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Key strategies to advancing Net-Zero Carbon procurement: An ISM-MICMAC approach

To Thi Huong Quynh[1*]

[1] Faculty of Construction Economics and Management, Hanoi University of Civil Engineering, Vietnam

KEYWORDS

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ABSTRACT

The paper presents an analysis of the Interpretive Structure Model (ISM) and the Cross-Impact Matrix Multiplication Applied to Classification (MICMAC) as a tool for classifying the specific importance of key strategies in advancing Net-Zero Carbon procurement (NZCP) and their relationships. The hierarchical relationship between the twelve NZCP strategies helps to propose solutions to promote Net-Zero Carbon Building development in the Vietnamese construction industry more closely and more effectively. These main NZCP strategies are grouped into three broad categories, comprising 12 sub-NZCP strategies, which were identified through survey results from eight Net-Zero Carbon Building experts. The results showed that the cluster "Drivers", including S1 “Developing NZC Procurement Strategies and Policies” and S2 “Establishing NZC Procurement standards”, has the strongest impact and plays the leading role in advancing Net-Zero Carbon procurement in Vietnam.

1. Introduction

Achieving Net-Zero Carbon (NZC) in the built environment has become a global priority in response to climate change. According to the IPCC [1], the building sector accounts for approximately 37% of global energy-related CO_2 emissions, highlighting both the potential and the urgency for emission reductions in this domain. NZC in construction refers to a state of balance between greenhouse gas emissions and removals across the entire building lifecycle—from design and construction to operation and eventual deconstruction [2].

To realise this goal, several strategies have been proposed, including enhancing energy efficiency, integrating renewable energy systems (e.g., building-integrated photovoltaics—BIPV), reducing embodied carbon in materials, and adopting circular economy principles [3], [4]. However, procurement, which serves as a critical link between design decisions and physical implementation, is often underestimated in its strategic importance. Procurement decisions influence both embodied and operational carbon emissions and are vital instruments for embedding low-carbon standards and requirements throughout the construction value chain [5], [6].

Sustainable procurement contributes directly to the United Nations Sustainable Development Goal 12 on responsible consumption and production (UN SDG 12). NZC-oriented procurement strategies may include prioritising suppliers offering low-carbon materials, requiring transparent lifecycle carbon data in bidding documents, integrating energy performance criteria in equipment tenders, encouraging the use of renewable energy in supplier operations, or embedding circular economy principles into procurement contracts [7], [8].

Nevertheless, a systematic method is required to identify and classify the influence of various NZC procurement strategies. In this context, the ISM-MICMAC methodology (Interpretive Structural Modelling – Cross Impact Matrix Multiplication Applied to Classification) has been effectively employed in related fields such as green supply chain management [9], sustainable logistics[10], technological transition [11], and construction innovation studies [12]. ISM helps to structure the interrelationships among factors into a hierarchical model, while MICMAC classifies these factors based on their driving and dependence powers—thereby identifying key “driver” or “linkage” variables in the system.

Although the ISM-MICMAC approach has not yet been widely applied specifically to NZC procurement in construction, its successful use in analogous domains suggests strong methodological suitability. Factors such as policy and governance, top management commitment, technological innovation, information sharing, and financial resources have consistently emerged as influential elements in sustainable transition systems [10], [13]. Therefore, this study proposes to apply the ISM-MICMAC method to identify, structure, and classify procurement strategies that support NZC goals in the built environment. The findings are expected to provide both theoretical and practical insights for policymakers, developers, consultants, and contractors in making strategic decisions and accelerating the transition toward low-carbon construction.

2. Research objectives, theoretical framework and methods

2.1. Research objectives

This study aims to explore and systematise procurement strategies that support the achievement of Net-Zero Carbon (NZC) goals in the built environment through the application of the ISM-MICMAC methodology. The specific objectives of the study are as follows:

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1. To identify key procurement strategies relevant to NZC goals in Vietnam based on literature review and expert insights.
2. To examine the interrelationships among these strategies and develop a hierarchical structure using Interpretive Structural Modelling (ISM).
3. To classify the strategies based on their driving and dependence power using MICMAC analysis.
4. To highlight the most influential and interdependent strategies that can serve as leverage points for accelerating NZC transition in the construction sector in Vietnam.

