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Analyzing Barriers to Sustainable Enterprise Risk Management in the Construction Sector: A Delphi Method and Interpretive Structural Modelling Approach

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Analyzing Barriers to Sustainable Enterprise Risk Management in the Construction Sector: A Delphi Method and Interpretive Structural Modelling Approach

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Abstract

Although sustainability has become a central concern in project management research, its integration into enterprise risk practices in construction remains limited. This study investigates the complex set of barriers preventing effective implementation of Sustainable Enterprise Risk Management (SERM) within the construction industry of the United Arab Emirates (UAE). With increasing pressures on construction projects to embed sustainability and resilience into risk governance, understanding why SERM adoption continues to lag remains a critical concern. To address this gap, a structured four-stage methodology was employed. First, a Systematic Literature Review (SLR) was conducted to extract potential barriers to SERM implementation from the academic and industry literature. These barriers were then evaluated through expert input using the Delphi method, allowing for consensus validation and refinement. The validated barriers were subsequently examined using Interpretive Structural Modelling (ISM) to understand their directional relationships and hierarchical linkages. Finally, MICMAC analysis was used to assess each barrier's driving and dependence power within the system. Results revealed that certain barriers, most notably the lack of senior management commitment, exert significant influence over others and act as root challenges that sustain systemic resistance to SERM adoption. These findings highlight the importance of addressing foundational organizational issues before technical or procedural improvements can be effective. The study offers valuable guidance for policymakers, contractors, and project leaders working in the UAE context by identifying high-leverage points for intervention. It also contributes to the growing body of research on sustainable risk practices by combining expert-driven validation and structured modelling to expose the underlying architecture of implementation barriers in construction risk governance.

Keywords: Sustainable Enterprise Risk Management (SERM); barriers; construction projects; Interpretive Structural Modeling (ISM); Matrice d'Impacts Croisés Multiplication Appliquée à un Classement (MICMAC)

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1. Introduction

The construction industry faces a wide array of complex risks that can impact project outcomes and organizational stability [1–3]. These risks encompass management-related issues such as poor communication and inadequate leadership; legal challenges including contract disputes and regulatory compliance; financial uncertainties like budget overruns and funding shortages; technical difficulties involving design errors and construction defects; logistical problems such as supply chain disruptions; and human resource concerns, notably skilled labor shortages. Additionally, external factors like political instability and security threats further exacerbate these challenges, particularly in critical infrastructure projects [4–6]. Risk management in the construction sector has traditionally been centered on individual projects, given their role as key revenue generators [7,8]. However, this project-specific approach often results in a disjointed perception of risks, restricted visibility across different projects, inefficient allocation of resources, and difficulties in aligning with overarching corporate objectives [9,10]. In response, many industries have shifted toward a more integrated approach to risk management, emphasizing a more holistic perspective [11,12]. Within this evolution, Enterprise Risk Management (ERM) has emerged as a key framework, gaining significant traction among scholars and industry professionals worldwide [13]. According to the Committee of Sponsoring Organizations of the Treadway Commission [14], ERM is characterized as "a process, carried out by an organization's board of directors, management, and staff, that is integrated into strategy formulation and across the organization, aimed at identifying potential events that could impact the organization and managing risks in alignment with its risk appetite, thereby providing reasonable assurance for the achievement of organizational objectives". This study adopts COSO's definition of ERM as a foundation for analyzing risk management practices in construction.

Ensuring long-term sustainability in the construction industry requires a proactive approach to risk management, particularly in economies like the United Arab Emirates (UAE), where large-scale infrastructure projects drive national development. In this context, ERM serves as a critical mechanism for identifying, assessing, and mitigating risks that could hinder sustainability objectives [15,16]. Companies implement ERM to improve performance indicators, optimize decision-making, and minimize losses [17]. However, for ERM to deliver lasting value, it must be integrated into an organization's long-term strategy, continuously improved, and adapted to changing environments [18]. This shift towards Sustainable ERM (SERM) is not about managing sustainability-related risks but rather ensuring that ERM itself remains effective, agile, and resilient over time [19]. Recent sustainability-oriented frameworks, such as ASCE 73-23: Standard Practice for Sustainable Infrastructure [20] and the Envision Framework developed by the Institute for Sustainable Infrastructure (ISI), reinforce this perspective by providing structured guidance on embedding resilience and sustainability into infrastructure decision-making. Their emphasis on long-term, cross-sectoral planning aligns directly with the goals of SERM, particularly in high-growth environments like the UAE where strategic risk governance must account for economic, environmental, and social dimensions. As such, these frameworks not only complement the ERM approach but also strengthen its relevance in guiding sustainable practices across the construction sector.

ERM has gained significant attention in the construction industry due to its ability to address risks beyond the project level, enabling a firm-wide approach to risk mitigation [21,22]. While larger construction firms have progressively integrated ERM into their operations by adopting comprehensive frameworks, smaller firms often struggle to do the same. The absence of dedicated risk management personnel, limited awareness, insufficient data, and resource constraints create significant barriers to ERM implementation [23,24]. Research across various industries suggests that these challenges contribute to the overall low adoption of ERM frameworks [25]. The transition toward SERM introduces additional complexities, as it requires firms not only to integrate ERM into their strategic decision-making but also to ensure its adaptability to evolving sustainability requirements [26]. The need for long-term resilience, compliance with sustainability regulations, and alignment with global environmental and social governance (ESG) standards further intensifies the challenges associated with ERM implementation in construction firms [27]. Consequently, firms must navigate these obstacles while striving to establish risk management frameworks that are both effective and sustainable. While ERM has been widely examined across industries such as manufacturing [28], banking [26], construction [10] and healthcare [29], the barriers to implementing SERM in the UAE construction sector remain largely unexplored. Given the country's rapid urbanization and regulatory advancements, the integration of SERM is increasingly critical. However, construction firms continue to face significant challenges that hinder its adoption.

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A handful of studies have investigated general risk management practices within UAE construction, highlighting issues such as poor risk culture, lack of strategic alignment, and fragmented implementation [30–32]. Yet, these studies largely focus on conventional or project-level risk approaches and fail to address the long-term, adaptive nature of ERM required for sustainability integration. The absence of empirical research specifically targeting SERM in the UAE construction context reveals a substantial gap. To this end, this study seeks to identify the key barriers hindering the effective implementation of SERM frameworks in the UAE construction industry and to model the interrelationships among these barriers. Theoretically, this research addresses a critical gap by deepening the understanding of SERM within an underexplored sector and contributes to the broader ERM discourse by establishing a structured set of industry-specific barriers. From a practical standpoint, identifying these barriers equips industry professionals with a systematic approach to evaluating and enhancing SERM adoption. This enables management to anticipate potential challenges, implement proactive risk mitigation strategies, and refine overall risk management effectiveness.

