the dynamics of stakeholder interactions, as elucidated by Le et al. (2024), indicate that clear communication and collaboration among parties is vital for effectively addressing logistical challenges. Failure to recognise and address these dynamics can lead to compounded sustainability issues, thereby further emphasising the importance of effective logistics management in construction projects. Consequently, acknowledging and strategically managing the complex interplay between logistical obstacles and stakeholder encouragement is essential for improving the sustainability of construction logistics. Therefore, we hypothesise the following:

H3: Logistics challenges adversely affect sustainability in the construction industry.

5.5. Logistics Solutions and Critical Success Factors

Transaction Cost Analysis (TCA) offers a detailed approach to scrutinising the complex relationship between logistics solutions and critical success factors (CSFs) in the construction industry. TCA concentrates on minimising expenses associated with inefficiencies and risks in supply chain transactions, particularly those arising from communication lags, material waste, and poorly managed resources (Janne and Rudberg, 2020). Within the construction sector, logistical solutions, such as just-in-time (JIT) delivery, real-time tracking systems, and the Last Planner System (LPS), effectively address these transaction costs by streamlining the material flow and reducing waste, thus directly contributing to cost savings and improved operational efficiency. Furthermore, when logistics solutions are aligned with crucial CSFs, including effective risk management, strong communication, and robust support from senior leadership, a synergistic effect emerges, further diminishing transaction costs. This alignment enhances operational efficiency and mitigates logistical disruptions, ultimately boosting sustainability (Chawathe et al. 2023). For instance, the adoption of LPS has been demonstrated to significantly reduce project delays and ensure prompt material delivery, thereby lowering storage expenses and waste (Fredriksson and Huge, 2022). The effectiveness of LPS is further enhanced when underpinned by robust CSFs such as systematic project planning and collaboration with suppliers. As Pivaa (2024) noted, these factors foster an environment conducive to efficiency and streamlined decision-making, which are vital for project execution. Le and Nguyen (2023) underscore that the incorporation of technology in logistics management improves communication and coordination among stakeholders, which is crucial for minimising transaction costs and enhancing sustainability outcomes. Nevertheless, while the benefits of aligning logistics solutions with CSFs are evident, it is essential to consider potential obstacles such as organisational unwillingness and resistance to change among stakeholders. These challenges can impede the effective implementation of logistics strategies and their associated CSFs, as observed by Luong Le et al. (2024). Consequently, acknowledging and addressing these dynamics is crucial for leveraging TCA to enhance both the sustainability and cost-effectiveness of construction projects. Thus, we propose the following hypotheses:

H4: Interaction exists between logistics solutions and critical success factors in the construction industry.

5.6. Interaction Between Logistics Solutions and Logistics Challenges

Transaction Cost Analysis (TCA) offers crucial insights into the interaction between logistics solutions and construction industry challenges, demonstrating how well-designed logistics strategies can effectively reduce costs stemming from inefficiencies. Construction projects frequently encounter logistical difficulties, such as late material deliveries, unreliable supply chains, and poorly coordinated schedules, resulting in increased transaction costs in the form of storage fees, project setbacks, and inefficient resource utilisation (Lam et al., 2024). These impediments create inefficiencies that strain budgets and disrupt project timelines, underscoring the need for robust logistics management approaches. To address these transaction costs, tailored logistics solutions, including just-in-time (JIT) delivery, real-time tracking systems, and sophisticated scheduling tools, have become essential for optimising processes and minimising uncertainties in construction logistics. However, the efficacy of these solutions depends on their precise alignment with the project's requirements and logistical context. For instance, while JIT delivery can reduce the costs associated with excess stock, it requires dependable suppliers and a consistent delivery schedule. Any interruption in JIT deliveries can impede project progress, potentially increasing transaction costs (Chawathe et al., 2023). Similarly, real-time tracking systems can mitigate the risk of material delays by providing instant visibility of the shipment locations. However, their effectiveness relies on the level of integration among all parties involved, including suppliers and on-site personnel (Pivaa, 2024). When logistics solutions are poorly matched with existing challenges, such as implementing JIT in volatile supply chains, the anticipated benefits of reduced transaction costs may be compromised, exposing the project to unexpected delays and increasing waste. In this context, TCA emphasises that effective logistics solutions must be sufficiently flexible to address logistical challenges of each construction project. Techniques such as the last planar system (LPS) and Value Stream Mapping (VSM) synchronise project scheduling with material flow, enabling better coordination between supply availability and project needs (Le and Nguyen, 2023). When customised to address project logistics issues, these solutions can reduce miscommunication, prevent material excesses or shortages, and minimise delays. Thus, TCA illustrates that logistics solutions, when responsive to each project's unique challenges, not only decrease costs but also enhance the resilience of the construction supply chain. This adaptability allows firms to achieve greater operational efficiency, minimise waste, and ultimately improve project outcomes (Lam et al., 2024). Consequently, we propose the following hypotheses:

H5: There is interaction between logistics solutions and challenges in the construction industry.

5.7. Interaction Between Critical Success Factors and Logistics Challenges

The interplay between critical success factors (CSFs) and logistical challenges is key to achieving sustainability in construction. Resource-based theory (RBT) posits that an organisation's distinctive assets and capabilities can be utilised to effectively address logistical challenges (Balasubramanian and Shukla, 2017). For instance, a construction firm with robust risk management capabilities as a critical success factor may be better equipped to address logistical issues such as supply chain disruptions or unexpected project scope alterations. This expertise enables organisations to formulate alternative approaches that mitigate the negative impacts of logistical obstacles on sustainability, thus fostering more resilient project implementation (Le and Nguyen, 2022). Furthermore, the principal–agent theory (PAT) elucidates the interactions among various stakeholders and potential conflicts that may arise during logistical difficulties (Fredriksson and Huge, 2022). Effective management of critical success factors, such as streamlined communication and coordination, enables construction firms to synchronise their efforts to address logistical challenges more efficiently, resulting in improved sustainability outcomes. For instance, when suppliers and contractors align sustainability objectives and adopt coordinated risk management strategies, overall project performance can be significantly enhanced, underscoring the importance of collaborative engagement among stakeholders (Chawathe et al., 2023). Additionally, the incorporation of cutting-edge technologies and practices in logistics management can facilitate this collaborative approach. According to Lam et al. (2024), the utilisation of real-time data analytics and communication tools enhances stakeholder coordination, allowing prompt responses to logistical disruptions and promoting sustainable practices throughout the project lifecycle. By fostering an environment of transparency and cooperation, construction firms can align their operational objectives with sustainability goals, reinforcing the significance of CSFs in overcoming logistical challenges. Consequently, it is hypothesised that

H6: There is an interaction between critical success factors and logistics challenges in the construction industry.

5.8. Moderating Effects of Project Type on Logistics Challenges and Sustainability

The relationship between logistics challenges and sustainability may be influenced by the nature of a project. Network Theory suggests that various types of construction projects, including residential, commercial, and infrastructure developments, present unique logistical demands and obstacles (Le and Nguyen, 2022). For instance, large-scale infrastructure projects typically involve multiple stakeholders, intricate coordination, and extensive resource management. These projects often face logistical challenges such as handling large quantities of materials and ensuring effective communication among diverse parties. Addressing these logistics issues within the context of project types can considerably enhance sustainability outcomes by promoting efficient resource utilisation and reducing waste (Chawathe et al., 2023). Furthermore, Transaction Cost Theory (TCA) supports the notion that the type of construction project affects the transaction costs associated with managing logistics challenges (Lam et al., 2024). More complex projects, owing to their intricate interdependencies, may incur higher transaction costs resulting from increased coordination and communication requirements among stakeholders (Fredriksson and Huge, 2022). Conversely, smaller projects often benefit from lower transaction costs, which can facilitate more efficient logistics management and enable expeditious decision-making processes (Le and Nguyen, 2023). This variation in project complexity highlights the need for tailored logistics strategies that align with the characteristics of each project type. For instance, implementing agile logistics practices may be particularly advantageous in smaller, less complex projects, whereas larger infrastructure projects may require more robust and systematic approaches to logistics management (Le et al., 2024). Understanding how different project types moderate the relationship between logistics challenges and sustainability is crucial for developing effective logistics strategies to improve project performance and sustainability outcomes. Consequently, we hypothesise that

H7: The relationship between logistics challenges and sustainability is moderated by construction project type. (M1)

5.9. Moderating Effects of Country on Logistics Challenges and Sustainability

The influence of logistical challenges on sustainability varies depending on the country in which the construction is undertaken. Principal-agent theory (PAT) elucidates how diverse regulatory landscapes and cultural contexts across nations shape the efficacy of logistics management (Rad et al., 2022). For instance, countries with rigorous environmental regulations may present logistical obstacles related to compliance and resource allocation. These regulatory demands influence how construction firms approach sustainability, often necessitating advanced logistics solutions to meet local requirements (Balasubramanian and Shukla, 2017). Consequently, the success of logistics strategies in addressing these challenges will vary substantially based on each country's regulatory framework, as organisations must adapt their practices to conform to local laws and standards (Le and Nguyen, 2023). Network Theory enhances the understanding of logistics challenges by emphasising the interconnectedness of stakeholders within different national contexts (Janne and Fredriksson, 2021). The quality of the relationships among suppliers, contractors, and regulatory bodies can either facilitate or hinder logistics operations, impacting sustainability outcomes. Nations with well-developed logistics networks and strong collaborations among stakeholders are likely to encounter fewer challenges, enabling more efficient resource allocation and improved sustainability performance (Chawathe et al., 2023). Conversely, countries with fragmented supply chains and weak inter-stakeholder relationships may face significant logistical issues, leading to increased costs and inefficiencies that negatively affect sustainability efforts (Le et al., 2024). Understanding how a country moderates the relationship between logistics challenges and sustainability is crucial for its effective management. By recognising the unique regulatory and cultural dynamics that influence logistics practices, construction firms can develop targeted strategies that align with both local sustainability goals and logistical capabilities. Thus, we hypothesise that

H8: The relationship between logistics challenges and sustainability is moderated by the country of construction project. (M2)

5.10. Moderating Effects of Location on Logistics Challenges and Sustainability

The location of a construction project may influence the interplay between logistical complexity and sustainability. The resource-based theory (RBT) posits that the regional availability of resources and capabilities substantially affects the management of logistical challenges (Le and Nguyen, 2022). For instance, urban projects generally benefit from enhanced transportation networks, closer supplier proximity, and access to advanced technologies, which collectively mitigate logistical difficulties and improve sustainability outcomes (Balasubramanian and Shukla, 2017). In contrast, rural projects often encounter logistical barriers owing to limited resource accessibility, potentially impeding the implementation of effective sustainability measures (Fredriksson and Huge, 2022). This dichotomy underscores the importance of understanding location-specific dynamics to effectively tailor logistics strategies, ensuring that they address unique challenges while meeting sustainability objectives. Additionally, Transaction Cost Theory (TCA) supports the notion that geographical location affects the costs associated with logistics operations (Lam et al., 2024). Projects in isolated areas may incur higher transport expenses and face delays due to inadequate infrastructure, resulting in increased transaction costs that complicate logistics management and hinder sustainability efforts (Le et al., 2024). Conversely, projects in well-connected urban areas can benefit from reduced logistical expenses and fewer obstacles, thus facilitating the implementation of sustainability programs (Chawathe et al., 2023). Recognising the moderating role of location in shaping logistical challenges is essential for developing effective strategies for promoting sustainability in construction projects. By comprehending how geographical factors influence both logistics management and sustainability outcomes, construction firms can better align their operational strategies with their local conditions. Consequently, we hypothesise that

H9: The relationship between logistics challenges and sustainability is moderated by the location of the construction projects. (M3)

5.11. Moderating Effects of Project Type on Logistics Challenges and Solutions

Various construction project categories, such as residential, commercial, and infrastructure development, pose distinct logistical challenges that necessitate bespoke logistics solutions (Le and Nguyen, 2022). For instance, large-scale infrastructure projects often involve complicated coordination among numerous stakeholders, extensive resource management, and complex scheduling, leading to logistical issues that are markedly different from those encountered in smaller housing projects (Fredriksson and Huge, 2022). By employing tailored logistics strategies that address a project's particular context, construction firms can address these challenges more effectively, ultimately improving sustainability outcomes (Balasubramanian and Shukla, 2017). The Transaction Cost Theory (TCA) lends support to the notion that the nature of a construction project can significantly influence the expenses associated with logistics operations (Lam et al., 2024). More intricate projects may incur higher transaction costs owing to the increased need for stakeholder coordination and communication, potentially resulting in inefficiencies if not properly managed (Chawathe et al., 2023). As a result, adapting logistics solutions to address the challenges presented by different project types not only reduces transaction costs but also enables more efficient project execution and fosters sustainable practices throughout the project lifecycle (Le et al., 2024). This adaptability underscores the significance of aligning logistics solutions with the demands of each project type, allowing construction companies to maximise resource utilisation and minimise waste. Consequently, we hypothesise that

H10: The relationship between logistics challenges and solutions is moderated by construction project type. (M4)

5.12. Moderating Effects of Country on Logistics Challenges and Solutions

The effectiveness of logistics solutions and the challenges they address are inextricably linked to the country in which construction projects are executed, as various nation-specific elements shape logistical requirements and resolutions. Principal-agent theory (PAT) elucidates how different regulatory frameworks and cultural norms across countries can impact the success of logistics management, particularly in achieving a balance between compliance and operational efficiency (Rad et al., 2022). For instance, nations with stringent environmental regulations may require tailored logistics approaches to meet legal obligations, which affects both the cost and complexity of logistics operations. These regulatory differences often lead to conflicts among stakeholders with competing priorities, emphasising the need for logistics solutions that are adaptable to national contexts and align with stakeholder interests (Chawathe et al., 2023). In cases where stakeholder interests clash, such as balancing environmental compliance with cost efficiency, PAT highlights the importance of well-aligned context-solutions to enhance coordination and compliance. Network Theory complements this perspective by emphasising the significance of robust stakeholder networks in international construction projects, which often involve complex webs of contractors, suppliers, and regulatory bodies. The quality of inter-organisational relationships and logistical infrastructure in each country significantly influences logistics performance. For instance, in countries with advanced logistical infrastructure and well-established supplier networks, construction firms may face fewer logistical obstacles, enabling quicker response times and more effective implementation of solutions (Janne and Fredriksson, 2021). By contrast, countries with weaker networks or fragmented supply chains may experience greater logistical inefficiencies and delays, underscoring the impact of location-specific network dynamics on project success (Le et al., 2024). The necessity of adapting logistics strategies to local conditions, as indicated by PAT and Network Theory, suggests that firms must recognise and align with national regulatory and infrastructural contexts to address logistical challenges and achieve sustainability outcomes. Thus, we propose the following hypothesis:

H11: The relationship between logistics challenges and solutions is moderated by the country of construction project. (M5)

5.13. Moderating Effects of Location on Logistics Challenges and Solutions

The geographical context of a construction project may play a crucial role in shaping the interplay between logistical challenges and their solutions, emphasising the need to tailor logistics strategies to site conditions. Network Theory posits that the efficacy of logistics solutions often depends on the accessibility of local infrastructure and resources, which differs between urban and rural environments (Ekeskar and Rudberg, 2020). For instance, construction projects in rural areas typically encounter logistical hurdles such as restricted access to transport networks and fewer supplier options, necessitating bespoke approaches to ensure timely resource delivery and minimise project delays. Conversely, urban projects benefit from superior infrastructure and readily available resources, facilitating logistics management and enhancing project efficiency. The application of network Theory in this context underscores the need for adaptable logistics strategies that account for disparities in infrastructure and resource availability across locations (Fredriksson and Huge, 2022). Transaction Cost Theory (TCA) corroborates this perspective by suggesting that a project's location directly impacts the transaction costs associated with logistics, as factors such as transportation expenses, travel duration, and coordination complexity vary between urban and remote settings (Lam et al., 2024). Projects in areas with underdeveloped infrastructure may incur higher transport costs and experience increased logistical delays owing to inadequate road networks and limited supplier access (Chawathe et al., 2023). These elevated transaction costs underscore the importance of developing efficient logistics strategies that address location inefficiencies to optimise project outcomes. By acknowledging the impact of geographical location, construction firms can devise logistics solutions that not only address inherent challenges but also contribute to achieving sustainability objectives through improved resource management and cost control (Pivaa, 2024). Through the implementation of flexible and tailored approaches to address these geographical logistics challenges, organisations can more effectively manage logistical complexities and enhance their capacity to achieve sustainability objectives. Consequently, we propose the following hypothesis:

H12: The relationship between logistics challenges and solutions is moderated by the location of the construction projects. (M6)

5.14. Moderating Effects of Project Type on CSFs and Sustainability

The impact of Critical Success Factors (CSFs) on sustainability outcomes in construction projects is influenced by the nature of the project, highlighting the necessity of tailoring CSFs to sustainability objectives. According to Resource-based theory (RBT), an organisation's distinct resources and capabilities are crucial in utilising CSFs for sustainability (Le and Nguyen, 2022). Various construction project types, such as commercial, residential, and infrastructure, often require different CSFs owing to their unique sustainability priorities. For instance, large commercial projects may emphasise stakeholder engagement and community impact to enhance social sustainability given their greater public visibility and community interactions. Conversely, residential developments might prioritise resource efficiency and cost management as CSFs, focusing on economic and environmental sustainability due to stricter budget limitations and resource utilisation (Balasubramanian and Shukla, 2017). Acknowledging these contextual differences is vital for effectively adapting CSFs to support sustainability goals, thereby improving project outcomes. Principal-agent theory (PAT) further elucidates how stakeholder alignment varies across project types and affects the implementation of CSFs (Rad et al., 2022). In certain projects, particularly those with extensive stakeholder involvement, conflicting objectives among stakeholders (e.g. developers, contractors, and local communities) can hinder the execution of CSFs. For instance, stakeholders may disagree with budget allocations for sustainability measures. Conversely, in tightly regulated infrastructure projects, stakeholders' interests may be more aligned, fostering collaboration towards shared sustainability goals. Addressing these variations by customising CSFs to project contexts allows organisations to manage stakeholder relationships more effectively, promoting both enhanced sustainability and project performance (Chawathe et al., 2023). By adapting CSFs to the context of a project, construction firms can better navigate stakeholder dynamics and maximise their contributions to sustainability objectives. Consequently, we propose the following hypothesis:

H13: The relationship between CSFs and sustainability is moderated by construction project type. (M7)

5.15. Moderating Effects of Country on CSFs and Sustainability

The impact of Critical Success Factors (CSFs) on sustainability outcomes in construction projects varies depending on the country in which the project is undertaken. Network Theory indicates that national differences in cultural practices and regulatory environments influence the implementation and effectiveness of CSFs, necessitating approaches tailored to contexts (Janne and Fredriksson, 2021). For instance, nations with stringent environmental regulations may emphasise sustainability-focused CSFs, such as waste reduction and energy efficiency CSFs, to meet legal requirements. In these environments, construction companies are more likely to prioritise CSFs that directly address regulatory demands, aligning their sustainability initiatives with national environmental objectives. Conversely, countries with less rigorous environmental standards may adopt a more flexible stance towards sustainability, potentially giving less importance to certain CSFs in favour of cost or speed, based on local expectations and norms. Furthermore, Transaction Cost Theory (TCA) suggests that varying regulatory frameworks affect the transaction costs linked to implementing CSFs, influencing the ease with which companies can achieve sustainability goals (Pivaa, 2024). In countries where regulatory compliance is costly or requires complex documentation, construction firms may encounter difficulties in implementing CSFs effectively because of increased financial and administrative burdens. These heightened transaction costs can impede sustainability efforts, as companies may need to allocate resources to compliance rather than innovation in sustainable practices. By contrast, countries with supportive regulatory environments may reduce transaction costs, facilitating the smooth integration of CSFs that promote sustainability. Acknowledging the moderating role of a country's unique regulatory and cultural context in the relationship between CSFs and sustainability is crucial for the development of effective location strategies. By adapting CSFs to align with national requirements and norms, construction firms can navigate local challenges more effectively, improve sustainability outcomes, and ensure regulatory compliance. Consequently, we propose the following hypothesis is put forward:

H14: The relationship between CSFs and sustainability is moderated by the country of construction project. (M8)

5.16. Moderating Effects of Location on CSFs and Sustainability

The impact of Critical Success Factors (CSFs) on sustainability in construction projects may be influenced by the geographical context, as the availability of resources and stakeholder alignment differ between urban and rural settings. The resource-based theory (RBT) emphasises how the accessibility of resources in a particular location can affect the efficacy of CSFs, as urban areas typically have superior access to eco-friendly materials and technologies, thereby promoting sustainability. In contrast, rural locations may encounter logistical obstacles owing to limited accessibility, potentially impeding the implementation of sustainable practices (Le and Nguyen, 2022). This disparity necessitates the development of location-CSF strategies to optimise sustainability outcomes. Principal-agent theory (PAT) further elucidates how stakeholder alignment affects location-based sustainability initiatives. In areas with high community engagement, stakeholders may strongly endorse sustainability efforts, amplifying the impact of CSFs on environmental objectives. Conversely, in regions with conflicting community interests, achieving sustainability goals may prove challenging because misaligned priorities can generate resistance (Rad et al., 2022). This underscores the importance of comprehending community dynamics to enhance CSF implementation. On the other hand, Network Theory offers a valuable modelfor addressing these challenges by concentrating on interconnectivity, information dissemination, adaptability, and resource optimisation across project networks. Robust connectivity among suppliers, contractors, and local communities in urban environments enhances coordination, whereas rural projects can leverage well-established networks to mitigate resource limitations (Janne and Fredriksson, 2021). Effective information sharing promotes transparency and stakeholder alignment, particularly in areas in which local support for sustainability is crucial. Adaptability within the logistics network enables construction firms to customise their CSFs to regional constraints, such as prioritising local sourcing or modifying delivery schedules in rural areas, to meet sustainability objectives effectively. Acknowledging these location-dynamics is essential to efficiently manage CSFs and foster sustainability in construction projects. Consequently, it is hypothesised that

H15: The relationship between CSFs and sustainability is moderated by the location of the construction projects. (M9)

5.17. Moderating Effects of Project Type on Logistics Solutions and Sustainability

The interplay between logistics solutions and sustainability in construction projects may be influenced by the nature of the project, as diverse construction projects require bespoke logistics approaches for optimal outcomes. Network Theory underscores the importance of aligning logistics solutions with distinct characteristics and sustainability objectives of each project type. For instance, large-scale infrastructure initiatives typically involve extensive material management and coordination among stakeholders. Consequently, these projects benefit from sophisticated integrated logistics solutions designed to manage substantial volumes, enhance communication across multiple parties, and ensure timely resource distribution (Ekeskar and Rudberg, 2020). Conversely, residential projects, often less complex, can achieve greater efficiency through streamlined logistics practices that minimise resource utilisation and environmental impact, exemplifying the adaptability principle in Network Theory. The focus of this theory on connectivity and customisation enables firms to optimise logistics strategies according to project requirements, enhancing sustainability across projects of varying scales. Moreover, the Transaction Cost Theory (TCA) further corroborates the notion that project type influences logistics-related expenses. Different construction projects incur varying transaction costs, depending on their scale, complexity, and stakeholder interactions. Large infrastructure developments typically incur higher transaction costs, owing to extensive coordination needs and increased risk. Tailored logistics solutions can effectively reduce these costs by enhancing communication, eliminating redundancies, and improving resource allocation (Lam et al., 2024). By contrast, smaller or more straightforward projects, such as residential developments, generally incur lower transaction costs and benefit from simplified logistics solutions that prioritise efficient resource utilisation and waste reduction. By aligning logistics solutions with the demands and sustainability goals of each project type, construction firms can manage their transaction costs and promote sustainable practices. Network Theory's principles of adaptability and tailored connectivity enable construction firms to develop logistics frameworks that address each project's unique logistical challenges, while TCA's cost-reduction perspective ensures the economic viability of these solutions. Consequently, we hypothesise that

H16: The relationship between logistics solutions and sustainability is moderated by construction project type. (M10)

5.18. Moderating Effects of Country on Logistics Solutions and Sustainability

The effectiveness of logistics solutions in promoting sustainability within construction projects may be influenced by the country of implementation, as local regulations and cultural norms shape their impact. Principal-agent theory (PAT) provides valuable insights into how diverse regulatory environments and stakeholder dynamics affect the application of these solutions across nations. Countries with strict environmental regulations often compel construction firms to adopt more thorough and specialised logistics solutions to meet legal requirements. These regulations may govern various aspects, from sourcing materials to managing waste, thus necessitating a more structured approach to logistics management. Conversely, nations with less rigid regulatory frameworks may allow for more adaptable logistics strategies, potentially reducing costs, but possibly compromising sustainability objectives (Rad et al., 2022). Thus, PAT emphasises the necessity for bespoke logistics approaches that align with each country's regulatory demands and cultural practices, ensuring that sustainability goals are met while adhering to local standards. Network Theory further enhances this understanding by emphasising how a country's infrastructure and stakeholder relationships influence the efficacy of logistics solutions. The quality of transport networks, supplier availability, and strength of inter-organisational collaborations significantly affect logistics performance. Countries with advanced infrastructure and well-established stakeholder networks typically face fewer logistics challenges, facilitating efficient implementation of sustainability-focused logistics solutions. For instance, nations with robust transportation systems can minimise delays and environmental impacts through efficient material handling and distribution (Janne and Fredriksson, 2021). Conversely, countries with inadequate infrastructure encounter substantial logistical obstacles that can hinder the adoption of sustainable practices, resulting in inefficiencies and increased carbon footprint. Consequently, we propose the following hypothesis:

H17: The relationship between logistics solutions and sustainability is moderated by the country of construction project. (M11)

5.19. Moderating Effects of Location on Logistics Solutions and Sustainability

The geographical location of a construction project may influence the interplay between logistics solutions and sustainability, as local circumstances determine the feasibility and effectiveness of logistical operations. Network Theory posits that the success of logistics strategies is closely tied to the availability of infrastructure and resources in the project's vicinity. Urban development typically benefits from logistical advantages including proximity to suppliers, robust transportation networks, and access to sustainable technologies. These factors enable the implementation of efficient logistics solutions that promote sustainability by decreasing transit times and energy usage in line with green supply chain management concepts (Chhabra et al., 2020; Chhabra et al., 2022). In urban environments, firms can more readily employ practices such as just-in-time (JIT) deliveries or centralised resource hubs, both of which enhance sustainability by reducing resource waste and improving inventory control (Behera et al., 2021). In contrast, rural projects encounter logistical challenges owing to limited infrastructure, reduced supplier access, and occasionally challenging terrain, which can hinder transportation and material handling. Projects in these areas often require alternative logistics approaches, such as sourcing materials locally to shorten transport distances or adopting flexible scheduling to address infrastructure constraints (Ahmed and Amir, 2023). Moreover, rural projects may face increased energy consumption and emissions owing to extended supply routes and less frequent deliveries, underscoring the sustainability challenges unique to remote locations. By addressing these logistical demands, construction companies can lower operational costs and resource inefficiency, thus contributing to sustainable practices tailored to their environments (Fernandes et al., 2021). Transaction Cost Theory (TCA) supports this view by demonstrating how location influences logistics-related costs, particularly in regions with inadequate infrastructure. Construction projects in remote areas often incur higher transaction costs owing to increased transportation expenses, supply chain delays, and greater resource-handling requirements, which can undermine the efficacy of sustainability-focused logistics solutions (Lam et al., 2024; Wu et al., 2023). For example, insufficient transport infrastructure can lead to higher fuel consumption and emissions, thereby posing obstacles to sustainable practices (Lee et al., 2023). By recognising these transaction costs, construction firms can better adapt their logistics strategies, striking a balance between cost-effectiveness and sustainability. This flexible approach enables companies to efficiently meet sustainability targets, supporting the following hypothesis

H18: The relationship between logistics solutions and sustainability is moderated by the location of the construction projects. (M12)

5.20. Mediating Role of Critical Success Factors Between Logistics Solutions and Sustainability

In the construction sector, Critical Success Factors (CSFs), notably accurate demand forecasting and planning coupled with supplier collaboration, function as pivotal mediators between logistics solutions, including just-in-time (JIT), lean practices, project management tools, and sustainable outcomes. Resource-based theory (RBT) posits that distinctive capabilities, such as precise demand forecasting, enable construction firms to harmonise logistics practices with project requirements, thus minimising waste and preserving resources (Le and Nguyen, 2022). When JIT and Lean practices are informed by accurate demand forecasting, organisations can curtail excess inventory and avert overproduction, significantly reducing environmental impact by preventing resource squandering (Ekeskar and Rudberg, 2020). For instance, efficacious forecasting underpins JIT processes by ensuring that materials arrive precisely when needed, thereby reducing storage requirements and associated costs, which in turn fosters sustainability (Ali and Hassan, 2021). Supplier collaboration further augments the sustainability potential of logistics solutions. Forging robust supplier relationships facilitates dependable and timely deliveries, which are crucial for the efficacy of JIT and Lean practices, as this necessitates coordinated efforts to minimise delays and maximise efficiency (Ahmed et al., 2022). Such collaboration also encourages joint initiatives for continuous improvement, aligned with lean principles aimed at eradicating waste and enhancing process efficiency (Janne and Fredriksson, 2021). For example, suppliers working in close partnerships with construction firms can modify packaging methods to reduce waste or synchronise transport schedules to decrease emissions and directly bolster sustainable logistics (Eckhardt et al., 2023). Furthermore, principal–agent theory (PAT) emphasises the importance of aligning stakeholder interests, particularly with suppliers, to achieve sustainability goals. When suppliers are engaged as active stakeholders with shared sustainability objectives, they become more inclined to support JIT and Lean logistics practices, thus fostering an efficient waste-reducing supply chain (Rad et al., 2022). By implementing performance-based contracts and incentives for sustainable practices, construction firms can motivate suppliers to participate actively in sustainability initiatives, thereby amplifying the impact of logistics solutions on sustainability (Lam et al., 2024). Project management tools also play a crucial role when integrated with accurate demand forecasting and supplier collaborations. These tools enable construction firms to monitor real-time data, refine forecasts, and adapt logistics operations to evolving project demands, thereby minimising resource consumption (Pivaa, 2024). By leveraging project management tools, firms can dynamically update schedules and inventory requirements, ensuring that JIT and Lean practices are optimised for sustainability and reducing both waste and costs (Janne and Fredriksson, 2021). Consequently, the mediating role of CSFs, such as demand forecasting and supplier collaboration, ensures that logistics solutions such as JIT, Lean, and project management tools align with the sustainability objectives. This alignment enables construction firms to reduce waste, optimise resources, and enhance environmental performance, underscoring that CSFs are integral to maximising the sustainability impact of logistics practices. Thus, it is hypothesised

H19: Critical success factors mediate the relationship between logistics solutions and sustainability in the construction industry. (LS -> CSF -> SF)

5.21. Mediating Role of Logistics Challenges Between Logistics Solutions and Sustainability

In the construction industry, logistics challenges mediate the relationship between logistics solutions and sustainability. According to Transaction Cost Theory (TCA), inefficiencies arising from these challenges can significantly impact the overall effectiveness of logistics solutions (Pivaa, 2024). For instance, when a construction company implements advanced logistics solutions but encounters substantial logistical obstacles such as delays or inadequate communication, the anticipated sustainability benefits may not be realized. Consequently, logistics challenges can attenuate the positive effects of these solutions on sustainability. Network Theory corroborates this mediating effect by emphasising the significance of stakeholder relationships in addressing logistics challenges (Janne and Fredriksson, 2021). When network stakeholders experience difficulties in effective communication or collaboration, logistics challenges are more likely to manifest, thereby compromising the efficacy of the implemented logistics solutions. Therefore, understanding the mediating role of logistics challenges is essential for construction firms seeking to enhance their logistics solutions to improve sustainability. Therefore, it is proposed that:

H20: Logistics challenges mediate the relationship between logistics solutions and sustainability in the construction industry. (LS -> LC -> SF)

5.22. Mediating Role of Logistics Challenges Between CSFs and Sustainability

In construction processes, logistical challenges can function as mediators between Critical Success Factors (CSFs) and sustainability outcomes. Resource-based theory (RBT) posits that an organisation's unique resources and capabilities, embodied in CSFs, can facilitate the mitigation of logistical challenges, thereby enhancing sustainability performance (Le and Nguyen, 2022). For instance, when an organisation prioritises effective communication and stakeholder engagement as CSFs, it becomes better equipped to navigate logistical obstacles, as these elements foster improved coordination and problem-solving across various project stages. Addressing logistical inefficiencies is crucial, as delays, suboptimal resource allocation, or communication breakdowns often impede sustainability initiatives by generating waste and increasing costs. Furthermore, principal-agent theory (PAT) supports the notion that well-managed CSFs can help align stakeholder interests, which is essential in overcoming logistical barriers that compromise sustainability (Rad et al., 2022). Thus, the effective management of CSFs, such as communication and stakeholder involvement, can mitigate logistical challenges that negatively impact sustainability. By addressing these mediating factors, an organisation enhances its capacity to implement sustainability-focused practices effectively, underscoring the pivotal role of CSFs in logistics management. Considering this, the research proposes the following hypothesis:

H21: Logistics challenges mediate the relationship between critical success factors and sustainability in the construction industry. (CSFs -> LC -> SF)

6. Chapter Six: Quantitative Finding and Model Testing

6.1. Introduction

This chapter discusses the statistical analysis that adheres to the previous chapters' research objectives and framework. The chapter discusses the reliability of the survey responses through several tests, including Cronbach's Alpha, and the normality of the samples being studied. Additionally, the survey instrument consisted of the main features of the items presented through summary statistics. Frequency tables and diagrams organise these summary statistics. The validity of the survey instrument is tested in the next section of the chapter by conducting a Confirmatory Factor Analysis (CFA) with SPSS-AMOS. The chapter discusses testing the research hypotheses throughout the structural model presented by AMOSS.

6.2. The Survey Instrument's Reliability

Cronbach's Alpha determines the reliability of survey items within the latent construct. To obtain meaningful results, it is necessary to evaluate the accuracy of the survey items; otherwise, the results will be meaningless because the survey items do not measure what they are supposed to. According to a rule of thumb, a Cronbach's Alpha coefficient that exceeds 0.70 is regarded as having a reliable scale (Cronbach, 1951).

The logistics challenges construct has 23 items with a Cronbach's Alpha coefficient of 0.99, the logistics solutions construct has 18 items with a Cronbach's Alpha coefficient of 0.94, the critical success factors construct has 11 items with a Cronbach's Alpha coefficient of 0.97, the sustainable factor construct has seven items with a Cronbach's Alpha coefficient of 0.88 Table 6-1 provides a summary of the calculated Cronbach's Alpha coefficients.

Table 6-1 Cronbach's Alpha results of factors' scales.

Construct	# of variables	Cronbach's Alpha coefficient
The logistics challenges construct	23	0.99
The logistics solutions construct	18	0.94
The critical success factors construct	11	0.97
The sustainable factor construct	7	0.88

6.3. Respondents Background

The respondent pool is predominantly composed of engineers (34.12%), reflecting their central role in construction logistics. Project managers follow at 23.93%, highlighting their strategic oversight in project execution. Contractor representatives account for 21.56%, indicating their involvement in logistical decision-making and resource allocation. Foremen, comprising 20.56% of respondents, represent the on-site operational perspective, ensuring practical implementation of logistics solutions.

6.4. Years of Experience

The participants' experience levels varied, with the majority (45.7%) having two to eight years of experience, reflecting a balanced mix of early-career and mid-level professionals. Those with less than two years of experience accounted for 30.09%, representing emerging professionals entering the field. Meanwhile, 24.17% had over eight years of experience, contributing seasoned insights into construction logistics challenges and solutions.

6.5. Construction’s Project Category

The questionnaire covered a diverse range of construction project categories, with urban projects comprising the largest share at 36.73%, reflecting the sector's focus on infrastructure expansion and modernization. Rural projects followed at 32.23%, highlighting the industry's role in regional development. Meanwhile, city-centre projects accounted for 31.04%, emphasising the complexities of high-density construction and logistical challenges in congested areas.

6.6. Experience Field

The participants' experiences spanned various construction sectors, with the majority (27.25%) working in residential and housing projects, reflecting the sector's continuous demand. Commercial projects followed at 25.59%, highlighting the significance of business and retail development. Institutional projects accounted for 20.85%, showing involvement in educational, healthcare, and public facilities. Infrastructure projects made up 14.22%, emphasising large-scale developments like roads and utilities, while industrial building projects comprised 12.09%, representing specialised facilities such as factories and warehouses.

6.7. Country Vs the Projects' Type

Visualising and interpreting the distribution of various construction projects across multiple countries can be achieved using cross-tabulation in SPSS to analyse the relationship between country and construction project types. The distribution of construction project types across different countries shows a non-statistically significant association between project type and country due to a significant p-value ($p=0.08 > 0.05$), which suggests that the distribution of project types is not different across countries.

6.8. Country Versus the Projects' Location

The analysis reveals a comparable distribution of construction project locations (urban, rural, city centre) across various countries, including the UAE, KSA, Jordan, and Palestine. The lack of a statistically significant association between project location and country (with a p-value of 0.9, which is greater than 0.05) indicates that the distribution of project locations is similar across these countries, showing no significant difference in location patterns between them.

6.9. Descriptive Statistics for Challenges Affecting Construction Logistics

Table 6-2 shows the frequency of the questionnaire responses regarding the 23 factors affecting construction logistics in the Middle East construction industry using a Likert scale (not at all influential (1), slightly influential, somewhat influential, very influential, extremely influential). The factors were ranked according to their mean, from highest to lowest. The table consists of the mean of all variables, deviation from the mean, and standard deviation.

Table 6-2 Respondents' satisfaction with challenges affecting construction logistics processes.

Challenges	Mean	Std.	Variance
CHL17: Accuracy of goods (orders) received from suppliers	4.33	1.21	1.47
CHL11: Delays in decision-making by the consultant engineer	4.33	1.19	1.43
CHL4: Inadequate alignment between construction schedules and logistics practices	4.30	1.23	1.51
CHL14: lack of coordination and integration with suppliers	4.28	1.18	1.39
CHL10: Ambiguity in logistics responsibilities for the construction team	4.27	1.30	1.71
CHL20: The use of inappropriate types of vehicles in transportation	4.27	1.19	1.43
CHL22: (Temporary) Closures resulting from unstable political conditions	4.27	1.27	1.61
CHL18: waste of materials due to inefficient material handling	4.25	1.163	1.35
CHL8: Inadequate communication among internal parties	4.24	1.18	1.40
CHL1: Inadequate planning for logistics processes, including resource management	4.24	1.20	1.44
CHL7: Ineffective coordination among internal parties	4.22	1.19	1.43
CHL2: A lack of expertise (or knowledge) in construction logistics	4.21	1.18	1.41
CHL23: The sudden labour shortage	4.21	1.28	1.64
CHL5: Inefficient site layout	4.20	1.20	1.46
CHL16: Poor material identification and estimation	4.20	1.31	1.73

Table 6-2 Respondents' satisfaction with challenges affecting construction logistics processes, Continued

Challenges	**Mean**	**Std.**	**Variance**
CHL6: Management's insufficient commitment to on-site logistics operations	4.19	1.21	1.47
CHL12: Duplication and errors caused by excessive paperwork	4.18	1.184	1.40
CHL15: Neglecting the understanding of quality in purchasing processes	4.17	1.25	1.56
CHL3: Ineffective monitoring and control of logistics activities	4.15	1.28	1.66
CHL21: Inefficient management of the return process for purchased materials	4.15	1.26	1.59
CHL19: Inaccurate inventory records	4.14	1.18	1.40
CHL13: The fluctuating prices of construction materials and components	4.12	1.28	1.64
CHL9: lack of real-time tracking of fleet and equipment used in construction logistics	4.07	1.33	1.77

6.10. Analysis of Variance (ANOVA) for Logistics Challenges

Comparing mean values across multiple groups and investigating the influence of categorical independent variables on a continuous dependent variable was achieved through ANOVA in SPSS, a powerful statistical tool (Arbuckle, 2009). In experiments and observational studies, it is particularly useful to rigorously analyse and interpret group differences (Hair et al., 2010). The test examined the mean differences between two or more groups. This section aims to expand on logistics challenges based on the demographic characteristics of the surveyed participants, including county, project location, and project type. It may be advantageous to observe how logistics challenges differ based on demographic variables. The following subsections evaluate whether there are any demographic influences on logistics challenges.