2.2. Research questions

To achieve the above objectives, the study addresses the following research questions:

1. What are the most critical procurement strategies for achieving Net-Zero Carbon in the built environment?
2. How are these strategies interrelated in terms of influence and dependency?
3. Which strategies act as key drivers or linkage variables in advancing NZC procurement?
4. How can ISM-MICMAC analysis support decision-makers in prioritising procurement actions toward NZC objectives?

2.3. Theoretical framework

The theoretical framework of this study is grounded in the intersection of sustainable procurement, net-zero carbon transition, and system-based decision-making tools.

– Sustainable Procurement Theory emphasises the integration of environmental and social considerations into purchasing decisions, aligning procurement with broader sustainability objectives such as SDG 12 (Responsible Consumption and Production).

– Net-Zero Carbon in the Built Environment is approached from a lifecycle perspective, considering both operational and embodied emissions. This aligns with frameworks that promote holistic decarbonization through material choices, energy systems, and supply chain engagement.

– ISM-MICMAC Methodology serves as the analytical foundation. ISM helps model the hierarchical relationships among NZC procurement strategies, while MICMAC allows for categorisation based on driving and dependence power, as informed by systems thinking and structural modelling theory. This enables a structured understanding of which strategies are foundational versus those that are outcomes or dependent measures.

Together, these theoretical lenses facilitate a comprehensive and structured approach to understanding how procurement can effectively contribute to NZC goals in construction and how decision-makers can prioritise strategies based on systemic influence.

3. Methodology

3.1. Research framework

To ensure a comprehensive and actionable understanding of the mechanisms underpinning the implementation of Net-Zero Carbon (NZC) procurement in the built environment, this study adopts a hybrid research methodology that integrates both qualitative and interpretive modelling techniques (Fig 1). Specifically, the study employs Interpretive Structural Modelling (ISM) and MICMAC (Cross-Impact Matrix Multiplication Applied to Classification) analysis to explore the interrelationships among twelve identified NZC procurement strategies.

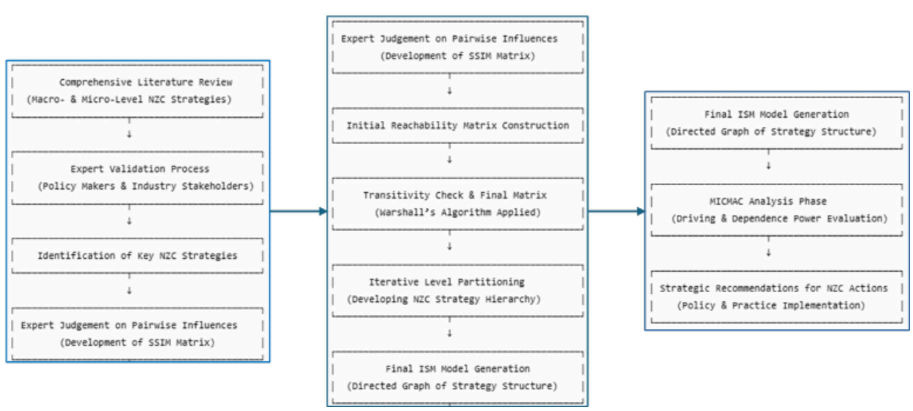

Figure 1. Research framework.

The research commenced with an extensive review of academic literature, international policy frameworks, and technical reports to identify relevant micro- and macro-level strategies for NZC procurement. Following this, a series of expert consultations involving stakeholders from academia, construction practice, and policy-making were conducted to validate the relevance and applicability of these strategies within the context of the built environment sector.

In the ISM phase, a panel of eight experts—comprising professionals with extensive experience in sustainable construction and procurement—was engaged to define the contextual relationships between the strategies. A Structural Self-Interaction Matrix (SSIM) was developed, using a pairwise comparison approach to capture the perceived direction of influence among the strategies. The SSIM was subsequently converted into an Initial Reachability Matrix (IRM) using established transformation rules [14], and the Final Reachability Matrix (FRM) was derived through transitivity checks based on Warshall's algorithm [15].