1.1. UAE Construction Industry

The construction sector in the UAE stands at the heart of the country's economic diversification agenda, fueling transformative projects such as smart cities, and extensive infrastructure development. It is one of the primary contributors to national GDP and employment [33]. Yet, despite its strategic significance, the sector faces persistent and compounding risks that threaten the success of its projects [34]. Chronic issues like cost overruns and schedule delays continue to plague the industry, particularly in the Middle East, where poor planning, scope creep, funding gaps, and skilled labor shortages are cited as leading causes [35]. These operational risks are further magnified by the UAE's rapid infrastructure expansion and evolving regulatory environment, making the country a timely and relevant setting for investigating SERM. Although ERM has gradually gained traction in the UAE construction sector, its adoption remains uneven and often superficial, focused more on short-term compliance than long-term strategic integration [30,36]. Many firms still exhibit fragmented risk practices, reactive decision-making, and a lack of cross-functional alignment, particularly in how risk insights are embedded into organizational planning [22].

Krechovská & Procházková [15] argue, truly sustainable ERM is not about managing sustainability-related risks, but rather about ensuring that risk management itself remains robust, forward-looking, and adaptable over time. In a volatile project environment like that of the UAE, which is marked by shifting regulations, labor dependencies, and ESG pressures, this level of strategic risk governance is not just ideal but imperative. This study responds to that gap by focusing on the long-term sustainability of ERM in UAE construction firms and identifying the key barriers that prevent its effective implementation. In doing so, it supports the advancement of resilient, enterprise-level risk practices aligned with the nation's sustainability and development ambitions.

1.2. Identification of the Knowledge Gaps

While ERM has received increasing attention in construction research, most studies focus on general project-level risks, often overlooking sustainability integration. Al-Mhdawi et al. [37] identified 34 risk management barriers during the COVID-19 pandemic, such as complex tools and ineffective communication. However, their study did not explore the interrelationships among these barriers, nor did it consider environmental or social sustainability concerns. El-Sayegh et al. [30] examined risks specific to sustainable construction projects in the UAE, identifying challenges like lack of sustainable design data and material shortages. Yet, the study remained limited to the project level and did not incorporate these risks into an enterprise wide ERM framework. Similarly, Bashir et al. [38] found 12 critical barriers to implementing environmental sustainability in UAE construction such as limited management commitment and resistance to change, but did not link these to ERM processes or firm-wide strategies.

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Only a few studies, such as Prakash and Ambekar ([10], have modeled the interdependencies among ERM barriers using Interpretive Structural Modeling (ISM) and MICMAC. Their findings showed how basic awareness issues drive broader organizational barriers, but their model excluded sustainability and was region-specific to India. Likewise, Prieto (2022) examined ERM in the engineering and construction industry in the U.S., emphasizing the need for strategic integration of ERM into decision-making processes. However, the study remains broad and does not address sustainability dimensions or the specific context of construction in the UAE. This leaves a notable gap in UAE-focused, sustainability-integrated ERM research. Overall, literature remains fragmented, either examining ERM without sustainability, or addressing sustainability without modeling how organizational barriers interact in an ERM context. This study addresses these gaps by focusing on SERM in the UAE construction sector, identifying key implementation barriers, and modeling their interrelationships through a structured methodology. Table 1 summarizes the most recent and relevant studies, highlighting their focus, findings, and the specific gaps that the current research seeks to fill.

Table 1. Summary of Existing Studies.

Reference	Region	Focus and Context	Key Findings	Limitations / Gap
[37]	Iraq	Risk management challenges during COVID-19 in construction projects.	Identified 34 barriers grouped into analytical, behavioral, managerial, and team-related categories: highlighted critical barriers like complex risk tools and poor communication.	Focused on pandemic context; no consideration of sustainability aspects; barriers were listed but not quantitatively modeled for interrelationships; not specific to UAE.
[30]	UAE	Risks in sustainable construction projects at the project level.	Compiled 30 risks in green building projects and ranked them by severity; top risks included funding shortages and design information gaps.	Project-centric scope; addressed sustainability risks in projects but did not link to enterprise-level ERM; no analysis of barrier interactions or ERM integration.
[38]	UAE	Barriers to implementing environmental sustainability in construction management.	Identified 12 key sustainability barrier; used mixed methods to highlight the need for addressing root causes.	Focused on sustainability without ERM context; does not address how to incorporate these sustainability barriers into an ERM framework; no quantitative modeling of inter-barrier influences.
[10]	India	Barriers to ERM implementation in construction firms using ISM and MICMAC	Mapped hierarchical relationships among ERM barriers; found fundamental individual-level barriers underpin organizational-level issues; demonstrated	No sustainability dimension considered; findings are region-specific to India; UAE context not addressed.

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			how some barriers drive others.	
[39]	USA	ERM in the engineering and construction industry.	Highlighted the need for integrating ERM into strategic decision-making processes; emphasized tailoring ERM frameworks to address dynamic risks inherent in construction projects.	Focused on the U.S. context; findings may not be directly applicable to the UAE construction sector, which operates under different regulatory, economic, and cultural conditions.

2. Methodology

The study employed a structured mixed-method approach, following a series of five clearly defined steps, as shown in Figure 1.