Logistics Challenges by Country

Table 6-3 summarises the mean for each country's logistics challenges. The challenges between countries are similar, except for the KSA. An ANOVA was conducted to confirm the statistical significance of the difference.

Table 6-3 The mean for logistics challenges for each country

Logistics challenges

Tukey Ba,b

Country	N	Subset for alpha = 0.05	
		1	2
KSA	100	3.1017	
UAE	117		4.5388
Palestine	97		4.5755
Jordan	108		4.6006

As the p-value for the ANOVA in Table 6-4 is less than 0.05, the logistics challenges between countries are significant, as indicated by the results.

Table 6-4 ANOVA test for the logistics challenges between countries

Logistics challenges

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	164.850	3	54.950	61.444	.000
Within Groups	373.823	418	.894		
Total	538.673	421			

Following the significant ANOVA results, a post-hoc test (for example, Tukey's HSD, Bonferroni) was used to identify which countries differed from the others (Kline, 2005). The null hypothesis is dismissed with a p-value of 0, assuming that all countries are experiencing the same average logistics challenge ratings. These post-hoc comparisons revealed that the KSA significantly differs in logistics challenges from other countries. According to post-hoc analysis, Saudi Arabia (KSA) is unique in its logistics challenges. This suggests that the logistics challenges faced in Saudi Arabia are significantly dissimilar or less harsh (the mean of logistics challenges is less than that of the others) than those in the UAE, Palestine, and Jordan.

Logistics Challenges by Project's Location

Table 6-5 summarises the means for logistics challenges for each location. Logistics challenges between locations (urban, rural, city centre) seem similar. However, ANOVA was conducted to confirm the statistical significance of the difference.

Table 6-5 The mean for logistics challenges for each location

Logistics challenges

Tukey B[a,b]

Projects Location	N	Subset for alpha = 0.05 1
Urban	155	4.1492
Rural	136	4.2260
City centre	131	4.3057

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 139.938.
b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

The results of the ANOVA in Table 6-6 indicate that the logistics challenges faced by locations, including urban, rural, and city centres, are not significantly different if the p-value is not less than 0.05 ($p=0.50$).

Table 6-6 ANOVA test for the logistics challenges between projects' locations

ANOVA

Logistics challenges

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.740	2	.870	.679	.508
Within Groups	536.933	419	1.281		
Total	538.673	421			

Logistics Challenges by Project's Type

Table 6-7 summarises the means for logistics challenges for each project type. Logistics challenges between countries are similar, except for commercial and residential. An ANOVA was conducted to confirm the statistical significance of the difference.

Table 6-7 The mean for logistics challenges for each project type

Logistics challenges

Tukey B[a,b]

Project's type	N	Subset for alpha = 0.05		
		1	2	3
Residential / Housing	115	3.5928		
Commercial	108		4.0741	
Institutional	88			4.6522
Infrastructure	60			4.6732
Industrial Buildings	51			4.6854

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 76.228.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

As the p-value for the ANOVA in Table 6-8 is less than 0.05, the logistics challenges between project types are significant, as indicated by the results.

Table 6-8 ANOVA test for logistics challenges between project types

ANOVA

Logistics challenges

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	87.340	4	21.835	20.174	.000
Within Groups	451.333	417	1.082		
Total	538.673	421			

Following the significant ANOVA results, a post-hoc test (for example, Tukey's HSD, Bonferroni) was used to identify which countries differed from the others (Kline, 2005). Post-hoc comparisons demonstrated that commercial and residential areas have significant logistical challenges that differ from others. Residential settings have unique logistics challenges compared to commercial, institutional, infrastructure, and industrial buildings, resulting from the important difference between residential and other project types. Likewise, a substantial difference between commercial projects and others proposes that logistics challenges in commercial projects stand out, particularly from those in residential, infrastructural, institutional, and industrial projects. According to the findings, logistics challenges are more noticeable in institutional, infrastructure, and industrial buildings than in residential and commercial buildings (Bolarinwa, 2015).

6.11. Descriptive Statistics for Critical Success Factors (CSFs)

Table 6-9 shows the frequency of the questionnaire responses regarding the 11 logistics critical success factors to be considered for enhancing the success/efficiency/effectiveness of the construction logistics process in the Middle East construction industry using a Likert scale (not at all influential (1), slightly influential, somewhat influential, very influential, extremely influential). The factors were ranked according to their mean, from highest to lowest. The table consists of the mean of all variables, deviation from the mean, and standard deviation.

Table 6-9 Respondents' satisfaction with critical success factors for enhancing the success, efficiency, and effectiveness of the construction logistics process

CSFs	Mean	Std	Variance
CSF6: Effective risk management	4.33	.053	1.21
CSF9: Collaborating with suppliers	4.28	.060	1.52
CSF10: Adequate training and skill development	4.25	.057	1.407
CSF7: Integration of technology	4.22	.058	1.44
CSF5: Compliance with safety, environmental and regulations	4.21	.059	1.50
CSF2: Efficient transportation and delivery management	4.17	.061	1.5
CSF4: Proper information flow	4.16	.064	1.74

Table 6-9 Respondents' satisfaction with critical success factors for enhancing the construction logistics process's success/efficiency/effectiveness, Continued

CSFs	Mean	Std	Variance
CSF8: Efficient resource allocation	4.14	.062	1.64
CSF3: Effective inventory management	4.14	.064	1.73
CSF1: Accurate demand forecasting and planning	4.11	.064	1.77
CSF11: Strong commitment and support from top management	4.11	.06	1.56

6.12. Analysis of Variance (ANOVA) for Critical Success Factors

This section expands on the critical success factors (CSFs) based on the demographic characteristics of the surveyed participants, which include county, project location, and project type. It may be advantageous to observe how critical success factors differ based on demographic variables. The following subsections evaluate whether there are any demographic influences on CSFs.

The Critical Success Factors by Country

Table 6-10 summarises the mean CSFs for critical success factors for each country. CSFs between countries are similar, except for KSA. An ANOVA was conducted to confirm the statistical significance of the difference.

Table 6-10 The mean for critical success factors CSFs for each country

CSFs

Tukey B[a,b]

		Subset for alpha = 0.05	
Country	N	1	2
KSA	100	3.15	
UAE	117		4.43
Palestine	97		4.55
Jordan	108		4.58

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 104.944.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

As the p-value for the ANOVA in Table 6-11 is less than 0.05, the CSFs between countries are significant, as indicated by the results.

Table 6-11 ANOVA test for the CSFs between countries

ANOVA

CSFs

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	143.915	3	47.97	53.084	.000
Within Groups	377.746	418	.904		
Total	521.661	421			

Following the significant ANOVA results, a post-hoc test (for example, Tukey's HSD, Bonferroni) was used to identify which countries differed from the others (Kline, 2005). Post-hoc comparisons revealed that KSA significantly differs from different countries regarding CSFS. Post-hoc analysis shows that Saudi Arabia (KSA) is unique in its CSFs. Based on the findings, KSA is significantly different from the other countries, and the critical success factors in KSA are substantially different from those in the UAE, Palestine, and Jordan. Several possible explanations exist for this disparity, including cultural, economic, and social factors exclusive to the KSA (Alkahtani and Almalki, 2022).

The Critical Success Factors by Project Location

Table 6-12 summarises the mean CSFs for each location. CSFs between locations (urban, rural, city centre) seem similar. However, ANOVA was conducted to confirm the statistical significance of the difference.

Table 6-12 The mean for critical success factors CSFs for project location

CSFs

Tukey B[a,b]

Projects Location	N	Subset for alpha = 0.05
		1
Urban	155	4.14
Rural	136	4.17
City centre	131	4.28

The results of the ANOVA in Table 6-13 indicate that the CSFs implemented by locations, including urban, rural, and city centres, are not significantly different if the p-value is not less than 0.05 (p=0.50).

Table 6-13 ANOVA test for the CSFs between projects' location

ANOVA

CSFs

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.487	2	.744	.599	.550
Within Groups	520.174	419	1.241		
Total	521.661	421			

The Critical Success Factors by Project Type

Table 6-14 summarises the mean CSFs for each project type. The CSFs between countries are similar, except for commercial and residential. An ANOVA was conducted to confirm the statistical significance of the difference.

Table 6-14 The mean for CSFs for each project type.

CSFs

Tukey B[a,b]

Project's type	N	Subset for alpha = 0.05		
		1	2	3
Residential / Housing	115	3.5937		
Commercial	108		4.0328	
Industrial Buildings	51			4.6150
Institutional	88			4.6188
Infrastructure	60			4.6848

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 76.228.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

As the p-value for the ANOVA in Table 6-15 is less than 0.05, the CSFs between project types are significant, as indicated by the results.

Table 6-15 ANOVA test for the CSFs between projects' type

ANOVA

CSFs

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	83.616	4	20.904	19.900	.000
Within Groups	438.045	417	1.050		
Total	521.661	421			

Following the significant ANOVA result, a post-hoc test (e.g. Tukey's HSD, Bonferroni) was conducted to identify which particular country differs from the other (Kline, 2005). Post-hoc comparisons demonstrated that commercial and residential areas have significant CSFs that are distinct from others. It can be concluded that residential projects differ significantly from the others, which suggests that the CSFs for residential projects are not the same as those for commercial, institutional, infrastructure, and industrial buildings. This may be due to factors such as design preferences, occupancy patterns, or regulatory requirements to residential developments (Ahmed, 2017). The conclusion that commercial projects are significantly different from other projects suggests that CSFs for commercial projects differ considerably from those of other project types. This could be influenced by factors such as economic drivers, usage, or user expectations exclusive to the commercial context (Luong Le et al., 2021).

6.13. Descriptive Statistics for Logistics Solutions

Table 6-16 shows the frequency of the questionnaire responses regarding the 18 logistics solutions to be considered for enhancing the success/efficiency/effectiveness of the construction logistics process in the Middle East construction industry using a Likert scale (not at all influential (1), slightly influential, somewhat influential, very influential, extremely influential). The factors were ranked according to their mean, from highest to lowest. The table consists of the mean of all variables, deviation from the mean, and standard deviation.

Table 6-16 Respondents' satisfaction with logistics solutions for enhancing the success/efficiency/effectiveness of the construction logistics process

Logistics Solutions	Mean	Std.	Variance
LS17: Participate in associations, non-profit activities, and events	4.73	.58	.34
LS6: Implementation of logistic centres	4.72	.59	.35
LS5: Utilisation of Third-party logistics (3PL) services	4.71	.60	.36
LS11: Implementing Poka-Yoke (Error-prevention)	4.69	.65	.43
LS18: Use of Information Systems and Modelling Tools such as BIM and 3D	4.69	.52	.27
LS4: The utilisation of Real-time visibility tools	4.33	1.30	1.70
LS10: Applying the Kaizen principle (Continuous Improvement)	4.31	1.31	1.71
LS2: Implementing the Last Planner System (LPS)	4.31	1.29	1.68
LS8: Utilizing project management tools and procedures	4.29	1.30	1.71

Table 6-16 Respondents' satisfaction with logistics solutions for enhancing the success/efficiency/effectiveness of the construction logistics process, Continued

Logistics Solutions	Mean	Std.	Variance
LS14: Applying the 5S Methodology	4.28	1.26	1.6
LS1: Implementing the Kanban system	4.27	1.26	1.5
LS7: Applying lean design principles in designing construction projects	4.25	1.27	1.61
LS3: Implementing Just-in-time (JIT)	4.2417	1.32	1.76
LS15: Applying ABC (Pareto) analysis for inventory management.	4.23	1.29	1.68
LS9: Using Value Stream Mapping to assist in identifying and eliminating non-value-added activities	4.21	1.35	1.83
LS12: Optimized transportation routes	4.20	1.26	1.60
LS16: Implementing the Andon system	4.11	1.32	1.75
LS13: Conducting a regular on-site visit (Gemba Walks)	4.11	1.25	1.58

6.14. Analysis of Variance (ANOVA) for Logistics Solutions

This section expands on logistics solutions based on the surveyed participants' demographic characteristics, including county, project location, and project type. It may be advantageous to observe how logistics solutions differ based on demographic variables. The following subsections evaluate whether there are any demographic influences on logistics solutions.

The Logistics Solutions by Country

Table 6-17 summarises the mean for logistics solutions for each country. Logistics solutions between countries are similar, except for the KSA. An ANOVA was conducted to confirm the statistical significance of the difference.

Table 6-17 The means of logistics solutions for each country

logistics solutions

Tukey B[a,b]

Country	N	Subset for alpha = 0.05	
		1	2
KSA	100	3.4500	
Palestine	97		4.5733
UAE	117		4.6990
Jordan	108		4.7047

As the p-value for the ANOVA in Table 6-18 is less than 0.05, the CSFs between countries are significant, as indicated by the results.

Table 6-18 ANOVA test for the logistics solutions between countries

ANOVA

logistics solutions

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	35.904	4	8.976	15.312	.000
Within Groups	244.450	417	.586		
Total	280.354	421			

Following the significant ANOVA result, a post-hoc test (e.g. Tukey's HSD, Bonferroni) was conducted to identify which country differs from the other. Post-hoc comparisons revealed that KSA significantly differs from other countries in terms of logistics solutions. According to post-hoc analysis, Saudi Arabia (KSA) has unique logistics solutions. There are several possible reasons for this difference, including infrastructure differences, and regulatory and policy variations that influence logistics operations within the KSA (Taha, 2019).

The Logistics Solutions by Project Location

Table 6-19 summarises the mean for logistics solutions for each location. Logistics solutions between locations (urban, rural, city centre) seem similar. However, an ANOVA was conducted to confirm the statistical non-significance of the difference.

Table 6-19 The means for logistics solutions for each location

logistics solutions

Tukey B[a,b]

Projects Location	N	Subset for alpha = 0.05 1
Urban	155	4.3373
Rural	136	4.3619
City centre	131	4.4351

The results of the ANOVA in Table 6-20 indicate that the logistics solutions implemented by locations, including urban, rural, and city centres, are not significantly different as long as the p-value is not less than 0.05 (p=0.50).

Table 6-20 ANOVA test for the logistics solutions between project locations

ANOVA

logistics solutions

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.717	2	.359	.537	.585
Within Groups	279.637	419	.667		
Total	280.354	421			

The Logistics Solutions by Project Type

Table 6-21 summarises the mean for logistics solutions for each project type. Logistics solutions between countries are similar, except for commercial and residential. An ANOVA was conducted to confirm the statistical significance of the difference.

Table 6-21 The mean for logistics solutions for each project type

logistics solutions

Tukey B[a,b]

Project's type	N	Subset for alpha = 0.05	
		1	2
Residential / Housing	115	3.9923	
Commercial	108	4.2438	
Infrastructure	60		4.6463
Industrial Buildings	51		4.6743
Institutional	88		4.6806

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 76.228.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

As the p-value for the ANOVA in Table 6-22 is less than 0.05, the logistics solutions between project types are significant, as indicated by the results.

Table 6-22 ANOVA test for the logistics solutions between project types

ANOVA

logistics solutions

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	35.904	4	8.976	15.312	.000
Within Groups	244.450	417	.586		
Total	280.354	421			

Following the significant ANOVA results, a post-hoc test (for example, Tukey's HSD, Bonferroni) was used to identify which countries differed from the others (Kline, 2005). Post-hoc comparisons demonstrated that commercial and residential areas have significant CSFs that are distinct from others. Based on the crucial differences observed between residential and commercial projects, it can be inferred that logistics solutions for these project types are markedly different from those for institutional, infrastructural, and industrial buildings. This is due to certain considerations, such as customer preferences affecting logistics processes for residential and commercial projects (Le-Hoai et al., 2008).

6.15. Descriptive Statistics for Sustainable Factors

Table 6-23 shows the frequency of the questionnaire responses regarding the seven factors contributing to the sustainability of construction logistics processes using a Likert scale (Not at all, Slightly, Somewhat, Very Extremely). The factors were ranked according to their mean, from highest to lowest. The table consists of the mean of all variables, deviation from the mean, and standard deviation.

Table 6-23 Respondents' satisfaction with factors that contribute to the sustainability of construction projects.

Factors	Mean	Std	Variance
SF6: Employee well-being	4.63	.74	.55
SF5: Waste reduction	4.61	.66	.43
SF7: Enhancing technology adoption	4.57	.74	.55
SF2: Greenhouse gas emissions	4.55	.68	.47
SF3: Total cost of completing a project	4.53	.70	.49
SF4: Resource efficiency	4.52	.68	.46
SF1: Labour productivity	4.50	.69	.48

6.16. Analysis of Variance (ANOVA) for Sustainability Factor by Country

Tables 6-24 to 6-26 summarise the mean for sustainability factors for each country, type, and location. Sustainability factors between countries (Palestine, Jordan, the UAE, and the KSA) seem similar. Additionally, the project type and location were the same. However, ANOVA was conducted to confirm the statistical non-significance of the difference.

Table 6-24 the mean for sustainability factors for each country

Sustainability factor

Tukey B[a,b]

Country	N	Subset for alpha = 0.05 1
Palestine	97	4.4904
KSA	100	4.5000
Jordan	108	4.5886
UAE	117	4.6471

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 104.944.
b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

Table 6-25 The mean for sustainability factors for each type

Sustainability factor

Tukey B[a,b]

Project's type	N	Subset for alpha = 0.05 1
Residential / Housing	115	4.5081
Infrastructure	60	4.5595
Industrial Buildings	51	4.5686
Institutional	88	4.5909
Commercial	108	4.5913

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 76.228.
b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

Table 6-26 The mean for sustainability factors for each location

Sustainability factor

Tukey B[a,b]

Projects Location	N	Subset for alpha = 0.05 1
Urban	155	4.5502
Rural	136	4.5630
City centre	131	4.5725

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 139.938.
b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

The results of ANOVA in Table 6-27 indicate that the sustainability factors are not significantly different between countries if the p-value is not less than 0.05 (p=0.50).

Table 6-27 ANOVA test for sustainability factors between countries

ANOVA

Sustainability factor

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.806	3	.602	2.071	.103
Within Groups	121.498	418	.291		
Total	123.303	421			

6.17. The Validity of the Survey Instrument

This section examines the validity of the survey instrument through Confirmatory Factor Analysis (CFA). CFA is regarded as a reliable technique employed to measure the one-dimensionality of a set of objects (Hair et al., 2010). The objective of conducting CFA in this situation is to validate the number of items that comprise the construct (factor) and evaluate the correlation between the items and their corresponding factors (Kline, 2005; Hair et al., 2010). To perform CFA, researchers must have a clear understanding of (a) the total number of factors, (b) the variables that represent the factors, and (c) the factors that are connected. Within the CFA, it is possible to test whether the collected data represent the theoretical model by examining the measurement model. CFA can estimate different fit models until the best-fit model is obtained. (Han et al., 1998). The initial stage of CFA involves developing a theoretical model (hypothesis) to measure the latent variables. The fitted model will be statistically tested using the available data in the next step. According to Harrington (2009), CFA's basic logic can be summarised as follows.

1. An operational definition can be achieved by arranging questions or statements (items) to measure a concept or attribute of ability. This ability, known as a factor, is measured by analysing the responses (the answers to the questions).
2. The item measures only one factor; therefore, the model is one-dimensional.
3. A set of mathematical equations can be defined by following the previously mentioned unidimensional model. Using these equations, it is possible to predict the correlation matrix between items. Sigma Σ is the name given to this correlation matrix. If the correlation between items is accurate (unidimensional), it can be used to determine the correlation. The correlation matrix obtained empirically from the data was compared with this matrix after

comparison. Matrix S refers to this correlation. If our theory is accurate concerning the actual underlying model (unidimensional), there will be no substantial difference between the elements in the correlation matrix S and Σ. The mathematical expression for this concept is S - Σ = 0

4. The hypothesis was tested using a significance test. The researcher's objective is to determine whether the correlation matrix S and Σ differs significantly from zero. In simpler terms, this hypothesis can be expressed as follows.
   $H0$: $S - \Sigma = 0$
   $H1$: $S - \Sigma \neq 0$
5. Our theoretical model will be accepted if the data support it, and the difference between correlation matrix S and Σ will not be statistically significant. In other words, the model was a good fit for the data. The data show that the hypothesis of measuring the same thing (or factor) by all elements is valid. If the data do not support our theoretical model, the null hypothesis is rejected (the alternate hypothesis is accepted), resulting in a significant difference in correlation matrix S and Σ. Therefore, the fitted model does not represent the observed data.
6. After the theoretical model has been accepted or the model matches the data, the next step is to determine the significance of each item by performing a t-test to determine whether it accurately measures the intended outcome. To determine whether the model fits the observed data well, the fit statistics must be examined during the estimation process of the CFA model, as stated in (4) above. If the model does not show a good fit, modifications are necessary to improve it. Various fit indices include the chi-square test RMSEA, TLI, CFI, NFI, SRMR, and more. To determine a good fit, the minimum score/value level was determined by following rules of thumb for these indices (Byrne, 2001). The chi-square test, RMSEA, TLI, and CFI are frequently employed in this research.

To assess whether the model fits the observed data, the Chi-square χ 2 test is a significant test. The null hypothesis was tested against the alternative hypothesis of a substantial difference between the observed and predicted data. The significance level (usually p= 5%) is set to obtain $\chi 2$ to assess whether the null hypothesis of no difference can be rejected by examining this difference. The null hypothesis was not rejected if the probability was higher than 0.05. (Smith et al., 2004). A good fit model was considered when the p-value exceeded the significance level. The Chi-square test has a flaw that stems from its high sensitivity to the sample size. Increasing the sample size makes it harder to fit a model in the CFA because it increases the likelihood of rejecting the null hypothesis.

Root Mean Square Error of Approximation (RMSEA) is an alternative that does not rely on the sample size during the calculation. Steiger (1990) proposed an RMSEA index to evaluate the probability of obtaining an RMSEA value lower than 0.08. If the probability is higher than 0.05, the model displays a good fit, that is, p (RMSEA < 0.08). The Tucker-Lewis Index (TLI) introduced by Tucker and Lewis (1973) and the comparative fit index (CFI) introduced by Bentler (1990) are the most frequently utilised tools for evaluating the improved fitted model in the baseline comparison. To accomplish this, the proposed model was compared to a baseline model's fit criteria. The TLI and CFI values fall within a range of zero to one. If the value approaches 0.90, the model is an adequate fit model, and if the value is above 0.95, the model is a very good fit model (Hulland et al., 1996).

6.18. Results of Confirmatory Factor Analysis (CFA)

Results of One-Dimensionality, Convergent Validity and Discriminant Validity of Research Concept

The structural equation model depicted in Figure 6-1 and the measures elaborated in Tables 6-28 to 6-30 exhibit a robust overall fit. The chi-square value (χ^2 = 4425.177) with 1575 degrees of freedom results in a χ^2/df ratio of 2.81, which is below the recommended maximum of 5. The p-value of 0.00 indicates statistical significance ($p < 0.05$). Additional fit indices further support the model's suitability: the Tucker-Lewis Index (TLI) of 0.91 exceeds the acceptable threshold of 0.90, whilst the Comparative Fit Index (CFI) of 0.92 approaches the ideal value of 0.95. The Root Mean Square Error of Approximation (RMSEA) is 0.06, which is below the 0.08 threshold for an acceptable fit. Collectively, these metrics validate the model's satisfactory fit to the industry data, suggesting that the proposed structure effectively captures the interrelationships among the variables under investigation. The chi-square ratio confirms the model's comparative parsimony, while the TLI and CFI demonstrate its adequacy relative to a baseline model. Lastly, the RMSEA value indicates that the model's approximation error falls within an acceptable range, further substantiating its compatibility with the industry data.

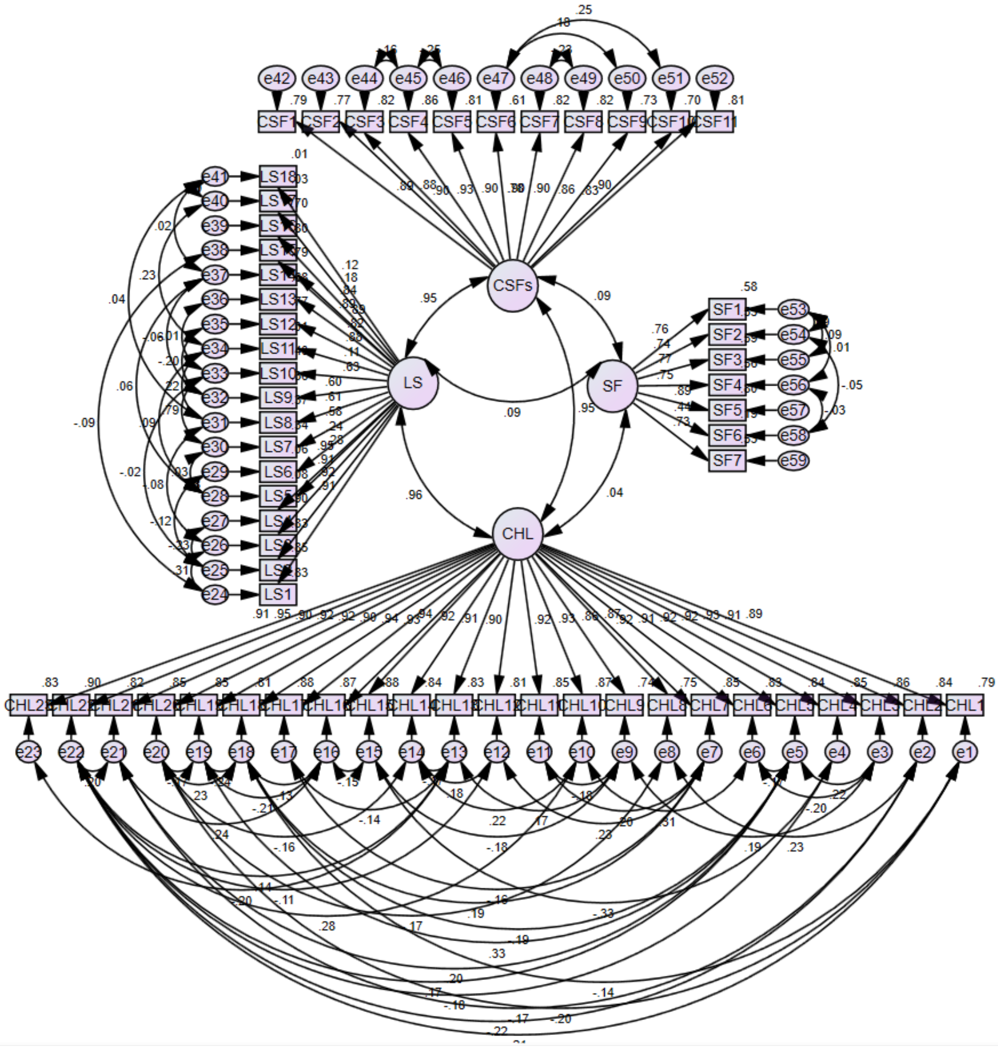

Figure 6-1 CFA analysis for the research model.

Table 6-28 Goodness-of-Fit Chi-Square (CMIN/DF)

Model	NPAR	CMIN	DF	P	CMIN/DF
Default model	195	4425.177	1575	.000	2.810
Saturated model	1770	.000	0		
Independence model	59	36035.278	1711	.000	21.061

Table 6-29 Model Fit Indices: CFI, TLI, and Baseline Comparisons

Model	NFI Delta1	RFI rho1	IFI Delta2	TLI rho2	CFI
Default model	.877	.867	.917	.910	.917
Saturated model	1.000		1.000		1.000
Independence model	.000	.000	.000	.000	.000

Table 6-30 Root Mean Square Error of Approximation (RMSEA)

Model	RMSEA	LO 90	HI 90	PCLOSE
Default model	.066	.063	.068	.000
Independence model	.218	.216	.220	.000

According to Hair et al. (2010), the concepts of the research meet the requirements for discriminant validity because all the correlation coefficients and covariances associated with the standard errors (correlations coefficients and covariances value tests between factors in CFA analysis will be represented in the Appendix) differ from 1. According to Steenkamp and Van Trijp (1991), observational variables achieve one-dimensionality when the measurement variables' error is uncorrelated, and they achieve convergent validity when the standardised regression weights are statistically significant (Gerbing and Anderson, 1988). In summary, the study model attained discriminant validity, convergence validity, and one-dimensionality.

Once the model fit has been confirmed based on the observed data, the next step is to check whether every item measures the constructs, which include logistics challenges, logistics solutions, critical success factors, and sustainability factors. First, the logistics challenges construct showed significant estimated factor loading for each item, with p-values below 0.05. Thus, it can be concluded that the survey items have statistical significance when measuring logistics challenges. Furthermore, standardised coefficients exceeding 0.5 indicate that all items have high loadings. Second, the logistics solution construct showed significant estimated factor loading for each item, with p-values below 0.05. Thus, it can be concluded that the survey items have statistical significance when measuring logistics solutions. Furthermore, the standardised coefficients for most constructs exceeding 0.5 indicate high loadings.

Third, the critical success factor construct showed significant estimated factor loading for each item, with p-values below 0.05. Thus, it can be concluded that the survey items have statistical significance when measuring critical success factors. Furthermore, standardised coefficients exceeding 0.5 indicate that all items have high loadings. Finally, the sustainable factor construct showed significant estimated factor loading for each item, with p-values below 0.05. Thus, it can be concluded that the survey items have statistical significance when measuring sustainable factors. Furthermore, standardised coefficients exceeding 0.5 indicate that all items have high loadings. Table 6-31 depicts the factor loading for each item, along with the p-values.

Table 6-31 Factor loading for each item, along with the p-value for every construct.

Item		Construct	Estimate	S.E.	C.R.	P
CHL1	<---	CHL	1.00			
CHL1	<---	CHL	.88	.034	30.00	***
CHL2	<---	CHL	.91	.036	31.18	***
CHL3	<---	CHL	.92	.035	30.49	***
CHL4	<---	CHL	.92	.034	30.24	***
CHL5	<---	CHL	.91	.035	29.71	***
CHL6	<---	CHL	.91	.034	30.48	***
CHL7	<---	CHL	.92	.036	26.46	***
CHL8	<---	CHL	.86	.041	26.02	***
CHL9	<---	CHL	.86	.036	31.52	***
CHL10	<---	CHL	.93	.034	30.63	***
CHL11	<---	CHL	.92	.035	28.67	***
CHL12	<---	CHL	.89	.037	29.76	***
CHL13	<---	CHL	.91	.034	30.33	***
CHL14	<---	CHL	.91	.034	32.32	***
CHL15	<---	CHL	.94	.037	31.44	***
CHL16	<---	CHL	.93	.033	32.18	***
CHL17	<---	CHL	.93	.036	27.08	***
CHL18	<---	CHL	.90	.033	30.83	***
CHL19	<---	CHL	.92	.037	28.07	***
CHL20	<---	CHL	.92	.037	29.04	***
CHL21	<---	CHL	.90	.030	36.92	***
CHL22	<---	CHL	.94	.037	29.82	***

Table 6-31 The factor loading for each item, along with the p-value for every construct, Continued

Item	Construct	Estimate	S.E.	C.R.	P
LS1	<---LS		1.00		
LS1	<--- LS	.90	.032	32.52	***
LS2	<--- LS	.92	.028	37.96	***
LS3	<--- LS	.91	.030	35.66	***
LS4	<--- LS	.94	.025	5.92	***
LS5	<--- LS	.28	.025	4.90	***
LS6	<--- LS	.23	.047	13.87	***
LS7	<--- LS	.58	.047	14.79	***
LS8	<--- LS	.61	.049	14.28	***
LS9	<--- LS	.59	.047	15.56	***
LS10	<--- LS	.63	.028	2.28	.023
LS11	<--- LS	.11	.034	28.46	***
LS12	<--- LS	.87	.037	24.59	***
LS13	<--- LS	.82	.033	29.40	***
LS14	<--- LS	.89	.036	28.43	***
LS15	<--- LS	.89	.038	25.50	***
LS16	<--- LS	.83	.025	3.66	***
LS17	<--- LS	.17	.023	2.37	.017
CSF1	<--- CSFs	.89			
CSF2	<--- CSFs	.87	.034	27.27	***
CSF3	<--- CSFs	.90	.035	29.08	***
CSF4	<--- CSFs	.92	.033	30.88	***
CSF5	<--- CSFs	.90	.032	28.96	***
CSF6	<--- CSFs	.78	.034	21.46	***
CSF7	<--- CSFs	.90	.032	29.02	***
CSF8	<--- CSFs	.90	.034	29.15	***
CSF9	<--- CSFs	.85	.035	25.75	***
CSF10	<--- CSFs	.83	.034	24.31	***
CSF11	<--- CSFs	.89	.033	28.72	***
SF1	<--- SF	1.00			
SF1	<--- SF	.76	.06	15.97	***
SF2	<--- SF	.74	.06	16.76	***
SF3	<--- SF	.77	.06	15.49	***
SF4	<--- SF	.74	.06	18.07	***
SF5	<--- SF	.89	.07	8.62	***
SF6	<--- SF	.43	.06	14.95	***

Results of Composite Reliability and Average Variance Extracted from the Research Concepts.

The results in Table 6-32 show that all the concepts meet the requirements of Composite Reliability and Average Variance Extracted, with Composite Reliability needing 0.7 or above, and Average Variance Extracted needing 0.5 or above (Hair et al., 2010).

Table 6-32 Results of composite reliability and average variance extracted from the research concepts.

Research concepts	Code	# of observed variables	Composite reliability	Convergent Validity (AVE) to be 0.5 and greater
Logistics Challenges	CHL	23	0.9	0.83
Logistics solutions	LS	18	0.8	0.51
Critical success factors	CSFs	11	0.9	0.77
Sustainable factors	SF	7	0.82	0.54

6.19. Endogeneity Test

In structural equation modelling (SEM), endogeneity presents a significant challenge, potentially biasing estimates and leading to misinterpretations of variable relationships (Smith et al., 2004). This study initially observed an unusually high residual correlation of 1.2 between logistics solutions and critical success factors (CSFs), indicating a potential endogeneity issue (Sundquist et al., 2018). This problem may originate from simultaneity, wherein logistics solutions and CSFs exert reciprocal influences. Addressing this concern is essential to ensure the validity of the model and obtain reliable estimates. To mitigate endogeneity, the model underwent a systematic refinement process that involved eliminating certain highly interdependent CSFs and logistics solutions. Specifically, three CSFs were removed: efficient transportation and delivery, effective inventory management, and integration of technology. These factors were identified as overlapping logistics solutions that generated a feedback loop. For instance:

- Efficient transportation and delivery are inherently linked to the logistics solution of optimising transportation routes, which could have created simultaneity between the two variables.

- Effective inventory management is strongly tied to the logistics solutions of ABC (Pareto) analysis and just-in-time (JIT) principles, which directly affect how inventory is managed.
- Integration of technology, especially tools such as BIM and 3D modelling, was a logistics solution, contributing to a circular relationship with the corresponding success factor.

Moreover, the analysis eliminated the logistics solution involving participation in associations, non-profit activities, and events because of its minimal impact on the critical success factor (CSF) of ongoing training and skill enhancement. This elimination did not significantly affect the model's fit or explanatory power for CSFs and facilitated the streamlining of the model's relationships. These modifications effectively decreased the residual correlation between logistics solutions and CSFs from 1.2 to 0.41, bringing it within a more acceptable range that accurately reflects the relationship (Smith et al., 2004). By removing these overlapping variables, this study mitigated the risk of simultaneity and omitted-variable bias. The refined model presented in Figure 6-2 addresses endogeneity by ensuring that logistics solutions and CSFs are distinct constructs with clear influence pathways. These modifications enable the structural equation modelling (SEM) model to capture the unique effects of logistics solutions on achieving CSFs without the confounding influence of closely related or redundant variables. This refinement enhances the robustness of the model, improving both its internal validity and the causal interpretability of the findings within the context of logistics challenges in the construction industry.

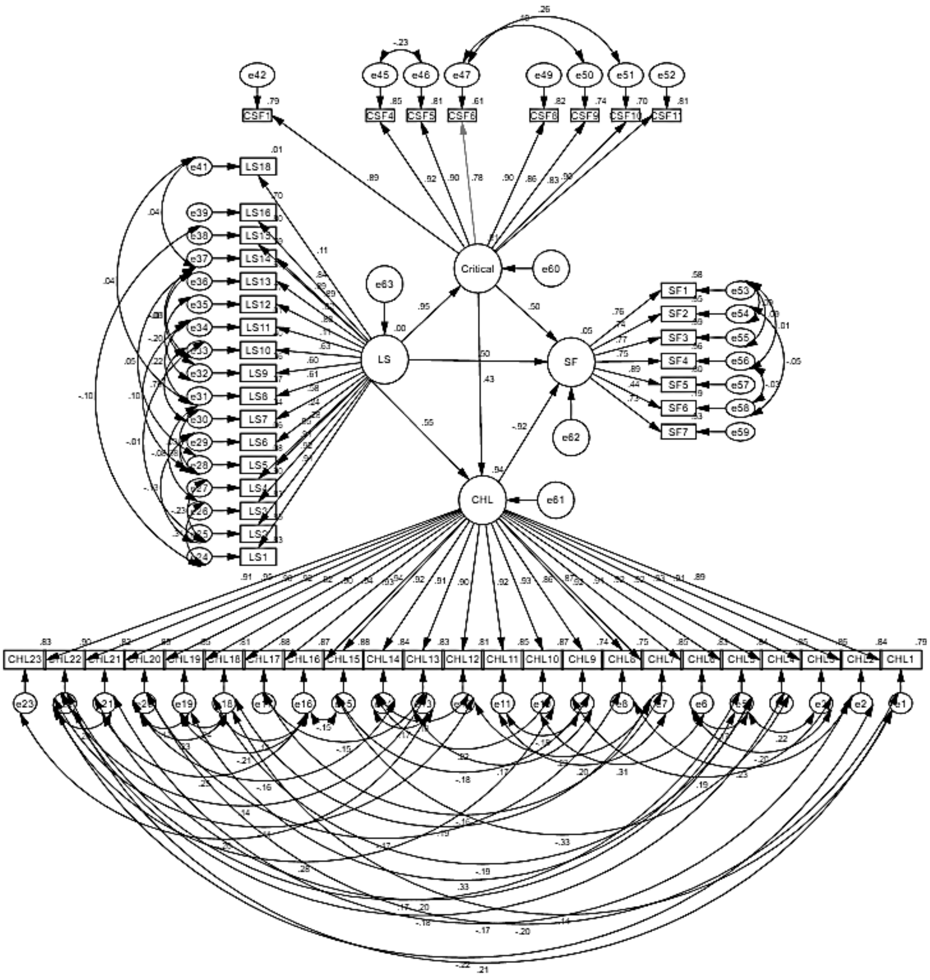

Figure 6-2 SEM of the research model

6.20. Results of Research Hypotheses Testing

Amos Graphics software version 21.0.0 handles the Structural Equation Model (SEM) processing. The illustration in Figure 24 shows a well-fit model.