The reachability and antecedent sets for each strategy were analysed iteratively to determine their respective hierarchical levels, resulting in a multi-level structural model that reveals the foundational and dependent strategies in NZC procurement implementation [14], [16]. To further analyse the systemic role of each strategy, MICMAC analysis was conducted by evaluating the driving and dependence power of the strategies based on the FRM. The strategies were subsequently classified into four categories—autonomous, dependent, linkage, and independent—thereby providing insight into their strategic significance and guiding prioritisation efforts [17].

This integrated ISM-MICMAC approach not only elucidates the structural relationships among the strategies but also informs targeted policy and practical interventions to accelerate the decarbonisation of procurement practices in the construction sector [16], [18].

3.2. Survey participants

The survey was conducted through direct interviews with 8 NZCB experts (Table 1). The information of the participants is as follows:

Table 1. Demographics of the survey participants.

ID	Educational level	Major	Work experience
E1	PhD candidate	Urban planning	20 years
E2	Doctor	Structure engineer	15 years
E3	Associated professor	Construction management	23 years
E4	PhD candidate	Construction management	11 years
E5	Associated professor	Construction material	20 years
E6	Doctor	MEP engineer	22 years
E7	Doctor	Construction management	15 years
E8	Doctor	Architecture	18 years

4. Results

4.1. Potential strategies for advancing Net-Zero Carbon procurement

Derived from an extensive synthesis of relevant academic literature and policy documents, twelve strategic approaches—encompassing both macro-level and micro-level dimensions—have been identified. These strategies collectively represent a structured framework for advancing Net-Zero Carbon (NZC) procurement within the built environment sector. At the macro level, they focus on policy formulation, regulatory standardisation, and financial mobilisation, while at the micro level, they address implementation practices such as technological innovation, material specification, and stakeholder engagement. The identified strategies include: (1) developing NZC procurement strategies and policies, (2) establishing NZC procurement standards, (3) investing in green finance, (4) adopting smart procurement platforms, (5) implementing pilot practices, (6) integrating NZC principles into urban and socio-economic infrastructure, (7) enhancing stakeholder capacity and human resource development, (8) strengthening institutional coordination, (9) improving the quality and availability of green building materials, (10) advancing technology development, (11) increasing stakeholder awareness, and (12) embedding NZC considerations into the planning and design process. Collectively, these strategies constitute a comprehensive foundation for institutionalising low-carbon procurement practices, aligned with global climate imperatives and the broader sustainable development agenda. A detailed explanation and references of each strategy are presented in Table 2.

S1. Developing NZC Procurement Strategies and Policies

The formulation of comprehensive Net-Zero Carbon (NZC) procurement strategies is paramount to institutionalising decarbonisation in the construction sector. Effective strategies must account for lifecycle carbon emissions, foster sustainability across the supply chain, and embed emissions reduction benchmarks into procurement frameworks. Policymakers have a crucial role in establishing mandatory low-carbon procurement policies and aligning them with national climate objectives. Long-term strategies should encompass measurable carbon targets, structured implementation roadmaps, and transparent accountability mechanisms. The UK's Net Zero Strategy, for instance, requires procurement processes to evaluate carbon impacts at key project stages [5]. Furthermore, the presence of robust institutional policies underpinned by enforceable legal frameworks, combined with active stakeholder participation, is indispensable for coherent policy implementation and minimising executive inconsistencies [1], [4].

S2. Establishing NZC Procurement Standards

The development of NZC procurement standards ensures consistency and clarity in reducing carbon emissions across construction projects. These standards should define clear metrics for embodied and operational carbon, supported by verified certifications such as Environmental Product Declarations (EPDs), ISO 14001, and LEED [6]. Standardisation enhances transparency, facilitates benchmarking, and supports informed decision-making, thereby mitigating greenwashing risks. By encouraging innovation and harmonisation, these standards align supply chain practices with NZC goals and promote comparability across projects [3], [6].

S3. Investment in Green Finance for NZC Procurement

Investment in green finance is essential for supporting the implementation of low-carbon procurement practices. Financial tools such as green bonds, concessional loans, and blended finance mechanisms help reduce investment risks and attract capital for NZC-aligned infrastructure [8]. These instruments align investor objectives with sustainability outcomes and direct funding toward low-carbon technologies, materials, and construction methods. The OECD highlights the critical role of green bonds in financing climate-resilient procurement [8].