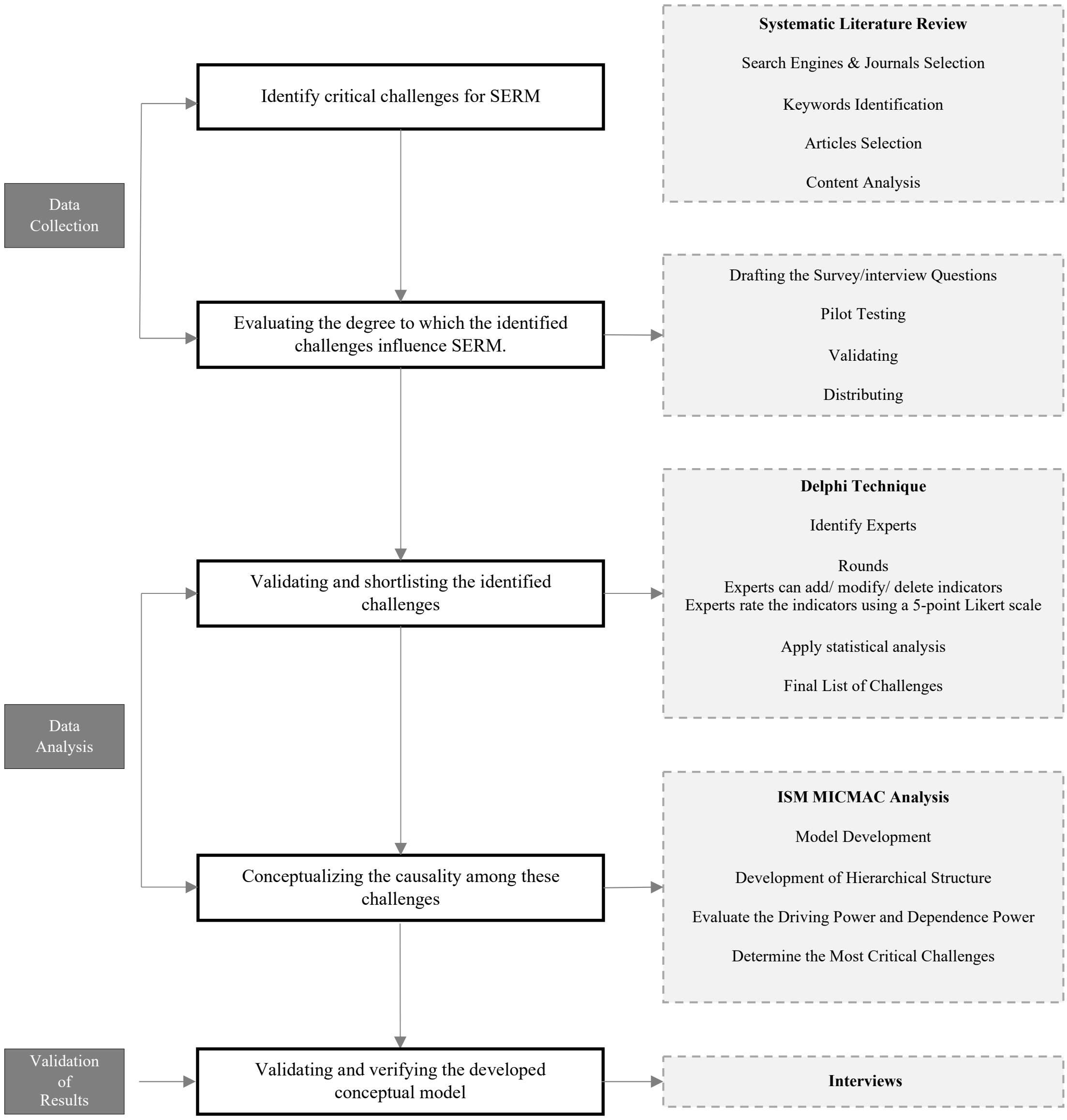

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Figure 1. Research Methodology.

Step 1: ***Challenges identification***

A Systematic Literature Review (SLR) was conducted to identify the key challenges for SERM. The review focused on studies from 2015 to 2025, a period marked by a growing emphasis on sustainability in organizational strategies, particularly in the construction sector due to significant global and regional sustainability initiatives. Following the 2015 Paris Agreement, sustainability in construction gained prominence, emphasizing environmental, social, and economic stability in a resource-intensive industry [40]. As climate-related risks intensified, organizations were forced to rethink their approach to risk management, integrating sophisticated tools and methodologies to navigate emerging sustainability challenges [41]. At the same time, the rise of digital transformation, along with technologies like AI and IoT, revolutionized risk monitoring and management, embedding sustainability deeper into enterprise risk frameworks and shaping the future of risk resilience [42]. The concept of "sustainable ERM" may still be evolving, but the industry's shift toward integrating sustainability into risk management is undeniable [10,43,44]. A significant turning point came in 2015 with the adoption of the United Nations' Sustainable Development Goals (SDGs), which prompted organizations to embed sustainability within their strategic frameworks, addressing environmental concerns and improving resource efficiency [45]. This shift positioned sustainability as a fundamental aspect of innovation and long-term strategic planning, reinforcing its role in shaping modern risk management approaches [46].

A thorough search was conducted using Scopus, Taylor & Francis, IEEE Xplore, Emerald Insight, Wiley, and Google Scholar, chosen for their strong academic relevance. The selection prioritized high-quality, Scopus-indexed journals published in English with an impact factor of at least 2.0. Keywords such as "barriers," "challenges, "hindrances," for ERM, and "factors for ERM sustainability in the construction industry" were used, applying Boolean operators (AND, OR) and database-specific filters for precision. Content analysis was then performed to evaluate article relevance and extract key challenges hindering SERM implementation, a method commonly applied in construction risk management research [47].

Step 2: ***Challenges validation***

After conducting a thorough literature review to identify the key challenges for implementing SERM in the construction sector, the next step is to validate these findings with industry experts. To achieve this, the study uses the Delphi Technique, a method designed to build consensus through multiple rounds of questionnaires sent to a panel of experts [48,49]. The Delphi Technique was chosen for its ability to efficiently gather diverse opinions, allow experts to participate without needing to be physically present, and give them the freedom to share their views openly [50]. Its structured process ensures that a broad range of perspectives is considered, facilitating a more robust validation of the challenges identified in the literature. A semi-structured survey questionnaire was developed for the Delphi analysis, combining Likert-scale questions to rate various factors with open-ended sections for expert feedback. Experts were invited to suggest changes to the grouping of challenges, such as adding, removing, or merging clusters. To ensure its effectiveness, the questionnaire underwent a thorough validity assessment. Face validity—examining clarity, style, and usability—was confirmed [51], while content validity was evaluated to ensure alignment with the study's objectives [52]. A panel of five experts reviewed and validated the instrument [53]. Following validation, a pilot study assessed the questionnaire's reliability, measured through Cronbach's alpha, with a threshold of 0.7 or higher deemed acceptable [54]. Having satisfied both validity and reliability requirements, the instrument was finalized for use in the Delphi process.

Step 3: Conceptualizing the causality among the identified challenges

Semi-structured interviews were selected as the main data collection approach for their adaptable nature, which enables participants to elaborate while ensuring comprehensive topic coverage [55]. The study involved ten experts from the Architecture, Engineering, and Construction (AEC) industry, each with over ten years of UAE experience and direct involvement in construction risk management. Their role was crucial in contributing to the development of a causal model, which explores the cause-and-effect dynamics of challenges impeding the successful implementation of SERM in the construction sector. Given the study's qualitative focus, semi-structured interviews were deemed most suitable for generating rich, detailed data [56], a choice further supported by prior research emphasizing the method's effectiveness with industry professionals [57,58]. After data collection, transcripts were systematically analyzed using content analysis techniques [59], highlighting key statements while omitting repetitive or irrelevant content. The highlighted responses were then categorized, creating a structured analysis grid that facilitated the organization of findings.

Step 4: ***ISM–MICMAC challenges modeling***

The insights gathered from the semi-structured interviews were analyzed using Interpretive Structural Modeling (ISM), a widely recognized methodology in management and engineering research for structuring complex interrelationships among variables [60]. ISM is particularly effective for identifying interdependent challenges, making it highly suitable for examining the layered obstacles within the construction sector. Recent construction management studies have increasingly applied ISM to deconstruct complex systems into manageable hierarchical models [10,60,61]. This technique draws on expert knowledge to systematically map the relationships among factors, organizing them into a structured, multi-level framework. A key strength of ISM is its ability to distinguish between direct and indirect relationships, thereby assigning logical direction and priority to each element [62]. Following the ISM modeling, MICMAC (Matrice d'Impacts Croisés Multiplication Appliquée à un Classement) analysis was conducted to classify variables based on their driving power and dependence, highlighting which factors exert the greatest influence and which are most susceptible to external impacts [63]. This combined ISM–MICMAC approach offers a structured visualization of the challenge landscape and actionable insights for targeted interventions.

Step 5: ***Model validation***

In the final phase of the research methodology, interviews were conducted to validate the model and examine the interrelationships among the key challenges influencing SERM UAE construction projects. A panel of six industry experts participated, carefully selected for their significant decision-making roles and academic contributions in the field. The group included two project managers, a construction manager, a consultant, and two academics, each with over a decade of professional experience. Their collective expertise provided diverse perspectives and valuable insights, enriching the study's findings.