Results for Testing of the Research Hypotheses

The research hypotheses were tested at a significance level of 5m %, and a confidence level of 95 %. Table 0-2 in the appendix shows the results of hypothesis testing. This study proposes and tests 21 hypotheses using SEM. The hypotheses were either accepted or rejected based on the significance level (p values) and path direction (estimated coefficient values). Consequently, as shown in Table 6-33, logistics solutions have a direct positive effect on sustainability in the construction industry (0.51, p= 0.03 <0.05), and critical success factors positively influence sustainability in the construction industry. (0.48, p=0.02<0.05), and logistics challenges adversely affect sustainability in the construction industry. (-0.92, p=0.00<0.05). Thus, hypotheses H1_1, H2_1, and H3_1 were accepted, and the associated null hypotheses were rejected (*H1_0, H2_0, and H3_0*). The results further reveal an interaction between logistics solutions and critical success factors in the construction industry (0.94, p=0.00<0.05) and logistics challenges (0.60, p=0.00<0.05). Additionally, an interaction was noted between the critical success factors and logistics challenges in the construction industry (0.4, p=0.00<0.05). Therefore, hypotheses H4, H5, and H6 were accepted, and the associated null hypotheses were rejected (*H4 0, H5 0, H6 0*).

Table 6-33 Results of direct path analysis.

Construct		Construct	Estimate	S.E.	C.R.	P	Label
CSFs	<---	LS	.94	.037	26.47	***	par_129
CHL	<---	LS	.58	.050	10.80	***	par_130
CHL	<---	CSFs	.40	.047	7.77	***	par_132
SF	<---	LS	.51	.113	2.12	.034	par_127
SF	<---	CSFs	.48	.094	2.32	.020	par_128
SF	<---	CHL	-.92	.124	-3.73	***	par_131

Moderation analysis then examined the relationship between sustainable factors (the dependent variable) and independent variables moderated or influenced by moderator variables (the demographic variables). First, the analysis fails to support H7_1 and rejects the null hypothesis as elaborated in Table 6-34 for the moderation effect of project type on the relationships between logistics challenges and sustainability (0.008, p=0.84>0.05). The relationship between logistics challenges and sustainability is likely not influenced by the moderating effect of project type. Sezer and Fredriksson (2021) argued that different project types have different external factors, such as regional conditions and regulatory frames. Consequently, the complexity of moderation effects that cannot be captured solely through statistical analysis is due to the unpredictable interaction of external factors with logistics challenges and sustainability output.

Table 6-34 Regression weights for the moderation effect of project type on the relationships between logistics challenges and sustainability

	Estimate	S.E.	C.R.	P
SF <--- CHL	.001	.06	.01	.99
SF <--- Type	-.021	.16	-.12	.90
SF <--- CHL_ type	.008	.03	.19	.84

Second, it is suggested that H8_1 be rejected and the null hypothesis accepted for the effect of the moderator (country) on the relationship between logistics challenges (independent variable) and sustainability (0.01, p=0.85>0.05) as elaborated in Table 6-35. This indicates that no statistically significant relationship or effect is observed between logistics challenges and sustainability outcomes across the different countries in which construction projects are located. This implies minimal variation in construction logistics challenges within the same region (Sundquist et al., 2018).

Table 6-35 Regression weights for the effect of the moderator (country) on the relationship between logistics challenges (independent variable) and sustainability

	Estimate	S.E.	C.R.	P
SF <--- CHL	-.019	.19	-.09	.92
SF <--- CHL_ Country	.010	.05	.19	.84
SF <--- Country	-.041	.21	-.18	.85

Third, the result (p=0.86>0.05) as elaborated in Table 6-36 suggests that the alternative hypothesis (H9_1) should be rejected, and the null hypothesis (H9_0) should be accepted for the moderation of the relationship between logistics challenges and sustainability through project location. A coefficient value of 0.005 indicates that the moderator (location) has only minor or negligible effects on the association between logistics challenges and sustainability. However, several construction projects have recently adopted standardised sustainable goals and best practices across diverse locations (Lundesjo,2015). These goals focus on resource efficiency, waste reduction, and community engagement, whether in rural, city centre, or urban contexts (Fredriksson et al., 2022).

Table 6-36 Regression weights for the moderation of the relationship between logistics challenges and sustainability through project location

			Estimate	S.E.	C.R.	P
SF	<---	CHL	.02	.05	.45	.64
SF	<---	Location	.04	.12	.33	.73
SF	<---	CHL_ Location	.00	.02	-.17	.86

Fourth, this analysis rejects H10_1, including no moderation effect of the project's type on the relationship between logistics challenges and logistics solutions (accepting the null hypothesis). Based on the provided significance level (p=0.72 >0.05) as elaborated in Table 6-37, the moderation effect coefficients were found to be non-statistically significant to accept the hypothesis. This suggests that the construction project type does not moderate the relationship between logistics challenges and solutions. This outcome indicates that the relationship between logistics challenges and solutions may be influenced more by other factors or variables, regardless of the country's context. Logistics challenges could be shaped more by internal organisational processes, project features, or industry patterns, even if the country is unimportant (Sezer and Fredriksson, 2021). Detecting a significant moderation effect may be difficult because logistics challenges and solutions differ little between project types (Fredriksson and Huge-Brodin, 2022).

Table 6-37 Regression weights for the moderation effect of the project's type on the relationship between logistics challenges and logistics solutions

			Estimate	S.E.	C.R.	P	Label
CHL	<---	LS	.90	.021	44.14	***	b1_1
CHL	<---	Type	.03	.070	.52	.59	b2_1
CHL	<---	Solution_ type	-.005	.015	-.35	.72	b3_1

Fifth, the analysis accepts H11 and rejects the null hypothesis, as the relationship between logistics solutions and logistics challenges can be influenced or changed by the geographical location of the construction project as elaborated in Table 6-38. Logistics challenges have different effects on finding solutions in other countries. The statistical significance of this moderation effect is indicated by a significance level of less than 0.05. The estimates given for different countries (Palestine, Jordan, UAE, and

KSA) show the intensity and direction of the moderating effect in each. The impact of the modifier (country) on the relationship between variables can be quantified by estimating the coefficients. The 0.36 moderation effect coefficient in Palestine indicates a significantly stronger positive moderation effect than that in the UAE. Thus, in Palestine, finding solutions to address logistics challenges is significant.

Table 6-38 The geographical location of the construction project influences the regression weights for the relationship between logistics solutions and logistics challenges

			Estimate	S.E.	C.R.	P	Label
CHL	<---	LS	.620	.055	11.23	***	b1_1
CHL	<---	Country	-.366	.070	-5.22	***	b2_1
CHL	<---	solution_ Country	.081	.015	5.22	***	b3_1
		Palestine	0.36				
		Jordan	0.14				
		UAE	0.03				
		KSA	0.23				

Sixth, it was assumed that the location of construction projects did not moderate the relationship between logistics challenges and solutions (0.02, $p = 0.10 > 0.05$) as elaborated in Table 6-39. This entails rejecting the alternative hypothesis (H12_1) and accepting the null hypothesis (H12_0). Logistics challenges can be eliminated by consistently applying logistics solutions, such as adopting lean principles and implementing best practices (Bergman, 2016). Thus, the standardisation of logistics solutions reduces the moderating impact of project location on logistics challenges (Hedlund and Telese, 2019).

Table 6-39 Regression weights for moderating effects of location of construction projects on the relationship between logistics challenges and solutions

			Estimate	S.E.	C.R.	P
CHL	<---	LS	.94	.027	35.20	***
CHL	<---	Location	.10	.061	1.64	.100
CHL	<---	Solution_ location	.02	.013	-1.62	.105

Seventh, the type of construction project moderates (influences) the relationship between CSFs and sustainability in construction projects, as indicated by the moderation analysis in Table 6-40. This includes accepting the alternative hypothesis (H13_1) and rejecting the null hypothesis (H13_0) with a significance level of less than 0.05. The impact of CSFs on sustainability can vary according to the type of construction project being considered. The estimations for each type of construction project (residential, commercial, industrial, infrastructure, institutional) provided a detailed assessment of the strength and direction of each type of moderation effect. The relationship between CSFs and sustainability is typically reflected in the coefficients for each project type. Residential projects have a strong positive moderating effect, as shown by the high moderating effect coefficient (0.97). This is confirmed by Janne and Fredriksson (2019), as residential projects often strongly emphasise meeting sustainability goals due to increasing demand for environmentally friendly and energy-efficient housing. CSFs significantly impact the promotion of sustainability in residential construction projects. Implementing CSFs for sustainability may be easier if sustainable building materials and technologies are readily available and accepted in residential construction. A small positive moderation effect in industrial, infrastructure, and institutional projects indicates that CSFs have a small effect on sustainability compared to other projects. This is because of the complexity of these projects, which involve several stakeholders, numerous regulatory requirements, and technical constraints (Alkahtani and Almalki, 2022). This makes it challenging to prioritise CSFs aimed explicitly at sustainability as other objectives (e.g. customer satisfaction, cost control, schedule adherence) (Alptekin, 2019).

Table 6-40 Regression weights for the moderation effect of the type of construction project on the relationship between CSFs and sustainability of construction projects.

			Estimate	S.E.	C.R.	P	Label
SF	<---	Critical	.37	.042	8.95	***	b1_1
SF	<---	Type	.97	.134	7.27	***	b2_1
SF	<---	CSFs_ type	-.21	.031	-6.84	***	b3_1
		Residential	0.97				
		Commercial	0.68				
		Industrial	0.11				
		Infrastructure	0.12				

	Estimate	S.E.	C.R.	P	Label
Institutional	0.12				

The analysis supported accepting H14 and rejecting the null hypothesis with a significance level of less than 0.05. For instance, it has been proposed that the link between CSFs and sustainability in construction projects is moderated by the country in which the construction project is located. Sustainability is impacted by CSFs differently depending on the country's context. Table 6-41 indicates a strong positive moderation effect due to the high moderation effect coefficient for Palestine, the UAE, and the KSA. CSFs significantly influence sustainability outcomes in construction projects. However, CSFs positively impact sustainability, but not to the same extent as other factors, as Jordan displays a moderate positive effect (0.21). In Jordan, the effectiveness of CSFs in driving sustainability outcomes may be affected by the availability of resources, such as access to sustainable building materials, skilled labour, and financing for green technologies. The impact of CSFs on sustainability outcomes could be limited by the lack of support in Jordan's regulatory environment for sustainable construction practices (Labib, 2016). Compared to Jordan, the high estimate for Palestine that approached the UAE and KSA resulted from the opportunities it gave as additional resources, technical expertise, and capacity-building opportunities from external support, international collaborations, and donor-funded initiatives focused on sustainable development (Taha, 2019).

Table 6-41 Regression weights for the moderating effect of the country on the relationships between CSFS and sustainability.

			Estimate	S.E.	C.R.	P	Label
SF	<---	Critical	.583	.093	6.29	***	b1_1
SF	<---	Country	.714	.121	5.88	***	b2_1
SF	<---	CSFs_ Country	-.155	.028	-5.52	***	b3_1
		Palestine	0.71				
		Jordan	0.21				
		UAE	0.81				
		KSA	0.72				

Ninth, based on the analysis elaborated in Table 6-42, the null hypothesis is not rejected (H15_0), suggesting that there is a non-significant effect between the CSFs and the moderator (location of the construction project) on sustainability (0.019, p=0.47>0.05). This study shows that variations in CSFs and locations do not significantly affect sustainability outcomes. Despite differences in project locations, implementing CSFs in different regions may be relatively consistent (Rao et al., 2015). Regardless of location, construction companies may prioritise CSFs to ensure project success (Sundquist et al., 2018).

Table 6-42 Regression weights between the CSFs and the moderator (location of the construction project) on sustainability

			Estimate	S.E.	C.R.	P
SF	<---	Critical	.07	.05	1.45	.14
SF	<---	Location	.09	.11	.84	.40
SF	<---	CSFs_ location	.01	.02	-.71	.47

Tenth, the type of construction project moderates the relationship between logistics solutions and sustainability in construction projects, as suggested by the moderation analysis. This indicates as depicted in Table 6-43 the acceptance of the alternative hypothesis H16_1 and rejection of the null hypothesis. The type of construction project influences the sustainability of the logistics solutions under consideration. The statistical significance of this moderation effect is indicated by a lower significance level of 0.05. Table 55 presents an estimate that measures the strength and direction of the moderation effect for construction projects, including residential, commercial, industrial, infrastructure, and institutional. Residential projects had a strong positive moderation effect, as revealed by the high moderation effect coefficient (0.83). Thus, implementing efficient logistics solutions significantly affects the sustainability of residential projects. Logistics solutions have a moderate positive moderation effect (0.38) in commercial projects, which indicates that sustainability outcomes are positively influenced, but to a lesser extent than in residential projects. The relatively weak positive moderation effect examined for industrial, infrastructure, and institutional projects suggests that logistics solutions significantly impact sustainability less than residential and commercial projects.

Table 6-43 Regression weights for the effect of the type of construction project (moderates) on the relationship between logistics solutions and sustainability

			Estimate	S.E.	C.R.	P
SF	<---	LS	-.07	.053	-1.37	.16
SF	<---	Type	-.36	.158	-2.27	.02
SF	<---	Solution_ type	.076	.033	2.32	.02
		Residential	0.83			
		Commercial	0.38			
		Industrial	0.11			
		Infrastructure	0.09			
		Institutional	0.09			

Eleventh, the analysis shows that the country in which the construction project is being built affects the relationship between logistics solutions and sustainability in construction projects, supporting the alternative hypothesis H17_1. Depending on the country's context, logistics solutions can affect sustainability in various ways. This moderating effect is statistically significant, as indicated by the significance level being less than 0.05. Regarding strength and direction, the moderation effect for each country (Palestine, Jordan, the UAE, and the KSA) is quantified by the estimates provided in Table 6-44. The relationship between logistics solutions and sustainability is typically affected by the coefficients that result from these estimates. A relatively weak positive moderation effect is indicated by Palestine and Jordan's moderation effect coefficient (0.14, 0.13). Thus, the use of logistics solutions has a small impact on promoting sustainability in construction projects. Logistics solutions play a significant role in promoting sustainability in construction projects in the UAE context, as the UAE has a more substantial positive moderation effect (0.24). In Saudi Arabia (KSA), sustainability outcomes in construction projects are heavily influenced by logistics solutions, as indicated by the strongest positive moderation effect (0.52).

Table 6-44 Regression weights for the effect of the country of construction project (moderates) on the relationship between logistics solutions and sustainability in construction

			Estimate	S.E.	C.R.	P
SF	<---	LS	.59	.15	3.94	***
SF	<---	Country	.69	.20	3.46	***
SF	<---	solution_ Country	.14	.04	-3.31	***
		Palestine	0.14			
		Jordan	0.12			
		UAE	0.24			
		KSA	0.52			

Finally, the analysis (Table 6-45) rejects the alternative hypothesis H18_1 and accepts the null hypothesis, as there is a non-significant effect between logistics solutions and the location of the construction project (moderator) on sustainability (0.003, $p=0.92>0.05$). Therefore, the relationship between logistics solutions and sustainability is not influenced by project location. Sezer and Fredriksson (2021) point out that sustainability practices in the construction industry have become standardised and guided by industry standards (Ekeskar and Rudberg, 2020). Common sustainability challenges are tackled by effective logistics solutions, regardless of project location, resulting in consistent outcomes (Janne and Rudberg, 2020).

Table 6-45 Regression weights for the effect of the location of the construction project (moderates) on the relationship between logistics solutions and sustainability in construction

			Estimate	S.E.	C.R.	P
SF	<---	LS	.035	.056	.62	.53
SF	<---	Location	.006	.126	.05	.96
SF	<---	Solution_ location	.003	.028	.09	.92

Subsequently, mediation analysis was performed to gain insight into the underlying mechanisms or pathways through which an independent variable (IV) affects a dependent variable (DV) through a mediator variable (M). This test is utilised to examine the indirect effect of IV on DV through a (M) using path analysis. First, the mediation analysis rejects the alternative hypothesis H19 and accepts the null hypothesis. This revealed a non-significant indirect effect of logistics solutions on sustainability through critical success factors (β = 0.063, p=0.536>0.05) (Table 6-46), indicating that C.S.F.s poorly mediated the relationship between logistics solutions and sustainability.

Table 6-46 Indirect Effects - Two-Tailed Significance for the effect of logistics solutions on sustainability through critical success factors

	LS	Critical
Critical	...	...
SF	.536	...

The findings indicate that logistics solutions have the potential to impact CSFs and sustainability, but their effects are not statistically significant. For instance, logistics solutions to sustainability may be accompanied by multiple intermediate steps or confounding variables as a pathway to sustainability. The complexity of this mediation pathway can obscure the direct impact of logistics solutions on sustainability (Tarhini 2013). The relationship between logistics solutions and sustainability outcomes can be affected by factors other than CSFs. These confounding variables may include regulatory changes or fluctuations in customer preferences (Ghanem et al. 2018).

Second, the mediation analysis (Table 6-47) suggests the acceptance of the alternative hypothesis (H20_1), which represents a significant indirect effect of logistics solutions on sustainability through logistics challenges (β = -0.406, p=0.021<0.05), indicating that logistics challenges mediated the relationship between logistics solutions and sustainability, including weakening the relationships.

Table 6-47 Indirect Effects - Two-Tailed Significance for the effect of logistics solutions on sustainability through logistics challenges

	LS	CHL
CHL	...	...
SF	.021	...

A negative coefficient indicates that logistics solutions may initially intend to improve sustainability, but significant logistics challenges can reduce or counteract the positive effects. For instance, logistics challenges, such as ineffective coordination among internal parties and ambiguity in logistics responsibilities for the construction team, may directly impact the efficiency and effectiveness of implementing logistics solutions (Ekeskar and Rudberg, 2020). Thus, logistics challenges play a substantial role in explaining the impact of logistics solutions on sustainability. The effects of logistics solutions on sustainability are transmitted because logistics challenges act as intermediary mechanisms (Hedlund and Telese, 2019).

Third, the alternative hypothesis H21_1 is supported as the mediation analysis revealed a significant indirect effect of the critical success factors on sustainability through logistics challenges ($\beta = -0.331$, $p=0.021<0.05$) (Table 6-48), indicating that logistics challenges mediated the relationship between the critical success factors and sustainability, including weakening the relationships.

Table 6-48 Indirect Effects - Two-Tailed Significance for the effect of the critical success factors on sustainability through logistics challenges

	Critical	CHL
CHL	...	...
SF	.012	...

The impact of logistics challenges on sustainability is both direct and indirect. As highlighted by these findings, it is vital to address logistics challenges to achieve sustainable outcomes. Moreover, improving sustainability may not come from CSFs alone if logistics challenges are not effectively managed (Janne and Fredriksson, 2019; Lindholm and Behrends, 2012). Therefore, construction firms should prioritise addressing logistics challenges along with CSFs to enhance sustainability (Huge-Brodin et al., 2022).

7. Chapter Seven: Discussion

Chapter 5 showcases the outcomes of the suggested research model, which explores the potential factors impacting sustainability in construction projects owing to inefficient logistics practices. The data analysis followed a two-phase approach. Initially, Confirmatory Factor Analysis (CFA) was employed to evaluate the validity of the constructs and model fit. Subsequently, the Structural Equation Modelling (SEM) method was utilised to examine hypothesised relationships between independent and dependent variables and assess the moderating influence of geographical location, construction project types, logistics solutions, and critical success factors. Additionally, mediation analysis was conducted to investigate the indirect relationships between independent and dependent variables. The primary objective of this chapter is to provide an explanation of the main findings presented in Chapter 5 and connect them to the research's central aim and objectives. This chapter focuses on comprehending the impact of the research construct on sustainability and examining the relationships between the model constructs.

7.1. Respondents' Background and Current Situation Concerning Logistics Processes in the Middle East.

The survey findings provide a detailed snapshot of the construction industry's demographic composition and expertise. Engineers comprised the largest respondent group at 34.12 %, highlighting their significant representation. Experience levels varied widely, with 45.7 % having two to eight years of experience, indicating a substantial mid-career cohort. The nearly equal involvement in urban (36.73 %), rural (32.23 %), and city-centre (31.04 %) projects reflects diverse experiences and perspectives. This diversity ensures a balanced representation of different roles, experience levels, and project contexts (Hosseini et al., 2014). The survey's credibility and relevance are heightened by this diversity, potentially reducing biases and increasing their significance for stakeholders and decision-makers (Wisner, 2003). Notably, 27.25 % of respondents have experience in residential/housing projects, followed by commercial (25.59 %) and institutional projects (20.85 %). Additionally, respondents were significantly involved in infrastructure (14.22 %) and industrial projects (12.09 %). This detailed breakdown of project experience enhances the reliability of the survey outcomes by showcasing diverse professional backgrounds. A broad spectrum of expertise strengthens the robustness and applicability of the results, making them more valuable in informing industry practices and decisions (Ruparathna and Hewage, 2013).

7.2. The Practical Model

Based on the relationships depicted in Figure 7-1, for the research model.

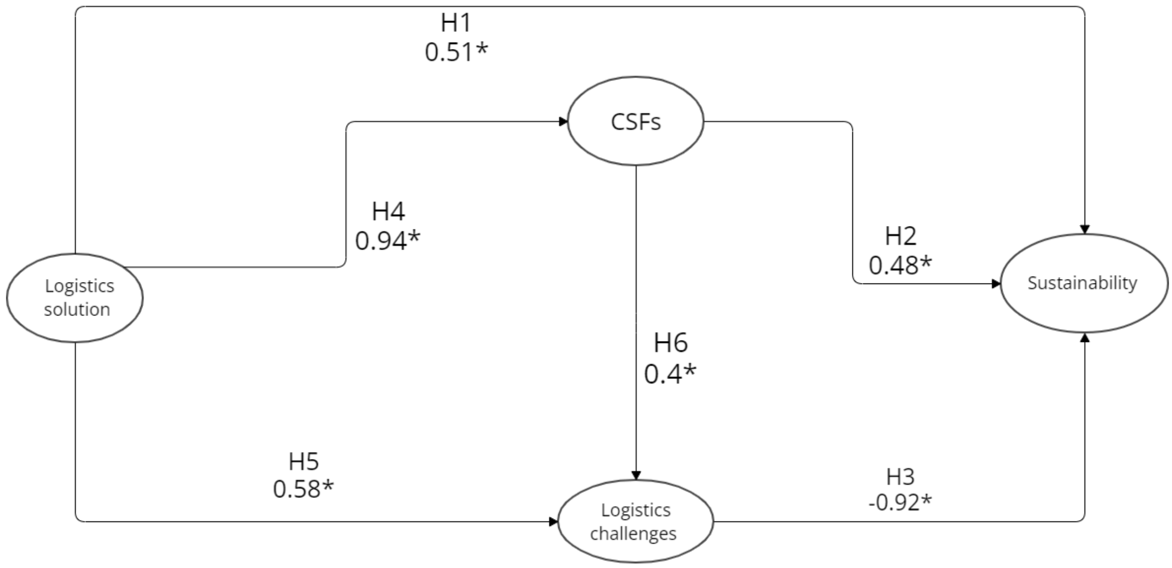

Figure 7-1 The relationships that were directly hypothesized in the proposed research model for the sample (Created by the Author, 2025)

Empirical findings indicate that sustainability (SF) in Middle Eastern construction is affected by logistics challenges (CHL), logistics solutions (LS), and critical success factors (CSFs). The proposed practical models show significant links between CHL, LS, CSFs, and SF. The following sections provide a detailed discussion of the significant relationships between the constructs based on the research hypothesis.

7.2.1. The Impact of Logistics Solutions on Sustainability within the Middle East

The third chapter examines four crucial logistics frameworks that substantially improve sustainability in construction: the Green Logistics Framework, A-S-I/AS-I-F Framework, TIMBER Framework, and IF-TOLD Framework. These structures encompass various logistics solutions that positively influence sustainability. According to the survey findings, these logistics solutions, represented by 18 observed variables, are valid and effective in enhancing sustainability outcomes. This aligns with earlier research by Hedlund and Telese (2019) and Dhawan et al. (2022), who acknowledge the significance of logistics solutions in bolstering sustainability efforts. The Structural Equation Modelling (SEM) results further support the efficacy of these solutions, emphasising their capacity to reduce costs and enhance project performance while promoting sustainability in Middle Eastern construction projects. This corroborates previous studies, such as those conducted by Taha (2019) and Labib (2016), which emphasise that logistics solutions can lead to considerable sustainability improvements in the construction industry.

The study evaluated various logistics solutions, with several approaches receiving high recommendations and mean values exceeding 4.7. These highly rated strategies include establishing logistics centres (LS6), engaging in non-profit and associative activities (LS17), and utilising third-party logistics (3PL) services (LS5). This reflects their ability to address the unique challenges of the region, particularly in terms of scale, resource management, and the need for collaboration. The top-rated strategies—establishing logistics centres (LS6), engaging in non-profit and associative activities (LS17), and utilising third-party logistics (3PL) services (LS5)—underscore key principles that are essential for sustainable construction practices. These highly rated solutions emphasise key themes, such as collaboration, resource efficiency, and supply chain optimisation. While logistics centres (LS6) focus on centralised material management, non-profit activities (LS17) promote industry-wide collaboration and knowledge-sharing, and 3PL services (LS5) ensure seamless execution of logistics activities across projects. Here are why these strategies received such high evaluations:

Establishing Logistics Centre (LS6)

Logistics centres are crucial for optimising the flow of materials and resources in large construction projects, particularly in the Middle East, where infrastructure projects are often vast and geographically spread. The high mean value reflects the recognition of logistics centres as centralised hubs that improve resource efficiency by consolidating storage, reducing transportation distances, and lowering operational costs. These centres allow for bulk purchasing and storage management, reducing waste and minimising the environmental impact by reducing the number of trips required for material delivery (Sundquist et al., 2018). The importance of logistics centres in the Middle East context lies in their ability to handle the complexity and scale of large construction projects more efficiently than in other regions. The consolidation of materials at logistics centres also enhances project coordination and reduces delays, contributing to better sustainability outcomes through resource optimisation and cost reduction.

Utilizing Third-Party Logistics (3PL) Services (LS5)

Third-party logistics (3PL) services play a vital role in streamlining supply chains and ensuring that resources are efficiently managed across construction projects. In the Middle East, outsourcing logistics to specialist providers is particularly valuable because of the region's fragmented logistics infrastructure and complex cross-border supply chains. 3PL providers provide expertise, advanced technologies, and established networks that enable smooth operation, timely delivery, and cost-efficient solutions (Janne and Rudberg, 2020). The high mean value reflects the recognition of the 3PL's capability to optimise logistics processes, minimise material waste, and enhance overall project sustainability. The use of 3PL providers in the Middle East is differentiated by their ability to navigate regional logistics challenges, such as import/export regulations, customs procedures, and long transportation distances. This added value is less pronounced in regions with more established and integrated logistics infrastructure, making 3PL services particularly crucial for sustainable operations in the Middle East.

Furthermore, solutions focused on error prevention (LS11) and the application of modelling tools and information systems (LS18) were identified as critical factors in enhancing quality and driving technical innovation, thereby promoting sustainability. The following points illustrate how these solutions received such high evaluations.

Error Prevention (LS11)

By reducing the number of errors, construction projects generate less waste, which directly contributes to environmental sustainability. Less rework means that fewer resources are consumed, and fewer materials end up in landfills. This solution aligns with circular economy principles by ensuring that materials are used efficiently and effectively. However, many studies acknowledge the importance of minimising errors, and the Middle East construction context demands even greater emphasis on error prevention owing to the scale of projects and the region's unique environmental conditions. Error prevention systems are crucial for handling the complex logistics of megaprojects in the Middle East.

Modelling Tools and Information Systems (LS18)

Information systems and modelling tools help optimise the use of materials and labour by providing real-time data and simulations. For instance, BIM helps visualise the entire project and its components, ensuring that the right materials are available at the right time and place, which reduces over-ordering and waste. The literature stresses the benefits of modelling tools and emphasises their potential for sustainability in logistics. The construction industry in the Middle East often involves large-scale and highly complex projects, where the use of BIM and other digital tools can have a greater impact on reducing inefficiencies than smaller or less complex projects. Furthermore, the region's push for smart city development and sustainable infrastructure makes the application of such tools a critical enabler for achieving these ambitious sustainability goals.

Other solutions garnered moderate recommendations, achieving mean values greater than 4.2. The investigation elucidates several efficacious lean solutions, including the Kanban system (LS1), the Last Planner System (LPS) (LS2), and project management tools (LS8), which demonstrate potential for enhancing scheduling, workflow, and resource allocation. Furthermore, this study acknowledges the significance of continuous improvement principles (LS10) and workplace organisation methodologies (LS14) in augmenting operational efficiency and mitigating waste. Although real-time visibility tools (LS4) and on-site visits (LS13) were found to contribute positively to sustainability efforts, they received marginally lower mean ratings than the solutions. The following points discuss how these solutions are to enhance sustainability within the Middle East

Kanban System (LS1)

The Kanban system is a visual workflow management method that helps regulate material flow and inventory by signalling when materials should be replenished. In the construction sector, this system streamlines operations, reduces inventory waste, and ensures that resources are available when needed. Its moderate recommendation in this study, with a mean value exceeding 4.2, reflects its incremental benefits for improving resource allocation and minimising excess inventory. In the Middle East, where construction projects are large and often complex, the Kanban system can be integrated to ensure efficient material handling, particularly when dealing with variable lead times and multiple suppliers. However, its impact on overall sustainability may be more incremental than that of larger systemic logistics solutions. The use of Kanban could be optimised by coupling it with digital tools that track inventory in real-time, adapting its traditional role to suit the fast-paced construction environment in the region.

Last Planner System (LPS) (LS2)

The Last Planner System (LPS) is a collaborative planning tool designed to improve project scheduling, workflow, and resource management. LPS involves key stakeholders in planning tasks, ensuring that each project stage is completed on time and that resources are used efficiently. In the context of Middle East construction, LPS holds particular significance because of the region's large-scale, multi-phase projects that involve numerous contractors and complex logistics. The system's potential to reduce delays and improve resource coordination is invaluable in such environments, although the study's moderate recommendation (mean value over 4.2) suggests that its effectiveness may depend on how well stakeholders collaborate. To enhance its sustainability impact, LPS could be integrated with building information modelling (BIM) and real-time visibility tools, ensuring proactive decision-making throughout the project lifecycle.

Project Management Tools (LS8)

Project management tools, such as Primavera and Microsoft Project, are essential for coordinating tasks, resources, and timelines in construction projects. These tools optimise resource utilisation, ensure timely project completion, and help reduce the risks of delays and cost overruns. In the Middle East, where large, complex construction projects are common, project management tools provide a centralised platform for tracking progress and coordinating efforts across different teams. Their moderate recommendation (mean value over 4.2) indicates that while they contribute to efficiency and sustainability through improved project control, their effect on environmental sustainability may be indirect. For broader adoption in the region, project management tools should be paired with data integration systems and sustainability metrics to allow construction managers to monitor environmental performance along with traditional project timelines and budgets.

Continuous Improvement Principles (LS10)

The Kaizen principle, which focuses on continuous improvement, encourages teams to make incremental process improvements. In construction logistics, kaizen helps reduce waste, enhance process efficiency, and foster a culture of ongoing optimisation. In the Middle East, where large-scale projects often span multiple phases and years, continuous improvement offers long-term benefits, although the gradual nature of its impact may explain its moderate recommendation (mean value above 4.2). To maximise its effectiveness, Kaizen can be paired with workplace methodologies such as 5S or lean tools such as Kanban, ensuring that operational efficiency gains compound over time. Adopting a Kaizen approach in the region's construction sector would require a shift toward lean thinking, encouraging both management and field workers to seek continuous improvement.

Workplace Organization Methodologies (LS14)

The 5S methodologies focus on workplace organisation, ensuring that construction sites are well-ordered, and operations are streamlined. By focusing on sorting, organising, cleaning, standardising, and sustaining processes, 5S contributes to enhanced efficiency and reduced material waste. Its moderate recommendation in the study (mean value over 4.2) indicates its significance in maintaining order and improving workflow, although its impact on sustainability is more indirect. In the Middle East, where construction sites can be chaotic owing to their size and the number of contractors involved, workplace organisation is crucial for maintaining operational efficiency. Incorporating 5S methodologies at the planning stage and enforcing them throughout the project lifecycle can lead to smoother operations and better resource management, indirectly supporting sustainability by reducing wasted time and materials.

Real-time Visibility Tools (LS4)

Real-time visibility tools provide up-to-date information on project progress, enabling better decision-making and efficient resource allocation. These tools allow construction managers to identify potential delays or material shortages early, improving responsiveness and efficiency on-site. Although real-time visibility tools received a moderately lower mean rating (4.3), their potential for driving sustainability through real-time monitoring was significant. In the Middle East, where logistics complexity can lead to delays and disruptions, real-time visibility is crucial for maintaining project timelines and ensuring effective resource use. Integrating these tools with advanced BIM systems or automated logistics solutions could significantly enhance a region's ability to track and optimise construction operations, contributing to more sustainable practices by reducing waste and ensuring efficient material use.

On-site Visits (Gemba Walks) (LS13)

On-site visits or Gemba walks involve construction managers physically visiting work areas to observe operations, identify issues, and ensure compliance with lean principles. The study's moderate recommendation (mean value of 4.1) for on-site visits highlights their importance in communication, problem-solving, and promoting continuous improvement. In the Middle East, where large, geographically dispersed projects make remote supervision challenging, regular on-site visits are necessary to ensure that lean methods and sustainability protocols are consistently followed. However, the slightly lower rating compared to other solutions may reflect the time-intensive nature of these visits and the fact that they rely heavily on on-site managers' expertise. To increase their impact, on-site visits can be complemented with real-time data tools, providing managers with the ability to verify in-person observations with digital insights for sustainability.

These logistics solutions offer significant value through their capacity to generate systematic and scalable enhancements in sustainability outcomes within the Middle Eastern construction sector. This study extends beyond merely identifying logistics solutions by emphasising the interconnectivity of these approaches within a regional framework. For instance, integrating logistics centres (LS6) with sophisticated information systems (LS18) establishes a data-driven approach to logistics management, enhancing both resource allocation and the precision of sustainability metrics. Furthermore, solutions such as 3PL services (LS5) and error-reduction strategies (LS11) have introduced cost-effectiveness into sustainability initiatives. These approaches enable organisations to achieve sustainable results without substantial investments in logistics infrastructure or major operational changes. Instead, they can focus on incremental improvements, including error reduction, transport route optimisation, and enhanced collaboration, all of which contribute to long-term sustainability. The subsequent section provides an in-depth analysis of how these logistics solutions should be implemented and how they should interact to form a cohesive sustainability strategy.

Implementation of Logistics Centres (LS6) and Use of Information Systems (LS18):

In sustainable supply chain management, particularly for construction projects requiring extensive material coordination, logistics centres (LS6) play a crucial role. The Middle East's emphasis on large-scale infrastructure development has increased the significance of these centres in managing bulk materials and cross-regional supply chains, distinguishing them from centralised logistics hubs in other regions. This approach is notable owing to its incorporation of real-time data analytics and modelling tools such as BIM (LS18). Although BIM and 3D modelling are utilised globally to enhance project coordination and resource management (Le-Hoai et al., 2008), their integration with logistics centres in the Middle East is particularly effective. The robust interconnection between information systems and logistics centres facilitates streamlined operations. By integrating BIM data into logistics centres, inventory levels can be optimised, material transit status can be monitored, and deliveries can be synchronised with construction schedules, resulting in reduced material waste and transportation emissions.

Error Prevention (Poka-Yoke) (LS11), Lean Design (LS7), and Continuous Improvement (Kaizen) (LS10)

The manufacturing and construction industries extensively utilise error prevention (Poka-Yoke) and lean design principles (LS7) to minimise waste and optimise efficiency. These methodologies are particularly critical in the Middle East, where large-scale and complex construction projects require that even minor errors can result in substantial material waste and resource inefficiencies (Luong Le et al., 2021). While previous research has often considered these as discrete solutions, this study emphasises their interconnected nature, particularly when integrated with continuous improvement principles such as Kaizen (LS10). The interrelationship between these approaches is evident in how lean design principles aim to minimise waste during project planning, Poka-Yoke mitigates errors during implementation, and Kaizen facilitates ongoing process enhancement throughout the project's lifecycle. Collectively, these solutions create a cyclical process that ensures the continuous refinement and improvement of logistics processes, which is essential for achieving long-term sustainability in the Middle East.

Kanban (LS1), Last Planner System (LPS) (LS2), and Project Management Tools (LS8)

The Kanban system (LS1) and the Last Planner System (LPS) (LS2) are logistical approaches that aim to enhance workflow efficiency and facilitate just-in-time (JIT) delivery, both essential for minimising waste and increasing productivity in the construction industry. In Middle Eastern countries, where urban expansion often necessitates accelerated construction schedules, these systems diverge from their global counterparts by emphasising the management of substantial material quantities and complex supply networks (Fredriksson et al., 2021). The interrelationship between Kanban, LPS, and project management tools (LS8) is evident when considering the necessity for precise scheduling and resource allocation. Kanban optimises material flow by ensuring timely resource delivery, whereas LPS coordinates project activities to minimise bottlenecks and delays. Project management tools monitor these processes in real-time, offering an overview of project progress and resource utilisation. These tools form an integrated logistics model that enhances operational efficiency, reduces waste, and promotes sustainability.

Third-Party Logistics (3PL) Services (LS5) and Just-in-Time (JIT) (LS3)

In global construction industries, just-in-time (JIT) delivery (LS3) and third-party logistics (3PL) services (LS5) are frequently utilised strategies to reduce inventory costs and enhance sustainability. These approaches are particularly significant in the Middle East, where construction projects often face logistical challenges such as extended transportation distances and custom-related delays. The distinctive value proposition in this region arises from 3PL providers' capacity to optimise JIT logistics through advanced technologies and extensive distribution networks. The interrelationship between 3PL providers and JIT is evident in how 3PL providers facilitate timely deliveries, thereby reducing the necessity for on-site storage. This, in turn, decreases costs and mitigates the environmental impact associated with maintaining substantial inventories. The synergy between JIT and 3PL results in an optimised logistics system that minimises waste improves resource utilisation, and contributes to sustainability objectives.