S4. Smart Procurement Platforms in Facilitating the Net-Zero Carbon Transition

Smart procurement platforms integrate digital tools like Building Information Modelling (BIM), artificial intelligence, and blockchain to enhance procurement efficiency and sustainability [7]. These platforms support real-time carbon tracking, supplier monitoring, and data-driven decision-making. By embedding carbon criteria into bid evaluations, they enable transparent, accountable, and standardised procurement processes, thereby supporting broader NZC transition goals.

S5. Pilot Practices in Net-Zero Carbon Procurement

Pilot projects provide practical insights into innovative procurement models and NZC strategies. These initiatives allow testing of performance-based contracts, low-carbon technologies, and integrated stakeholder approaches. Empirical data from pilots inform policy refinement and help overcome implementation challenges [10]. For instance, Scandinavian countries have successfully used pilot projects to incorporate lifecycle carbon criteria into public procurement [12].

S6. Urban and Socio-Economic Infrastructure in the NZC Transition

Integrating NZC procurement into urban and socio-economic infrastructure projects is crucial for achieving systemic decarbonisation. Public infrastructure, including housing and transport, offers significant emission reduction opportunities when guided by green procurement policies [2], [11]. Such integration ensures sustainable urban development while also delivering socio-economic benefits like job creation and improved public health.

S7. Enhancing Stakeholder Capacity and Human Resource Development

Skilled human resources are vital for NZC procurement implementation. Capacity-building initiatives, professional training, and sustainability-focused curricula can equip practitioners with the expertise to manage lifecycle carbon and sustainable procurement practices [13]. Enhancing knowledge across the supply chain ensures broader adoption of NZC principles and fosters innovation in procurement processes.

S8. Enhancing Coordination for Effective NZC Procurement Implementation

Cross-sectoral and inter-agency coordination is essential for the success of NZC procurement. Integrated policy frameworks and multi-level collaboration help streamline implementation, avoid duplication, and foster shared accountability [10]. Mechanisms such as joint procurement and knowledge-sharing platforms can align public and private sector efforts and accelerate NZC outcomes.

S9. Enhancing the Quality and Availability of Green Building Materials

The availability of certified low-carbon materials is a critical enabler of NZC procurement. Investment in material innovation, certification systems, and supply chain transparency can support this goal [4], [9]. Policies that promote preferential treatment for sustainable materials and support local production further enhance accessibility and market readiness.

S10. Advancing Technology Development for Net-Zero Carbon Procurement

Technological innovation underpins NZC procurement. Investments in R&D for energy-efficient methods, renewable integration, and digital tools enhance the effectiveness of procurement strategies [7], [10]. Embedding innovation criteria in procurement can drive market transformation and ensure long-term climate resilience.

S11. Enhancing Stakeholder Awareness for Net-Zero Carbon Procurement

Raising awareness is key to NZC procurement success. Campaigns, workshops, and dissemination of best practices engage stakeholders and promote behavioural change [11], [13]. Transparency in procurement outcomes builds trust and accelerates the adoption of low-carbon practices.

S12. Planning and Design for Net-Zero Carbon Procurement

NZC objectives must be integrated at the planning and design stages. Early carbon assessments, sustainable design briefs, and multidisciplinary collaboration ensure procurement strategies align with long-term environmental goals [3], [6]. This foundational approach maximises climate impact and supports effective NZC implementation.

Table 2. Potential strategies for advancing Net-Zero Carbon procurement.

Code	Strategy	Explanation	References
S1	Developing NZC Procurement Strategies and Policies	Define long-term goals, integrate life-cycle thinking, and mandate low-carbon criteria in all government and institutional procurement policies	[5]
S2	Establishing NZC Procurement standards	Promote consistent use of carbon metrics, product labelling, and third-party certifications (e.g., ISO 14001, EPDs)	[6]
S3	Investment in Green Finance for NZC Procurement	Facilitate green bonds, climate funds, and blended finance models to support low-carbon procurement solutions	[3], [8]
S4	Smart Procurement Platforms in Facilitating the Net-Zero Carbon Transition	Deploy digital procurement tools to improve emissions tracking, tender evaluation, and supplier performance transparency	[4], [7]