3. Analysis and Results

3.1. Identified Challenges for SERM

In line with the inclusion criteria set out during the initial phase of the research, a total of 216 studies published between 2015 and 2025 were identified, focusing on the challenges associated with SERM. These studies were carefully assessed by reviewing their titles and abstracts to determine their relevance and suitability for inclusion in the analysis. A rigorous two-step screening process was implemented to ensure methodological consistency and uphold high standards of research quality. After this detailed evaluation, only 26 studies were found to be directly applicable to the challenges impeding SERM across diverse industries. This process ultimately led to the identification of 28 key challenges. Notably, to the authors' knowledge, no prior research has comprehensively addressed all 28 challenges in unison, particularly in the context of SERM within construction projects. As a result, this study contributes substantially to the field. Figure 2 provides a visual representation of the SLR outcomes, mapping the identified challenges against the reviewed literature.

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Code	CHALLENGES	(Farrell & Gallagher, 2015)	(Gatzert & Martin, 2015)	(Lundqvist, 2015)	(Brustbauer, 2016)	(Fraser & Simkins, 2016)	(Lechner & Gatzert, 2018)	(Liu et al., 2018)	(Bensaada & Taghezout, 2019)	(Bohnert et al., 2019)	(Hanggraeni et al., 2019)	(Oliveira et al., 2019)	(Saeidi et al., 2019)	(Horvey & Ankamah, 2020)	(Altuntas et al., 2020)	(Malik et al., 2020)	(Jean-Jules & Vicente, 2021)	(Qazi & Simsekler, 2021)	(Saeidi et al., 2021)	(Lacković et al., 2022)	(Nocco & Stulz, 2022)	(Tan & Lee, 2022)	(Oyeyipo & Osuizugbo,2023)	(Zhu et al., 2023)	(Hristov et al., 2024)	(Prakash & Ambekar, 2024)	(Agarwal, 2025)
C01	Lack of Board Leadership	■			■	■	■	■	■	■	■	■				■	■	■	■	■			■	■	■	■	
C02	Lack of Senior Management Commitment	■	■		■	■	■	■	■		■	■		■			■	■	■	■	■	■	■	■	■	■	
C03	Lack of Perceived Value		■	■		■		■					■					■					■	■	■		
C04	Lack of ERM Business Case		■													■							■				
C05	Failure to Maintain Risk Culture	■	■		■					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■			■
C06	Cultural Resistance		■	■	■	■		■	■	■		■	■		■		■	■			■	■		■	■	■	
C07	Unsupportive Organizational Culture and Structure	■							■			■	■	■	■	■	■	■	■	■			■	■		■	■
C08	Siloed Risk Management	■	■	■		■	■		■	■							■	■	■				■	■		■	
C09	Confidence in Existing Practices						■				■										■		■	■			
C10	Short-Term Business Focus					■	■	■		■		■					■		■	■					■		
C11	Frequent Organizational Restructuring												■												■		
C12	Insufficient Resources	■	■	■	■	■	■	■	■	■	■	■	■	■		■		■	■	■		■	■	■		■	
C13	Inconsistent Funding	■	■	■			■	■	■				■						■		■					■	
C14	Perception of Increased Costs	■	■									■										■	■			■	
C15	Economic Downturn	■	■						■													■					
C16	Lack of Risk Management Tools		■	■			■		■				■	■		■		■					■	■		■	
C17	Lack of Risk Information System			■			■	■				■				■					■		■			■	
C18	Limited Technological Integration		■		■		■				■					■	■					■				■	
C19	Inadequate Data Quality and Availability								■				■			■		■				■	■			■	
C20	Inadequate Integration with Strategy			■		■			■							■		■			■	■		■	■	■	■
C21	Interference with Business		■																							■	
C22	Lack of Stakeholder Involvement			■								■		■		■			■		■		■			■	
C23	No Performance Metrics		■	■		■		■																			
C24	Unclear Responsibility		■										■										■			■	
C25	Lack of Qualified Personnel		■		■	■	■	■	■	■		■	■	■		■		■				■	■	■		■	
C26	Inadequate Training		■			■	■	■	■			■	■			■		■						■		■	
C27	Poor Department Coordination			■		■						■														■	
C28	Lack of Risk Awareness		■			■					■	■	■		■	■	■	■	■		■	■	■	■	■	■	

Figure 2. A Mapping Between the Identified Challenges and the Reviewed Literature.

Although the challenges associated with ERM implementation have been widely explored, a critical gap remains in the causality-based assessment of these challenges, particularly within the emerging framework of SERM. While prior research has identified numerous barriers, little attention has been given to understanding the cause-effect dynamics that underpin risk management practices, despite their importance in shaping managerial mental models [64]. SERM extends traditional ERM by focusing on maintaining the effectiveness, agility, and resilience of risk management over time, rather than solely addressing sustainability-related risks. However, a review of existing literature reveals that studies specifically targeting SERM, and particularly its causality-based assessment, are absent. In the construction industry, the successful implementation of SERM necessitates a comprehensive understanding of key challenges and their interdependencies. Yet, literature reflects a lack of consensus on how these challenges interact. Many obstacles, rooted in organizational culture, technology use, human capital, and processes, are interconnected. For instance, resistance to change often hinges on leadership support and effective knowledge sharing [10]. Without mapping these causal relationships, efforts to overcome barriers remain disjointed. This study addresses this critical gap by exploring the interdependencies among challenges to SERM implementation in construction firms, offering a timely and necessary contribution to sustainable risk management practices.

3.2. Delphi Results

To assess expert consensus on the initial set of challenges identified from the literature, the Delphi method was employed. Experts were selected through non-probability purposive sampling, ensuring substantial field experience. A total of 10 experts were assembled to capture diverse perspectives on ERM in the UAE construction sector. As noted Galvin [65] and [66], qualitative research does not require a fixed number of interviews as long as data saturation is achieved. Accordingly, Delphi studies in existing literature have varied significantly in sample size, with some engaging as few as three experts and others exceeding 50 participants [67]. To strengthen the credibility of the findings, the panel included representatives from key areas of the AEC industry,

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covering project planning, risk assessment, environmental compliance, financial risk management, operational safety, and academia. All participants had at least 10 years of UAE construction experience and held academic qualifications ranging from bachelor's to doctoral degrees. Table 1 summarizes the expert profiles involved in the study.

Table 1. Experts' profile.

Expert	Experience	Job Title	Education		
			BSc	MSc	PhD
1	10–15 years	Professor			X
2	>20 years	Professor			X
3	10–15 years	Professor			X
4	10–15 years	Project Manager	X		
5	10–15 years	Project Manager		X	
6	>20 years	Senior Construction Director		X	
7	10–15 years	Construction Manager	X		
8	>20 years	Managing Consultant	X		
9	10–15 years	Construction Consultant		X	
10	10–15 years	Technical Director		X	

The Delphi process spanned two months and consisted of two rounds of questionnaires. After each round, data were analyzed to assess expert consensus and provide feedback, allowing participants to refine their responses. The experts were identified through email and social media, participated. The survey combined closed and open-ended questions, with experts rating each criterion on a five-point Likert scale (1 = Very Low to 5 = Very High) and suggesting additions, deletions, or modifications to the indicators based on their professional judgment.