Real-Time Visibility Tools (LS4) and Optimized Transportation Routes (LS12)

Construction managers can use real-time visibility tools (LS4) to monitor and adjust logistics operations dynamically, facilitating rapid modifications to the supply chain processes when required. This capability is particularly critical in the Middle East, where construction projects frequently occur in remote or rapidly developing regions. Logistical inefficiencies can significantly affect sustainability. In the Middle Eastern context, the application of real-time data for route optimisation (LS12) serves as a key differentiating factor. Although global research emphasises route optimisation to reduce transportation costs and emissions, this study highlights the additional benefits of real-time visibility tools. These tools ensure continuous route optimisation based on current traffic conditions, site circumstances, and material availability. The interconnection between these two solutions lies in their capacity to dynamically modify transportation strategies, ensuring that materials are delivered in the most efficient and environmentally sustainable manner possible, thereby minimising fuel consumption, emissions, and expenses.

Kaizen (LS10) and Andon System (LS16)

The principles of Kaizen (LS10) and Andon (LS16) are both oriented towards enhancing process efficiency and supporting sustainability. Kaizen, which emphasizes continuous improvement, is typically implemented at the organizational level globally to achieve incremental enhancements. In contrast, the Andon system, which utilises visual indicators to identify issues in real-time, is more frequently employed in manufacturing environments. However, within the Middle Eastern construction sector, these two approaches are interconnected to facilitate both proactive and reactive sustainability measures. The Kaizen methodology ensures that logistical processes undergo constant refinement to minimise waste and increase efficiency over time. Concurrently, the Andon system provides immediate notifications when deviations from sustainability targets occur. In combination, these systems create a feedback loop that not only focuses on long-term process improvements but also ensures rapid corrective actions when issues arise, thereby enhancing both operational effectiveness and sustainability.

5S Methodology (LS14) and Value Stream Mapping (VSM) (LS9)

The construction industry employs two primary methodologies to enhance efficiency and sustainability: 5S (LS14) and Value Stream Mapping (VSM) (LS9). While 5S aims to optimise construction site organisation, thereby reducing waste and improving efficiency, VSM focuses on identifying and eliminating non-value-added activities in logistics processes. Although these approaches are typically implemented independently, this research elucidates their interconnectedness. In Middle Eastern construction projects, which are frequently large-scale and involve numerous stakeholders, the synergy between 5S and VSM is particularly advantageous. By utilising VSM to detect inefficiencies in logistics processes and applying 5S principles to enhance the site layout, these methodologies function in concert to facilitate efficient material flow throughout the construction site. This integrated approach resulted in reduced delays and improved sustainability outcomes.

The added value of these logistics solutions lies in their capacity to generate systematic and scalable improvements in sustainability outcomes within the Middle East's construction industry. This study extends beyond merely identifying logistics solutions and elucidates the interconnectedness of these solutions in a regional context. For instance, the integration of logistics centres (LS6) with advanced information systems (LS18) establishes a data-driven approach to logistics management, enhancing not only resource allocation but also the precision of sustainability metrics. Furthermore, solutions such as 3PL services (LS5) and error-prevention strategies (LS11) introduce cost efficiency into sustainability initiatives. These solutions enable organisations to achieve sustainable outcomes without necessitating extensive investments in logistics infrastructure or operational overhauls. Instead, they can focus on incremental enhancements, such as minimising errors, optimising transportation routes, and improving collaboration, all of which contribute to long-term sustainability.

7.2.2. The Impact of Critical Success Factors on Sustainability within the Middle East Construction Industry

Critical success factors (CSFs) are instrumental in enhancing operational efficiency, promoting sustainability, and ensuring overall project success. This study examines the essential logistics CSFs that significantly influence project outcomes, including demand forecasting, resource allocation, inventory management, and securing executive support. These elements contribute to waste reduction, delay minimisation, and resource optimisation, which are particularly significant in a region characterised by ambitious large-scale projects and a competitive construction industry. By identifying and implementing these crucial success factors, construction firms can improve their operational performance, ensure timely project completion, and maintain financial stability. The subsequent sections explore the impact of these CSFs on sustainability in the Middle Eastern context.

Effective Risk Management (CSF6)

This finding holds substantial importance because of its direct correlation with the efficacy and long-term viability of construction processes in the Middle East. The region's construction sector is characterised by extensive, high-stakes projects that frequently contend with adverse environmental conditions, stringent timelines, and limited resources. The mean score of 4.33 underscores the critical role of robust risk management in addressing these challenges. Effective risk mitigation not only prevents budget overruns and schedule delays but also ensures that projects remain on track and within financial parameters. This is particularly crucial in the Middle East, where project setbacks can result in substantial monetary losses, owing to the region's significant infrastructure investments and rapid urban development. Moreover, by enhancing safety measures and minimising workplace risks, risk management fosters a more secure work environment, which is essential for maintaining productivity and avoiding costly legal problems. Consequently, this result emphasises the importance of proactive risk management as a strategic approach that enhances operational efficiency, safeguards investment interests, and bolsters the overall sustainability of the Middle Eastern construction industry, a region heavily dependent on the timely and safe completion of projects.

Collaborating with Suppliers (CSF9)

In the Middle East construction sector, supplier collaboration plays a pivotal role in logistical success by directly enhancing efficiency and minimising delays. The region's large-scale projects necessitate robust supplier partnerships to ensure timely delivery of materials and equipment, which is crucial for meeting stringent deadlines. By cultivating strong supplier relationships, construction companies can mitigate the risks associated with material procurement delays, leading to more efficient project implementation. Moreover, effective collaboration enables improved planning and forecasting, allowing suppliers to better anticipate and fulfil project requirements. This is particularly significant in the Middle East, where unforeseen challenges, such as supply chain disruptions and political instability, may arise. The flexibility in these relationships facilitates rapid adjustments to project changes or unforeseen obstacles, helping maintain project timelines despite potential setbacks. Additionally, cost reductions are achieved through price negotiations, volume purchases, and waste elimination as suppliers become more acquainted with project needs and schedules (Riazi et al., 2020). These cost efficiencies are vital for maintaining budgets in the Middle East's typically large, extended, and resource-intensive construction projects. Furthermore, strong supplier partnerships contribute to improved material quality because ongoing communication and feedback uphold high standards, thereby reducing the likelihood of costly rework or defects (Le et al., 2021).

Adequate Training and Skill Development (CSF10):

In the Middle East, where large-scale construction projects have been established, the significance of appropriate training and skill enhancement for construction logistics cannot be overstated. Worker proficiency, safety, and efficiency are critical for maintaining project productivity in this region. Personnel with adequate training can utilise equipment and tools more effectively, leading to fewer errors, accidents, and operational interruptions. This is particularly crucial in the Middle East, where rapid development necessitates timely project completion, as delays can result in substantial financial repercussions. Construction companies can achieve superior quality outcomes with less rework by improving their workforce capabilities, thereby keeping projects on schedule and within financial constraints. Continuous skill improvement ensures that workers remain current with the latest construction technologies and industry standards, allowing them to adapt rapidly to new methodologies and challenges (Hedlund and Telese, 2019). In a region that increasingly adopts advanced technologies such as Building Information Modelling (BIM) and modular construction, a skilled workforce is essential for maximising the potential of these innovations. Furthermore, training promotes a culture of safety and decreases the likelihood of workplace incidents and their associated setback. This is particularly important in the Middle East, where construction projects often involve complex environments, making worker safety a primary concern. Well-informed workers can also identify potential issues early and implement preventive measures to address them, optimising operations, and minimising disruptions (Hedlund and Telese, 2019). The significance of this outcome lies in its effect on project efficiency and cost management. In the Middle East, where construction projects are extensive and stakes are high, having a well-trained workforce is essential for ensuring that projects are completed on schedule, safely, and to the highest standards.

Compliance with Safety, Environmental, and Regulations (CSF5)

In the Middle East, the effectiveness of construction logistics is heavily dependent on adherence to safety, environmental, and regulatory standards, as this prevents costly setbacks, penalties, and project disruptions. For the region's extensive and high-profile construction businesses, following safety protocols is essential to maintain a protected work environment, minimising the risk of accidents and injuries that could impede operations and incur additional costs. Considering the challenging environmental conditions and complex logistics in the Middle East, safeguarding worker well-being is particularly critical to avoid project cessations and delays. Equally significant is environmental compliance because disregarding regulations may lead to legal consequences or even project termination. By observing environmental laws, Middle Eastern construction companies can promote sustainable methods, enhance their public perception, and contribute to the long-term viability of their projects (Luong et al., 2021). This is increasingly pertinent, as the region aims to balance rapid growth with environmental sustainability, a growing concern in nations such as the UAE and Saudi Arabia. Furthermore, adhering to regulatory requirements ensures the timely acquisition of the necessary permits and approvals, thus averting bureaucratic impediments that could hinder project advancement. In the Middle East, where government oversight and regulations are often stringent, meeting all legal obligations is crucial for maintaining smooth project operations and avoiding costly interruptions. This outcome is noteworthy, as it underscores how compliance fosters a culture of accountability and professionalism at construction sites, enhancing worker morale and productivity. In the Middle East, where numerous projects rely on a diverse workforce, establishing a compliant and well-regulated environment can facilitate efficient, timely, and cost-effective project execution, thereby supporting the region's ambitious infrastructure objectives.

Proper Information Flow (CSF4)

In the domain of construction projects, particularly in the Middle East, the significance of efficient information exchange among stakeholders cannot be overstated. Accurate and timely data sharing is crucial for project managers to optimise resource allocation and enhance coordination. This is particularly relevant in regions experiencing rapid urban development and large-scale projects, where seamless collaboration is essential to maintain schedules and financial constraints. Effective communication facilitates prompt problem identification and resolution, mitigating common issues such as delays and budget overruns in the region's construction industry. This proactive approach is vital for navigating the complexities of Middle Eastern construction, where unforeseen setbacks due to regulatory, logistical, or environmental factors can significantly affect the project timelines. Transparent communication ensures that all team members are well-informed about their responsibilities, timelines, and obligations, minimising the risk of misunderstandings that could result in costly errors. Moreover, real-time project updates enable rapid adaptations to changing circumstances, such as supply chain disruptions or on-site challenges, which are common in this region owing to fluctuating material availability and diverse workforce conditions. Furthermore, proper information flow promotes accountability and trust, thereby fostering collaboration among stakeholders. This is especially crucial in the Middle East, where projects often involve international partners, and maintaining open communication is essential for establishing long-term relationships (Fredriksson et al., 2021). By facilitating smooth information exchange, construction projects can eliminate bottlenecks, enhance operational efficiency, and meet a region's high expectations for timely completion and cost-effective management.

Efficient Resource Allocation (CSF8):

This study underscores the critical importance of effective resource management in construction logistics, particularly in the Middle Eastern construction sector. Appropriate allocation of workforce, supplies, and machinery directly influences cost management, project timelines, and overall operational efficiency. Khan et al. (2022) posit that proper resource allocation enables construction firms to minimise waste, mitigate delays, and control expenditures, which are crucial factors in the Middle East, where construction projects are often large-scale and time sensitive. The region's pressing need for rapid infrastructure development, especially in urban centres such as Dubai, necessitates optimal utilisation of resources to maintain project momentum and avoid costly interruptions. Ensuring timely access to the requisite materials and equipment for personnel enhances productivity by facilitating unimpeded task progression. This efficiency is particularly significant in the Middle East, where adverse weather conditions and logistical challenges can further complicate project schedules. By minimising idle time, efficient resource management enables construction teams to maintain consistent progress, which is essential for meeting stringent deadlines in the region's fast-paced construction environment. Furthermore, the timely availability of appropriate resources reduces the necessity for rework, ensuring that quality standards are met while minimising associated costs. This is particularly relevant in the Middle East, where maintaining high-quality outcomes is crucial for upholding a region's growing reputation as a hub for innovative architecture and large-scale infrastructure projects. Moreover, meeting project deadlines and maintaining quality standards not only enhances a construction firm's reputation but also ensures compliance with regulations, which is critical in the highly regulated environments of countries such as Saudi Arabia and the UAE. Therefore, efficient resource allocation supports both operational and strategic objectives, rendering it a fundamental element of success in the region's dynamic construction industry.

Accurate Demand Forecasting and Planning (CSF1)

In the Middle East, where large-scale projects dominate, precise demand forecasting and planning are essential for construction logistics. Accurately predicting resource requirements throughout a project's lifecycle enables the optimal allocation of materials, equipment, and workforce, which is crucial for minimising waste and ensuring efficient execution. This is particularly significant in the context of mega projects, such as NEOM in Saudi Arabia and extensive infrastructure developments in the UAE and KSA. Efficient procurement and delivery schedules, achieved through meticulous planning, prevent work disruptions due to shortages and eliminate the need for costly expedited orders. Given the magnitude of construction projects in a region, any logistical delay can have significant ramifications. Moreover, precise demand forecasting facilitates more advantageous supplier negotiations, allowing for improved pricing and terms through volume purchasing and extended agreements. This is a critical factor in managing costs in high-budget environments. By aligning resources closely with project requirements, effective demand forecasting enhances efficiency by reducing downtime and avoiding idle labour or equipment, which is particularly costly in a region where labour expenses and imported specialised equipment can be substantial. This alignment ensures more streamlined construction activities, minimising interruptions, and maintaining project schedules.

Accurate forecasting enhances budget management and expenditure control, which are essential for maintaining financial stability throughout a project's lifecycle. Project managers can mitigate budget overruns by allocating funds according to anticipated resource requirements. This is particularly significant in the Middle East, where high-profile, prestigious projects are prevalent and rapid development is emphasised. The ability to prevent costly delays, inefficiencies, and budget excesses is crucial because it enables Middle Eastern construction companies to complete projects on schedule and within parameters, aligning with the region's ambitious development objectives. As noted by Janne and Fredriksson (2021), effective demand forecasting is a critical component that supports the long-term sustainability and success of construction logistics.

Strong Commitment and Support from Top Management (CSF11)

The efficacy of construction logistics in the Middle East's building industry, which is characterised by complex and extensive projects, is significantly dependent on robust support and commitment from senior leadership. Active engagement of top executives ensures appropriate resource allocation, alignment of strategies with project objectives, and expeditious and effective decision-making. This is particularly crucial in a region hosting large-scale projects such as Dubai's Expo 2020 and Saudi Arabia's NEOM city, which necessitates precise coordination, strong leadership, and meticulous logistical oversight to meet stringent deadlines and specifications. By committing to implementing best practices, upper management fosters an environment of accountability and continuous improvement, enhancing operational efficiency. In the Middle East, where construction companies often face intense pressure to deliver high-profile projects, executive leadership plays a vital role in maintaining streamlined logistics, which is essential for reducing delays, controlling costs, and sustaining a competitive advantage. Furthermore, top management's guidance is critical in risk management, especially in a region where construction projects encounter unique challenges, such as extreme weather conditions, limited resources, and evolving regulatory landscapes. By prioritising proactive measures and ensuring effective performance monitoring, senior executives can anticipate and mitigate potential disruptions and maintain project schedules. The significance of this finding lies in its ability to emphasise the crucial role of executive leadership in ensuring logistics efficiency, a key factor for success in the Middle East's ambitious construction sector. As Jones et al. (2021) note, strong involvement from top management not only supports resource allocation but also promotes a sustainable, long-term approach to project delivery, which is essential for the region's continued growth and global competitiveness.

7.2.3. The Impact of Logistics Challenges on Sustainability within the Middle East Construction Industry

This study employs Structural Equation Modelling (SEM) to offer how logistical issues impact sustainability in Middle Eastern construction. By combining SEM with PESTLE analysis, this study examines 23 logistics challenges affecting the region's construction sector, emphasising their sustainability implications. The results indicate that these challenges are not merely operational inefficiencies but are intricately linked to political, economic, social, technological, legal, and environmental factors. PESTLE analysis proves crucial in examining logistics challenges in the Middle East construction industry, as it provides a methodical model for exploring external influences on logistics operations. This approach enables the evaluation of Political, Economic, Social, Technological, Legal, and Environmental factors, capturing the complexities and interdependencies characteristic of the region's logistics landscape. PESTLE elucidates how external elements drive logistical inefficiencies and delays, such as the direct impact of political instability on supply chain disruptions or the effect of economic fluctuations on material costs and availability. By identifying these external factors, PESTLE enhances research by contextualising logistics challenges within a broader socioeconomic and political framework, ultimately informing targeted solutions and strategies. This thorough analysis directly addresses the research question by elucidating the root causes of logistics issues and provides recommendations for enhancing resource management and operational efficiency. PESTLE analysis is particularly valuable within the critical realism methodology, as it facilitates an in-depth examination of external structures and mechanisms influencing logistics challenges, aligning with critical realism's aim to uncover underlying causes beyond observable phenomena. Moreover, PESTLE's structured analysis aids in proposing practical, context-solutions, which is essential for the goal of critical realism of producing actionable insights. In the Middle Eastern context, where logistics are shaped by a highly dynamic and often unstable external environment, combining PESTLE with critical realism provides model for understanding and addresses logistics challenges at their core. This research is significant because it transcends operational inefficiencies and offers a robust model to explore the macro-environmental forces uniquely impacting logistics in this region. This differs from other studies that may focus solely on internal or operational factors without considering the broader external context. This detailed analysis underscores the importance of this research by demonstrating how regional factors exacerbate logistics challenges and how these factors are often overlooked in existing studies. This study provides a thorough examination of the 23 logistics challenges confronting the Middle East construction industry, with a particular focus on their sustainability impacts.

Political Factors

The disruption of logistics operations in the Middle East is significantly influenced by political instability, as demonstrated by CHL22 (political instability causing closure). This instability results in delays, inefficient resource utilisation, and increased project expenditure. The region's geopolitical tensions frequently affect trade routes and supply chains, creating logistical obstacles and increasing costs due to project delays. While Riazi et al. (2020) addressed these issues, they did not fully explore broader sustainability implications, such as increased carbon emissions and resource depletion resulting from extended construction timelines. This research emphasises that political challenges, particularly in conflict-prone areas, not only hinder projects but also contribute to environmental degradation through inefficient resource utilisation. Furthermore, government policies and regulatory changes can directly impact labour availability (CHL23), as many Middle Eastern countries depend on foreign workers who are susceptible to political fluctuations. Existing literature often fails to address how these political shifts substantially affect logistics planning and workforce availability, thereby impacting sustainability by impeding progress and increasing carbon emissions from delayed or stalled construction activities. This finding provides a better understanding of how political instability affects the construction supply chain, particularly in the environmentally sensitive Middle East, where logistics disruptions due to political unrest can have magnified effects on sustainability.

Economic Factors

In the Middle East construction sector, key factors contributing to logistics inefficiencies include economic issues such as unstable material costs (CHL13) and inadequate inventory management (CHL19). While Ekeskar and Rudberg (2016) address the unpredictable nature of construction material prices, they do not explore how these fluctuations compel contractors to opt for less sustainable materials to remain within the budget, thereby negatively impacting long-term environmental sustainability. This study expands on this concept by noting that in the Middle East, where economic instability is prevalent due to oil price fluctuations and political unrest, these financial pressures result in unsustainable procurement practices. The problem is further exacerbated by inaccurate material and inventory tracking (CHL19), leading to excess ordering or shortages and increased waste. Although Janne and Rudberg (2020) mentioned inventory-related challenges, they did not fully examine the connection between these issues and sustainability, particularly regarding resource depletion and increased carbon emissions.

Social Factors

In the Middle East, significant social factors affecting logistics challenges include workforce shortages (CHL23) and insufficient logistics expertise (CHL2). The region's substantial dependence on foreign workers indicates that any disruption in labour supply, whether due to political instability or economic fluctuations, can result in severe project delays and increased logistical complexities. While Khan and Lockhart (2019) examine the dependence on expatriate labour, they do not fully explore how labour scarcity directly affects sustainability, particularly through project delays that lead to inefficient resource utilisation and higher carbon emissions. Additionally, Janne and Fredriksson (2021) assert that a dearth of logistics management expertise significantly contributes to inefficiencies, resulting in suboptimal material handling, delayed delivery, and increased waste production. This research uniquely links these social challenges to sustainability issues, positing that the shortage of skilled labour and logistics expertise is not merely a workforce issue but one with substantial environmental ramifications. It argues that labour-related challenges not only impede progress but also exacerbate environmental degradation by extending the duration of construction processes.

Technological Factors

Construction logistics encounters significant technological challenges, primarily the absence of real-time monitoring systems for fleets and equipment (CHL9) and issues associated with imprecise estimations (CHL16). While Fredriksson et al. (2021) examined the inefficiencies resulting from inadequate tracking systems, they did not explore how these technological deficiencies impact sustainability, particularly in terms of increased fuel consumption and emissions due to ineffective fleet management. This study expands on this topic by demonstrating how these technological gaps contribute to greater environmental consequences in the Middle East. In this region, extensive construction projects often encompass large areas, making efficient fleet management essential for sustainability. The lack of real-time tracking systems results in higher fuel consumption and extended transport duration, negatively affecting sustainability through increased carbon emissions. Similarly, inaccurate estimation (CHL16) leads to overordering, excessive material waste, and inefficient resource allocation, directly contributing to sustainability challenges. Ghanem et al. (2018) emphasise the operational inefficiencies caused by poor estimation practices, but this study builds on their findings by illustrating that these inefficiencies contribute to environmental degradation. Consequently, technological advancements in logistics are crucial for achieving sustainability in the Middle Eastern construction industry.

Legal Factors

In the Middle East, efficient logistics operations encounter significant challenges in the form of legal obstacles, including protracted decision-making processes by consultant engineers (CHL11) and ambiguous logistics responsibility allocation (CHL10). While Ahmed (2017) elucidates how legal delays can create project bottlenecks, his study does not examine the environmental ramifications of these setbacks, particularly those concerning sustainability. This study addresses this gap by demonstrating that legal delays increase project expenses and extend construction duration, resulting in higher energy consumption, resource inefficiency, and increased emissions. Furthermore, the lack of clarity in logistics responsibilities (CHL10) exacerbates these inefficiencies, because unclear accountability can lead to redundant efforts, poor material management, and extended project timelines. Although Fredriksson et al. (2021) broadly discuss this issue, they do not establish a connection to wider sustainability implications. This research bridges this gap by illustrating how legal and organizational inefficiencies can lead to substantial environmental and logistical challenges in construction projects across the Middle East.

Environmental Factors

The construction sector in the Middle East has encountered significant logistical challenges that have impacted sustainability. These include environmental concerns, such as material waste resulting from ineffective handling (CHL18) and the utilisation of unsuitable vehicles for transport (CHL20). While Patel and Vyas (2011) discussed inefficiencies in material handling, they did not explore how these deficiencies exacerbate environmental impacts, including increased waste generation and resource depletion. This study extends their work by demonstrating that poor material handling not only increases costs but also substantially contributes to sustainability issues through excessive waste production and increased energy consumption. Furthermore, the utilisation of inappropriate vehicles (CHL20) in construction logistics results in greater fuel consumption and elevated emissions, a problem particularly pronounced in the Middle East owing to the often-extensive distances that materials must traverse. Although Dhawan et al. (2022) examined transportation inefficiencies, this study expands on their findings by focusing on the environmental consequences of these inefficiencies, particularly in terms of carbon emissions and resource depletion, emphasising the necessity for more sustainable logistics practices in the region. Additionally, in the Middle Eastern context, where large-scale construction projects generate substantial waste, reverse logistics play a crucial role in minimising environmental impact and promoting resource efficiency. Incorporating reverse logistics into construction logistics aids in reducing raw material consumption and decreasing the waste sent to landfills, contributing to a circular economy. While studies such as Ghanem et al. (2018) and Hedlund and Telese (2019) recognise reverse logistics as a sustainability-enhancing practice, they often underestimate its full potential in mitigating the environmental footprint of construction. In the Middle East, where sustainability has become a priority considering ambitious national visions (for example, Saudi Vision 2030), reverse logistics is becoming increasingly essential for achieving environmental objectives.

7.2.4. The Impact of Logistics Solutions on Critical Success Factors within the Middle East Construction Industry

This study demonstrates the significant impact of logistics solutions on enhancing critical success factors, indicating a strategic shift in the Middle Eastern construction sector towards sustainability, resilience, and operational efficiency. These findings represent a substantial advancement in addressing logistics challenges that have historically hindered project success in the region. By implementing advanced logistics strategies, construction projects in the Middle East can effectively manage supply chain issues, resource allocation, and compliance with environmental regulations. The implementation of sophisticated logistics methods, including Kanban (LS1), Last Planner System (LPS) (LS2), Just-in-Time (JIT) (LS3), real-time tracking systems (LS4), and enhanced transportation planning (LS12), demonstrates the significant achievement of critical Success Factors (CSFs). These CSFs encompass accurate demand forecasting, efficient inventory management, timely resource allocation, risk mitigation strategies, and adherence to safety and environmental regulations. This approach represents a crucial advancement in addressing persistent construction logistics challenges within the region.

Kanban System (LS1) and the CSFs

The Kanban system demonstrates a robust connection to Critical Success Factors (CSFs) that enhance material handling, demand prediction, and operational productivity. In Middle Eastern countries, where construction projects are typically large-scale and complex, the ability to optimise resource allocation is crucial. The region's reliance on imported materials and equipment, combined with supply chain volatility, underscores the necessity for efficient logistical frameworks, such as Kanban. Ekeskar and Rudberg (2016) noted that Kanban's real-time inventory control minimises excess stock, thereby reducing waste and the environmental impact of construction projects. By decreasing storage requirements and improving material flow, Kanban assists in addressing some of the Middle East's logistical challenges, such as limited warehousing infrastructure and variable supply chain lead times. Furthermore, Kanban's contribution to fostering supplier relationships aligns with broader sustainability objectives. The enhanced communication it facilitates among project stakeholders ensures timely material delivery, mitigating project delays, and supporting resource conservation (Luong Le et al., 2021). This is particularly significant in Middle

Eastern nations, such as the UAE and Saudi Arabia, where stringent sustainability mandates, including Dubai's Green Building Regulations, require construction projects to minimise waste and energy consumption. Implementing Kanban enables projects to better adhere to these regulations by reducing unnecessary inventory and ensuring efficient material utilisation.

Last Planner System (LS2) and Collaborative Planning

The Last Planner System (LPS) demonstrates project scheduling and demand forecasting in Middle Eastern construction. LPS emphasises collaborative planning, incorporating key personnel and vendors in the decision-making process, which is crucial for complex large-scale projects such as NEOM in Saudi Arabia and Expo 2020 in Dubai. This system reinforces Critical Success Factors (CSFs) by incorporating real-time data and ensuring the synchronisation of materials, workforce, and resources with project timelines. Seneviratne et al. (2017) note that LPS reduces the likelihood of delays, a frequent challenge in Middle Eastern construction due to workforce fluctuations, supply chain interruptions, and severe weather conditions. The sustainability component of LPS is equally significant. The system promotes proactive risk management by anticipating potential project obstacles, thus minimising resource waste and energy consumption. Kasim et al. (2005) contend that LPS-driven coordination results in decreased transportation requirements and improved resource allocation, essential for reducing the environmental impact of extensive construction projects in regions with challenging climates. By implementing LPS, Middle Eastern projects can better align with sustainability goals, such as Saudi Vision 2030, which aims to enhance energy efficiency and promote environmentally responsible infrastructure development.

Just-in-Time (LS3) and Optimized Inventory

Just-in-time (JIT) logistics approaches demonstrate suitability for the Middle East construction industry's efforts to optimise resources and implement lean methodologies. Based on the work of Ameh et al. (2010), JIT's capacity to reduce excess inventory expenses and shorten lead times is essential in regions where construction timelines are frequently extended owing to lengthy procurement cycles and complex customs procedures. The Middle East's reliance on imported materials, particularly for advanced and specialised construction projects, renders JIT a crucial strategy for maintaining project schedules while preventing stockouts and surplus inventory. Moreover, JIT's contribution of JIT to sustainability in the region is significant. By synchronising demand forecasting with immediate requirements, JIT diminishes the environmental impact associated with material storage and handling. Thunberg et al. (2014) observed that the system also enhances transportation efficiency, decreasing fuel consumption and emissions – factors that are increasingly regulated in Middle Eastern nations striving to achieve carbon neutrality. For instance, the United Arab Emirates' Net Zero by 2050 initiative places considerable emphasis on reducing emissions across all sectors, including construction, thereby rendering JIT an indispensable tool for meeting these objectives.

Real-time Visibility Tools (LS4) and Project Efficiency

Real-time visibility tools offer substantial benefits in terms of enhancing logistics transparency, mitigating risks, and promoting sustainability. These tools are particularly advantageous for the construction sector of the Middle East, which is renowned for its extensive infrastructure projects. They facilitate real-time monitoring of project progression, material availability, and delivery schedules (Shigute and Nasirian, 2014). In regions characterised by complex logistics environments, such as Saudi Arabia's remote desert areas or Dubai's densely populated urban centres, these tools effectively reduce transportation costs and mitigate delays by monitoring materials and optimising delivery routes. Furthermore, real-time visibility tools assist Middle Eastern nations in meeting regulatory requirements by monitoring safety and environmental indicators throughout a project. Le et al. (2021) assert that these tools enhance project sustainability by minimising material waste and facilitating more accurate resource forecasting. For instance, in Qatar, where sustainability initiatives such as the Qatar National Vision 2030 are driving the adoption of more environmentally conscious construction methods, real-time visibility tools play a crucial role in ensuring that projects meet green building standards while maintaining efficiency and cost-effectiveness.

Optimized Transportation Routes (LS12) and Resource Efficiency

The enhancement of transportation networks (LS12) plays a crucial role in improving the efficiency and environmental sustainability of logistics operations in the Middle East. The implementation of advanced technologies, including real-time monitoring systems, GPS tracking, and route optimisation algorithms, directly enhances delivery reliability, mitigates delays, and reduces transportation costs. Sundquist et al. (2018) observed that optimised routes not only decrease fuel consumption and emissions but also enhance project resilience by mitigating risks associated with transportation disruptions. In the Middle Eastern context, where construction projects often encompass vast and geographically diverse areas, efficient transportation is essential to meet both productivity and environmental objectives. For instance, large-scale infrastructure developments, such as Saudi Arabia's Red Sea Project, necessitate precise management of transportation to minimise delays and environmental impact. By reducing energy consumption and maximising vehicle utilisation, optimised transportation routes contribute to decreasing the project's overall ecological footprint.

ABC Analysis (LS15) and Effective Inventory Management, Accurate Demand Forecasting

Implementing ABC analysis for inventory management has a substantial strategic impact on Critical Success Factors (CSFs). This approach categorises inventory into three groups (A, B, and C) based on their value contribution, enabling construction managers to prioritise high-value items effectively (Janne and Rudberg, 2020). In Middle Eastern construction projects, which frequently involve costly materials and components, focusing on high-value items facilitates improved demand forecasting and resource allocation. Precise inventory management through ABC analysis is crucial for mitigating material shortages, particularly in regions with complex supply chains and potential logistical challenges. Furthermore, it aids in optimising transportation logistics by identifying critical items for expedited delivery, ultimately reducing overall expenses (Le et al., 2021). The integration of data analytics and inventory management software enables organisations to monitor inventory levels in real-time, enhancing their responsiveness and operational efficiency (Sundquist et al., 2018).

Andon System (LS16), Real-time Problem Solving, and Project Scheduling Efficiency

The Andon system plays a significant role in construction logistics owing to its capacity for real-time monitoring and expeditious problem resolution. This technology promptly alerts project managers to workflow disruptions, thereby facilitating immediate intervention (Shigute and Nasirian, 2014). Within the intricate logistics and multistakeholder environment of Middle Eastern construction projects, the Andon system is instrumental in enhancing project scheduling and resource allocation. Furthermore, it contributes to compliance with the region's stringent safety and regulatory requirements, as exemplified by initiatives such as Saudi Vision 2030. By facilitating improved communication and collaboration, the system enables effective risk management, thereby minimising delays and maintaining project timelines (Navon and Berkovich, 2005). This approach is particularly advantageous for sustaining operational efficiency in the dynamic conditions prevalent at numerous Middle Eastern construction sites.

Information Systems and BIM (LS18) and Effective Communication, Regulatory Compliance

The combined utilisation of Information Systems and BIM/3D modelling tools demonstrates a substantial impact on project performance. BIM technology enhances the visualisation of construction processes, enabling accurate prediction and planning (Janne and Fredriksson, 2021). In the Middle East, where international collaboration is prevalent, centralised BIM data management facilitates improved information sharing and communication among stakeholders (Janne and Rudberg, 2020). The incorporation of regulatory requirements into digital models enhances compliance, which is crucial in regions characterised by a complex regulatory landscape. Through the visualisation of material movement, BIM technology contributes to optimal resource allocation and increased logistics efficiency, thereby reducing waste and ensuring timely project delivery. Furthermore, the ongoing training initiatives associated with BIM implementation provide teams with the requisite skills to effectively utilise these technologies.

Lean Design Principles (LS7) and Waste Reduction, Efficiency in Operations

The implementation of lean design principles, which emphasise process optimisation and waste elimination, has a direct impact on logistics operations by improving demand prediction accuracy and minimising excess inventory (Janne and Fredriksson, 2021). In the Middle Eastern construction sector, where numerous projects are subject to stringent temporal and financial constraints, lean design principles facilitate the optimization of project configurations and procedures. The application of just-in-time delivery methods and inventory reduction techniques, which are fundamental to lean practices, enhances logistics efficiency and reduces expenditures (Thunberg et al., 2014). Furthermore, lean design emphasises safety and sustainability and ensures compliance with local regulations, which are becoming increasingly stringent as nations pursue environmentally conscious construction methodologies.

Project Management Procedures (LS8) and Accurate Planning, Risk Management

Implementing project management methods enhances demand prediction and planning by providing data-driven insights into project timelines and resource requirements (Thunberg et al., 2014). In Middle Eastern construction projects, which frequently encompass multiple phases and stakeholders, project management tools facilitate the effective coordination of transportation and delivery through precise scheduling and real-time monitoring. The centralisation of communication and document sharing enhances information exchange among stakeholders, which is crucial in complex projects that require coordinated efforts (Donyavi, 2009). Moreover, these tools support compliance with safety and environmental regulations and address stringent regional standards (Hedlund and Telese, 2019).

Value Stream Mapping (LS9) and Continuous Improvement, Supplier Collaboration

The findings demonstrate that the application of Value Stream Mapping (VSM) to identify and eliminate non-value-adding activities can enhance operational efficiency and overall performance. This methodology focuses on improving logistics processes, facilitating effective information dissemination, and ensuring adherence to regulatory standards (Patel and Vyas, 2011). In Middle Eastern construction projects, which frequently involve complex supply chains, VSM facilitates the optimisation of transportation and delivery management by streamlining logistics and material flow (Kasim et al., 2005). By identifying inefficiencies and bottlenecks, VSM enables improved demand forecasting and resource allocation, which are essential for project completion within the scheduled timeframes. Furthermore, VSM's emphasis on continuous improvement supports the development of workforce competencies, ensuring that personnel are adequately prepared to address challenges effectively (Kasim et al., 2005).

Kaizen Principles (LS10) and Employee Empowerment, Process Standardization

Kaizen philosophy emphasises the continuous improvement of logistical operations. Through the cultivation of an environment focused on ongoing problem-solving, Kaizen enhances the management of transport and delivery by reducing delays and increasing efficiency (Patel and Vyas, 2011). In the Middle Eastern regions, where large-scale construction projects are prevalent, the Kaizen methodology facilitates effective risk management through proactive identification and mitigation strategies. By emphasising standardisation and adherence, Kaizen principles ensure consistent compliance with safety regulations and industry standards (Fredriksson et al., 2021). Commitment to empowering workers and enhancing their skills through training initiatives further promotes continuous improvement in project implementation.

Gemba Walks (LS13) and On-Site Problem Solving, Training and Skill Development

Gemba walks involve systematic on-site visits to enhance direct communication and feedback among personnel, thereby improving coordination and information flow. In Middle Eastern construction projects, which are frequently large-scale and complex, Gemba Walks enables project managers to obtain real-time insights into progress, material requirements, and potential risks. These on-site inspections facilitate improved resource allocation by identifying inefficiencies, supporting more effective inventory management, and adhering to safety and environmental protocols. Furthermore, Gemba walks strengthen relationships with suppliers by incorporating them into on-site evaluations, fostering collaboration, and enhancing project outcomes (Sundquist et al., 2018).

Third-Party Logistics (LS5) and Expertise in logistics, Risk Mitigation

The adoption of third-party logistics (3PL) provides valuable insights for demand forecasting and inventory management. Although certain limitations exist, this interaction suggests the potential for enhancing logistics efficiency (Janne and Fredriksson, 2021). In Middle Eastern countries, where construction projects frequently require expertise in managing complex supply chains, 3PL services can improve transportation and delivery management by leveraging extensive networks and technological resources (Sundquist et al., 2018). However, the strength of this relationship may vary depending on the regulatory requirements and capabilities of 3PL providers (Patel and Vyas, 2011). The effective integration of 3PL services is largely dependent on the commitment of senior leadership to align these services with strategic objectives and foster collaboration with suppliers, ultimately enhancing overall project outcomes.

Logistics Centres (LS6) and Inventory Management, Operational Efficiency

Logistics centres serve as key hubs for managing inventory and distribution, enabling accurate forecasting and planning of demand. This coordination highlights the vital importance of logistical alignment in intricate construction settings (Fredriksson et al., 2021). In Middle Eastern areas, where building projects often span extensive geographic regions, these centres can improve transportation and delivery by consolidating materials and enhancing route efficiency (Navon and Berkovich, 2004). By centralising communication channels, logistics centres ensure effective information sharing among involved parties, which is crucial for project execution. The incorporation of technology in these centres improves data visibility and operational efficiency, although the degree of technological integration may impact overall project results (Patel and Vyas, 2011).

Poka-Yoke (LS11) and Quality Assurance, Regulatory Compliance

The implementation of Poka-Yoke and its impact on Critical Success Factors (CSFs) underscores its significance in enhancing process design and error prevention. Although it may not directly influence demand forecasting, it contributes to overall project predictability by ensuring consistency (Le-Hoai et al., 2008). In the Middle Eastern context, where regulatory adherence is crucial, Poka-Yoke enhances transportation and delivery management by minimising delays caused by material-related errors (Janne and Fredriksson, 2021). Facilitation of efficient communication and optimal resource utilisation aids in meeting safety and environmental regulatory requirements. The implementation of error-prevention techniques mitigates risks and disruptions, thereby strengthening effective risk-management approaches in construction projects (Luong Le et al., 2021).