Code	Strategy	Explanation	References
S5	Pilot Practices in Net-Zero Carbon Procurement	Launch experimental projects to test innovative procurement models, collect performance data, and refine policy instruments	[10]
S6	Urban and Socio-Economic Infrastructure in the NZC Transition	Align procurement with integrated planning that supports both decarbonization and equitable urban development	[2], [11]
S7	Enhancing Stakeholder Capacity and Human Resource Development	Train professionals across the value chain to incorporate NZC thinking into procurement and construction decisions	[13]
S8	Enhancing Coordination for Effective NZC Procurement Implementation	Foster collaborative frameworks that bridge public-private actors, regulatory bodies, and the supply chain	[10], [12]
S9	Enhancing the Quality and Availability of Green Building Materials	Support local innovation, sustainable material production, and logistics infrastructure for low-carbon options	[4], [9]
S10	Advancing Technology Development for Net-Zero Carbon Procurement	Invest in research and development for sustainable building technologies and supply chain optimisation tools	[7], [10]
S11	Enhancing Stakeholder Awareness for Net-Zero Carbon Procurement	Run awareness campaigns, share best practices, and publish performance benchmarks to engage communities and stakeholders	[11], [13]
S12	Planning and Design for Net-Zero Carbon Procurement	Integrate low-carbon goals from project inception through early-stage design and feasibility assessments	[3], [6]

4.2. Establishing Interpretive Structural Modelling (ISM) analysis

To structure the interdependencies among the identified strategies for advancing Net-Zero Carbon (NZC) procurement in the built environment, the Interpretive Structural Modelling (ISM) methodology is employed. The initial step in ISM involves constructing a Structural Self-Interaction Matrix (SSIM), which systematically captures the contextual relationships between each pair of strategies. These relationships are established based on expert judgment, synthesis of existing literature, and logical reasoning to determine which strategies influence others [14], [19].

Each cell in the SSIM represents the directional influence between two strategies, coded with the following notations:

- **V**: Strategy *i* influences Strategy *j*
- **A**: Strategy *j* influences Strategy *i*
- **X**: Strategies *i* and *j* mutually influence each other
- **O**: No significant influence between Strategies *i* and *j*

This qualitative assessment is fundamental for distinguishing *driver* strategies (high influence on others) from *dependent* strategies (those highly influenced by others), thereby enabling a nuanced understanding of the systemic structure inherent in NZC procurement practices.

The SSIM also establishes the foundation for constructing a binary reachability matrix, which subsequently facilitates the derivation of hierarchical levels and strategic classifications via the next phases of ISM analysis [15].

By applying this SSIM framework to all twelve NZC procurement strategies—spanning policy development, standardisation, green finance, technology innovation, and stakeholder engagement—a coherent hierarchical model is created.

This model informs the planning and implementation of climate-resilient procurement outcomes in built environment projects [16], [18].

4.2.1. Structural Self-Interaction Matrix (SSIM)

Below is the Structural Self-Interaction Matrix (SSIM) for the twelve Net-Zero Carbon (NZC) procurement strategies. Each strategy is compared pairwise with the others to determine the directional relationship using ISM logic (V, A, X, O) in Table 3.

Table 3. Structural Self-Interaction Matrix (SSIM) for the twelve Net-Zero Carbon (NZC) procurement strategies

Strategies	1	2	3	4	5	6	7	8	9	10	11	12
S1		V	V	V	V	V	V	V	V	V	V	V
S2			O	V	V	V	V	V	V	V	V	V
S3				V	O	O	A	A	V	V	A	A
S4					V	O	O	A	A	V	A	A
S5						V	V	V	A	A	A	A
S6							A	A	V	V	A	V
S7								A	A	A	V	A
S8									V	V	A	V
S9										V	A	A
S10											A	A
S11												O
S12												

4.2.2. Establishing Reachability Matrix (Transitive Closure)

To convert the SSIM into a binary matrix, replace the symbols V, A, X, and O with 1s and 0s using the following rules:

- If the entry (i, j) in the SSIM is V, then the entry (i, j) in the binary matrix becomes 1 and the entry (j, i) becomes 0.