3.2.1. Response and Drop-Out Rates

The expert recruitment process began with an email outlining the research goals, followed by a detailed explanation of the study's stages, methodology, and preliminary findings sent to interested respondents. Experts were also asked to provide referrals. Initially, 13 experts joined the panel, reflecting a 17% response rate, and completed the first-round questionnaire. Three experts withdrew during the second round, leaving 10 experts, representing a 77% response rate, who continued participating in the Delphi process. Response and participation rates are summarized in Table 2.

Table 2. Response rate statistics.

Response Rate	Invitations Sent	Declared Not Available	Round 1	Round 2
	78	**6 (8%)**	**13 (17%)**	**10 (77%)**

3.2.2. Achieving Consensus

The Delphi method was employed to assess expert consensus on challenges identified from the literature and to determine the most critical ones. A structured survey was designed and refined with input from four experts experienced in questionnaire development, ensuring face validity. Experts rated each item for relevance, clarity, and simplicity on a four-point scale. The Content Validity Index (CVI) for individual items ranged from 0.8 to 1.0, with an average CVI of 0.94, confirming the questionnaire's strong validity and consistency. During the first round of the Delphi process, experts were invited to provide open-ended feedback, suggesting additions, removals, modifications, or reclassifications of indicators. The results showed agreement on some indicators, while others remained disputed. Despite these disagreements, all indicators were retained for the second round after refinement based on expert feedback and clearer definitions. The second round included all

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challenges, even those initially rejected, allowing experts to reassess them. Some indicators were reconsidered and accepted, while others were excluded based on continued expert evaluation. [68] notes, there is no universally accepted method for evaluating consensus in Delphi studies. Various approaches exist, including measures of central tendency (mean, SD), frequency distributions, inter-quartile deviation (IQD), and coefficient of variation (CV) [69]. In this study, consensus was evaluated using mean, SD, CV, and IQD, with indicators deemed acceptable if they achieved a mean score of at least 3.7, a CV below 0.5, and SD and IQD values not exceeding 1[70]. If consensus was not reached on certain items, subsequent rounds were planned, providing experts with anonymized group feedback alongside their previous responses to encourage further convergence toward agreement. The quantitative results from the second and final round of the Delphi phase are presented in Table 3. From the initial 28 challenges identified through the literature review, 16 challenges met the established cut-off criteria and were selected for the next phase of the study, which focuses on structuring the ISM-MICMAC analysis.

Table 3. Summary of Delphi results of round 2.

Challenges	Mean	SD	CV	IQD
C01: Lack of Senior Management Commitment	4.6	0.49	0.11	0.75
C02: Lack of ERM Business Case	4.4	0.49	0.11	0.75
C03: Siloed Risk Management	4.7	0.46	0.10	0.50
C04: Confidence in Existing Practices	4.3	0.64	0.15	0.75
C05: Short-Term Business Focus	4.7	0.46	0.10	0.50
C06: Frequent Organizational Restructuring	4.6	0.49	0.11	0.75
C07: Inadequate Resources	4.8	0.40	0.08	0.00
C08: Limited Technological Integration	4.6	0.49	0.11	0.75
C09: Inadequate Data Quality and Availability	4.6	0.49	0.11	0.75
C10: Inadequate Integration with Organization Strategy	4.5	0.50	0.11	0.75
C11: Lack of Stakeholder Involvement	4.6	0.49	0.11	0.75
C12: No Performance Metrics	5.0	0.00	0.00	0.00
C13: Talent and Training Deficiencies	4.5	0.67	0.15	0.75
C14: Lack of Risk Awareness	4.6	0.49	0.11	0.75
C15: Resistance to Change	4.9	0.30	0.06	0.00
C16: Lack of Communication and Knowledge Sharing	4.9	0.30	0.06	0.00

3.3. Modeling the Challenges for SERM in the Construction Sector

To develop the causal structure among the final set of challenges (Table 4), an Interpretive Structural Modeling (ISM) methodology was implemented [71]. A structured evaluation was conducted, wherein ten domain experts assessed the pairwise relationships among the identified barriers. Each relationship was classified into one of four categories: 'V', 'A', 'X', or 'O', where 'V' indicates that the row element influences the column element, 'A' denotes the reverse influence, 'X' reflects mutual influence between the two elements, and 'O' signifies no direct relationship.

Table 4. Structural self-interaction matrix.

	C01	C02	C03	C04	C05	C06	C07	C08	C09	C10	C11	C12	C13	C14	C15	C16
C01	-	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
C02		-	V	O	V	O	V	V	V	V	V	V	V	O	V	O
C03			-	A	V	V	O	V	V	V	V	V	O	O	O	V

C04				-	V	O	O	O	V	V	O	O	O	V	V	V
C05					-	V	V	V	V	V	O	V	O	O	O	O
C06						-	V	V	V	V	V	V	V	V	V	V
C07							-	V	V	V	V	V	V	O	O	V
C08								-	V	X	V	V	X	O	A	X
C09									-	V	V	V	X	O	O	V
C10										-	V	V	V	O	O	V
C11											-	V	V	V	X	X
C12												-	V	V	V	V
C13													-	V	V	X
C14														-	X	V
C15															-	X
C16																-

The resulting Structural Self-Interaction Matrix (SSIM) was subsequently converted into a binary matrix by substituting the categorical symbols with corresponding binary values (0s and 1s), as presented in Table 5. Incorporating transitivity, a final reachability matrix was derived to accurately capture both direct and indirect relationships among the barriers. The analysis further examined two critical dimensions: driving power, representing the extent to which a barrier can influence others, and dependence power, indicating the degree to which a barrier is influenced by external factors (Table 6). This hierarchical modeling provided essential insights into the systemic interactions among the barriers and facilitated the identification of their relative importance within the overall framework.

The process of level partitioning was conducted using three key sets derived from Table 6: the reachability set, the antecedent set, and the intersection set. The reachability set identifies each challenge alongside the other challenges it can influence. In contrast, the antecedent set lists each challenge with the challenges that exert influence over it. The intersection set captures the common challenges found in both the reachability and antecedent sets. A challenge is assigned to a specific hierarchical level when its intersection set matches its antecedent set during a given cycle. After assigning challenges to a level, they are excluded from subsequent iterations to allow the identification of the next set of levels. Table 7 presents the final structure of these level partitions.

The driving and dependence values derived from the final reachability matrix (Table 6) were utilized to construct the dependence–driving power diagram (Figure 2), which illustrates the relative significance of each challenge. This analysis classifies the challenges into four exclusive categories: autonomous, dependent, independent, and linkage, each reflecting a distinct role within the structural model. The figure demonstrates that challenges such as C01, C02, C03, C04, and C05 possess the highest driving powers, indicating their strong influence over the system (Independent Variables in Quadrant IV). Notably, C01 demonstrates the highest driving power, influencing all other challenges with a score of 16. Yet, it is not directly influenced by any other factor, resulting in a low dependence value of 1. Conversely, challenges C08 to C16 share relatively lower driving powers (each with a value of 9) and show extremely high dependence powers (each at 16), indicating their vulnerability to changes in the system. Their classification as Linkage Variables in Quadrant III highlights their dynamic role, as they both influence and are influenced by other elements, contributing to feedback loops that can either reinforce or weaken SERM efforts. No challenges were classified as Autonomous or Purely Dependent Variables, indicating that all challenges are significantly interconnected.