Participation in Associations (LS17) and Knowledge Sharing, Industry Networking

Participation in professional and non-profit organisations serves as an indirect logistical mechanism that influences Critical Success Factors (CSFs). The dissemination of information and establishment of professional networks through these activities can enhance logistics operations and overall project outcomes (Fredriksson et al., 2021). In the rapidly evolving construction sector of the Middle East, engagement in industry associations fosters collaboration and innovation. These professional networks contribute to improved demand forecasting and strategic planning by facilitating the exchange of industry insights and effective methodologies among domain experts.

7.2.5. The Impact of Logistics Solutions on Logistics Challenges within the Middle East Construction Industry

The construction industry in the Middle East encounters significant logistical challenges owing to project complexities, geopolitical factors, and unique market conditions. Addressing these challenges requires implementing region-efficacious logistics solutions. Statistical analysis utilising structural equation modelling (SEM) reveals a substantial impact, with a path coefficient of 0.58, highlighting the crucial role of logistics solutions in mitigating industry logistics challenges. This finding underscores the imperative of adopting approaches such as digital transformation, transport optimisation, and Kanban system implementation to address these issues. The subsequent section examines how logistics solutions impact various logistical challenges and enhance operational efficiency and sustainability in the Middle Eastern construction sector.

Kanban System (LS1)

The Kanban methodology has demonstrated significant efficacy in addressing various logistical challenges commonly encountered in Middle Eastern construction projects, including inadequate logistics planning, ambiguous responsibility allocation, and suboptimal internal coordination. The pervasive issue of insufficient planning and resource management in the region frequently results in inefficient material utilisation and project delays. Kanban addressed this by providing a visual representation of resource and material flows, enabling construction teams to expeditiously identify and rectify supply imbalances. By consolidating logistics information on a centralised

Kanban board, teams can enhance communication of material requirements, thus minimising ambiguity regarding logistics responsibilities and ensuring that all stakeholders comprehend their roles in the supply chain (Janne and Fredriksson, 2021). Kanban also effectively addressed the challenge of poor internal coordination. The visual nature of Kanban boards facilitates alignment among various internal teams, such as procurement, logistics, and site management, regarding resource status. This improved synchronisation reduces delays caused by miscommunication and redundant efforts, particularly in projects that are heavily dependent on teamwork and collaborative decision-making (Labib, 2016). Furthermore, the Kanban system resolves issues related to inaccurate material identification, estimation, and inefficient site layouts. By providing real-time tracking of resource movement and material consumption, Kanban enables project teams to make more precise material requirement estimates, thereby reducing waste and improving site layout planning. The system's emphasis on lean principles ensures that only essential materials are maintained on-site, minimising clutter and maximising space utilisation, which is crucial for efficient construction operations.

Last Planner System (LS2)

The Last Planner System (LPS) provides a systematic, collaborative approach to address various logistical challenges, including inadequate logistics planning, limited construction logistics expertise, and poor synchronisation between construction schedules and logistics operations. A critical component of LPS is its emphasis on integrating logistics considerations into project plans and addressing the prevalent issue of insufficient logistics process planning. LPS facilitates collaboration among diverse stakeholders, from project managers to subcontractors, to collectively develop logistics plans that are both feasible and tailored to the project's requirements (Saleh et al., 2023). This ensures the integration of logistics needs into the overall project timeline, resulting in improved alignment between construction schedules and logistics practices. LPS also addresses the deficiency in construction logistics expertise by fostering collaborative learning environments in which various participants can exchange knowledge and enhance their understanding of logistics requirements. Regular meetings and progress evaluations enable continuous improvement, ensuring that logistics practices are modified to address emerging challenges (Bilau et al., 2018). Furthermore, LPS helps mitigate common issues, such as delayed decision-making by consultant engineers and redundant efforts caused by excessive paperwork. By streamlining decision-making processes and minimising reliance on paperwork, LPS enhances overall project flow and ensures expeditious and efficient logistics-related decisions (Ophiyandri et al., 2013). This reduction in delays leads to improved coordination between logistics and construction timelines, resulting in more efficient project execution.

Just-in-Time (JIT) Logistics (LS3)

The Just-in-Time (JIT) logistics system effectively addresses inventory management, material waste, and supplier coordination challenges prevalent in Middle Eastern construction projects. By delivering materials precisely when required, JIT minimises on-site storage requirements, thereby reducing the risk of material damage or waste. In a region where construction material prices fluctuate significantly, JIT's waste reduction capability of JIT directly contributes to cost savings. Furthermore, JIT enhances supplier coordination, which is crucial in areas such as the Middle East, where supply chains may be disrupted by geopolitical instability or other external factors. Through close supplier relationships, JIT ensures timely material delivery, thus shortening lead times and maintaining project schedules (Duiyong et al., 2014). The system also addresses issues such as inaccurate inventory records and unsuitable vehicles by emphasising real-time monitoring and precise delivery. Moreover, JIT improves the management of returned purchased materials, a significant challenge in projects dealing with surplus or damaged goods. By streamlining material flow and implementing lean practices, JIT facilitates the efficient return of excess materials, thereby reducing the financial burden on construction firms and enhancing the overall logistics performance.

Real-Time Visibility Tools (LS4)

In the Middle East, advanced monitoring systems, such as GPS and RFID technology, address critical logistical challenges, including insufficient oversight of logistics operations, lack of real-time fleet and equipment monitoring, and inadequate material identification. These real-time visibility solutions enable construction managers to instantaneously track resources, machinery, and personnel in an industry in which logistics management is often impeded by extensive project locations and complex supply networks. This enhanced oversight mitigates delays caused by logistical constraints and ensures timely material availability, thereby improving overall project productivity (Barakat et al., 2018). Another challenge effectively addressed by these tools is fleet and equipment monitoring. In large-scale construction projects, delays frequently occur owing to insufficient real-time tracking of logistics vehicles and machinery. For instance, GPS tracking enables project leaders to observe vehicle and equipment movements in real time, facilitating punctual deliveries and minimising periods of inactivity. This is particularly crucial in the Middle East, where projects may encompass vast areas, and transportation logistics can become a significant impediment if not efficiently managed. Furthermore, these systems help reduce redundant efforts and errors resulting from excessive paperwork, a prevalent issue in logistics administration. By digitising logistics information and streamlining reporting procedures, real-time visibility tools ensure accurate record-keeping and reduce the likelihood of human error, resulting in more efficient operations and fewer setbacks.

Utilisation of Third-party Logistics (3PL) Services (LS5)

Construction companies can benefit from specialised logistics expertise by utilising third-party logistics (3PL) services, which facilitate the outsourcing of transportation, warehousing, and distribution functions. In the Middle East, these services can address various logistical challenges, including inadequate site organisation, suboptimal resource management, and inefficient inventory control. 3PL providers offer access to extensive transportation and distribution networks, enabling construction firms to enhance their material and equipment delivery processes. By leveraging these external systems, construction teams can ensure timely delivery, even in the presence of political instability or supply chain disruptions, which frequently occur in certain Middle Eastern regions. Furthermore, 3PL services provide real-time material tracking, helping to minimise communication gaps and coordination issues that frequently lead to project delays. Outsourcing logistics tasks allow construction companies to focus on their core activities while benefiting from more efficient and flexible logistics operations. The Just-in-Time (JIT) delivery capabilities offered by 3PL also assist in managing material shortages and mitigating the risks associated with labour scarcity, which can significantly impact construction timelines.

Implementation of Logistics Centres (LS6)

Logistics centres provide a solution to significant construction challenges by centralising the storage and distribution of building materials. This approach addresses issues such as inadequate site management, inefficient material handling, and delivery delays. In Middle Eastern construction projects, which frequently involve complex logistics across extensive urban or remote areas, centralising logistics operations can enhance efficiency and coordination. By consolidating material storage in a single location, these centres improve inventory management, reducing the necessity for on-site storage and minimising material accumulation at construction sites. This strategy addresses issues such as material waste and ineffective handling, resulting in streamlined logistics processes and improved site organisation. Moreover, logistics centres facilitate enhanced synchronisation between construction timelines and logistics operations by integrating with suppliers and coordinating deliveries to various locations. The centralised nature of these facilities enables construction companies to reduce unnecessary transportation expenses, minimise paperwork redundancy, and optimise delivery schedules.

Applying Lean Design Principles in Designing Construction Projects (LS7)

In the Middle East construction industry, the implementation of lean design principles is essential for addressing logistics challenges. These principles emphasise the minimisation of waste, optimisation of resource utilisation, and enhancement of process efficiency. By adopting lean design strategies, construction companies can address prevalent issues such as ineffective material management, excessive transport, and inadequate internal communication. The lean approach emphasises the efficient utilisation of resources and encourages teams to eliminate non-value-adding activities, such as unnecessary inventory movement or surplus material storage. This methodology enhances the synchronisation between construction timelines and logistics operations, thereby reducing delays caused by inadequate logistics planning. Furthermore, lean design principles promote improved collaboration among construction teams, leading to better alignment and communication across departments. By ensuring that each logistics activity contributes value to the overall project, construction firms can minimise material waste and optimise the utilisation of on-site resources.

Utilizing Project Management Tools and Procedures (LS8)

The effective implementation of project management methodologies and instruments is crucial for addressing logistical challenges, such as suboptimal planning, inefficient resource allocation, and inadequate coordination. Construction managers can enhance their capacity to plan, organise, and supervise logistics operations by employing tools such as Gantt charts, the Critical Path Method (CPM), and Project Management Information Systems (PMIS). In Middle Eastern nations, where large-scale construction projects are prevalent, these project management tools facilitate the efficient distribution of resources and ensure the timely availability of materials and equipment. This approach assists in resolving issues related to misalignment between construction timelines and logistics practices, as well as ineffective management of logistics activities. By integrating project management tools with logistics operations, construction teams can minimise delays in material delivery, reduce excessive documentation, and improve communication among stakeholders. These tools also enable real-time decision-making, facilitating rapid responses to emerging logistics challenges.

Using Value Stream Mapping (VSM) to Eliminate Non-Value-Added Activities (LS9)

VSM is a methodology used to enhance processes by visualising and optimising the flow of materials and information (Hedlund and Telese, 2019). This tool particularly addresses logistical challenges, such as inefficient material handling, redundant tasks, and unnecessary transportation. By generating a map of the logistics process, from material procurement to on-site delivery, construction teams can identify areas of delay, bottlenecks, and non-value-adding activities that contribute to increased costs and waste. In the Middle Eastern construction sector, where projects frequently encounter issues with excess inventory and inadequate communication, VSM enables teams to identify inefficiencies and improve their operations. The implementation of VSM allows construction companies to enhance coordination with suppliers, reduce lead times, and improve inventory control.

Applying the Kaizen Principle (Continuous Improvement) (LS10)

The concept of Kaizen, which emphasises continuous improvement, motivates construction teams to implement incremental modifications to enhance processes and reduce waste (Bilau et al., 2018). This approach addresses logistical challenges, such as suboptimal resource utilisation, inadequate communication, and inefficient decision-making processes. By adopting Kaizen, construction companies in the Middle East can foster an environment of continuous learning and problem-solving, enabling teams to actively participate in identifying logistical challenges and developing solutions. For instance, workers can propose improvements to material management processes, thereby reducing delays and minimising waste. Kaizen also enhances team collaboration by promoting transparent communication between workers and management. This strategy helps address deficiencies in logistical responsibilities and improves the coordination of logistical activities, resulting in more efficient project execution and reduced costs.

Implementing Poka-Yoke (Error Prevention) (LS11)

Error Prevention, also known as Poka-Yoke, is a methodology employed to eliminate errors and defects in logistics operations (Janne and Fredriksson, 2021). In the Middle East construction sector, where logistical challenges frequently arise from human errors, inadequate material management, and ineffective communication, Poka-Yoke plays a crucial role in identifying and rectifying potential errors before they result in delays or increased costs. The implementation of the Poka-Yoke, including visual indicators, error-prevention mechanisms, and automated verification systems, helps mitigate issues such as redundant documentation and inaccurate inventory tracking. By minimising human error, Poka-Yoke enhances the accuracy of material reception, improves inventory management, and decreases the probability of material waste. This methodology also enables logistics teams to expeditiously address unforeseen issues, such as equipment failures or material shortages, by incorporating error-proofing measures into routine operations.

Optimizing Transportation Routes (LS12)

Enhancing transportation route efficiency is essential for addressing logistics challenges by reducing costs, decreasing fuel consumption, and mitigating environmental impact. The construction sector in the Middle East frequently encounters issues such as inadequate transport planning, unsuitable vehicles, and high fuel expenses, which are further exacerbated by volatile fuel prices and regional geopolitical uncertainty. Construction companies can identify optimal transport routes by implementing optimisation strategies such as GPS tracking, real-time traffic updates, and data analysis. This approach facilitates the reduction of delays, lowers fuel consumption, and ensures timely delivery. Real-time traffic monitoring enables logistics teams to circumvent congestion and adjust vehicle routes, resulting in improved fleet management and punctual material delivery. This is particularly significant in Middle Eastern urban centres, where traffic congestion can cause substantial delays.

Gemba Walks (LS13)

On-site visits, referred to as Gemba Walks, have the potential to significantly enhance communication, teamwork, and issue resolution among construction teams by facilitating real-time observation and evaluation of logistics processes (Bilau et al., 2018). In Middle Eastern construction projects, logistical challenges frequently arise from inadequate internal communication, insufficient oversight, and delayed decision-making by consultants or engineers. Construction managers and logistics personnel can use Gemba Walks to identify bottlenecks and inefficiencies in material handling, storage, and equipment utilisation. Through direct engagement with on-site workers, managers can promptly identify issues such as suboptimal site organisation, misaligned schedules, or inefficient material movement. This direct approach fosters collaboration, enabling workers to propose immediate solutions, such as modifying work processes or reorganising material storage to enhance efficiency. The implementation of Gemba Walks assists construction companies in addressing communication gaps and improving decision-making, particularly when unforeseen logistics issues arise. By enabling teams to proactively identify and resolve problems, Gemba Walks increases the adaptability and responsiveness of logistics operations, contributing to more efficient project execution.

5S Methodology (LS14)

The 5S approach, comprising Sort, Set in Order, Shine, Standardise, and Sustain, is instrumental in establishing an organised and efficient workplace, which is essential for addressing logistics issues such as inadequate inventory management, improper material handling, and ineffective site organisation (Hedlund and Telese, 2019). In Middle Eastern construction projects, where large-scale projects often encounter challenges related to waste and poor communication, the 5S methodology can enhance logistics performance by promoting discipline and uniformity. Implementation of 5S ensures systematic arrangement of materials and equipment, enabling workers to efficiently locate necessary resources and reducing the time expended in searching. This is particularly crucial for expansive construction sites, where disorganised storage can result in delays, confusion, and logistical inefficiencies. The method's emphasis on visual management facilitates a clear demarcation and regular updating of inventory levels, thus minimising the risk of inaccurate stock records and material deficits. Furthermore, 5S fosters an environment of continuous improvement, encouraging workers to maintain cleanliness and order, thereby creating a safer and more efficient workplace.

ABC (Pareto) Analysis (LS15)

ABC analysis is an inventory management methodology that categorises items into three categories based on their value and impact on overall expenditure: A (high value), B (moderate value), and C (low value) (Ameh et al., 2010). In the Middle Eastern construction sector, where material costs can fluctuate owing to global supply chain issues and market volatility, ABC analysis aids construction companies in prioritising resources, minimising inventory expenses, and preventing excess stock. By focusing on high-value items (A-items), construction firms can ensure the availability of critical materials and mitigate project delays caused by material scarcity. This is particularly crucial in regions where logistical constraints and supply chain unpredictability can affect material accessibility. ABC analysis enables companies to allocate resources more efficiently, maintaining optimal inventory levels for essential items, while reducing the costs associated with surplus stock. Moreover, ABC analysis can enhance procurement processes by enabling construction firms to negotiate more favourable terms with suppliers for high-value items, thus reducing expenses and mitigating the impact of price fluctuations.

Andon System (LS16)

Visual indicators, such as lights or alarms, are utilised by the Andon system to highlight issues or deviations in logistics processes (Labib, 2016). This system demonstrates efficacy in Middle Eastern construction projects, where communication and coordination frequently present challenges. By providing real-time notifications, the Andon system facilitates the rapid identification and resolution of logistics problems, including material shortages, equipment malfunctions, or delivery delays. In scenarios where immediate communication is crucial for project progression, this system proves to be especially advantageous. For instance, when a material shortage occurs, the

Andon system promptly notifies relevant stakeholders, enabling them to implement immediate corrective measures, such as expediting an order or reallocating resources before the situation deteriorates (Saleh et al., 2023). The Andon system promotes collaborative problem solving, encourages personnel to assume responsibility for logistics challenges, and contributes to expeditious solutions. This approach enhances overall team coordination and augments the efficiency of logistics operations.

Use of Information Systems and Modelling Tools Such as BIM and 3D (LS18)

The implementation of digital technologies, such as Building Information Modelling (BIM) and 3D modelling, significantly transforms construction logistics processes (Saleh et al., 2023). These advanced systems effectively address challenges, including inadequate project planning, inefficient resource utilisation, and poor stakeholder coordination. Through the creation of digital project representations, BIM and 3D tools facilitate the visualisation of all aspects, including logistics flows, and provide real-time updates to enhance coordination. The incorporation of logistics requirements into BIM ensures timely material delivery, minimises delays caused by over- or under-stocking, and enhances inventory control and resource management (Le et al., 2021). BIM's precise quantity estimations and delivery schedules of BIM address logistics issues such as inaccurate forecasting and suboptimal material handling, thereby preventing costly delays and misallocation of resources. Its simulation capabilities identify potential logistics process bottlenecks, enabling proactive optimisation of routes and material flow to mitigate delays (Fayazi et al., 2017). Additionally, BIM facilitates improved collaboration among stakeholders through a shared digital platform, enhancing communication, and ensuring timely material delivery (Islam et al., 2018). Furthermore, BIM integrates supply chain management tools, providing real-time visibility of material lifecycles from procurement to delivery, thus improving decision-making and facilitating efficient material flow (Sundquist et al., 2018).

7.2.6. The Impact of Critical Success Factors on Logistics Challenges within the Middle East Construction Industry

In the Middle Eastern construction sector, where projects encounter distinct challenges, such as political instability, unexpected workforce shortages, and volatile material costs, this research emphasises the significance of enhancing these key success factors. For instance, accurate demand forecasting and strategic planning can mitigate resource mismanagement risks in unpredictable environments, whereas adherence to safety and environmental regulations becomes essential when external threats, such as political circumstances, arise. Establishing partnerships with suppliers and implementing effective risk management strategies are particularly crucial in regions prone to frequent supply chain disruptions. The moderate influence of CSFs on logistical challenges (0.4) suggests that while improving these areas is beneficial, external factors, such as political instability and regional economic fluctuations, also require consideration for more substantial improvements in logistics efficiency. This finding has significant implications for construction projects across the Middle East, particularly in areas susceptible to sudden disruptions. The subsequent section provides insights into how the identified CSFs are utilised to address logistics challenges.

Accurate Demand Forecasting and Planning (CSF1)

In the Middle Eastern construction industry, accurate demand prediction and planning are essential for addressing various logistical challenges, including inadequate planning, imprecise inventory tracking, and suboptimal material identification. By improving their demand forecasting capabilities, construction firms in the region can optimise resource allocation, mitigate material shortages, and ensure the timely delivery of resources to appropriate locations. This is particularly critical in areas susceptible to supply chain disruptions resulting from political instability. Research by Enshassi et al. (2017) suggests that precise forecasting enhances collaboration with suppliers and leads to more effective inventory management and project timelines

Proper Information Flow (CSF4)

Effective information dissemination is essential for addressing challenges such as inadequate communication, ambiguous role delineations, and protracted decision-making processes. In construction projects, seamless interaction among suppliers, contractors, and project teams ensures the synchronisation of project schedules, material requirements, and logistical planning. Labib (2016) emphasised the necessity of instantaneous data sharing to prevent delays and maintain all parties' awareness of the latest project updates. Taha (2019) further asserted that enhanced communication systems can significantly reduce errors and misunderstandings, thereby optimising logistics operations.

Compliance with Safety, Environmental, and Regulatory Standards (CSF5)

Adherence to safety, environmental, and regulatory standards is imperative for the operation of logistics processes. Challenges such as insufficient supervision and deficient management support can be addressed by ensuring that logistics activities comply with safety and environmental regulations. Labib (2016) posited that proactive adherence to these standards minimises the probability of project interruptions due to penalties, setbacks, or safety-related incidents. This is particularly crucial in the Middle East, where regulatory requirements may vary among countries, and environmental factors can significantly impact project continuity.

Effective Risk Management (CSF6)

Effective risk management is essential for addressing logistical challenges, such as unexpected workforce shortages, transportation delays, and fluctuating raw material costs. According to Saleh et al. (2023), construction projects in the Middle East, a region characterised by political and economic instability, must implement proper risk management strategies to mitigate disruptions. These approaches include developing contingency plans, identifying alternative suppliers, and establishing redundant transportation networks. By proactively addressing risks, organisations can enhance their resilience to project challenges, enabling them to adapt swiftly to unforeseen environmental changes.

Efficient Resource Allocation (CSF8)

Addressing the logistical challenges associated with suboptimal resource management, inadequate scheduling, and supply chain bottlenecks is essential for effective resource allocation. According to Ophiyandri et al. (2013), construction firms can enhance project efficiency and mitigate delays by optimising the utilisation of materials, equipment, and workforce. In Middle Eastern contexts, where resource availability can be variable, it is imperative to implement appropriate scheduling and allocation of labour and machinery to prevent downtime and augment productivity.

Collaboration with Suppliers (CSF9)

Collaborating closely with suppliers is required to address challenges such as inadequate coordination, imprecise deliveries, and quality deficiencies. According to Fredriksson et al. (2021) and Hamieh and Ginty (2010), effective communication with suppliers facilitates accurate forecasting of material requirements and adherence to delivery schedules. This is particularly crucial in the Middle East, where external factors, such as instability or transportation delays, can disrupt supply chains. Construction companies can enhance supply chain transparency and responsiveness by cultivating stronger supplier relationships, thereby mitigating logistical difficulties.

Adequate Training and Skill Development (CSF10)

To address logistics challenges stemming from insufficient expertise, inadequate coordination, and suboptimal scheduling, it is essential to provide appropriate training and foster skill development. According to Shigute and Nasirian (2014), implementing targeted training initiatives can enhance the capabilities of logistics personnel, enabling them to manage complex operations more effectively, such as inventory control, materials handling, and scheduling. In Middle Eastern countries, where there may be a deficiency in specialised construction logistics professionals, it is crucial to invest in skill enhancement to improve overall operational efficiency.

Strong Commitment and Support from Top Management (CSF11)

The commitment of senior leadership is essential for addressing the issues of inadequate synchronisation, suboptimal resource allocation, and ambiguous role delineation in logistics management. Ekeskar and Rudberg (2020) assert that when executives prioritise the enhancement of logistics operations and allocate sufficient resources, the efficiency of logistics processes improves substantially. This is particularly critical in the Middle Eastern context, where large-scale projects require robust leadership and collaboration among diverse stakeholders. Executive support ensures that logistics challenges are proactively addressed, resulting in improved project outcomes.

7.2.7. Discussion Related to the Results of Analysis of Variance (ANOVA) for Logistics Challenges

Statistical analysis utilising ANOVA post-hoc comparisons has demonstrated that Saudi Arabia (KSA) exhibits significant differences in logistics challenges compared to other nations. The post-hoc analysis indicates that the KSA's logistics challenges are distinct. This suggests that the obstacles encountered in the KSA's logistics sector are either substantially different or less severe (with a lower mean of logistics challenges) than those experienced in the UAE, Palestine, and Jordan. Recently, the KSA government implemented strategic initiatives and policies aimed at enhancing logistics capabilities and streamlining trade. These measures are anticipated to benefit construction contractors through simplified procedures, logistics providers through investment incentives, and supply chain efficiency through strategic partnerships (Labib, 2019). Moreover, the KSA has been significantly investing in infrastructure development, including transportation systems, ports, and logistics hubs (Almalki and Almalki, 2022). This ongoing development has considerably enhanced the country's logistical capabilities, mitigating some of the difficulties associated with transporting construction materials and equipment (Almalki and Almalki, 2022). The extensive geographical expansion of Saudi Arabia allows for greater flexibility in planning and executing construction logistics (Skender et al., 2016). The abundance of space and fewer land use restrictions provide advantages to Saudi Arabia's logistics sector, in contrast to smaller countries such as the UAE and Jordan (Almalki and Almalki, 2022).

The ANOVA findings indicate that urban, rural, and city centre locations experience comparable logistics challenges. According to Cataldo et al. (2021), these areas encounter similar difficulties related to infrastructure and transportation, such as inadequate road networks, limited access to logistics hubs, and restrictions on transport movements. The analysis also revealed that commercial and residential projects face significant and distinct logistical challenges compared to other types. Residential projects encounter unique logistics issues that differentiate them from commercial, institutional, infrastructural, and industrial buildings. Similarly, commercial projects exhibit notable differences in their logistics challenges when compared to residential, infrastructural, institutional, and industrial projects.

The study demonstrates that institutional, infrastructure, and industrial buildings experience more pronounced logistics challenges than residential and commercial structures. Institutions such as schools, hospitals, and government buildings often require complex and specialised logistics to manage frequent deliveries of essential equipment, materials, or resources. Coordinating these deliveries and managing inventory can be challenging owing to the diversity and volume of materials involved (Bolarinwa, 2015). Infrastructure and industrial projects, such as roads, bridges, factories, and utilities, typically require large-scale logistical operations that involve extensive coordination of machinery, materials, and workforce. The logistics of these projects are particularly complex, necessitating the management of substantial quantities of materials, adherence to project schedules, and navigation of regulatory requirements (Soliman, 2014).

7.2.8. Discussion Related to the results of Analysis of Variance (ANOVA) for Critical Success Factors

The analysis indicates that KSA exhibits notable differences from the UAE, Palestine, and Jordan in terms of critical success factors, which can be attributed to unique cultural, economic, and social aspects given to KSA. While Saudi Arabia's Vision 2030 outlines distinct goals and strategies for economic and social transformation, other nations adhere to their standard development approaches (Alkahtani and Almalki, 2022). Despite variations in project locations, construction companies generally share similar overarching objectives, such as enhancing productivity, ensuring client satisfaction, maximising profitability, and improving efficiency. The core CSFs required to achieve these aims remain consistent across different settings. The analysis reveals that commercial and residential areas possess considerable CSFs that differentiate them from other project types. Notably, residential projects demonstrate substantial differences, suggesting unique CSF compared to commercial, institutional, infrastructure, and industrial construction. This distinction may stem from factors such as design preferences, occupancy patterns, or regulatory requirements associated with residential development (Ahmed, 2017). For instance, consumer behaviour and demand patterns play a crucial role in determining CSFs for residential projects (Durdyev et al., 2018). By contrast, commercial projects often involve large-scale deliveries of goods and materials based on customer experience, influencing the necessary CSFs (Luong Le et al., 2021).

7.2.9. Discussion Related to the Results of Analysis of Variance (ANOVA) for Logistics Solutions

It was found that the logistics solutions implemented by locations including urban, rural, and city centres are similar. Consequently, despite these differences, construction projects across countries often have different overall goals and objectives. Projects that share the same culture of adopting logistics solutions to enhance productivity and efficiency. Furthermore, it has been demonstrated that commercial and residential areas have significant solutions that are distinct from others. Based on the important differences observed between residential and commercial projects, it can be inferred that logistics solutions for these project types are markedly different from those for institutional, infrastructure, and industrial buildings. This is due to particular considerations, such as customer preferences affecting logistics processes for residential and commercial projects (Le-Hoai et al., 2008). This includes the fact that logistics solutions in commercial and residential project areas often revolve around customer satisfaction and profitability.

7.2.10. Discussion Related to Moderation Effects

The relationship between logistics challenges and sustainability was not moderated across various project types, including residential, commercial, infrastructural, and institutional projects. Sezer and Fredriksson (2021) assert that irrespective of the construction project type, sustainability objectives, such as reducing carbon emissions, minimising waste, and optimising resources, are critical goals for all projects. For instance, the logistics strategies employed, rather than the type of project, will impact logistics challenges, resulting in enhanced sustainability. The adoption of appropriate logistics management strategies and technologies is more significant than the nature of a construction project for effectively managing logistics challenges and achieving sustainability goals (Gan et al., 2017). Real-time tracking systems or just-in-time practices can assist in mitigating logistics challenges and improving sustainability for residential and commercial projects (Durdyev et al., 2018).

However, statistical analysis indicates that the relationship between logistics challenges and sustainability remains consistent across various countries. This suggests minimal variation in construction logistics challenges within the same region. Consequently, standardised practices, regulations, or industry norms that apply broadly within the construction sector may result in consistent impacts of logistics challenges on sustainability outcomes in different countries (Gan et al., 2017). For instance, sustainability outcomes across various countries can be impacted by logistics challenges such as inefficient material handling and poor transportation methods (Chan and Adabre, 2019). Additionally, the project location (rural, urban, city centre) was not found to moderate the relationship between logistics challenges and sustainability. However, several construction projects have recently adopted standardised sustainable goals and best practices across diverse locations (Lundesjo, 2015). These goals focus on resource efficiency, waste reduction, and community engagement, whether they are in the rural, city centre, or urban contexts (Maria Huge-Brodin and Fredriksson, 2022).

This indicates that sustainability goals in construction, such as minimising the carbon footprint and waste, are universal and do not vary with project location.

Moreover, the analysis indicated no moderating effect of project type on the relationship between logistics challenges and solutions. The outcome demonstrates that the relationship between logistics challenges and solutions may be influenced more by other factors or variables, regardless of the country's context. For instance, logistics challenges can be shaped more by internal organizational processes, project-features, or industry patterns, even if the country is inconsequential. Thus, detecting a significant moderation effect may be challenging because logistics challenges and solutions differ minimally between project types. This means that construction businesses frequently implement standardised logistics systems and solutions, regardless of the project type (Janne and Fredriksson, 2021). The optimisation of logistics processes is achieved by applying lean principles, logistics management techniques, and technology, which are independent of the project type (Durdyev et al., 2018).

Logistics challenges have varying effects on finding solutions in different countries. The estimates for various countries (Palestine, Jordan, the UAE, and the KSA) show the intensity and direction of the moderating effect in Palestine that differs from the others. Thus, in Palestine, finding solutions to address logistics challenges is significant. Firms' experiences and responses to logistics issues may be influenced by differences in economic development and stability across these countries. However, logistics challenges and sustainability can be affected by the effect of instability on economic factors, which can influence material delivery and resource acquisition (Saleha et al., 2023). Moreover, the location of construction projects does not have any moderating effects on the relationship between logistics challenges and solutions. Different locations face similar logistical challenges in construction projects. Regardless of where the construction project is situated (rural, urban, or city centre), it is expected to encounter challenges such as material delays, transportation constraints, and coordination problems (Askar et al. 2019). Conversely, logistics challenges can be mitigated by the consistent application of logistics solutions, such as adopting lean principles and implementing best practices. Thus, the standardisation of logistics solutions reduces the moderating impact of project location on logistics challenges.

The analysis reveals that the type of construction project moderates the relationship between Critical Success Factors (CSFs) and sustainability in construction projects. The impact of CSFs on sustainability varies according to the type of construction project under consideration. Residential projects demonstrated a robust positive moderation effect, as evidenced by the high moderation effect coefficient (0.97). This finding is corroborated by Janne and Fredriksson (2019), who noted that residential projects often place strong emphasis on meeting sustainability goals due to increasing demand for environmentally friendly and energy-efficient housing. Residential projects involve close interaction with end users (residents), rendering participant engagement a crucial success factor (Ghannad et al. 2019). Furthermore, sustainable features and practices may be of greater importance to residents because of their vested interest in their homes' sustainability (Saleha et al., 2023). The implementation of CSFs for sustainability may be facilitated by the greater availability and acceptance of sustainable building materials and technologies in residential construction (Enshassi et al., 2019). A small positive moderation effect in industrial, infrastructure, and institutional projects indicates that CSFs have a limited impact on sustainability compared to other projects. This can be attributed to the complexity of these projects, which involve multiple stakeholders, numerous regulatory requirements, and technical constraints (Alkahtani and Almalki, 2022). Consequently, it becomes challenging to prioritise CSFs aimed explicitly at sustainability, as other objectives (e.g. customer satisfaction, cost control, and schedule adherence) may take precedence (Alptekin, 2019). Conversely, it is proposed that the country in which the construction project is located moderates the relationship between sustainability and CSFs. CSFs demonstrate a positive impact on sustainability, albeit not to the same extent as other factors. For instance, Jordan exhibits a moderately positive effect (0.21), while KSA, UAE, and Palestine display a high impact, with coefficients of approximately 0.75. In Jordan, the effectiveness of CSFs in driving sustainability outcomes may be influenced by the availability of resources, such as access to sustainable building materials, skilled labour, and financing for green technologies (Saleh et al., 2023). The impact of CSFs on sustainability could be constrained by the limited support in Jordan's regulatory environment for sustainable construction practices (Labib, 2016). In contrast to Jordan, the high estimate for Palestine, which approached that of UAE and KSA, can be attributed to the opportunities afforded by additional resources, technical expertise, and capacity-building opportunities from external support, international collaborations, and donor-funded initiatives focused on sustainable development (Taha, 2019). Sustainability initiatives and regulations are also prioritised by the governments of the KSA and the UAE. Their targets include promoting renewable energy adoption, implementing green building guidelines (such as LEED), and establishing sustainability standards for construction projects (Alkahtani and Almalki, 2022). The analysis indicates that variations in CSFs and locations do not significantly affect sustainability outcomes. Despite differences in project locations, the implementation of CSFs in different locations may be relatively consistent (Rao et al., 2015). This encompasses factors such as proper information flow, effective inventory management, stakeholder engagement, and efficient resource allocation, which are critical for achieving sustainability objectives regardless of whether the construction project is situated in urban, rural, or city centre areas (Sundquist et al., 2018).

Moderation analysis indicates that the type of construction project moderates the relationship between logistics solutions and sustainability in construction projects. Explicitly, the nature of a construction project influences the sustainability of logistics solutions. Residential projects demonstrated a strong positive moderation effect, as evidenced by the high moderation effect coefficient (0.83). Consequently, the implementation of efficient logistics solutions significantly affects the sustainability of residential projects. Residential projects have a direct impact on the quality of life of residents. The creation of comfortable and sustainable living environments can be achieved through efficient logistics solutions in residential projects (Saleh et al., 2023) by ensuring timely and organised material delivery, reducing construction-related disruptions, and minimising environmental impact. Thus, the significance of logistics solutions for sustainability promotion in residential projects is heightened owing to their direct effect on residents' well-being (Islam et al., 2018). Conversely, the relatively low positive moderation effect observed for commercial, industrial, infrastructure and institutional projects suggests that logistics solutions have a less significant impact on sustainability than residential and commercial projects (Saleh et al., 2023). The effect of logistics solutions on sustainability outcomes in these contexts may vary depending on factors such as project scale, complexity, and operational characteristics (Barakat et al., 2018). Furthermore, the impact of logistics solutions on sustainability can vary depending on the country's context. This moderating effect is statistically significant, as indicated by the analysis results. However, the moderation effect coefficients (0.14, 0.13) for Palestine and Jordan indicate no moderation effect. Consequently, the utilisation of logistics solutions has a minimal impact on promoting sustainability in construction projects. This is attributed to the small scale of the construction industry within Palestine and Jordan, where project sizes are smaller than in the KSA and UAE (Taha, 2019). Additionally, lower market maturity and demand for sustainability compared to other countries affect the priority of sustainable logistics. In contrast, logistics solutions significantly promote sustainability in construction projects within the UAE and KSA (Kudumovic, 2020). The construction markets of the UAE and KSA are characterised by a high demand for sustainable development, driven by government initiatives and consumer preferences (Enshassi et al. 2019). In these countries, contractors and developers are required to implement efficient logistics solutions to meet sustainability targets (Alkahtani and Almalki, 2022). Lastly, it is observed that the relationship between logistics solutions and sustainability is not moderated by project location (rural, urban, or city centre). Sezer and Fredriksson (2021) noted that sustainability practices in the construction industry have become standardised and guided by industry standards (Ekeskar and Rudberg, 2020). Effective logistics solutions address common sustainability challenges regardless of project location, resulting in consistent outcomes (Janne and Rudberg, 2020).

7.2.11. Discussion Related to the Mediation Effect

These findings indicate that CSFs have the potential to mediate the relationship between logistics solutions and sustainability; however, their effects are not statistically significant. Logistic solutions to sustainability may involve multiple intermediate steps or confounding variables in the sustainability pathway. The complexity of this mediation pathway can obscure the direct impact of logistics solutions on sustainability (Tarhini 2013). This includes the possibility that the relationship between logistics solutions and sustainability outcomes could be influenced by factors other than CSFs. These confounding variables may include regulatory changes or fluctuations in customer preferences (Ghanem et al., 2018). Mediation analysis reveals that logistics challenges mediate the relationship between logistics solutions and sustainability. However, while logistics solutions may initially aim to improve sustainability, the presence of significant logistics challenges can diminish or counteract the positive effects. For example, logistics challenges, such as ineffective coordination among internal parties and ambiguity in logistics responsibilities for the construction team, may directly impact the efficiency and effectiveness of implementing logistics solutions (Ekeskar and Rudberg, 2020). Thus, logistics challenges play a substantial role in elucidating the impact of logistics solutions on sustainability. The effects of logistics solutions on sustainability are transmitted through logistics challenges, acting as an intermediary mechanism (Hedlund and Telese, 2019). Moreover, the utilisation of logistics solutions necessitates the elimination of logistics challenges for improvement. For instance, applying the Kaizen principle (continuous improvement) requires proper planning and coordination (Askar et al. 2019).

8. Chapter Eight: Conclusion

This chapter reviews the aim and research questions to demonstrate how they were addressed. Subsequently, the major contributions of this study are presented. Finally, the limitations of this study are outlined, and recommendations for future research are provided.

8.1. Review of the Research Aim and Questions

This study aims to develop a practical model for addressing logistical challenges in construction within the Middle East by utilising logistics solutions and critical success factors to enhance sustainability. The research objective was accomplished through the application of a critical realist philosophy that incorporated both qualitative and quantitative methodologies. A conceptual model was formulated based on the literature review and exploratory research. Subsequently, this preliminary model was refined through the implementation of a survey questionnaire and Structural Equation Modelling. The research objectives initially proposed in this study were evaluated. Following each objective, a concise response was provided to elucidate the evolution of the research process.

Objective one: To investigate logistics processes and challenges within the construction along with their impact on sustainability

This research investigated logistics processes and challenges in the construction sector, with a particular emphasis on their sustainability implications. Twenty-three key logistical issues were identified, including inadequate planning, material deficits, lack of coordination and communication, and workforce ineffectiveness. These challenges elucidate the substantial obstacles that construction projects encounter in managing resources and maintaining operational efficiency. The significance of these issues lies in their direct impact on sustainability, which results in project delays that lead to increased costs. By examining the intricate connection between logistics challenges and sustainability, this study provides valuable insights into how logistical inefficiencies impede sustainable construction practices. It offers an understanding of how logistics-related problems directly contribute to unsustainable practices, such as excessive energy consumption, increased waste generation, and higher emissions. Thus, this research underscores the urgent necessity to address these issues for improving sustainability within the construction sector. This study makes a significant contribution to understanding how logistics processes impact sustainability, demonstrating that inefficiencies in logistics pose a substantial barrier to achieving sustainable construction outcomes. The research accomplishes this by establishing connections between logistics challenges, solutions, critical success factors (CSFs), and sustainability, illustrating how logistical inefficiencies exacerbate environmental harm in construction projects, and proposing effective methods to address these issues.