Figure 3 presents the ISM model, illustrating a clear hierarchical structure among the challenges. The bottom-level challenges are identified as the fundamental drivers of SERM in the construction sector, exerting influence across the system. The mid-level challenges act as critical conduits, transmitting the effects of these foundational barriers toward higher levels. At the top of the hierarchy, the most dependent challenges are positioned, reflecting barriers that are heavily influenced by upstream factors and have limited independent driving power.

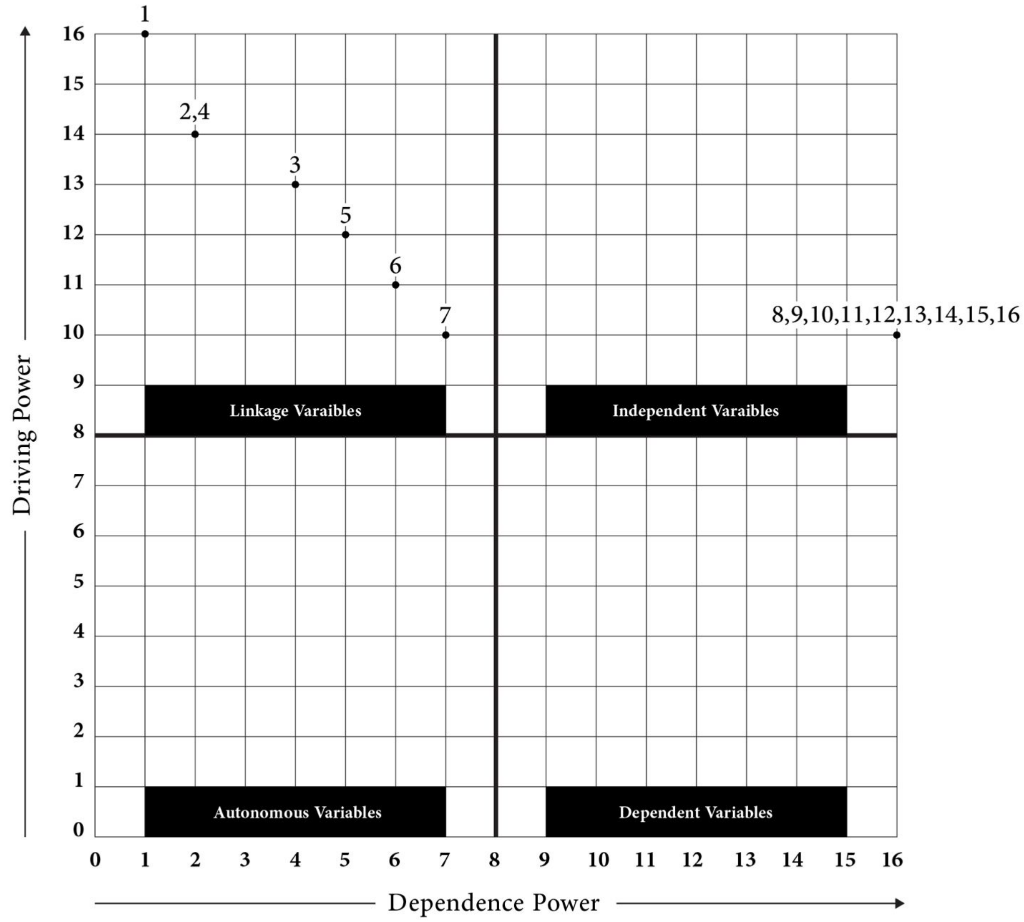

Figure 2. Dependence-driving power matrix.

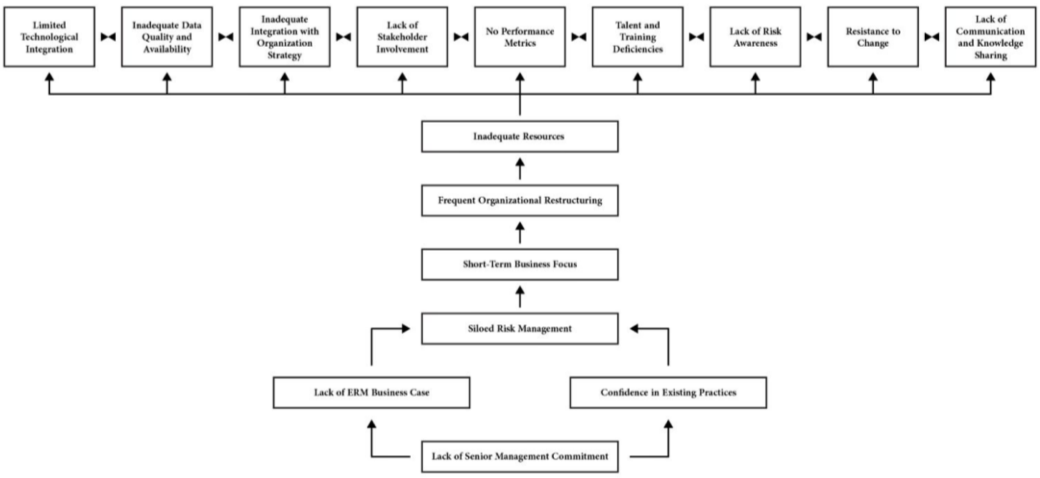

Figure 3. Causality of Challenges influencing the efficacy of SERM in the Construction Sector.

Table 5. Initial reachability matrix.

	C01	C02	C03	C04	C05	C06	C07	C08	C09	C10	C11	C12	C13	C14	C15	C16
C01	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
C02	0	1	1	0	1	1	1	1	1	1	1	1	1	0	1	0

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C03	0	0	1	0	1	1	0	1	1	1	1	1	0	0	0	1
C04	0	0	1	1	1	0	0	0	1	1	0	0	0	1	1	1
C05	0	0	0	0	1	1	1	1	1	1	0	1	0	0	0	0
C06	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1
C07	0	0	0	0	0	0	1	1	1	1	1	1	1	0	0	1
C08	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	1
C09	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	1
C10	0	0	0	0	0	0	0	1	0	1	1	1	1	0	0	1
C11	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1
C12	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1
C13	0	0	0	0	0	0	0	1	1	0	0	0	1	1	1	1
C14	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
C15	0	0	0	0	0	0	0	1	0	0	1	0	0	1	1	1
C16	0	0	0	0	0	0	0	1	0	1	1	0	1	0	1	1

Table 6. Final reachability matrix.