Objective two: Exploring and understanding construction logistics processes within the context of the Middle East, including challenges and logistics initiatives.

The focused investigation through semi-structured interviews revealed unique challenges in Middle Eastern construction logistics, impacting both project efficiency and sustainability. This study contextualises these issues within the region's distinct political, economic, and labour landscape, contributing a crucial regional perspective to the global understanding of construction logistics. The research identified several region-logistical obstacles, including unreliable material storage, inadequate design specifications, and poor communication. These issues are exacerbated by unclear role assignments, excessive bureaucracy, and inappropriate vehicle use. Moreover, this study highlights political instability and workforce shortages as significant impediments to effective logistics management in the Middle East. These challenges collectively result in project delays, reduced productivity, budget overruns, and negative environmental impacts. The interview findings also reveal the root causes of logistics challenges in the Middle Eastern construction industry and propose potential solutions. A primary issue identified was the scarcity of experienced personnel and limited expertise in logistics and supply chain management. This lack of skilled professionals results in inefficient planning, miscommunication, and poorly coordinated deliveries, ultimately causing project delays, cost overruns, and decreased productivity. To address these issues, the respondents suggested several key initiatives for Middle Eastern construction companies. One crucial recommendation is the adoption of technology in logistics operations, such as real tracking for shipments and digital project management, to enhance real-time visibility and enable proactive problem-solving. Additionally, the implementation of lean logistics principles, including Kanban, the Last Planner System (LPS), and just-in-time (JIT) logistics, is proposed to optimise workflows, minimise waste, and reduce inventory costs. These approaches ensure timely material availability, mitigate delays, and prevent overstocking, which can lead to resource waste and environmental damage. Thus, the interviews not only explored the unique challenges in Middle Eastern construction logistics but also emphasised their intricate connection to sustainability, offering practical recommendations to improve logistics practices that align with both operational efficiency and environmental responsibility.

Objective three: To identify logistics solutions and critical success factors that can be used to address logistics challenges.

This study examines the extant literature on logistics solutions and critical success factors (CSFs) to obtain an understanding of their combined impact on improving construction logistics. A thorough analysis of current knowledge is essential for identifying effective logistics solutions and assessing the significance of CSFs. The research findings, supported by the substantial literature, suggest that the integration of logistics solutions with CSFs can significantly enhance construction logistics performance. This investigation expands the current understanding of how logistics solutions and CSFs interact in the construction sector. By utilising four key frameworks, namely the Green Logistics Framework, A-S-I/AS-I-F Framework, TIMBER Framework, and IF-TOLD Framework, this study presents a multifaceted perspective on logistics solutions. These frameworks address various logistics and supply chain issues and offer structured approaches to their resolution. For instance, the Green Logistics model emphasises the implementation of lean methodologies such as Kaizen to enhance quality control. The research identifies 17 logistics solutions, such as the Kanban system, Last Planner system, just-in-time principles, and real-time visibility tools, expanding the range of academically supported methods for optimising logistics processes in construction projects. Furthermore, the incorporation of principal-agent theory (PAT), transaction cost analysis (TCA), resource-based view (RBV), and network theory to develop seven CSFs adds theoretical depth to the discussion, providing a robust conceptual foundation for the study. This integration advances scholarly discourse by offering novel perspectives on applying theories traditionally used in business and economics to understand construction logistics. Consequently, the findings provide actionable strategies for enhancing logistics operations during construction. For construction companies, adopting these logistics solutions presents an opportunity to address logistics challenges, increase productivity, and minimise crucial waste factors in an industry characterised by strict project deadlines and budget constraints. For example, implementing lean design principles, utilising third-party logistics services, and employing real-time visibility tools can optimise transportation, inventory management, and resource allocation. By improving these core logistics functions, firms can enhance their project performance, meet stakeholder expectations, and achieve higher levels of customer satisfaction. Moreover, the identified CSFs offer construction companies a roadmap to ensure efficient logistics operations. Accurate demand forecasting, effective transportation management, and the integration of advanced technologies, such as building information modelling (BIM), can significantly reduce costs and improve operational efficiency. Ensuring firm commitment and support from top management, coupled with proper information flow and adherence to safety and environmental regulations, positions companies to not only enhance logistics efficiency but also improve health and safety standards, which is essential in high-risk industries such as construction.

Objective four: To develop a conceptual model for addressing logistics challenges within construction using logistics initiatives to enhance sustainability.

This study introduces a model for addressing logistical challenges in construction with a focus on enhancing sustainability. Model development was informed by an extensive literature review and insights from interviews with industry experts, resulting in a robust, evidence-based approach. By synthesising theoretical knowledge from practical perspectives, this model offers a more applicable and implementable strategy for improving logistics operations in Middle Eastern constructions. The integration of interview data into the model is crucial, as it bridges academic theory with industry practice. While numerous existing frameworks rely exclusively on the literature, the inclusion of empirical data ensures that this approach is not only theoretical but also practical and adaptable to the unique logistical challenges in the Middle East. This dual approach renders the model particularly valuable, as it addresses regional complexities, such as rapid urban growth, regulatory environments, and complex supply chains. The model was developed in multiple phases. Initially, key logistics challenges were identified through the literature review, highlighting issues such as inefficient transportation, resource misallocation, and supply chain delays. This was supplemented by interview data, which provided firsthand insights into the daily logistics difficulties encountered by the construction managers and project leaders in the region. These interviews were instrumental in ensuring that the model addresses both theoretical challenges and practical, on-the-ground obstacles to the Middle East. Subsequently, logistics solutions, including lean design principles, real-time visibility tools, and optimised transportation routes, were incorporated into the model based on their effectiveness in the literature and relevance to the interview data. The combination of these two data sources ensures that the proposed solutions are not only academically sound but also directly applicable in real-world construction settings. Finally, critical success factors (CSFs) were incorporated, drawing from theoretical foundations such as the resource-based view (RBV) and transaction cost analysis (TCA), as well as insights from industry professionals. These CSFs, including accurate demand forecasting, effective risk management, and the integration of advanced technologies, ensure that the model aligns logistics operations with broader organizational goals and stakeholder expectations. Consequently, the formulated model provides actionable insights for construction managers, offering a structured approach to optimise logistics, reduce operational costs, and improve sustainability. By implementing the model proposed logistics solutions and adhering to the identified CSFs, construction firms can achieve more efficient operations and align themselves with global sustainability trends. The focus on reducing waste, enhancing resource efficiency, and optimising transportation aligns with the growing importance of sustainability in construction, which is particularly critical in the Middle East region.

Objective five: To refine the conceptual model using construction contractors' experiences and propose a practical model that informs sustainability.

This study significantly contributes to construction logistics research by employing structural equation modelling (SEM) to create and verify a model addressing logistical issues and promoting sustainability in Middle Eastern construction. SEM serves as a crucial statistical tool in this research, enabling the analysis of complex relationships among multiple variables including logistics challenges, solutions, critical success factors (CSFs), and sustainability. Its capacity to evaluate both direct and indirect effects while considering multiple interactions makes it particularly suitable for understanding the intricate dynamics of construction logistics.

A key advantage of utilising SEM in this study is its ability to concurrently examine the relationships between logistics challenges, solutions, and CSFs and their collective influence on sustainability. Confirmatory factor analysis (CFA), conducted as part of

SEM, ensured data reliability and validity, bolstering confidence in the model's robustness. SEM allowed researchers to assess the main hypothesis's significance, with results indicating statistically significant model acceptance at a 95% confidence level. This high degree of statistical rigour enhances the credibility of the findings and distinguishes the model from studies employing simpler analytical techniques.

Furthermore, SEM facilitated the identification of crucial relationships between the constructs. They revealed that logistics challenges significantly and negatively impact sustainability; however, this effect can be mitigated through the implementation of logistics solutions and CSFs. The analysis also elucidates how these elements interact, demonstrating that adopting logistics solutions aids in achieving CSFs, which in turn drives sustainability outcomes. This integrative approach provided by SEM is essential in construction logistics research, in which multiple interrelated factors must be considered simultaneously for a holistic understanding of the system.

Additionally, the application of SEM in this study allowed for detailed moderation and mediation analyses. A moderation analysis demonstrated that factors such as geographical location and project type significantly influence the relationships between logistics challenges, solutions, and sustainability outcomes. For instance, logistics solutions were found to be more effective in Palestine than in other countries, while residential projects had a stronger positive moderation effect on sustainability than other project types. Mediation analysis further revealed how logistics challenges can attenuate the positive effects of solutions and CSFs on sustainability, emphasising the necessity to address these challenges directly to fully realise sustainability benefits. Consequently, the findings of the SEM analysis contribute significantly to both academic research and industry practice. They provide valuable insights for construction companies in the Middle East seeking to enhance their logistics operations and meet sustainability objectives. These results not only expand the existing body of knowledge but also offer practical recommendations for implementing more efficient and environmentally sustainable practices in the Middle East construction sector.

8.2. Contribution

This study makes several significant contributions to both academic literature and industry practice in the field of construction logistics, particularly within the Middle Eastern context. These contributions are highlighted as follows:

Contribution to Academic Literature: This research contributes significantly to the scholarly literature by presenting a precisely developed and empirically tested model that addresses logistics inefficiencies in the Middle Eastern construction sector, with an emphasis on sustainability. This study identifies logistical challenges, including inadequate planning, delayed decision-making, inefficient resource allocation, and workforce shortages. It examines potential solutions, such as implementing just-in-time (JIT) and Kanban systems, along with real-time visibility tools, offering practical strategies to enhance operational efficiency. The model also incorporates critical success factors (CSFs) that support effective logistics management, such as strong leadership commitment, robust risk management, and training initiatives. Notably, the research findings underscore the significant role of CSFs in addressing logistics challenges, emphasising the importance of elements such as precise demand forecasting, supplier collaboration, and adherence to safety standards. This approach, which combines logistics challenges, tailored solutions, and critical success factors, addresses this gap in the literature by providing a holistic model relevant to the Middle Eastern construction industry. By integrating these components, this study establishes a solid foundation for future research to investigate region-logistics strategies and expand sustainable practices within the construction field.

Contribution to the construction industry: This study presents a model that enables construction companies to address logistical inefficiencies, providing a structured approach to enhance project performance, reduce costs, and improve sustainability. By correlating logistical challenges with tailored solutions and critical success factors (CSFs), the model offers practical benefits that apply to diverse construction projects. For industry practitioners, this approach directly addresses persistent issues such as inaccurate demand forecasting, resource allocation constraints, and regulatory barriers that frequently impede project timelines and increase costs. Implementing methodologies such as the Last Planner System (LPS) for more precise scheduling and just-in-time (JIT) to minimise excess inventory allows firms to achieve more efficient project execution with reduced delays and material waste. Moreover, the integration of CSFs, including proactive risk management, close supplier collaborations, and dedicated leadership, establishes a robust support structure that reinforces these solutions. This methodology ensures that construction firms address immediate logistical challenges while maintaining long-term improvements. The adaptability of the model enables companies to optimise their logistics processes, achieve cost efficiency, and meet the growing industry demand for sustainable practices. Ultimately, by adopting this framework, construction firms are better positioned to complete projects on schedule, minimise operational expenses, and maintain a competitive advantage in a market that is increasingly focused on sustainability and efficiency.

Region-Insights: This study presents a specialised model designed for the Middle East, which suffers from accelerated urban growth, stringent regulatory environments, and resource scarcity. In contrast to generic models, this approach is tailored to address the needs of Middle Eastern markets, offering targeted strategies based on data from countries such as the United Arab Emirates, Palestine, Saudi Arabia, and Jordan. Construction companies in the region can derive significant benefits from this model by providing concrete solutions and critical success factors for common challenges. For instance, it proposes effective methods to manage regulatory impediments, optimise limited resources, and adapt to rapid urban expansion through strategies such as forming third-party logistics (3PL) partnerships and implementing real-time visibility systems. These approaches enable firms to mitigate project delays, enhance resource allocation, and alleviate operational constraints, which are particularly valuable given the unique regulatory and developmental pressures in the region.

Application of Structural Equation Modelling (SEM): The utilisation of Structural Equation Modelling (SEM) to validate this model represents a significant methodological advancement, enabling an examination of the complex interrelationships among logistical challenges, solutions, critical success factors, and sustainability. This sophisticated methodology ensures that the proposed model is both theoretically sound and empirically validated, thereby enhancing its credibility and practical applicability. For construction industry professionals, SEM's rigorous validation process lends substantial credence to the findings, fostering confidence that the model accurately reflects real-world scenarios. By elucidating the nuanced interactions between key components, such as risk mitigation, sustainable practices, and logistical solutions, SEM enhances the framework's analytical capabilities. This empirical foundation enables construction organisations to implement the model with confidence, knowing of its validation in addressing concrete logistical challenges. Ultimately, the integration of SEM not only augments the framework's scientific rigour but also enhances its functional utility, rendering it an invaluable tool for industry stakeholders seeking to optimise logistics strategies within the Middle East construction environments.

Practical Contributions to Sustainability: The impact of this study on advancing sustainability can be considerable. It presents a validated, evidence-based model that construction firms can implement to streamline their logistics operations while reducing their environmental impact. The proposed model not only guides industry professionals in achieving operational efficiency but also aligns their logistics practices with sustainability objectives. By emphasising critical success factors, such as strong leadership commitment to sustainability and proactive risk management, the model provides a strategic blueprint for companies to navigate regulatory landscapes and meet increasing market demands for environmentally responsible construction. It equips the construction industry with the necessary tools to implement sustainable practices that enhance resilience, ensure regulatory compliance, and gain a competitive advantage in an increasingly environmentally conscious market. This model enables firms to optimise their logistics operations while simultaneously minimising their ecological impact, offering a new approach to sustainability in the construction sector.

8.3. Limitations

The limitations of this study are as follows:

To manage production systems, Koskela (2000) defined three generic actions: design, operation, control, and improvement. Similar actions have been observed in construction logistics and supply chain management. The improvement aspects of logistics in the construction industry are the focus of this study in its inherent proposition. This study needs to address element control directly.

This research conducted a systematic literature review based on a trusted scientific English database, as the researcher needed help to determine if any other database from different languages could be considered for further information. Moreover, this research finds the publication from 2000 as research regarding logistics and supply chain management in construction was developed more recently, especially from 2000 onwards. However, the synthesis of literature findings from diverse studies using different methodologies, contexts, and outcomes can be complex and may be associated with subjective judgment.

This research collected primary data from main contractors within the Middle East (private sector), as the researcher had minimal access to the governmental sector, and the private sector implemented major construction projects. Thus, it is beneficial to consider other perspectives. Moreover, the data were collected from the contractors' staff, as they were the focus of this study, and they enhanced their performance. Therefore, considering other perspectives from consultants and clients would be beneficial. This research collected quantitative data through in-person distribution for the questionnaire, as the online method responses were unreliable. Therefore, the responses were collected from major countries within the Middle East, including KSA, UAE, Jordan, and Palestine. The researcher could not collect data from the remaining countries, including Syria and Lebanon, due to unstable conditions within the countries.

8.4. Suggestions For Further Research

The objectives and all research questions were met by implementing the research procedures. Several obstacles were encountered during data collection. In the beginning, there was a dearth of significant Middle Eastern literature on the subject. In addition, some individuals required more time to participate in the survey. Because numerous construction workers had yet to reply via email, it was necessary to distribute the questionnaire. Some respondents submitted incomplete questionnaire forms and were ultimately rejected owing to their instability. Owing to these obstacles, it was necessary to spend more time to obtain sufficient questionnaires.

- Research based on other scientific databases that investigate logistics practices in the construction industry would generate additional outcomes.
- Mixed methods were employed in this research through interviews and questionnaires. Further investigation could utilise action research to examine the ability to implement logistics solutions and CSFs and measure any significant decrease in waste, cost, quality, and time advantages.
- The research was restricted to large and medium-sized companies but could be expanded to include small-sized companies.
- Given the extensive and intricate nature of logistics solutions, more research could concentrate on a particular technique, such as JIT and LPS (Last Planner System).
- Additional investigation may lead to a comparison of this research with another research within the same field.

- Most of the participants in this research were employed in the private sector; therefore, the study was restricted to the private sector in the Middle East. Thus, additional research should focus on the public and government sectors.

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10. Appendixes:

Participant Invitation Letter (Interviews)

Dear Participant,

I would like to invite you to take part in PhD research at Birmingham City University entitled: The impact of utilising logistics initiative within construction on sustainability in The Middle East. This interview aims to identify the current logistics practices and challenges within construction in The Middle East that affect sustainability. This research also aims to identify any logistics solutions and critical success factors that are used to address challenges.

Participation in this interview is completely voluntary, and you may decline to participate without consequences. No confidential data will be recorded and shared. The collected anonymous data will only be used for academic research. The processed data can be published in academic papers only. Attached to this invitation is a Participant Information Sheet. This will provide you with further information about the interview and whom to contact if you have any concerns. I hope you choose to take part in this interview and consider sharing your experience, which will assist me in identifying ways to improve the Middle East construction industry considering logistics aspects.

Sincerely,

Abdulla Ruzieh

PhD students at the Faculty of Engineering and the Built Environment

Birmingham City University

e-mail: Abdulla.ruzieh@mail.bcu.ac.uk

Participant Consent Form (Interview)

Research Name: The impact of utilising logistics initiative within construction on sustainability in The Middle East.

Name of the researcher: Abdulla Ruzieh

The use info in this consent is being granted for A study that aims to develop a model for enhancing the sustainability of construction focusing on logistics challenges and the related aspects in The Middle East.

Please tick the following points before the start:

- I have read and understood the project information sheet.
- I have been allowed to ask questions about the project.
- I understand that taking part is voluntary; I can withdraw from the study at any time, and I do not have to give any reasons for why I no longer want to take part.
- I agree to take part in this interview.

Logistics status, challenges and promises within construction in the Middle East.

1. Could you please briefly introduce yourself and your experience within construction?
2. What is your impression of the logistics practices? (Kind of definition and understanding about the meaning).
3. Have you worked as a part of the logistics in construction and how would you summarise your experience of logistics within construction projects?
4. What are the major logistics problems and challenges you have dealt with in the Middle East construction industry?
5. In your opinion what are the root causes and consequences for each one of these challenges?
6. Have you developed or used any logistics solutions to be used in your construction project to enhance performance and sustainability? And could you please specify them?

Participant Invitation Letter (Survey)

Dear Participant,

I would like to invite you to take part in a research project entitled: **The Impact of Utilising Logistics Initiative within the Construction Industry on Sustainability – Evidence from Middle East Countries**. This survey aims to identify the current challenges affecting logistics practices within construction in the **Middle East countries** that affect Sustainability. There are no identified risks from participating in this research and it is completely voluntary, and you may refuse to participate without consequence. Attached to this invitation is a Participant Information Sheet. This will provide you with further information about the survey and whom to contact if you have any concerns. I hope you choose to take part in this survey and consider sharing your experience, which will help me identify ways to improve the performance of the construction industry considering logistics aspects.

Sincerely,

Abdulla Ruzieh

Ph.D. student at the Faculty of Engineering and the Built Environment

Birmingham City University

E-mail: Abdulla.ruzieh@mail.bcu.ac.uk

Participant Consent Form (Survey)

Research Name: The Impact of Utilising Logistics Initiative within the Construction Industry on Sustainability – Evidence from Middle East Countries

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The use info in this consent is being granted for a study that aims to develop a model for enhancing sustainability focusing on logistics aspects within the construction industry.

Please tick the following points before the start:

• I have read and understood the project information sheet.

• I have been allowed to ask questions about the project.

• I understand that participating is voluntary; I can withdraw from the study at any time, and I do not have to give any reasons why I no longer want to participate.

• I agree to take part in this survey.

1. How do you describe the influence of the listed challenges on the efficiency/effectiveness of the construction logistics process?

Challenges	not at all influential	slightly influential	somewhat influential	very influential	extremely influential
1. Inadequate planning for logistics processes, including resource management					
2. A lack of expertise (or knowledge) in construction logistics					
3. Ineffective monitoring and control of logistics activities					
4. Inadequate alignment between construction schedules and logistics practices					
5. Inefficient site layout					
6. Management's insufficient commitment to on-site logistics operations					
7. Ineffective coordination among internal parties					
8. Inadequate communication among internal parties					
9. lack of real-time tracking of fleet and equipment used in construction logistics					
10. Ambiguity in logistics responsibilities for the construction team					
11. Delays in decision-making by the consultant engineer					
12. Duplication and errors caused by excessive paperwork					
13. The fluctuating prices of construction materials and components					
14. lack of coordination and integration with suppliers					
15. Neglecting the understanding of quality in purchasing processes					
16. Poor material identification and estimation					
17. Accuracy of goods (orders) received from suppliers					
18. waste of materials due to inefficient material handling					
19. Inaccurate inventory records					
20. The use of inappropriate types of vehicles in transportation					
21. Inefficient management of the return process for purchased materials					
22. (Temporary) Closures resulting from unstable political conditions					
23. The sudden labour shortage					

2. **How do you describe the influence of the following initiatives on the success/efficiency/effectiveness of the construction logistics process?**

Logistics Critical success factors	not at all influential	slightly influential	somewhat influential	very influential	extremely influential
1. Accurate demand forecasting and planning					
2. Efficient transportation and delivery management					
3. Effective inventory management					
4. Proper information flow.					
5. Compliance with safety, environmental and regulations					
6. Effective risk management					
7. Integration of technology.					
8. Efficient resource allocation.					
9. Collaborating with suppliers					
10. Adequate training and skill development					
11. Strong commitment and support from top management					
Logistics Solutions					
1. Implementing the Kanban system					
2. Implementing the Last Planner System (LPS)					
3. Implementing Just-in-time (JIT)					
4. The utilisation of Real-time visibility tools					
5. Utilisation of Third-party logistics (3PL) services					
6. Implementation of logistic centres					
7. Applying lean design principles in designing the construction projects					
8. Utilizing project management tools and procedures					
9. Using Value Stream Mapping to assist in identifying and eliminating non-value-added activities.					
10. Applying the Kaizen principle (Continuous Improvement)					
11. Implementing Poka-Yoke (Error-prevention)					
12. Optimized transportation routes					
13. Conducting a regular on-site visit (Gemba Walks)					
14. Applying the 5S Methodology					
15. Applying ABC (Pareto) analysis for inventory management.					
16. Implementing the Andon system					
17. Participate in associations, non-profit activities, and events					
18. Use of Information Systems and Modelling Tools such as BIM and 3D					

3. **To what extent do you believe the following factors contribute to the sustainability of construction projects?**

Factors	**Not at all**	**Slightly**	**Somewhat**	**Very**	**Extremely**
1. Labour productivity					
2. Greenhouse gas emissions					
3. Total cost of completing a project					
4. Resource efficiency					
5. Waste reduction					
6. Employee well-being					
7. Enhancing technology adoption					

4. **General information**

i. Which of the following best describes your current role:

○ **Foreman**	○ **Project Manager**	○ **Other; please specify__________________**
○ **Engineer**	○ **Contractor representative**	

ii. Your experience in the construction industry

○ **Less than 2 years**	○ **Between 2 to 8 years**	○ **Above 8 years**

iii. The location of the latest construction project worked for:

○ **Urban**	○ **Rural**	○ **City centre**

iv. Your recent and most construction project worked for:

○ **Residential / housing**	○ **Commercial**	○ **Industrial Buildings**
○ **Infrastructure**	○ **Institutional**	

Thank you for taking the time to share your experience and knowledge. Your contribution is highly appreciated.

Clarifications for logistics solutions

1. Kanban system: Kanban is a visual signalling system that helps manage inventory levels, production, and logistics flow. It ensures that materials are replenished only when needed, reducing waste, and improving efficiency.
2. Last Planner System (LPS): Implement the Last Planner System, which involves collaborative planning and reliable commitments to improve the predictability of project schedules and reduce waste.
3. Just-in-time (JIT) delivery: Coordinate deliveries to the construction site to match the project's immediate needs, minimizing on-site storage and handling.
4. Lean Logistics Software: Implement logistics software including tracking systems to monitor the movement of materials, equipment, and labour, making it easier to identify and resolve issues (real-time visibility).
5. Third-party logistics (TPL) services: 3PL providers are experts in logistics and supply chain management. They bring specialized knowledge, technology, and best practices to optimize processes, improving efficiency and service quality.
6. Logistic centre: A logistics centre, also known as a distribution centre or warehouse, can serve as a key logistics solution to address a wide range of logistics challenges related to inventory management, order fulfilment, transportation, and storage. Optimizing the operations within the logistics centre and integrating them into your supply chain strategy, would enhance efficiency, reduce costs, and improve the overall performance of logistics processes.
7. Lean practices: Collaborate with architects and designers to create lean designs that simplify construction processes, reduce materials waste, and improve logistics. And to define key performance indicators (KPIs) to monitor project progress, including metrics related to lead times, cycle times, and waste reduction.
8. Utilize project management tools to visualize project timelines, dependencies, and milestones. These tools help schedule and track logistics activities.
9. Value Stream Mapping: VSM is a visual tool used to analyse and document the current state of logistics processes. It helps identify areas of waste and inefficiency, making it easier to develop improvement strategies.
10. Kaizen (Continuous Improvement): Kaizen encourages continuous, incremental improvements by involving employees at all levels in identifying and implementing better practices. In logistics, this can lead to process streamlining and waste reduction.

11. Poka-Yoke (Error-prevention): Poka-Yoke involves designing processes and systems to prevent errors and defects. In logistics, this can include quality checks, double-checking shipments, and using automated systems to reduce human error.

12. Optimized transportation routes: Optimize transportation routes and modes to reduce costs, delivery times, and emissions. Employ route planning software and load consolidation for efficiency.

13. Regular on-site visits (Gemba Walks): Conduct regular Gemba walks (on-site visits) to observe and engage with employees, identify opportunities for improvement, and understand real-world logistics challenges.

14. 5S Methodology: The 5S methodology (Sort, set in order, Shine, Standardize, Sustain) focuses on organizing and maintaining a clean, efficient workspace. This approach can be applied to logistics facilities to improve safety, visibility, and overall organization.

15. ABC analysis: ABC analysis classifies items in inventory or logistics processes into three categories: A, B, and C, based on their importance, value, or contribution to your business.

16. Andon system: This system enables quick response to issues or problems that occur while enhancing communication and teamwork.

Table 0-1 Interview data including Extracted response information

#		Role of Interviewees	Experience	1. Could you please give a brief introduction about yourself and your experience within construction?
1	**A**	Contractor's representative	More than 15 years	Building engineer. Owner of a construction and real estate company. Constructing several significant and iconic projects in the Middle East including governmental and special projects.
2	**B**	Project manager	12 years	Excellent experience in construction projects especially in building, high-rise buildings. Worked for several organisations including local and international organisations such as UNDP and USAID.
3	**C**	Senior Site engineer	15 years	Significant experience in roads and infrastructure projects. I have a master's degree in construction management. Worked for several local main contractors.
4	**D**	Logistics manager	12 years	Significant experience in construction logistics and supply chain management. Expert in procurement and purchasing. Responsible for material monitoring and ordering. Used to work on several construction projects in the Middle East.
5	**E**	Logistics manager	15 years	Good experience and knowledge in construction logistics and supply chain management. Have a master's degree in logistics and supply chain management from the UK. Expert in contract law and procurement.
6	**F**	Project manager	21 years	Significant experience in construction projects especially in infrastructure projects. Worked with several local main contractors. Implementing more than 50 big projects
7	**G**	Contractor's representative	18 years	Owner of a construction/Infrastructure company. I have a BA and MSc in project management. Constructing several huge projects with several local and international agencies.
8	**H**	Project engineer	10 years	Civil engineer. Responsible for resource estimation and material quantities. Also, the role includes monitoring and coordinating resources. Focusing on building projects. Small and medium projects.

#		Role of Interviewees	Experience	1. Could you please give a brief introduction about yourself and your experience within construction?
9	**I**	Senior office engineer	10 years	Significant experience in quantities surveying and procurement. Has a master's degree in quantity surveying. Worked for several main contractors as materil estimator, monitor, and delivery coordinator.
10	**J**	Project manager	20 years	Excellent experience in the Middle East construction industry especially in residential and commercial projects. I worked with several local main contractors and investors. The responsibility extended to include enhancing fast materil and resource delivery towards reducing costs.
11	**K**	PhD in construction management	More than 15 years	Researcher in construction logistics and construction management. I have significant experience in the Middle East construction industry as I worked on different construction projects as a consultant for management scheduling and resource estimation. And my experience includes medium and large projects.
12	**L**	Contractor's representative	13 years	Electromechanical engineer. Owner of a construction company and concrete factory. Constructing several construction projects in the Middle East including governmental, public and special projects.
13	**M**	Project manager	10 years	Excellent construction project experience, particularly in high-rise buildings. Worked for a variety of institutions, including local, national, and international ones like LGUs.
14	**N**	Senior Site engineer	18 years	Extensive knowledge of infrastructure and road developments. I'm a construction management master's graduate. Used to work for several large contractors in the Middle East.
15	**O**	Logistics manager	8 years	Substantial knowledge of supply chain management and logistics for the construction industry. Expert in purchasing and procurement. In charge of estimating and ordering materials. Worked on several building projects in the Middle East.

#		Role of Interviewees	Experience	1. Could you please give a brief introduction about yourself and your experience within construction?
16	**P**	Logistics manager	11 years	Good knowledge and expertise in supply chain management and logistics for the construction industry. Have a master's degree in supply chain management and logistics. Expert in both procurement and contract law.
17	**Q**	Project manager	17 years	substantial knowledge in construction projects, particularly infrastructure projects. Worked with several regional prime contractors. Putting more than 50 large initiatives into action
18	**R**	Contractor's representative	8 years	Owner of an Infrastructure company. Also, I have a shop for construction materials.
19	**S**	Supplier of construction material and Previous owner of a construction owner	20 years	Materil supplier is responsible for material construction material delivery. The position also checks material quantities. Concentrating on construction projects. Medium-sized and small projects. I am also the owner of a concrete factory.
20	**T**	Supplier of construction material and owner of Block factory	25 years	Substantial knowledge of quantity surveying and procurement. Is a quantity surveying master's degree holder. Worked as a material estimator, monitor, and delivery coordinator for many big contractors.
21	**J**	Master's in construction management	12 years	researcher in logistics and management of construction projects. As a consultant for management, scheduling, and resource estimation on several construction projects, I have extensive experience in the Middle East construction sector. Additionally, I've worked on both small and large projects.
22	**V**	Logistics manager	12 years	Good experience and knowledge in construction logistics and supply chain management. Have a master's degree in logistics and supply chain management from the USA. Expert in contract law and procurement.

#		Role of Interviewees	Experience	1. Could you please give a brief introduction about yourself and your experience within construction?
23	**W**	Logistics manager	15 years	Significant experience in construction projects especially in infrastructure projects. Worked with several local main contractors. Implementing more than 50 big projects
24	**X**	Project manager	12 years	Owner of a construction/Infrastructure company. I have a BA and MSc in project management. Constructing several huge projects with several local and international agencies.
25	**Y**	Contractor's representative	More than 18 years	Civil engineer. Responsible for resource estimation and material quantities. Also, the role includes monitoring and coordinating resources. Focusing on building projects. Small and medium projects.
26	**Z**	Project engineer	21 years	Significant experience in quantities surveying and procurement. Has a master's degree in quantity surveying. Worked for several main contractors as a material estimator, monitor, and delivery coordinator.
27	**AA**	Senior office engineer	18 years	Excellent experience in the Middle East construction industry especially in residential and commercial projects. I worked with several local main contractors and investors. The responsibility extended to include enhancing fast material and resource delivery towards reducing costs.
28	**BB**	Project manager	8 years	Researcher in construction logistics and construction management. I have significant experience in the Middle East construction industry as I worked on different construction projects as a consultant for management scheduling and resource estimation. And my experience includes medium and large projects.
29	**CC**	PhD in construction logistics	6 years	Researcher in construction logistics and construction management. I have significant experience in the construction industry as I worked on different construction projects as a consultant for management scheduling and resource estimation. And my experience includes medium and large projects.

#		Role of Interviewees	Experience	2. What is your impression of logistics practices? (Kind of definition and understanding about the meaning).
1	**A**	Contractor's representative	More than 15 years	Logistics in the construction industry in the Middle East suffer from a very poor understanding. For instance, the practitioners do not have the minimum knowledge of logistics and related practices. However local universities do not equip student engineers with the science of logistics and supply chain management. And they do not include any material for this science and the related important practices. Still, we regarded logistics and SCM the same for material monitoring and coordinating.
2	**B**	Project manager	12 years	Very few people working in the construction industry understand logistics and supply chain management and the related applications in construction. However, in the Middle East, we use logistics and SCM for material management only not for all the required resources for construction.
3	**C**	Senior Site engineer	15 years	People working in the Middle East's construction industry have little knowledge and experience in logistics and supply chain management. For instance, many of them do not understand what logistics and SCM are in terms of functions and roles. They deal with logistics activities daily and they limit the role of logistics to material management only.
4	**D**	Logistics manager	12 years	Logistics and supply chain management received little attention in the Middle East construction industry. Most contractors do not employ logistics officers as they do not understand the role and functions of logistics and SCM. They rely on unqualified staff to do logistics activities as they do not have enough knowledge of logistics and SCM.

#		Role of Interviewees	Experience	2. What is your impression of logistics practices? (Kind of definition and understanding about the meaning).
5	**E**	Logistics manager	15 years	A very poor understanding of logistics and SCM is always noticed in the construction industry in the Middle East as a minor part, not a major. For instance, engineers and other staff underestimate the functions and roles of logistics and SCM. They do not have the minimum knowledge of logistics and related practices. Local universities do not offer any logistics and SCM courses for people working in the construction industry. However, as logistics managers, we are dealing with material management only and we do not extend the logistics functions to include other sources in terms of planning coordinating and managing resources.
6	**F**	Project manager	21 years	Almost all people working in the construction industry in the Middle East underestimate logistics and supply chain management and its related applications in construction. However, in the Middle East, we consider logistics and SCM for material monitoring and coordinating and we neglect logistics and SCM to integrate all resources.
7	**G**	Contractor's representative	18 years	Logistics and SCM in the construction industry in the Middle East do not receive real attention from stakeholders. They deal with it as a minor part. And they limit their role to the material only. They did not realise its possibilities and promises. They are not used as a major function in the construction project. So, they deal with it to realise material coordination and monitoring rather than resource integration.
8	**H**	Project engineer	10 years	As a project engineer, I understand that logistics has a significant role in dealing with planning and coordinating project resources. In the Middle East, construction contractors underestimate the effect of it. Moreover, they distribute the logistics functions among several staff to save some money instead of employing logistics officers.

#		Role of Interviewees	Experience	2. What is your impression of logistics practices? (Kind of definition and understanding about the meaning).
9	**I**	Senior office engineer	10 years	In my opinion, logistics and SCM is one of the main pillars of any construction project. For instance, logistics is responsible to plan and coordinate all resources required to run the construction processes smoothly. Unfortunately, in the Middle East, they do not believe in logistics till now. And they are dealing with it daily rather than considering it from a strategic level
10	**J**	Project manager	20 years	Almost all people working in the construction industry in the Middle East underestimate logistics and supply chain management and the related functions in construction. However, in the Middle East, we consider logistics and SCM for material coordination only and we neglect logistics and SCM for resources integration. We are considering logistics and SCM for material management only. And we neglect to employ it for resource management. This is due to a bad understanding of this knowledge.
11	**K**	PhD in construction management	More than 15 years	Research in logistics and SCM within the construction industry in the Middle East receives little attention from the industry's stakeholders. Very little understanding from engineers, foremen, and managers is noticed frequently. They do not realise the functions of logistics and SCM and their application within construction. They regarded it for material monitoring only. And they do not use it to coordinate and integrate resources successfully.
12	**L**	Contractor's representative	13 years	Logistics in the construction industry in the Middle East face very poor understanding. The stakeholders do not have sufficient knowledge of logistics and related practices. However local educational businesses do not equip student engineers with the science of logistics and supply chain management. And they do not include any material for this science and the related important practices. Still, we regarded logistics and SCM for material monitoring and coordinating only rather than integrating all resources.

#		Role of Interviewees	Experience	2. What is your impression of logistics practices? (Kind of definition and understanding about the meaning).
13	**M**	Project manager	10 years	Few people who work in the construction sector are familiar with supply chain management, logistics, and its applications. However, in the Middle East, we just use logistics and SCM for managing the material, not for all the resources needed for building.
14	**N**	Senior Site engineer	18 years	People who work in the construction sector in the Middle East typically lack knowledge of logistics and supply chain management. For instance, many of them are unaware of the roles and duties of logistics and SCM. They solely use logistics for material management while dealing with logistics issues daily.
15	**O**	Logistics manager	8 years	The building sector in the Middle East paid little attention to logistics and supply chain management. Due to their ignorance of the roles and responsibilities of SCM and logistics, the majority of contractors do not employ logistics officers. Because they lack sufficient expertise in logistics and SCM, they rely on unqualified people to do logistics-related tasks.

#		Role of Interviewees	Experience	2. What is your impression of logistics practices? (Kind of definition and understanding about the meaning).
16	**P**	Logistics manager	11 years	The building sector in the Middle East, which is a large component of the economic sector of the Middle East, consistently has a very weak understanding of logistics and SCM. Engineers and other staff members frequently undervalue the roles and responsibilities of logistics and SCM. They lack a fundamental understanding of logistics and related procedures. There are no logistics or SCM courses offered by local universities for those working in the construction sector. As logistics managers, we do not extend the logistics functions to encompass additional sources in terms of planning, organising, and managing resources. Instead, we deal solely with material management.
17	**Q**	Project manager	17 years	Almost everyone who works in the construction sector in the Middle East undervalues supply chain management, logistics, and their related applications in the business. However, in the Middle East, we only take into account logistics and SCM for material monitoring and coordination, ignoring them for resource integration.
18	**R**	Contractor's representative	8 years	Stakeholders in the Middle East's building industry pay little attention to logistics and supply chain management. They treat it as a minor component. And they stick to the material in their function solely. They were unaware of its potential and prospects. They don't perform it as a primary duty during the construction process. Instead of integrating resources, they work with it to realise material coordination and monitoring.
19	**S**	Supplier of construction material and Previous owner of a construction owner	20 years	As a material supplier, I am aware of the importance of logistics in managing the planning and synchronisation of project resources. Construction companies in the Middle East underestimate its impact. In addition, they split up the logistics tasks among multiple employees rather than hiring logistics officers to save money.