	C01	**C02**	**C03**	**C04**	**C05**	**C06**	**C07**	**C08**	**C09**	**C10**	**C11**	**C12**	**C13**	**C14**	**C15**	**C16**	**Driving Power**
C01	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	16
C02	0	1	0	1	0	1*	1	1	1	1	1	1	1	1*	1	1*	14
C03	0	0	1	0	1	1	1*	1	1	1	1	1	1*	1*	1*	1	13
C04	0	0	1	1	1	1*	1*	1*	1	1	1*	1*	1*	1	1	1	14
C05	0	0	0	0	1	1	1	1	1	1	1*	1	1*	1*	1*	1*	12
C06	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	11
C07	0	0	0	0	0	1	1	1	1	1	1	1	1	1*	1*	1	10
C08	0	0	0	0	0	0	1	1	1	1	1	1	1	1*	1*	1	9
C09	0	0	0	0	0	0	1	1*	1	1	1	1	1	1*	1*	1	9
C10	0	0	0	0	0	0	1	1	1*	1	1	1	1	1*	1*	1	9
C11	0	0	0	0	0	0	1	1*	1*	1*	1	1	1	1	1	1	9
C12	0	0	0	0	0	0	1	1*	1*	1*	1*	1	1	1	1	1	9
C13	0	0	0	0	0	0	1	1	1	1*	1*	1*	1	1	1	1	9
C14	0	0	0	0	0	0	1	1*	1*	1*	1*	1*	1*	1	1	1	9
C15	0	0	0	0	0	0	1	1	1*	1*	1	1*	1*	1	1	1	9
C16	0	0	0	0	0	0	1	1	1*	1*	1	1*	1*	1*	1	1	9
Dependence Power	1	2	4	2	5	6	7	16	16	16	16	16	16	16	16	16	

Table 7. Level partition of challenges.

Challenge	**Reachability Set**	**Antecedent Set**	**Intersection Set**	**Level**
C01	1	1	1	7
C02	2	1, 2	2	6
C03	3	1, 2, 3, 4	3	5
C04	4	1, 4	4	6
C05	5	1, 2, 3, 4, 5	5	4
C06	6	1, 2, 3, 4, 5, 6	6	3
C07	7	1, 2, 3, 4, 5, 6, 7	7	2
C08	8, 9, 10, 11, 12, 13, 14, 15, 16	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16	8, 9, 10, 11, 12, 13, 14, 15, 16	1

C09	8, 9, 10, 11, 12, 13, 14, 15, 16	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16	8, 9, 10, 11, 12, 13, 14, 15, 16	1
C10	8, 9, 10, 11, 12, 13, 14, 15, 16	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16	8, 9, 10, 11, 12, 13, 14, 15, 16	1
C11	8, 9, 10, 11, 12, 13, 14, 15, 16	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16	8, 9, 10, 11, 12, 13, 14, 15, 16	1
C12	8, 9, 10, 11, 12, 13, 14, 15, 16	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16	8, 9, 10, 11, 12, 13, 14, 15, 16	1
C13	8, 9, 10, 11, 12, 13, 14, 15, 16	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16	8, 9, 10, 11, 12, 13, 14, 15, 16	1
C14	8, 9, 10, 11, 12, 13, 14, 15, 16	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16	8, 9, 10, 11, 12, 13, 14, 15, 16	1
C15	8, 9, 10, 11, 12, 13, 14, 15, 16	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16	8, 9, 10, 11, 12, 13, 14, 15, 16	1
C16	8, 9, 10, 11, 12, 13, 14, 15, 16	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16	8, 9, 10, 11, 12, 13, 14, 15, 16	1

3.4. Verification of the Developed Model

To support the credibility and applicability of the proposed model, validation interviews were conducted with six independent experts from the UAE construction industry (Table 8). These experts were not involved in earlier stages of data collection or model development, ensuring an unbiased evaluation. The validation process was structured around four criteria: practical relevance, clarity and interpretability, feasibility of implementation, and adaptability to industry changes. Practical relevance assessed whether the model accurately reflected the common barriers faced by construction firms in implementing sustainable enterprise risk management (SERM). Clarity and interpretability examined whether the interrelationships among the 16 challenges were logically structured and comprehensible to practitioners. Feasibility focused on whether the model could realistically be integrated into current operational and strategic frameworks within construction firms. Finally, adaptability considered the model's potential to remain applicable under evolving industry conditions, including digital transformation and updated sustainability regulations. The experts confirmed that the model captured relevant interdependencies and offered a structured foundation for addressing systemic barriers to SERM adoption, particularly in complex and dynamic project environments such as those in the UAE construction sector.

Table 8. Experts' profile for the validation phase.

Expert	Experience	Job Title	Education		
			BSc	MSc	PhD
1	10–15 years	Project Manager	X		
2	10–15 years	Construction Engineer		X	
3	>20 years	Professor			X
4	10–15 years	Project Manager	X		
5	>20 years	Professor			X
6	>20 years	Construction Consultant	X		

4. Discussion

The adoption of SERM within the UAE construction sector remains elusive despite its growing necessity. As infrastructure projects expand across the region, the complexity and uncertainty surrounding construction activities intensify, making traditional risk management approaches increasingly inadequate [72]. Integrating SERM into project management has thus become essential to enhance resilience and achieve sustainable outcomes. Yet, several interconnected barriers continue to hinder this transition. At the foundation of these challenges lies leadership. The ISM model reveals that the lack of senior management commitment (C01) acts as the root cause driving many other obstacles. Without executive support, risk management initiatives lack authority, resources, and strategic visibility, a finding well-documented across ERM literature [10,40,73]. In the UAE, leadership often prioritizes immediate project delivery over long-term risk mitigation (C05), weakening the institutionalization of SERM. As one expert aptly stated: *"In many UAE construction firms, leadership's fixation on immediate project wins over critical risk considerations leads to chronic underinvestment in risk management"*. This leadership gap feeds into a resistant organizational culture. Employees entrenched in traditional project-level practices exhibit resistance to change (C15) and confidence in existing methods (C04), impeding the acceptance of new frameworks. Studies consistently note that without a shift in cultural mindset, enterprise-wide risk approaches struggle to take hold [22,74,75]. The problem is compounded by a widespread lack of risk awareness (C14), as emphasized by another expert: *"In several construction environments, daily firefighting is mistaken for risk management. The urgency of today often blinds firms to the broader risks of tomorrow."* Supporting this observation, research shows that the majority of organizations struggle with developing a robust ERM culture [76,77]. In parallel, poor communication and knowledge sharing (C16) exacerbate organizational silos [78], while frequent restructuring (C06) disrupts risk governance frameworks [79].

Moving upward in the hierarchy, these cultural weaknesses manifest in organizational structures and resources. Without clear leadership, firms often lack a compelling ERM business case (C02), undermining efforts to secure necessary funding and support [80,81]. Inadequate resource allocation (C07) naturally follows [82], as captured by one participant: *"When leadership fails to champion SERM, budget allocations for risk functions dwindle. Risk managers, if they exist, are often overburdened and under-resourced"*. The impact on human capital is significant. Talent and training deficiencies (C13) emerge as firms fail to invest in risk management education, leaving staff ill-prepared to engage with enterprise-level risks [83,84]. Additionally, the absence of stakeholder involvement (C11) narrows risk perspectives, further isolating risk discussions from operational realities [10,85]. As another expert noted: *"Technical competence in project delivery does not automatically translate into risk competence"*.