#		Role of Interviewees	Experience	2. What is your impression of logistics practices? (Kind of definition and understanding about the meaning).
20	**T**	Supplier of construction material and owner of Block factory	25 years	One of the primary foundational elements of any building project, in my opinion, is logistics and SCM. For example, logistics is in charge of organising and planning all the resources needed to keep the building operations running efficiently. Unfortunately, up until today, the people of the Middle East have not believed in logistics. And they don't think about it from a strategic perspective because they deal with it on a regular basis.
21	**J**	Master's in construction management	12 years	The stakeholders in the industry pay little attention to research in logistics and SCM in the Middle East's building sector. It is regularly observed that engineers, foremen, and supervisors have very little comprehension. They are unaware of the roles played by logistics and SCM in the building industry. They solely considered it for material monitoring. Additionally, they do not successfully integrate and organise resources using it.
22	**V**	Logistics manager	12 years	A very poor understanding of logistics and SCM is always noticed in the construction industry in the Middle East as a minor part, not a major. For instance, engineers and other staff underestimate the functions and roles of logistics and SCM. They do not have the minimum knowledge of logistics and related practices. Local universities do not offer any logistics and SCM courses for people working in the construction industry. However, as logistics managers, we are dealing with material management only and we do not extend the logistics functions to include other resources in terms of planning coordinating and managing resources.
23	**W**	Logistics manager	15 years	Almost all people working in the construction industry in the Middle East underestimate logistics and supply chain management and its related applications in construction. However, in the Middle East, we consider logistics and SCM for material monitoring and coordinating and we neglect logistics and SCM to integrate all resources.

#		Role of Interviewees	Experience	2. What is your impression of the logistics practices? (Kind of definition and understanding about the meaning).
23	**W**	Logistics manager	15 years	Almost all people working in the construction industry in the Middle East underestimate logistics and supply chain management and its related applications in construction. However, in the Middle East, we consider logistics and SCM for material monitoring and coordinating and we neglect logistics and SCM to integrate all resources.
25	**Y**	Contractor's representative	More than 18 years	As a project engineer, I understand that logistics has a significant role in dealing with planning and coordinating project resources. In the Middle East, construction contractors underestimate the effect of it. Moreover, they distribute the logistics functions among several staff to save some money instead of employing logistics officers.
26	**Z**	Project engineer	21 years	In my opinion, logistics and SCM is one of the main pillars of any construction project. For instance, logistics is responsible to plan and coordinate all resources required to run the construction processes smoothly. Unfortunately, Middle East, they do not believe in logistics. And they are dealing with it on a daily basis rather than considering it from a strategic level
27	**AA**	Senior office engineer	18 years	Almost all people working in the construction industry in the Middle East underestimate logistics and supply chain management and the related functions in construction. However, in the Middle East, we consider logistics and SCM for material coordination only and we neglect logistics and SCM for resources integration. We are considering logistics and SCM for material management only. And we neglect to employ it for resource management. This is due to a bad understanding of this knowledge.
28	**BB**	Project manager	8 years	Research in logistics and SCM within the construction industry in the Middle East receives little attention from the industry's stakeholders. Very little understanding from engineers, foremen, and managers is noticed frequently. They do not realise the functions of logistics and SCM and their application within construction. They regarded it for material monitoring only. And they do not use it to coordinate and integrate resources successfully.

#		Role of Interviewees	Experience	2. What is your impression of the logistics practices? (Kind of definition and understanding about the meaning).
29	**CC**	PhD in construction logistics	6 years	Logistics in the construction industry in the Middle East face very poor understanding. The stakeholders do not have sufficient knowledge of logistics and related practices. However local educational businesses do not equip student engineers with the science of logistics and supply chain management. And they do not include any material for this science and the related important practices. Still, we regarded logistics and SCM for material monitoring and coordinating only rather than integrating all resources.

#		Role of Interviewees	Experience	3. Have you worked as a part of the logistics in construction and how would you summarise your experience of logistics within construction projects?
1	**A**	Contractor's representative	More than 15 years	My responsibility is to monitor material delivery, and handling, and to be located at its final destination. Even to the construction sites or warehouses. I worked as a coordinator for construction materials that were delivered to construction sites for several subcontractors. However, coordination between subcontractors is very difficult as they do not order materil according to the construction schedules. and some of them order materials without complying with project rules.
2	**B**	Project manager	12 years	I used to work as a coordinator for material estimation and delivery. The difficulty I face is the poor construction staff and the bad coordination between stakeholders. The other issue is that project engineers order material without coordinating the delivery with the other contractors. So several times duplications occur.
3	**C**	Senior Site engineer	15 years	My job was to prepare the lists for suppliers and material providers. However preparing the lists means selecting suppliers based on service quality, product quality, and price. In most cases collecting this information takes a long time. And some of them give unrealistic data. So every project we face this challenge in preparing the lists for potential companies and people to work with. Still, this causes delays in some material as we rely on false information
4	**D**	Logistics manager	12 years	As a logistics manager; my role is to enhance delivering of resources at the right time, correct place, and with the required quality. For every construction project; I request the material and the resources list from the beginning of the project. But I see that estimating of resources receives little attention and is done by inexperienced staff. So we receive these lists after a prolonged time. Moreover, they missed several items.

#		Role of Interviewees	Experience	3. Have you worked as a part of the logistics in construction and how would you summarise your experience of logistics within construction projects?
5	**E**	Logistics manager	15 years	My experience in construction logistics is summarised as follows. Firstly, I request the required resources and materials from the engineering staff at the initial stages of the project. Secondly, I prepared a list of these resources along with the suppliers and material providers. Thirdly, we seek alternatives to achieve the best quality and prices. Finally, we monitor and coordinate deliveries. However, construction logistics activities and processes require commitment from all parties which is unavailable within the construction industry in the Middle East. For instance, each subcontractor orders their resources without coordinating them with us as a main contractor as they stated they get better prices. on the other hand, construction businesses are less concerned with resources returning and reversing processes due to the associated cost of the material return, including labour and transportation costs
6	**F**	Project manager	21 years	Part of my role is to coordinate material and resources to be available according to the project schedule. The difficulty I face is the weak in communication and coordination. For instance, they rely on each other to estimate material or to monitor material. They do not commit to their work, and they work unreliably. Moreover, several times; materials arrive at construction sites, and no one receives them. Logistics require commitment from all parties, and I could not handle all logistics alone. Logistics is a cycle. dealing with logistics as a minor part, not a major.

#		Role of Interviewees	Experience	3. Have you worked as a part of the logistics in construction and how would you summarise your experience of logistics within construction projects?
7	**G**	Contractor's representative	18 years	I used to work as a material monitor to be available at the right time. During my work in construction logistics, I realised several issues. Firstly, construction logistics is a crucial part of the construction project as it is directly related to the significant project budget. Moreover, it controls the project expenses if it is managed properly. This means that logistics functions are not related to specific staff. However, it is collaborative work and requires commitment from all staff. construction logistics is related to acquiring the required resources according to the project schedule at the right time with the required quality. However, in the Middle East application of logistics is still in its fancy stages and several stakeholders underestimate its effect.
8	**H**	Project engineer	10 years	My work focuses on quantity estimation and resource acquisition. My work should integrate with other engineers and suppliers to develop a real estimation. For instance, resource acquisition requires collaboration between me and the contractor's representatives as they have the authority to create the deals. In most cases, contractor representatives generate deals without understanding the resource specifications and the required quantities, leading to time and cost waste.
9	**I**	Senior office engineer	10 years	I worked on several construction projects and my role has a significant contribution to logistics. For instance, proper logistics starts with proper resource estimation. Unfortunately, construction contractors in the Middle East rely on juniors or inexperienced staff to do the estimation which generates wrong quotations and orders. On the other hand, proper logistics are related to proper coordination and integration between all stakeholders. And this rarely occurs in Middle East construction. This leads to several arrivals at the same time to construction sites and creates chaos and losses of workers' time.

#		Role of Interviewees	Experience	3. Have you worked as a part of the logistics in construction and how would you summarise your experience of logistics within construction projects?
10	**J**	Project manager	20 years	My role is to monitor that the logistics activities in construction projects run smoothly and do not disturb the construction activities. This means ensuring that all parties conduct their jobs following the project logistics plan. Logistics in construction are related to ensuring that the required materials and resources are available at the right time and cost and with the required quality. This means building a reliable logistics staff including a logistics coordinator, quality officer, and senior engineers. In the Middle East, most construction projects do not employ and create a logistic centre in their project. As a result, we noticed that several problems emerged, and these problems could be solved or eliminated if we pay attention to logistics.
11	**K**	PhD in construction management	More than 15 years	I used to work as a consultant for several construction projects in the Middle East to build the logistics plan. I noticed that we are creating a plan on paper only and the contractor does not comply with it. The reason for that is they are creating it as a requirement from the owner rather than using it effectively. In the Middle East, construction contractors have very little experience in logistics and related activities, and they underestimate the effect of it. Moreover, they do not realise that several problems they face could be solved by proper logistics management. However, they are relying on inexperienced and unqualified staff for logistics activities and dealing with logistics daily without any previous planning or coordinating.
12	**L**	Contractor's representative	13 years	It is my obligation to keep an eye on the handling and delivery of the material and to be present when it gets there. even to warehouses or construction sites. I coordinated the delivery of building supplies to construction sites for several subcontractors. However, because they do not order materials in accordance with the building timetables, coordination amongst subcontractors is exceedingly challenging. and some of them place material orders against the project's guidelines.

#		Role of Interviewees	Experience	3. Have you worked as a part of the logistics in construction and how would you summarise your experience of logistics within construction projects?
13	**M**	Project manager	10 years	I once served as a coordinator for material delivery and estimation. The challenges I encounter are poor construction personnel and inadequate stakeholder collaboration. The other problem is that project engineers place material orders without informing the other subcontractors about the delivery schedule. As a result, duplications have happened repeatedly.
14	**N**	Senior Site engineer	18 years	It was my responsibility to create the lists of material providers and suppliers. Making the lists; requires choosing suppliers based on pricing, product quality, and service quality. Most of the time, gathering this information takes a lot of time. Additionally, some of them provide false data. To overcome this difficulty, we must create lists of potential businesses and suppliers for each project. However, because we rely on inaccurate information, this delays several materials.

#		Role of Interviewees	Experience	3. Have you worked as a part of the logistics in construction and how would you summarise your experience of logistics within construction projects?
15	**O**	Logistics manager	8 years	As a logistics manager, it is my responsibility to improve resource delivery at the appropriate time, location, and quality. I always ask for a materials and resources list at the beginning of every building project. However, I observe that staff members without much expertise pay little attention to resource estimation. So, it takes a while before we get these lists. They also missed several things including specifications and quantities.
16	**P**	Logistics manager	11 years	Here is a summary of my construction logistics experience. At the beginning of the project, I first ask the engineering staff for the necessary materials and resources. Second, I made a list of these resources, including the vendors and material providers. Thirdly, we look for alternatives to get the best pricing and quality. Finally, we keep track of and plan deliveries. However, this kind of activity necessitates a commitment from all sides, which is lacking in the Middle East's construction sector. For instance, because they claim to acquire lower costs, each subcontractor orders their resources independently from the main contractor.
17	**Q**	Project manager	17 years	Coordinating materials and resources so they are available following the project timeline is a part of my job. The challenge I experience is my lack of coordination and communication. For example, contractor or subcontractor staff depend on each other to monitor or estimate the material. They are unreliable in their work and do not commit to it. Additionally, material has frequently arrived at building sites without being picked up. All parties must be committed to logistics; thus I could not manage them all on my own. Due to the cycle of logistics. handling logistics as a small, not primary, aspect.

#		Role of Interviewees	Experience	3. Have you worked as a part of the logistics in construction and how would you summarise your experience of logistics within construction projects?
18	**R**	Contractor's representative	8 years	To be available when needed, I previously worked as a material monitor. While working in construction logistics, I became aware of a number of problems. First, because it directly affects the enormous project budget, construction logistics are a critical component of any building project. Furthermore, if handled effectively, it limits project expenses. This indicates that logistics tasks are not associated with a particular staff member. But because it involves teamwork, everyone on staff must be committed. Construction logistics is concerned with obtaining the necessary materials in accordance with the project schedule at the appropriate time and with the necessary quality. However, the use of logistics in the Middle East is still in its early stages, and many parties are underestimating its impact.
19	**S**	Supplier of construction material and Previous owner of a construction owner	20 years	Quantity estimate and delivery are the main topics of my work. To create a realistic outcome, my work should be integrated with that of other engineers and vendors. For instance, since they have the power to make the deals, resource acquisition necessitates cooperation between me and the contractor's representatives. The majority of the time, contractor reps generate transactions without being aware of the material requirements and necessary amounts, resulting in time and money waste.
20	**T**	Supplier of construction material and owner of Block factory	25 years	I participated in a number of construction projects, and my efforts had a big impact on logistics. For instance, accurate resource estimation is the first step in proper logistics. Unfortunately, Palestinian construction companies rely on unskilled or junior workers to perform the estimation, which results in inaccurate quotes and orders. On the other hand, effective coordination and integration between all stakeholders are necessary for effective logistics. And in the Middle East building, this is uncommon. This causes time waste and delays for the employees by causing multiple resources to arrive at building sites at once.

#		Role of Interviewees	Experience	3. Have you worked as a part of the logistics in construction and how would you summarise your experience of logistics within construction projects?
21	**J**	Masters in construction management	12 years	I served as a logistics consultant for several numbers of building projects in the Middle East. I saw that the contractor is not following the strategy we are merely developing on paper. That's because they're making it as a request from the owner rather than to use it well. Construction companies in the Middle East have relatively little expertise with logistics and related tasks and often undervalue their impact. Additionally, they are unaware that effective logistics management could help them resolve some issues. However, they are dealing with logistics on a daily basis without any prior planning or organising and relying on untrained and unqualified people for those duties.
22	**V**	Logistics manager	12 years	My experience in construction logistics is summarised as follows. Firstly, I request the required resources and materials from the engineering staff at the initial stages of the project. Secondly, I prepared a list of these resources along with the suppliers and material providers. Thirdly, we seek alternatives to achieve the best quality and prices. Finally, we monitor and coordinate deliveries. However, this type of work requires commitment from all parties which is unavailable within the construction industry in the Middle East. For instance, each subcontractor orders their resources without coordinating them with us as a main contractor as they stated they get better prices.
23	**W**	Logistics manager	15 years	Part of my role is to coordinate materials and resources to be available according to the project schedule. several construction projects in the Middle East face difficulties due to weak communication and coordination. For instance, they rely on each other to estimate materials or to monitor materials. They do not commit to their work, and they work unreliably. Moreover, several times; materials arrive at construction sites and no one receives them. Logistics require commitment from all parties, and I could not handle all logistics alone. Logistics is a cycle. dealing with logistics as a minor part, not a major.

#		Role of Interviewees	Experience	3. Have you worked as a part of the logistics in construction and how would you summarise your experience of logistics within construction projects?
24	**X**	Project manager	12 years	I used to work as a material monitor to be available at the right time. During my work in construction logistics, I realised several issues. Firstly, construction logistics is a crucial part of the construction project as it is directly related to the significant project budget. Moreover, it controls the project expenses if it is managed properly. This means that logistics functions are not associated with specific staff. However, it is collaborative work and requires commitment from all staff. Construction logistics is related to acquiring the required resources according to the project schedule at the right time with the required quality. However, in the Middle East, the application of logistics is still in its initial stages and several stakeholders underestimate its effect.
25	**Y**	Contractor's representative	More than 18 years	My work focuses on quantity estimation and resource acquisition. My work should integrate with other engineers and suppliers to develop a real estimation. For instance, resource acquisition requires collaboration between me and the contractor's representatives as they have the authority to create the deals. In most cases, contractor representatives generate deals without understanding the resource specifications and the required quantities, leading to time and cost waste.
26	**Z**	Project engineer	21 years	I worked on several construction projects and my role has a significant contribution to logistics. For instance, proper logistics starts with proper resource estimation. Unfortunately, construction contractors in the Middle East rely on juniors or inexperienced staff to do the estimation which generates wrong quotations and orders. On the other hand, proper logistics are related to proper coordination and integration between all stakeholders. And this rarely occurs in Middle East construction. This leads to several arrivals at the same time to construction sites and creates chaos and losses of workers' time.

#		Role of Interviewees	Experience	3. Have you worked as a part of the logistics in construction and how would you summarise your experience of logistics within construction projects?
27	**AA**	Senior office engineer	18 years	My role is to monitor that the logistics activities in construction projects run smoothly and do not disturb the construction activities. This means ensuring that all parties conduct their jobs following the project logistics plan. Logistics in construction are related to ensuring that the required materials and resources are available at the right time and cost and with the required quality. This means building a reliable logistics staff including a logistics coordinator, quality officer, and senior engineers. In the Middle East, most construction projects do not employ and create a logistic centre in their project. As a result, we noticed that several problems emerged, and these problems could be solved or eliminated if we pay attention to logistics.
28	**BB**	Project manager	8 years	I used to work as a consultant for several construction projects in the Middle East to build the logistics plan. I noticed that we are creating a plan on paper only and the contractor does not comply with it. The reason for that is they are creating it as a requirement from the owner rather than using it effectively. In the Middle East, construction contractors have very little experience in logistics and related activities and they underestimate the effect of it. Moreover, they do not realise that several problems they face could be solved by proper logistics management. However, they are relying on inexperienced and unqualified staff for logistics activities and dealing with logistics on a daily basis without any previous planning or coordinating.
29	**CC**	PhD in construction logistics	6 years	It is my obligation to keep an eye on the handling and delivery of the material and to be present when it gets there. even to warehouses or construction sites. I coordinated the delivery of building supplies to construction sites for several subcontractors. However, because they do not order materials in accordance with the building timetables, coordination amongst subcontractors is exceedingly challenging. and some of them place material orders against the project's guidelines.

#		Role of Interviewees	Experience	4. What are the major logistics problems and challenges you have dealt with in the construction industry?
1	**A**	Contractor's representative	More than 15 years	Several challenges are noticed in construction logistics. These challenges include. Lack of experience and knowledge, Poor Planning, monitoring, and control, Undetailed and inappropriate design drawings or specifications, Unclear responsibilities, Inappropriate methods for material storage and handling, Fluctuation of material prices and quantities in the market, and the use of improper types of vehicles used in transportation. Additionally, the practice of inventory management seems to be weak with unreliable practices. Several contractors rely on weak people to manage inventory resulting in poor availability of qualified materials and resources.
2	**B**	Project manager	12 years	Bad planning for material and resources routing, Poor plans and practices for the management of surplus material, Improper types of vehicles used in transportation, Lack of experience and knowledge, lack of management commitment, Poor work plans, limited budget for logistics and SCM, employing poor staff.
3	**C**	Senior Site engineer	15 years	Undetailed and inappropriate design drawings or specifications, no integration with suppliers and material providers, poor information sharing among parties, Unclear responsibilities, duplications and errors caused by excessive paperwork, unreliable practices, and the use of inappropriate methods for material storage and handling.
4	**D**	Logistics manager	12 years	We face several challenges affecting construction performance. And these challenges are related to inefficient logistics practices. This includes Lack of experience, Undetailed and inappropriate design drawings or specifications, Unclear responsibilities, Slowness in making decisions, and Improper types of vehicles used in transportation.

#		Role of Interviewees	Experience	4. What are the major logistics problems and challenges you have dealt with in the construction industry?
5	**E**	Logistics manager	15 years	The major challenges we face can be summarised as follows. Poor planning for logistics, A poor tracking system, improper types of vehicles used in transportation, bad planning for routing, poor practices for the management of surplus material, delivering the wrong material, and fluctuation of material quantities and prices in the market.
6	**F**	Project manager	21 years	Construction logistics major challenges in the Middle East are. Lack of experience, poor planning, monitoring, and control, neglect to employ logistic staff, implementation of poor work plans, and Lack of supervision. Undetailed and inappropriate design drawings or specifications No integration with suppliers, poor coordination and information transfer, unclear responsibilities, and delay in making decisions. And poor commitment from the top management.
7	**G**	Contractor's representative	18 years	In my opinion, the major logistics challenge within construction in the Middle East is the lack of knowledge and understanding. However, as a contractor's representative, I notice several challenges that contribute to productivity losses and cost overruns. These challenges are also related to inefficient or contribute to inefficient logistics practices such as poor construction plans, undetailed and inappropriate design drawings or specifications, unclear responsibilities, inappropriate methods for material storage and handling, and late delivery due to the use of improper and old vehicles in transportation.
8	**H**	Project engineer	10 years	As a project engineer logistics challenges vary from office challenges to site challenges. For instance, office challenges include poor and inappropriate design drawings or specifications, lack of experience, bad planning for material, and wrong estimation of resources. Site challenges include using inappropriate methods for material storage and handling, Bad site layout, no plans for the management of surplus material, and the work done separately as no coordination and integration occurs between subcontractors. However, these challenges affect labourers' productivity and project costs adversely.

#		Role of Interviewees	Experience	4. What are the major logistics problems and challenges you have dealt with in the construction industry?
9	**I**	Senior office engineer	10 years	I experienced several logistics challenges that affected productivity and project coat. These challenges include. bad and un-detailed design drawings and specifications, Poor integration with suppliers and material providers, weak information sharing between stakeholders, unclear responsibilities, duplications and errors caused by excessive paperwork, unreliable practices, and the use of inappropriate methods for material storage and handling, Improper types of vehicles used in transportation, and poor monitoring.
10	**J**	Project manager	20 years	Construction in the Middle East faces numerous logistics challenges that affect its performance and cause cost overruns. These challenges can be summarised as follows. relying on undetailed and inappropriate design drawings or specifications, unclear responsibilities, inappropriate methods for material storage and handling, late delivery due to the use of improper types of vehicles used in transportation, bad planning for routing, poor practices for the management of surplus material, delivering the wrong material due to poor quality checks, sever fluctuation of material in the market due to weak agreement, and forming agreement based on negotiation, not collaboration. Finally employing inexperienced or unqualified staff to handle logistics functions.
11	**K**	PhD in construction management	More than 15 years	I conducted several site visits for construction projects in the Middle East to identify the logistics challenges that affect the performance. During my visits, I noticed several challenges that are related to logistics practices. These challenges are undetailed and inappropriate design drawings or specifications, unclear responsibilities, duplications and errors caused by excessive paperwork, unreliable practices, poor commitment from the top management, lack of experience, delay in making decisions, Fluctuation of material in the market, lack of experience and knowledge, Poor Planning, monitoring, and control, the use of improper types of vehicles used in transportation, and finally, they are considering logistics as a minor part including not considering it as a primary function to improve the performance and reduce costs.

#		Role of Interviewees	Experience	4. What are the major logistics problems and challenges you have dealt with in the construction industry?
12	**L**	Contractor's representative	13 years	Construction logistics face many obstacles. These difficulties include. Lack of experience and knowledge, poor planning, monitoring, and control, inadequate design drawings or specifications, unclear roles, improper methods for material storage and handling, fluctuating material prices and quantities in the market, and the use of the wrong kinds of vehicles are all to blame. Finally, the unstable political situation affects the availability of resources.
13	**M**	Project manager	10 years	Inadequate material and resource planning inadequate strategies and procedures for managing extra materials, incorrectly designed transportation vehicles, lacking management commitment, lack of expertise and knowledge, inadequate logistics and SCM budgets, bad hiring practices, and poor work planning. finally, the theft.
14	**N**	Senior Site engineer	18 years	Lack of integration with suppliers and material providers, poor information sharing among parties, unclear responsibilities, duplications and errors brought on by excessive paperwork, unreliable practices, and the use of improper techniques for material storage and handling are all examples of inadequately detailed and inappropriate design drawings or specifications.
15	**O**	Logistics manager	8 years	Various issues have an impact on construction efficiency. Furthermore, ineffective logistical methods contribute to these difficulties. This includes a lack of experience, inadequately detailed or acceptable design drawings or specifications, a sudden labour shortage, a lack of clarity on roles and duties, a slow decision-making process, and the usage of the wrong kinds of transportation equipment.
16	**P**	Logistics manager	11 years	The main difficulties we encounter can be summed up as follows. Poor logistics planning, a poor tracking system, inappropriate vehicle types for transportation, inadequate routing planning, poor methods for managing surplus goods, delivering the incorrect item, and market fluctuations in material quantities and costs.

#		Role of Interviewees	Experience	4. What are the major logistics problems and challenges you have dealt with in the construction industry?
17	**Q**	Project manager	17 years	The main logistical issues in the Middle East are construction. Lack of experience, inadequate planning, monitoring, and control, a failure to hire logisticians, the execution of subpar work plans, inadequate oversight inadequate or insufficiently comprehensive design drawings or specifications Lack of integration with suppliers, ineffective coordination and information sharing, ambiguous responsibility assignments, and decision-making delays. And a lack of dedication from the upper executives.
18	**R**	Contractor's representative	8 years	The lack of knowledge and understanding, in my opinion, is the main logistical problem in building in the Middle East. However, from my perspective as a contractor's representative, I have observed a number of issues that result in decreased productivity and cost overruns. These difficulties are also connected to or contribute to ineffective logistics practices, such as inadequate construction plans, inadequately detailed and inappropriate design drawings or specifications, unclear roles, ineffective techniques for handling and storing materials, and delayed deliveries because of the use of the wrong kinds of vehicles.
19	**S**	Supplier of construction material and Previous owner of a construction owner	20 years	We face a variety of logistical difficulties. For example, the problems can include inadequate and improper design drawings or requirements, a lack of knowledge, poor material estimation, and inaccurate material assessment. The inability of subcontractors to coordinate and integrate their work results in the use of improper methods for material handling and storage, a poor site layout, insufficient planning for the management of excess material, and work that is completed separately. However, these difficulties harm project costs and worker productivity.

#		Role of Interviewees	Experience	4. What are the major logistics problems and challenges you have dealt with in the construction industry?
20	**T**	Supplier of construction material and owner of Block factory	25 years	I faced a number of logistical difficulties that had an impact on my output and project quality. These difficulties include. Unreliable practices, the use of inappropriate methods for material storage and handling, bad and inadequately detailed design drawings and specifications, poor integration with suppliers and material providers, weak information sharing between stakeholders, unclear responsibilities, duplications and errors brought on by excessive paperwork, unreliable practices, and improper types of vehicles used for transportation, and poor monitoring.
21	**J**	Master's in construction management	12 years	I made numerous site visits for building projects in the Middle East to find the logistical issues affecting the performance. During my visits, I identified a number of logistical practice-related difficulties. These difficulties include inadequately detailed or inappropriate design drawings or specifications, unclear roles, errors brought on by excessive paperwork, unreliable procedures, a lack of commitment from top management, a delay in decision-making, fluctuation in the price of materials, inadequate planning, monitoring, and control, and finally, the use of the wrong kinds of transportation vehicles.
22	**V**	Logistics manager	12 years	The major challenges we face can be summarised as follows. Poor planning for logistics, A poor tracking system, and improper types of vehicles used in transportation are among the primary challenges, improper types of vehicles used in transportation, bad planning for routing, poor practices for the management of surplus material, delivering the material, and fluctuation of material quantities and prices in the market.
23	**W**	Logistics manager	15 years	Construction logistics major challenges in the Middle East are. Lack of experience, poor planning, monitoring, and control, neglect to employ logistic staff, implementation of poor work plans, and Lack of supervision. Undetailed and inappropriate design drawings or specifications No integration with suppliers, poor coordination and information transfer, unclear responsibilities, and delay in making decisions. And poor commitment from the top management.

#		Role of Interviewees	Experience	4. What are the major logistics problems and challenges you have dealt with in the construction industry?
24	**X**	Project manager	12 years	In my opinion, the major logistics challenge within construction in the Middle East is the lack of knowledge and understanding. However, as a contractor's representative, I notice several challenges that contribute to poor efficiency and cost overruns. These challenges are also related to inefficient or contribute to inefficient logistics practices such as poor construction plans, undetailed and inappropriate design drawings or specifications, unclear responsibilities, inappropriate methods for material storage and handling, and late delivery due to the use of improper types of vehicles used in transportation.
25	**Y**	Contractor's representative	More than 18 years	As a project engineer logistics challenges vary from office challenges to site challenges. For instance, office challenges include poor and inappropriate design drawings or specifications, lack of experience, bad planning for material, and wrong estimation of resources. Site challenges include using inappropriate methods for material storage and handling, Bad site layout, no plans for the management of surplus material, and the work done separately as no coordination and integration occurs between subcontractors. However, these challenges affect labourers' performance and project costs adversely.

#		Role of Interviewees	Experience	4. What are the major logistics problems and challenges you have dealt with in the construction industry?
26	**Z**	Project engineer	21 years	I experienced several logistics challenges that affected performance and project coat. These challenges include. Bad and un-detailed design drawings and specifications, Poor integration with suppliers and material providers, weak information sharing between stakeholders, unclear responsibilities, duplications and errors caused by excessive paperwork, unreliable practices, and the use of inappropriate methods for material storage and handling, Improper types of vehicles used in transportation, and poor monitoring.
27	**AA**	Senior office engineer	18 years	Construction in the Middle East faces numerous logistics challenges that affect its performance and productivity and cause cost overruns. These challenges can be summarised as follows. Relying on undetailed and inappropriate design drawings or specifications, unclear responsibilities, inappropriate methods for material storage and handling, late delivery due to the use of improper types of vehicles used in transportation, bad planning for routing, poor practices for the management of surplus material, delivering the wrong material, fluctuation of material in the market, and employing inexperienced or unqualified staff to handle logistics functions.
28	**BB**	Project manager	8 years	I conducted several site visits for construction projects in the Middle East to identify the logistics challenges that affect the performance. During my visits, I noticed several challenges that are related to logistics practices. These challenges are undetailed and inappropriate design drawings or specifications, unclear responsibilities, duplications and errors caused by excessive paperwork, unreliable practices, poor commitment from the top management, lack of experience, delay in making decisions, Fluctuation of material in the market, lack of experience and knowledge, Poor Planning, monitoring, and control, the use of improper types of vehicles used in transportation, and finally, they are considering logistics as a minor part including not considering it as a primary function to improve the performance and reduce costs.

#		Role of Interviewees	Experience	4. What are the major logistics problems and challenges you have dealt with in the construction industry?
29	**CC**	PhD in construction logistics	6 years	Construction logistics face a number of obstacles. These difficulties include. Lack of experience and knowledge, poor planning, monitoring, and control, inadequate design drawings or specifications, unclear roles, improper methods for material storage and handling, fluctuating material prices and quantities in the market, and the use of the wrong kinds of transportation vehicles are all to blame. Finally, the unstable political situation affects the availability of resources.

#		Role of Interviewees	Experience	5. In your opinion what are the root causes and consequences for each one of these challenges? And what are the effects of these challenges on sustainability due to poor logistics practices?
1	**A**	Contractor's representative	More than 15 years	We face significant productivity losses and cost overruns due to inefficient logistics practices. However, in my opinion, the main causes for inefficient logistics practices are unreliable practices, poor management commitment, and not considering logistics as a primary part of the construction activity. For instance, we are solving logistics problems on a daily basis. And not proposing any budget for logistics activities. Moreover, we do not employ logistics officers and experts to handle logistics and SCM activities. We are relying on junior and low-knowledge or inexperienced people. In addition, in more cases, each subcontractor manages their logistics alone. creates several problems with the other subcontractors. and this affects our productivity through waiting due to a lack of workers and materials and disruptions of the process
2	**B**	Project manager	12 years	The main cause of these logistics challenges is that the stakeholders do not realise the effect of logistics on the project cost. For instance, they do not understand what logistics is and its potential and contribution. They underestimate its value and what can do. in addition, poor management commitment and lack of knowledge are other reasons. Moreover, the education system in the Middle East does not teach engineering students any courses related to the application of logistics and SCM in BA or MSC as they are focusing on project management and the related functions and neglecting SCM. As a result, we are facing huge productivity losses in terms of material and resource availability such as information, equipment and labour and cost overruns and delays due to these reasons.

#		Role of Interviewees	Experience	5. In your opinion what are the root causes and consequences for each one of these challenges? And what are the effects of these challenges on sustainability due to poor logistics practices?
3	**C**	Senior Site engineer	15 years	During my work, I try to investigate the reasons for the inefficient logistics practices. However, I realise that a poor understanding of logistics and SCM and its application in the construction industry is the main reason for these challenges. In addition, poor management commitment and low budget could be considered second-degree reasons. Most construction contractors in the Middle East that I work with do not employ any logistics staff to handle the logistics function. They claim that this function is not a primary function and that each one of the subcontractors and their staff could handle their logistics separately. However, this leads to disorder in the construction sites in terms of resource estimation and delivery. As a result, this leads to cost overruns and delays in terms of material and labour availability.
4	**D**	Logistics manager	12 years	I worked only on a huge-funded construction project in the Middle East. The reason for this is that employing a logistics staff was an owner requirement rather than a contractor commitment. So, most construction projects do not employ logistics offices as contractors claim to save costs. But this is truly false as they face huge productivity losses and delays due to neglecting logistics functions and roles. In the Middle East construction contractors still do not realise logistics and SCM and their contribution to saving time and cost. Students studying construction management and civil engineering do not learn any course about the application and the role of logistics and SCM in construction. So, in my opinion, lack of knowledge poor understanding, and underestimating logistics are the main reasons. We face several adverse effects of inefficient logistics practices that reduce productivity in terms of material loss and labour availability appropriately.

#		Role of Interviewees	Experience	5. In your opinion what are the root causes and consequences for each one of these challenges? And what are the effects of these challenges on sustainability due to poor logistics practices?
5	**E**	Logistics manager	15 years	Considering logistics as a minor part of the construction activities and processes is the cause for the identified challenges. In our construction project, we face severe adverse consequences including delays, waiting of workers, and project cost overruns. From my perspective, I noticed that a lack of knowledge and experience in construction logistics plays a major role in creating logistics challenges. Moreover, several construction contractors in the Middle East deal with logistics daily not creating or generating logistics plans as the construction activities plan. As a result, we are facing significant productivity losses in terms of the availability of the required resources for the construction activities such as materials.
6	**F**	Project manager	21 years	In my opinion, the main cause of these logistics challenges is poor top management commitment to employ logistics properly including assigning logistics-experienced people to conduct logistics functions. On the other hand, several stakeholders do not realise the effect of logistics on the project cost. For instance, they do not understand what logistics is and its potential and contribution. They underestimate its value and what can do. On the other hand, the education system in the Middle East does not offer logistics and SCM courses for engineering students as they conduct the logistics function later. As a result, we are facing huge productivity losses and delays which contribute to project cost overruns. However, Productivity loss occurs due to the unavailability of labour, information, and equipment. Furthermore, several processes do not start due to logistics challenges with the predecessors' activities.

#		Role of Interviewees	Experience	5. In your opinion what are the root causes and consequences for each one of these challenges? And what are the effects of these challenges on sustainability due to poor logistics practices?
7	**G**	Contractor's representative	18 years	As a contractor working in the Middle East environment, we are facing a significant deficiency in logistics staff. This includes logistics experts, logistics officers, and procurement experts. In most cases, we are relying on weak or inexperienced people to conduct the logistics function due to these deficiencies. On the other hand, in most cases, we outsource the main parts of the construction project to subcontractors. However, subcontractors in the Middle East have a very limited budget to employ logistics officers. The other cause is that the construction industry in the Middle East is still in its fancy stages in terms of project type. For instance, most construction projects in the Middle East are regarded as small with very limited activities and resources compared to other countries. So, construction contractors still manage their work in a traditional method while neglecting logistics knowledge. But still many construction projects in the Middle East face delays and cost overruns due to inefficient logistics practices this includes waiting due to labour availability, information sufficiency, and equipment utilisation.
8	**H**	Project engineer	10 years	I worked on several construction projects in the Middle East, and I noticed that the main reason for the logistics challenge was neglecting to employ expert staff to handle the logistics activities. For instance, construction contractors in the Middle East rely on engineering staff to handle logistics functions rather than employing logistics officers to save costs. Several times I asked the contractor about this issue they said that the project budget was limited, and we would not be able to employ any additional people. However, they do not realise the effect of logistics on efficiency and cost savings. They are dealing with logistics as a minor and secondary part with poor planning and this is the problem. In my perspective, a successful construction manager thinks and plans firstly for logistics by considering the best availability of material, labour and equipment and integrating logistics with construction processes.

#		Role of Interviewees	Experience	5. In your opinion what are the root causes and consequences for each one of these challenges? And what are the effects of these challenges on sustainability due to poor logistics practices?
9	**I**	Senior office engineer	10 years	During my work in the construction industry in the Middle East, I realised that the construction contractors still do not understand or realise logistics and SCM in construction and how to apply it towards successful performance. They are relying on weak or inexperienced people to handle logistics activities. Thus, facing delays and extra costs. On the other hand, they underestimate the effect of logistics and SCM on performance. As they are dealing with it without any planning or real attention. Moreover, they do not specify any budget for logistics compared to other functions such as management function. However, I think logistics challenges cause productivity losses as materials and resources are unavailable properly with quantities and qualities. Improving logistics within the construction industry in the Middle East would be achieved through the proper employment of logistics officers and experts as a main part.
10	**J**	Project manager	20 years	A very limited budget is the excuse that most construction contractors in the Middle East that I work with; always said about not employing logistics officers. Neglecting logistics and its related functions and dealing with it as a minor part of the construction activities generate most of the identified challenges. Logistics in construction from my perspective is a very essential part and neglecting it contributes to delays, losses, and cost overruns. So poor top management commitment and less understanding of the effect of logistics seem the main causes. On the other hand, logistics in construction in the Middle East do not receive much attention as project management. For instance, most construction projects create schedules for construction activities, but they do not create any logistics plan for the required resources that need to be available at a specific time. So poor planning for resource acquisition is the other reason for delays and troubles. Due to the identified logistics challenges we are facing huge productivity losses in terms of material and resource availability such as workers, information, data, equipment and labour.

#		Role of Interviewees	Experience	5. In your opinion what are the root causes and consequences for each one of these challenges? And what are the effects of these challenges on sustainability due to poor logistics practices?
11	**K**	PhD in construction management	More than 15 years	I think that the main reason for the inefficient logistics practice within construction is two reasons. The first is that the stakeholders have poor knowledge and experience of logistics and SCM including its functions and benefits. Secondly, managers and owners of construction companies do not support the implementation of proper logistics practices as they still do not consider logistics as a primary part of their work. Construction contractors in the Middle East underestimate logistics and how to conduct their processes carefully. For instance, they handle logistics unreliably and they rely on inexperienced people to do logistics activities rather than employing logistics experts. On the other hand, they focus on project management and do not pay much attention to logistics and how to use it to support their work. For instance, they create schedules for construction activities and do not create schedules or plans for resources. Thus, no integration exists between logistics and construction. As a result, they face severe productivity losses due to poor availability of materil and labour. Additionally, logistics challenges affect the payment to be at the right time which affects the payment to workers and prevents them from being at the right time to do their work.

#		Role of Interviewees	Experience	5. In your opinion what are the root causes and consequences for each one of these challenges? And what are the effects of these challenges on sustainability due to poor logistics practices?
12	**L**	Contractor's representative	13 years	Because of ineffective logistical procedures, we are experiencing severe productivity losses and cost overruns. However, I believe that unreliable practices, a lack of managerial commitment, and a failure to view logistics as a crucial component of the building activity are the main causes of inefficient logistics practices. For instance, we deal with logistics issues every day. Neither is any budget for logistics-related operations proposed. Additionally, we do not hire officers and specialists in logistics to manage logistics and SCM activities. We rely on young, unskilled, or inexperienced individuals. Additionally, it happens more frequently that each subcontractor handles their logistics. which causes several issues with the other subcontractors. I noticed several construction projects in the Middle East face severe productivity losses and cost overruns due to inefficient logistics practices this is related to waiting due to poor availability of labour, information, and equipment and payments to resources.
13	**M**	Project manager	10 years	The main reason for these logistical issues is that the project's stakeholders are unaware of how logistics affect project costs. For instance, they are unaware of the potential and significance of logistics. They undervalue it and what it is capable of. Other factors include inadequate management commitment and ignorance. Furthermore, because the education system in the Middle East places more emphasis on project management and related roles than SCM, it does not provide engineering students with any courses in the application of logistics and SCM. Due to these factors, we are currently experiencing significant productivity losses, cost overruns, and delays. For instance, we experience losses in labour numbers in the required time and equipment utilisation due to logistics inefficiency. Furthermore, logistics challenges cause bad availability of material.

#		Role of Interviewees	Experience	5. In your opinion what are the root causes and consequences for each one of these challenges? And what are the effects of these challenges on sustainability due to poor logistics practices?
14	**N**	Senior Site engineer	18 years	I try to look into the causes of ineffective logistical practices while at work. However, I now see that the fundamental cause of these difficulties is a lack of knowledge about logistics, SCM, and its use in the construction sector. Poor management commitment and a small budget may also be regarded as second-degree causes. The majority of the Palestinian construction companies I work with don't have any staff dedicated to handling logistics. They contend that this is not a fundamental role and that the staff of each subcontractor could manage the logistics on their own. However, in terms of resource estimation and delivery, this causes chaos on the construction sites. This causes delays and cost overruns as a result. Another issue causing the inefficiency is the unstable conditions in the Middle East that cause unstable materil and resource flow. However, this is associated with poor security for construction sites. Logistics inefficient practices affect productivity through waiting due to a lack of labour, equipment, materials and disruptions of the process
15	**O**	Logistics manager	8 years	I only contributed to a massively funded building project in the Middle East. The reason for this is that hiring logistics personnel was a necessity of the owner rather than a commitment made by the contractor. To save money, contractors claim that the majority of building projects do not use logistics offices. However, they experience significant productivity losses and delays as a result of ignoring logistics responsibilities and functions, therefore this is untrue. Construction workers in the Middle East are still unaware of the role that SCM and logistics play in time and money savings. The use of logistics and SCM in construction is not covered in any courses for students studying construction management or civil engineering. Therefore, in my opinion, the primary causes are a lack of information, a lack of comprehension, and an underestimate of logistics. Thus, logistics challenges lead to poor availability of materials and poor utilisation of tools and equipment. Additionally, information exchange become insufficient.

#		Role of Interviewees	Experience	5. In your opinion what are the root causes and consequences for each one of these challenges? And what are the effects of these challenges on sustainability due to poor logistics practices?
16	**P**	Logistics manager	11 years	The root of the problem is that logistics is undervalued in the construction processes and activities. We see severe negative outcomes in our construction project, such as delays, worker waiting times, and cost overruns. According to my observations, a significant factor in the development of logistical difficulties is a lack of expertise and experience in construction logistics. Furthermore, many building contractors in the Middle East deal with logistics on a daily basis without developing or producing logistics plans in conjunction with the schedule of construction activities. logistics challenges we are facing affect productivity adversely as material and resources would not be available according to time and quality. Furthermore, processes are not initiated according to schedules as they are stuck due to logistics issues.
17	**Q**	Project manager	17 years	I believe that weak top management commitment to efficiently using logistics, especially delegating logistics-experienced individuals to carry out logistics responsibilities, is the primary cause of these logistical issues. On the other hand, several stakeholders are unaware of how logistics affect project costs. For instance, they are unaware of the potential and significance of logistics. They undervalue it and what it is capable of. On the other hand, as engineers perform the logistics function later, the education system in the Middle East does not provide engineering students training in SCM or logistics. As a result, we are experiencing significant delays and productivity losses, which add to project cost overruns. Productivity is reduced as material and other resources are poorly managed and not available for construction activities properly. This includes also poor information exchange.

#		Role of Interviewees	Experience	5. In your opinion what are the root causes and consequences for each one of these challenges? And what are the effects of these challenges on sustainability due to poor logistics practices?
18	**R**	Contractor's representative	8 years	We face a serious shortage of logistics personnel as a contractor operating in the Middle East region. This includes procurement specialists as well as logistics professionals and officers. Due to these shortcomings, we frequently rely on unreliable or inexperienced individuals to handle the logistical role. On the other hand, we typically hire subcontractors to do the bulk of the construction project. However, the Middle East's subcontractors have very little money to spend on hiring logistics personnel. The other reason is that the Middle East's building market is still developing in terms of project types. For instance, the majority of construction projects in the Middle East are viewed as minor in comparison to those in other nations, with very few activities and resources. Thus, this is why logistics inefficiency adversely affects productivity and causes cost overruns. This includes poor management of labour and materials to be at the right time with the required quality. And to make sure that payment occurred according to cash flow.
19	**S**	Supplier of construction material and Previous owner of a construction owner	20 years	In the Middle East, where I worked on several building projects, I observed that the main cause of the logistics problem was a failure to hire qualified employees to manage the logistical activities. For instance, to cut expenses, Palestinian building contractors use engineering staff to do logistics tasks rather than hiring logistics officers. I questioned the contractor about this a number of times, and each time they said that the project's budget was constrained and that hiring any more workers was out of the budget. They are unaware of how logistics affect productivity and cost-cutting. The issue is that they are only dealing with a small portion of logistics. A competent construction manager, in my opinion, considers and plans for logistics first. in the Middle East Logistics inefficient practices affect productivity hugely as labour is forced to wait due to a lack of workers, information, equipment, and materials. Additionally, several construction activities are disrupted due to inefficient logistics.

#		Role of Interviewees	Experience	5. In your opinion what are the root causes and consequences for each one of these challenges? And what are the effects of these challenges on sustainability due to poor logistics practices?
20	**T**	Supplier of construction material and owner of Block factory	25 years	During my working time in the Middle East's construction sector, I learned that the industry's contractors still don't fully grasp the role of logistics and SCM in building or how to apply them to successful performance. To manage logistics tasks, they are relying on unreliable or unskilled individuals. resulting in a delay and additional costs. On the other hand, they grossly underrate how SCM and logistics affect performance. Since they are handling things without paying any attention. In contrast to other functions like management, they do not provide a budget for logistics. However, I believe that by properly utilising logistics officers and project managers, considerable issues in terms of productivity losses and cost overruns within the building industry in the Middle East would be reduced. Still, logistics challenges lead to productivity losses within construction due to poor availability of materials and poor utilisation of workers' tools and equipment.
21	**J**	Master's in construction management	12 years	I believe there are several key causes for ineffective logistics practices in the building industry. The first is that the stakeholders' understanding of logistics and SCM, particularly its features and advantages, is limited. Second, since they still do not view logistics as a major aspect of their jobs, managers and owners of construction enterprises do not promote the adoption of effective logistics practices. Palestinian builders undervalue logistics and the need to carefully manage their processes. For instance, rather than hiring logistics experts, they handle logistics in an unreliable manner and rely on untrained individuals to complete logistics tasks. On the other hand, they put a lot of emphasis on project management and pay little attention to how to leverage logistics to support their performance. Due to logistics challenges and inefficient practices, we are currently facing significant productivity loss and delays in several construction projects. This is due to lake of workers, materials, tools, and equipment to be available according to project timelines and schedules.

#		Role of Interviewees	Experience	5. In your opinion what are the root causes and consequences for each one of these challenges? And what are the effects of these challenges on sustainability due to poor logistics practices?
22	**V**	Logistics manager	12 years	Considering logistics as a minor part of the construction activities and processes is the cause for the identified challenges. In our construction project, we face severe adverse consequences including delays, waiting of workers, and project cost overruns. From my perspective, I noticed that a lack of knowledge and experience in construction logistics plays a major role in creating logistics challenges. Moreover, several construction contractors in the Middle East deal with logistics on a daily basis not creating or generating logistics plans as the construction activities plan. As a result, we are facing significant productivity losses in terms of the availability of the required resources for the construction activities such as material, information, equipment and labour.
23	**W**	Logistics manager	15 years	In my opinion, the main cause of these logistics challenges is poor top management commitment to employ logistics properly including assigning logistics-experienced people to conduct logistics functions. On the other hand, several stakeholders do not realise the effect of logistics on the project cost. For instance, they do not understand what logistics is and its potential and contribution. They underestimate its value and what can do. On the other hand, the education system in the Middle East does not offer logistics and SCM courses for engineering students as they conduct the logistics function later. As a result, we are facing huge productivity losses and delays which contribute to project cost overruns. However, Productivity losses occur due to the unavailability of labour, information, and equipment. Furthermore, several processes do not start due to logistics challenges with the predecessors' activities.

#		Role of Interviewees	Experience	5. In your opinion what are the root causes and consequences for each one of these challenges? And what are the effects of these challenges on sustainability due to poor logistics practices?
24	**X**	Project manager	12 years	As a contractor working in the Middle East environment, we are facing a significant deficiency in logistics staff. This includes logistics experts, logistics officers, and procurement experts. In most cases, we are relying on weak or inexperienced people to conduct the logistics function due to these deficiencies. On the other hand, in most cases, we outsource the main parts of the construction project to subcontractors. However, subcontractors in the Middle East have a very limited budget to employ logistics officers. The other cause is that the construction industry in the Middle East is still in its fancy stages in terms of project type. For instance, most construction projects in the Middle East are regarded as small with very limited activities and resources compared to other countries. So, construction contractors still manage their work in a traditional method while neglecting logistics knowledge. But still many construction projects in the Middle East face delays and disruption in schedules due to inefficient logistics practices this includes poor coordination between stakeholders waiting due to labour availability, information sufficiency, and equipment utilisation.
25	**Y**	Contractor's representative	More than 18 years	I worked on several construction projects in the Middle East, and I noticed that the main reason for the logistics challenge was neglecting to employ expert staff to handle the logistics activities. For instance, construction contractors in the Middle East rely on engineering staff to handle logistics functions rather than employing logistics officers to save costs. Several times I asked the contractor about this issue they said that the project budget was limited, and we would not be able to employ any additional people. However, they do not realize the effect of logistics on performance and cost savings. They are dealing with logistics as a minor and secondary part, and this is the problem. In my perspective, a successful construction manager thinks and plans firstly for logistics by considering the best availability of materials, labour, and equipment and integrating logistics with construction processes.

#		Role of Interviewees	Experience	5. In your opinion what are the root causes and consequences for each one of these challenges? And what are the effects of these challenges on sustainability due to poor logistics practices?
26	**Z**	Project engineer	21 years	During my work in the construction industry in the Middle East, I realized that the construction contractors still do not understand or realize logistics and SCM in construction and how to apply it towards successful performance. They are relying on weak or inexperienced people to handle logistics activities. Thus, facing delays and extra costs. On the other hand, they underestimate the effect of logistics and SCM on performance. As they are dealing with it without any planning or real attention. Moreover, they do not specify any budget for logistics compared to other functions such as management function. However, I think logistics challenges cause losses for materials and resources that are unavailable properly with quantities and qualities. Moreover, inefficacy in logistics practices in terms of poor monitoring and control causes transportation delays and emissions Improving logistics within the construction industry in the Middle East would be achieved through the proper employment of logistics officers and experts as a main part.
27	**AA**	Senior office engineer	18 years	A very limited budget is the excuse that most construction contractors in the Middle East that I work with; always said about not employing logistics officers. Neglecting logistics and its related functions and dealing with it as a minor part of the construction activities generate most of the identified challenges. Logistics in construction from my perspective is a very essential part and neglecting it contributes to delays, losses, and cost overruns. So poor top management commitment and less understanding of the effect of logistics seem the main causes. On the other hand, logistics in construction in the Middle East do not receive much attention as project management. For instance, several construction projects create schedules for construction activities, but they do not create any logistics plan for the required resources that need to be available at a specific time. So poor planning is the other reason. Due to the identified logistics challenges we are facing huge losses in terms of material and resource availability such as workers, information, data, equipment, and labour.

#		Role of Interviewees	Experience	5. In your opinion what are the root causes and consequences for each one of these challenges? And what are the effects of these challenges on sustainability due to poor logistics practices?
28	**BB**	Project manager	8 years	I think that the main reason for the inefficient logistics practice within construction is two reasons. The first is that the stakeholders have poor knowledge and experience of logistics and SCM including its functions and benefits. Secondly, managers and owners of construction companies do not support the implementation of proper logistics practices as they still do not consider logistics as a primary part of their work. Construction contractors in the Middle East underestimate logistics and how to conduct their processes carefully. For instance, they handle logistics unreliably and they rely on inexperienced people to do logistics activities rather than employing logistics experts. On the other hand, they focus on project management and do not pay much attention to logistics and how to use it to support their work. For instance, they create schedules for construction activities and do not create schedules or plans for resources. Thus, no integration exists between logistics and construction. As a result, they face severe productivity losses due to the poor availability of materials and labour. Additionally, logistics challenges affect the payment to be at the right time which affects the payment to workers and prevents them from being at the right time to do their work. Additionally, several contractors adopt poor transportation systems resulting in excessive emissions and time waste

#		Role of Interviewees	Experience	5. In your opinion what are the root causes and consequences for each one of these challenges? And what are the effects of these challenges on sustainability due to poor logistics practices?
29	**CC**	PhD in construction logistics	6 years	Because of ineffective logistical procedures, we are experiencing severe productivity losses and cost overruns. However, I believe that unreliable practices, a lack of managerial commitment, and a failure to view logistics as a crucial component of the building activity are the main causes of inefficient logistics practices. For instance, we deal with logistics issues every day. Neither is any budget for logistics-related operations proposed. Additionally, we do not hire officers and specialists in logistics to manage logistics and SCM activities. We rely on young, unskilled, or inexperienced individuals. Additionally, it happens more frequently that each subcontractor handles their logistics. Which causes several issues with the other subcontractors. I noticed several construction projects in the Middle East face severe productivity losses and do not utilise resources properly resulting in several wastes and cost overruns due to inefficient logistics practices this is related to waiting due to poor availability of labour, information, and equipment and payments lead to time waste.

#		Role of Interviewees	Experience	6. Have you developed or used any logistics solutions to be used in your construction project to enhance performance and sustainability? And could you please specify them?
1	**A**	Contractor's representative	More than 15 years	We try to improve our logistics performance to enhance productivity and reduce costs. For instance, we introduce several solutions as follows. We keep daily group meetings for all stakeholders, we conduct first-run studies (Feedback studies), we implement Kanban cards for recent projects, we build a central warehouse to overcome the material shortage and enhance material management, we adopt proper logistics plans and communication matrix, improve central coordination and planning, continuous training, and finally to employ logistics officers.
2	**B**	Project manager	12 years	As a project manager, I deal with logistics as a major part of my construction projects. Proper logistics management gives us a significant opportunity to save costs and reduce delays. So, I pay much attention to logistics and SCM functions. I always try to improve the performance of logistics in our construction project through several methods. This includes continuous training, employing logistics officers, forming a strategic agreement with experts and professionals, outsourcing logistics to a third party, employing technology to enhance monitoring and controlling, improving collaboration and coordination among parties, and creating logistics plans as the construction plans.
3	**C**	Senior Site engineer	15 years	Improving logistics and SCM in the Middle East's construction industry represents a major necessity to reduce costs and enhance performance. As I mentioned several challenges could be addressed through proper logistics management. In our company, we use several methods and techniques to enhance logistics performance and address logistics challenges. Enhance visualization and visibility through proper coordination and collaboration between all team members. We use the Last Planner System (LPS) for material and resource planning. For the huge project, we consider third-party logistics to handle logistics activities. Moreover, implement a consolidation centre to overcome material sudden shortages.

#		Role of Interviewees	Experience	6. Have you developed or used any logistics solutions to be used in your construction project to enhance performance and sustainability? And could you please specify them?
4	**D**	Logistics manager	12 years	As a logistics manager, I introduce several initiatives to be used by stakeholders to enhance the performance of logistics activities towards improving productivity. These methods enhance visibility and coordination among parties. These methods and techniques include holding continuous daily group meetings, getting continuous feedback studies, introducing Kanban cards to enhance resource planning, and using the Last Planner System (LPS) to enhance material management. For a special project, we consider third-party logistics to handle logistics activities. Finally, we implement a consolidation centre to address material shortcuts.
5	**E**	Logistics manager	15 years	Several methods and work procedures are initiated recently to enhance the logistics processes efficiency towards eliminating costs and reducing delays. This includes initiating a logistics centre for the construction project, supporting and improving coordination and collaboration, opening to new businesses to get their experience in managing construction logistics, and forming several agreements with professionals towards implementing specific activities rather than doing them. For instance, outsourcing, some activities save significant time.
6	**F**	Project manager	21 years	Recently we realised that improving logistics and SCM activity become necessary towards eliminating time and cost waste. Addressing logistics challenges starts by identifying them and their related causes. So, we identified causes to avoid or mitigate them. Then we introduce several solutions to improve the efficiency of the logistics activities. These solutions include enhancing coordination and collaboration among parties, adopting proper technological and communication solutions, implementing a tracking system for materil, outsourcing some activities towards save time and decreasing cost where possible, employing logistics officers for important and special projects, planning to initiate a central warehouse to improve material management and to overcome deficiencies in material and prices' fluctuation.

#		Role of Interviewees	Experience	6. Have you developed or used any logistics solutions to be used in your construction project to enhance performance and sustainability? And could you please specify them?
7	**G**	Contractor's representative	18 years	Improving logistics performance has become a priority for us working in the construction industry. For instance, recently we realised that logistics and SCM contribute to a significant amount of project cost. Moreover, project costs could be controlled by proper logistics and SCM practices. Several methods and working modes are introduced to enhance the efficiency of logistics activities. This includes employing logistics officers for every construction project we get. Enhancing coordination and collaboration between parties through continuous meetings and open communication. Adopting proper technological solutions for material tracking, outsourcing logistics functions to a third party for large projects, building warehouses to address material shortages, building relations with several suppliers and materil providers based on collaboration, not negotiation, and developing logistics plans for the construction projects that include resources for the construction activities on timely bases.
8	**H**	Project engineer	10 years	Improving logistic performance within construction in the Middle East starts by understanding challenges and trying to eliminate them. In our company, the first thing we achieve is management commitment. Managers in our company have less experience in logistics and SCM practices and roles. So, we held several meetings with them to clarify the contribution that proper logistics operations could make in terms of reducing delays and costs. Then several solutions we introduced to smooth the logistics processes towards improving its performance. These solutions include initiating proper logistics plans and communication matrix, joint Coordination, facilitating the ability for change of any processes or working mode, use of the last planner system for resources planning and estimation, and employing a logistics expert for any construction project rather than relying on inexperienced or unqualified staff.

#		Role of Interviewees	Experience	6. Have you developed or used any logistics solutions to be used in your construction project to enhance performance and sustainability? And could you please specify them?
9	**I**	Senior office engineer	10 years	The construction industry in the Middle East is now forced to improve logistics and SCM performance. For instance, several construction contractors in the Middle East faced recently huge cost overruns and delays due to bad resource estimation, acquisitions, tracking, and management. In our company, we faced the same challenges and consequences. So, the management board committed to improving logistics significantly by implementing several improvement and correction mechanisms. This includes employing logistics offices for every construction project, building several relationships based on collaborations with suppliers and material providers, developing a logistics plan that includes all the required resources over the project life, building warehouses to improve material monitoring and management, holding continuous training sessions, integrate construction activities with logistics functions, open communication, and delegating and authorising decisions at lower levels.
10	**J**	Project manager	20 years	I am always thrilled for any ideas, techniques, and initiatives to be used to improve logistics performance in our construction project. My priorities for any construction project are to deliver construction projects on time without delays and within budget. So, considering logistics functions carefully would assist in achieving the target that I wish for my construction projects. I used to introduce several ideas that contribute to improving logistics practices within our projects. These ideas include initiating a proper communication matrix to facilitate information sharing, employing a logistics staff, continuous feedback and training, creating an integrated construction-logistics plan, introducing the use of the last planner system to improve resources planning, developing collaborative relationships with suppliers and material providers, initiating several relationships with experts and professionals to implement special works (outsourcing), and finally implementing technological solutions for material monitoring and tracking enabled by logistics officers.

#		Role of Interviewees	Experience	6. Have you developed or used any logistics solutions to be used in your construction project to enhance performance and sustainability? And could you please specify them?
11	**K**	PhD in construction management	More than 15 years	I noticed recently that logistics and SCM got good attention from construction contractors in the Middle East, especially in building projects. I asked them about the reasons for this shift. However, they stated that logistics and SCM operations contribute to around one-third of their projects' costs. Moreover, the remaining cost is controlled by logistics and SCM. Improving performance becomes essential to save costs and avoid extra expenses. Improving performance implies working efficiently including eliminating nonphysical wastes and challenges. For instance, they enhance the ability to change several processes. Moreover, they integrated logistics with the construction process. For instance, several contractors develop plans that include resources and construction activities together. Improving communication and knowledge transfer has become visible in several projects. On the other hand, some construction contractors turn to outsource logistics activities to a third party of a large project or employ logistics officers in other projects. Some contractors have started to use the last planner system for resource estimation and scheduling. In addition, some contractors start building warehouses to improve material management and to address the fluctuations in material quantities and prices, and finally, they hold regular training and feedback meetings.
12	**L**	Contractor's representative	13 years	We work to enhance efficiency and save expenses by optimising our logistics performance. As an illustration, we present the following solutions. We conduct Feedback studies, we implement Kanban cards for the most recent projects, we maintain daily group meetings for all stakeholders, we adopt appropriate logistics plans and communication matrix, we improve central coordination and planning, continuous training, and finally, we hire logistics officers.

#		Role of Interviewees	Experience	6. Have you developed or used any logistics solutions to be used in your construction project to enhance performance and sustainability? And could you please specify them?
13	**M**	Project manager	10 years	As a project manager, logistics plays a significant role in my building projects. We have a great chance to cut expenses and shorten delays thanks to effective logistics management. I, therefore, pay close attention to SCM and logistical processes. I consistently work to enhance the effectiveness of the logistics in our building project using a variety of techniques. Continuous training, hiring logistics officers, establishing a strategic partnership with experts and professionals, outsourcing logistics to a third party, using technology to improve monitoring and controlling, enhancing collaboration and coordination between parties, and developing logistics plans concurrently with construction plans are some examples of the methods we implemented.
14	**N**	Senior Site engineer	18 years	To save costs and boost efficiency, the construction sector in the Middle East urgently needs to improve its logistics and SCM systems. As I said, good logistics management might help solve a number of problems. To improve logistics performance and deal with logistical issues, our organisation employs a variety of techniques. Improve visibility and visualisation by having all team members work together effectively. When planning our materials and resources, we employ the Last Planner System (LPS). We are thinking about using third-party logistics to handle logistics for the large project. Implement a consolidation hub as well to deal with unexpected material shortages.

#		Role of Interviewees	Experience	6. Have you developed or used any logistics solutions to be used in your construction project to enhance performance and sustainability? And could you please specify them?
15	**O**	Logistics manager	8 years	I introduce numerous approaches as a logistics manager to be adopted by stakeholders to improve the productivity of logistics activities. These procedures improve communication and cooperation between parties. The constant daily group meetings, getting ongoing feedback studies, implementing Kanban cards to improve resource planning, and utilising the Last Planner System (LPS) to improve material management are just a few of these strategies and methodologies. We explore using third-party logistics to undertake logistics tasks for a unique project. Finally, to overcome material shortcuts, we create a consolidation centre.
16	**P**	Logistics manager	11 years	Recently, several techniques and working practices have been introduced to improve the effectiveness of logistics processes to cut costs and shorten delays. To do this, the construction project should establish a logistics centre, support and enhance coordination and collaboration, welcome new businesses to gain their expertise in managing construction logistics, and establish many agreements with experts to implement certain tasks. Some tasks, like outsourcing, result in significant time savings.
17	**Q**	Project manager	17 years	Recently, we have realised that enhancing SCM and logistics operations is essential for reducing time and cost waste. Identifying logistics issues and their underlying causes is the first step in solving them. So, we determined the causes to prevent or lessen them. Then, we present some ways to boost the effectiveness of logistics-related tasks. These include improving communication and collaboration between parties, implementing a tracking system for material, outsourcing some tasks to cut down on time and costs where possible, hiring logistics officers for significant and special projects, and planning to start a central warehouse to enhance material management and address material shortages and price volatility.

#		Role of Interviewees	Experience	6. Have you developed or used any logistics solutions to be used in your construction project to enhance performance and sustainability? And could you please specify them?
18	**R**	Contractor's representative	8 years	For those of us in the construction sector, optimising logistics performance has taken on increased importance. For instance, we just realised that SCM and logistics account for a considerable portion of project costs. Additionally, SCM and logistics procedures could help to keep project costs under control. To increase the effectiveness of logistical tasks, many techniques and working patterns are introduced. For every building project we receive, this entails hiring logistics officers. Fostering open dialogue and ongoing discussions between parties to improve coordination and collaboration. Building warehouses to address material shortages, implementing the appropriate technological solutions for material tracking, outsourcing logistics functions to a third party for large projects, developing logistics plans for construction projects that will address material shortages
19	**S**	Supplier of construction material and Previous owner of a construction owner	20 years	Understanding obstacles and working to overcome them are the first steps in enhancing logistic performance in the Middle East's construction industry. In our business, obtaining managerial commitment comes first. Our company's managers have less knowledge of the roles and procedures associated with SCM and logistics. So, we have multiple sessions with them to explain to them how good logistics operations may help cut down on expenses and delays. Then, several solutions were devised to streamline the logistical operations and boost their effectiveness. The implementation of appropriate logistics plans and communication matrix, joint coordination, the use of the last planner system for resource planning and estimation and hiring a logistics expert for any construction project are some of these solutions.

#		Role of Interviewees	Experience	6. Have you developed or used any logistics solutions to be used in your construction project to enhance performance and sustainability? And could you please specify them?
20	**T**	Supplier of construction material and owner of Block factory	25 years	The performance of the Palestinian construction sector's logistics and SCM must now be improved. For example, several Palestinian construction companies recently had significant cost overruns and delays as a result of poor resource estimation, acquisition, tracking, and management. We experienced the same difficulties and outcomes with our business. The management board decided to employ several procedures for improvement and correction to considerably improve logistics. This entails hiring logistics offices for each construction project, forging many connections based on collaboration with suppliers and material providers, creating a logistics plan that includes all the resources needed over the life of the project, constructing warehouses to improve material monitoring and management, holding ongoing training sessions, integrating construction activities with logistics functions, open communication, and delegating and authorising duties.

#		Role of Interviewees	Experience	6. Have you developed or used any logistics solutions to be used in your construction project to enhance performance and sustainability? And could you please specify them?
21	**J**	Master's in construction management	12 years	Recently, I discovered that construction companies in the Middle East, particularly those working on building projects, paid poor attention to logistics and SCM. However, they claimed that approximately half of the costs of their projects are attributable to logistics and SCM activities. Moreover, logistics and SCM are in charge of the remaining costs. Enhancing performance has become crucial for cutting costs and preventing unforeseen charges. Enhancing performance means operating more effectively, which includes getting rid of difficulties and nonphysical waste. For instance, to improve the capacity to modify many procedures. In addition, they combined logistics with construction. For instance, a group of contractors creates plans that coordinate resources and construction tasks. In several projects, improved communication and knowledge sharing may be supportive. On the other hand, some building contractors decide to hire logistics officers for other projects or outsource the logistics of a big project to a third party. The last planner system is starting to be used by some contractors for resource estimation and scheduling. Finally, they have frequent training and feedback meetings. Some contractors also begin building warehouses to enhance material management and solve the variations in material quantities and pricing.
22	**V**	Logistics manager	12 years	Several methods and work procedures are initiated recently to enhance the logistics processes efficiency towards eliminating costs and reducing delays. This includes initiating a logistics centre for the construction project, supporting and improving coordination and collaboration, opening to new businesses to get their experience in managing construction logistics, and forming several agreements with professionals towards implementing specific activities rather than doing them. For instance, outsourcing, some activities save significant time.

#		Role of Interviewees	Experience	6. Have you developed or used any logistics solutions to be used in your construction project to enhance performance and sustainability? And could you please specify them?
23	**W**	Logistics manager	15 years	Recently we realised that improving logistics and SCM activity become necessary towards eliminating time and cost waste. Addressing logistics challenges starts by identifying them and their related causes. So, we identified causes to avoid or mitigate them. Then we introduce several solutions to improve the efficiency of the logistics activities. These solutions include enhancing coordination and collaboration among parties, adopting proper technological and communication solutions, implementing a tracking system for materil, outsourcing some activities towards save time and decreasing cost where possible, employing logistics officers for important and special projects, planning to initiate a central warehouse to improve materil management and to overcome deficiencies in materil and prices' fluctuation.
24	**X**	Project manager	12 years	Improving logistics performance has become a priority for us working in the construction industry. For instance, recently we realised that logistics and SCM contribute to a significant amount of project cost. Moreover, project costs could be controlled by proper logistics and SCM practices. Several methods and working modes are introduced to enhance the efficiency of logistics activities. This includes employing logistics officers for every construction project we get. Enhancing coordination and collaboration between parties through continuous meetings and open communication. Adopting proper technological solutions for material tracking, outsourcing logistics functions to a third party for large projects, building warehouses to address material shortages, building relations with several suppliers and materil providers based on collaboration, not negotiation, and developing logistics plans for the construction projects that include resources for the construction activities on timely bases.

#		Role of Interviewees	Experience	6. Have you developed or used any logistics solutions to be used in your construction project to enhance performance and sustainability? And could you please specify them?
25	**Y**	Contractor's representative	More than 18 years	Improving logistic performance within construction in the Middle East starts by understanding challenges and trying to eliminate them. In our company, the first thing we achieve is management commitment. Managers in our company have less experience in logistics and SCM practices and roles. So, we held several meetings with them to clarify the contribution that proper logistics operations could make in terms of reducing delays and costs. Then several solutions we introduced to smooth the logistics processes towards improving its performance. These solutions include initiating proper logistics plans and communication matrix, joint Coordination, facilitating the ability for change of any processes or working mode, use of the last planner system for resources planning and estimation, and employing a logistics expert for any construction project rather than relying on inexperienced or unqualified staff.
26	**Z**	Project engineer	21 years	The construction industry in the Middle East is now forced to improve logistics and SCM performance. For instance, several construction contractors in the Middle East faced recently huge cost overruns and delays due to bad resource estimation, acquisitions, tracking, and management. In our company, we faced the same challenges and consequences. So, the management board committed to improving logistics significantly by implementing several improvement and correction mechanisms. This includes continuous training and employing logistics offices for every construction project, building several relationships based on collaborations with suppliers and material providers, developing a logistics plan that includes all the required resources over the project life, building warehouses to improve material monitoring and management, holding continuous training sessions, integrate construction activities with logistics functions, open communication, and delegating and authorising decisions at lower levels.

#		Role of Interviewees	Experience	6. Have you developed or used any logistics solutions to be used in your construction project to enhance performance and sustainability? And could you please specify them?
27	**AA**	Senior office engineer	18 years	I am always thrilled for any ideas, techniques, and initiatives to be used to improve logistics performance in our construction project. My priorities for any construction project are to deliver construction projects on time without delays and within budget. So, considering logistics functions carefully would assist in achieving the target that I wish for my construction projects. I used to introduce several ideas that contribute to improving logistics practices within our projects. These ideas include initiating a proper communication matrix to facilitate information sharing, employing a logistics staff, continuous feedback and training, creating an integrated construction-logistics plan, introducing the use of the last planner system to improve resources planning, developing collaborative relationships with suppliers and material providers, initiating several relationships with experts and professionals to implement special works (outsourcing), and finally implementing technological solutions for material monitoring and tracking enabled by logistics officers.

#		Role of Interviewees	Experience	6. Have you developed or used any logistics solutions to be used in your construction project to enhance performance and sustainability? And could you please specify them?
28	**BB**	Project manager	8 years	I noticed recently that logistics and SCM got good attention from construction contractors in the Middle East, especially in building projects. I asked them about the reasons for this shift. However, they stated that logistics and SCM operations contribute to around one-third of their projects' costs. Moreover, the remaining cost is controlled by logistics and SCM. Improving performance becomes essential to save costs and avoid extra expenses. Improving performance implies working efficiently including eliminating nonphysical wastes and challenges. For instance, they enhance the ability to change several processes. Moreover, they integrated logistics with the construction process. For instance, several contractors develop plans that include resources and construction activities together. Improving communication and knowledge transfer has become visible in several projects. On the other hand, some construction contractors turn to outsource logistics activities to a third party of a large project or employ logistics officers in other projects. Some contractors have started to use the last planner system for resource estimation and scheduling. In addition, some contractors start establishing warehouses to improve material management and to address the fluctuations in material quantities and prices, and finally, they hold regular training and feedback meetings.
29	**CC**	PhD in construction logistics	6 years	We work to increase productivity and save expenses by optimising our logistics performance. As an illustration, we present the following solutions. We conduct Feedback studies, we implement Kanban cards for the most recent projects, we maintain daily group meetings for all stakeholders, we adopt appropriate logistics plans and communication matrix, we improve central coordination and planning, continuous training, and finally, we hire logistics officers.

Table 0-2 The research hypotheses' result

The Hypotheses	Effect	P	Decision
H1_1: Logistics solutions have a direct positive effect on sustainability in the construction industry. (LS->SF) *H1_0*: Logistics solutions do not have a direct positive effect on sustainability in the construction industry	0.516	0.034	Supported, and the null hypothesis rejected.
H2_1: Critical success factors positively influence sustainability in the construction industry. (CSF -> SF) *H2_0*: There is no influence of the critical success factors on sustainability in the construction industry.	0.487	0.02	Supported, and the null hypothesis rejected.
H3_1: Logistics challenges adversely affect sustainability in the construction industry. H3_*0*: Logistics challenges do not affect sustainability in the construction industry.	- 0.926	xxx	Supported, and the null hypothesis rejected
Interactions:			
H4_1: There is an interaction between logistics solutions and critical success factors in the construction industry. *H4_0*: There is no interaction between logistics solutions and essential success factors in the construction industry.	0.948	xxx	Supported, and the null hypothesis rejected

The Hypotheses	Effect	P	Decision
H5_1: There is an interaction between logistics solutions and logistics challenges in the construction industry. *H5_0*: There is no interaction between logistics solutions and logistics challenges in the construction industry.	0.58	xxx	Supported, and the null hypothesis rejected
H6_1: There is an interaction between critical success factors and logistics challenges in the construction industry. *H6_0*: There is no interaction between critical success factors and logistics challenges in the construction industry.	0.404	xxx	Supported, and the null hypothesis rejected
Moderation:			
H7_1: The relationship between logistics challenges and sustainability is moderated by the type of construction project.M1 *H7_0*: The relationship between logistics challenges and sustainability is not moderated by the type of construction project.	.008	0.9	Rejected, and the null hypothesis supported (no moderation effect).
H8_1: The relationship between logistics challenges and sustainability is moderated by the country of the construction project.M2 *H8_0*: The relationship between logistics challenges and sustainability is not moderated by the country of the construction project.	.041	0.85	Rejected, and the null hypothesis supported (no moderation effect).

The Hypotheses	Effect	P	Decision

H9_1: The relationship between logistics challenges and sustainability is moderated by the location of the construction project.M3 *H9_0*: The relationship between logistics challenges and sustainability is not moderated by the location of the construction project.	.005	0.86	Rejected, and the null hypothesis supported (no moderation effect).
H10_1: The relationship between logistics challenges and logistics solutions is moderated by the type of construction project.M4 *H10_0*: The relationship between logistics challenges and logistics solutions is not moderated by the type of construction project.	0.005	0.7	Rejected, and the null hypothesis supported (no moderation effect).
H11_1: The relationship between logistics challenges and logistics solutions is moderated by the country of the construction project.M5 *H11_0*: The relationship between logistics challenges and logistics solutions is not moderated by the country of the construction project.	0.17	xxx	Supported, and the null hypothesis rejected
H12_1: The relationship between logistics challenges and logistics solutions is moderated by the location of the construction project.M6 *H12_0*: The relationship between logistics challenges and logistics solutions is not moderated by the location of the construction project.	.002	0.105	Rejected, and the null hypothesis supported (no moderation effect).

The Hypotheses	**Effect**	**P**	**Decision**

H13_1: The relationship between CSFS and sustainability is moderated by the type of construction project.M7 *H13_0*: The relationship between CSFS and sustainability is not moderated by the type of construction project.	0.067	0.01	Supported, and the null hypothesis rejected.
H14_1: The relationship between CSFS and sustainability is moderated by the country of the construction project.M8 *H14_0*: The relationship between CSFS and sustainability is not moderated by the country of the construction project.	0.14	xxx	Supported, and the null hypothesis rejected
H15_1: The relationship between CSFS and sustainability is moderated by the location of the construction project.M9 *H15_0*: The relationship between CSFS and sustainability is not moderated by the location of the construction project.	.019	0.47	Rejected, and the null hypothesis supported (no moderation effect).
H16_1: The relationship between logistics solutions and sustainability is moderated by the type of construction project.M10 *H16_0*: The relationship between logistics solutions and sustainability is not moderated by the type of construction project.	.076	0.02	Supported, and the null hypothesis rejected
H17_1: The relationship between logistics solutions and sustainability is moderated by the country of the construction project.M11 *H17_0*: The relationship between logistics solutions and sustainability is not moderated by the country of the construction project.	0.13	xxx	Supported, and the null hypothesis rejected

The Hypotheses	Effect	P	Decision
H18_1: The relationship between logistics solutions and sustainability is moderated by the location of the construction project.M12 *H18_0*: The relationship between logistics solutions and sustainability is not moderated by the location of the construction project.	0.003	0.92	Rejected, and the null hypothesis supported (no moderation effect).
Mediation:			
H19_1: Critical success factors mediate the relationship between logistics solutions and sustainability in the construction industry (LS->CSF->SF). *H19_0:* Critical success factors do not mediate the relationship between logistics solutions and sustainability in the construction industry.	0.063	0.536	Rejected, and the null hypothesis supported (no mediator effect).
H20_1: Logistics challenges mediate the relationship between logistics solutions and sustainability in the construction industry. (LS -> LC -> SF) *H20_0*: Logistics challenges do not mediate the relationship between logistics solutions and sustainability in the construction industry.	0.406	0.02	Supported, and the null hypothesis rejected.
H21_1: Logistics challenges mediate the relationship between critical success factors and sustainability in the construction industry. (CSFs> CHL > SF) *H21_0*: Logistics challenges do not mediate the relationship between critical success factors and sustainability in the construction industry.	0.331	0.012	Supported, and the null hypothesis rejected.