Technological barriers reinforce this fragmentation. Siloed risk management (C03) persists, with departments operating in isolation and duplicating efforts [10,76]. Limited technological integration (C08) worsens the issue, leaving firms reliant on basic tools for complex risk portfolios [42]. This fragmentation results in poor data quality and availability (C09), hindering comprehensive risk analysis [21,86]. Inadequate data management in construction can lead to the loss of critical project information, compromised confidentiality, and weak decision-making, while also obstructing the development of a coherent view of risk exposure across projects and departments [87,88]. Without integrated, reliable data systems, SERM remains difficult to institutionalize in the construction sector. One participant highlighted: "*Far too many construction firms still rely on spreadsheets and standalone reports to manage complex risk portfolios*".

At the apex of the ISM model, these systemic weaknesses converge. The inadequate integration of risk management with organizational strategy (C10) reflects the cumulative effect of leadership, culture, and process failures [89,90]. Compounding the problem is the lack of performance metrics (C12), which leaves ERM efforts without accountability or continuous improvement frameworks [91,92]. Without measurable outcomes, risk management remains reactive and superficial. As one expert succinctly put it: *"When risk management is viewed as a compliance exercise rather than a strategic necessity, it naturally remains excluded from high-level decision-making"*. To date, no research on SERM have employed a causality-based approach to investigate the underlying cause–effect relationships among the challenges of ERM implementation. The existing body of research has predominantly utilized correlation-based methods, emphasizing statistical associations between ERM practices and organizational performance, rather than uncovering directional or structural linkages [93,94]. However, such analyses offer limited guidance for decision-makers, as they fail to prioritize critical challenges or reveal the underlying causal mechanisms essential for effective SERM implementation in construction projects. While causality has been well- examined in broader decision-making and risk management literature, using methods including causal loop diagrams [95], social network analysis [96], system dynamics [97], and Bayesian Belief Networks [98], these approaches have not yet been applied meaningfully to SERM. Respondents in this study emphasized the importance of adopting causality-based frameworks, appreciating the value of the causal mapping presented. By shifting focus from simple correlations to causal networks, practitioners and senior managers can gain deeper insights into prioritizing challenges and optimizing strategies.

4.1. Small Sample Size

In expert-driven methods like Delphi and ISM-MICMAC, methodological rigor depends more on the quality and relevance of expert insights than on sample size. The Delphi technique, built on iterative rounds to reach consensus, prioritizes expertise over quantity. Sample size in Delphi is not determined by statistical power but by ensuring subject-matter relevance [67]. Literature shows panels ranging from 3 to over 50 experts, with many studies recommending 10–18 as ideal [99]. Smaller panels often achieve consensus more effectively, reducing conflicting views and enhancing clarity [48,100]. Larger panels can lead to logistical challenges and introduce "noise" from marginally relevant input [101]. This rationale applies equally to ISM-MICMAC. The method is designed to work with a small group of experts, typically between 5–15 [102–104]. Even panels of six experts have successfully generated robust hierarchical models in engineering and decision science fields [105]. Adding more experts beyond a certain point may dilute insights rather than enhance them. In this study, 10 experts were selected for Delphi and 6 for ISM-MICMAC, choices firmly grounded in best practices. These focused, high-caliber panels ensured contributions were deeply informed, avoiding superficial or redundant input. As consistently demonstrated in the literature, such sample sizes strike the optimal balance between credibility, clarity, and methodological validity.

5. Conclusion

This study explored the major barriers hindering the successful adoption of SERM within the UAE construction industry and examined how these challenges are interconnected. Moving beyond traditional views of sustainability, the research emphasized the need for ERM systems that remain resilient and adaptable across the project lifecycle. An initial SLR uncovered 26 relevant studies and identified 28 potential challenges. Through Delphi analysis with ten field experts, these were refined into 16 core challenges grouped into four categories. Semi-structured interviews with the experienced professionals further deepened the exploration, focusing on understanding the causal relationships among the barriers. The final ISM model highlights how practitioners can systematically prioritize and address these obstacles, offering a structured pathway to enhance SERM adoption in construction firms. By visualizing interdependencies, this research provides valuable insights into transforming complex mental models into practical strategies. The application of ISM methodology advances the field by guiding firms toward first addressing critical dependent barriers, leading to more cohesive and integrated SERM practices. Ultimately, the findings offer a practical roadmap for construction firms striving to strengthen their risk management systems and achieve more sustainable and resilient project outcomes.

5.1. Theoretical and Practical Implications

The outcomes of this study offer both theoretical and practical value. From a theoretical perspective, the study systematically identified and categorized the key challenges facing the implementation of SERM within the construction sector in the UAE. In doing so, it addresses a significant research gap by deepening understanding of how SERM unfolds in a sector that has historically received limited academic focus. By situating SERM within the broader ERM discourse, this research contributes to the literature by presenting a structured, context-specific set of industry-related barriers, thereby offering a clearer foundation for future investigations and theoretical development in construction risk management. From a practical standpoint, this study underscores the need for holistic and context-sensitive approaches to ERM implementation. While the study focuses on the UAE construction sector, its findings offer a foundation for other construction firms to adapt and refine their own SERM frameworks. For the broader risk management profession, including practitioners, industry associations, and policymakers, the findings present an opportunity to refine existing frameworks and standards to prioritize long-term sustainability and systemic integration. The evidence emphasizes that effective SERM implementation depends on addressing foundational elements such as leadership commitment, organizational culture, and the presence of clearly defined frameworks, rather than relying solely on tools or compliance mechanisms. Accordingly, risk consultants and officers should shift focus toward building internal capacity and cultivating a risk-supportive environment.

5.2. Limitations

Although this study employed a structured methodology combining Delphi, ISM, and MICMAC techniques, it is essential to acknowledge the inherent subjectivity associated with expert-driven analyses. In particular, the structure and prioritization of barriers identified through ISM are influenced by the composition of the expert panel. While purposive sampling was used to ensure participants had substantial and diverse experience within the UAE construction sector, the insights they provided inevitably reflect their unique professional backgrounds, organizational contexts, and risk perceptions. This dependency introduces a potential source of variability. Alternative panels composed of experts from different regions, disciplines, or market segments might yield differing hierarchical relationships among barriers. As a result, while the findings are valid within the context studied, caution should be exercised when generalizing to broader settings or international contexts. To enhance robustness, future research should consider replicating the study using varied expert cohorts and applying sensitivity analysis to assess how changes in panel composition affect the structural model.

5.3. Suggestions for Future Work

Building on the findings of this study, several promising avenues for future research are proposed to further advance SERM in the construction sector, both within the UAE and globally. First, future studies could integrate project-based case analyses alongside expert interviews and surveys, offering richer, context-specific insights that deepen the understanding of SERM dynamics in practice. Second, new causality-based models could be developed to explore specific SERM themes, such as perceptions of its benefits across different organizational functions and departments. Investigating these nuances could provide a more granular view of barriers and enablers within firms. Third, expanding the current ISM framework by incorporating additional factors may enhance its practical relevance and precision. Applying this enhanced methodology across different regional and industrial contexts would further validate its generalizability and contribute to a broader global discourse on ERM practices. Finally, examining the role of advanced digital technologies, such as AI, IoT, and data analytics, in mitigating key challenges could open new pathways for strengthening SERM implementation. Exploring how technological innovation intersects with sustainable risk management presents an exciting frontier for both research and industry practice.

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