- If the entry (i, j) in the SSIM is A, then the entry (i, j) in the binary matrix becomes 0 and the entry (j, i) becomes 1.
- If the entry (i, j) in the SSIM is X, then both entries (i, j) and (j, i) in the binary matrix become 1.
- If the entry (i, j) in the SSIM is O, then both entries (i, j) and (j, i) in the binary matrix become 0.

The converted result is presented in Table 4.

Table 4. Reachability Matrix

Strategies	1	2	3	4	5	6	7	8	9	10	11	12	Driving Power
S1	1	1	1	1	1	1	1	1	1	1	1	1	12
S2	0	1	0	1	1	1	1	1	1	1	1	1	10
S3	0	0	1	1	0	0	0	0	1	1	0	0	4
S4	0	0	0	1	1	0	0	0	0	1	0	0	3
S5	0	0	0	0	1	1	1	1	0	0	0	0	4
S6	0	0	0	0	0	1	0	0	1	1	0	1	4
S7	0	0	1	0	0	1	1	0	0	0	1	0	4
S8	0	0	1	1	0	1	1	1	1	1	0	1	8
S9	0	0	0	1	1	0	1	0	1	1	0	0	5
S10	0	0	0	0	1	0	1	0	0	1	0	0	3
S11	0	0	1	1	1	1	0	1	1	1	1	0	8
S12	0	0	1	1	1	0	1	0	1	1	0	1	7
Dependence Power	1	2	6	8	8	7	8	5	8	10	4	5	

4.2.3. Ranking strategies

The Reachability (R) set and Antecedent (A) set are collections of elements derived for each barrier. The Reachability set includes the element itself and other elements it can help to achieve, whereas the Antecedent set includes the element and other elements that can help achieve it. The Intersection set is the common elements shared between the R and A sets. The highest-level strategy in the hierarchy does not contribute to the achievement of any strategies positioned above it. Once this top-level element is identified, the underlying strategies are those that facilitate its attainment. This procedure is conducted iteratively until all strategies are appropriately positioned within the hierarchical structure (Table 5).

4.3. Establishing MICMAC analysis

The MICMAC (Cross-Impact Matrix Multiplication Applied to Classification) analysis was conducted to further investigate the driving and dependence power of the twelve identified strategies for Net-Zero Carbon (NZC) procurement in the built environment. Based on Level Partitioning (LP) of strategies (Table 5), Reduced Conical Matrix (CM) (Table 6) was conducted.

Table 5. Level Partitioning (LP) of strategies.

Strategies	Reachability	Antecedent	Intersection	Level
1	1,	1,	1,	3
2	2,	1, 2,	2,	2
3	3, 4, 5, 6, 7, 8, 9, 10, 11, 12,	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12,	3, 4, 5, 6, 7, 8, 9, 10, 11, 12,	1
4	3, 4, 5, 6, 7, 8, 9, 10, 11, 12,	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12,	3, 4, 5, 6, 7, 8, 9, 10, 11, 12,	1
5	3, 4, 5, 6, 7, 8, 9, 10, 11, 12,	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12,	3, 4, 5, 6, 7, 8, 9, 10, 11, 12,	1
6	3, 4, 5, 6, 7, 8, 9, 10, 11, 12,	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12,	3, 4, 5, 6, 7, 8, 9, 10, 11, 12,	1
7	3, 4, 5, 6, 7, 8, 9, 10, 11, 12,	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12,	3, 4, 5, 6, 7, 8, 9, 10, 11, 12,	1
8	3, 4, 5, 6, 7, 8, 9, 10, 11, 12,	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12,	3, 4, 5, 6, 7, 8, 9, 10, 11, 12,	1
9	3, 4, 5, 6, 7, 8, 9, 10, 11, 12,	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12,	3, 4, 5, 6, 7, 8, 9, 10, 11, 12,	1
10	3, 4, 5, 6, 7, 8, 9, 10, 11, 12,	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12,	3, 4, 5, 6, 7, 8, 9, 10, 11, 12,	1
11	3, 4, 5, 6, 7, 8, 9, 10, 11, 12,	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12,	3, 4, 5, 6, 7, 8, 9, 10, 11, 12,	1
12	3, 4, 5, 6, 7, 8, 9, 10, 11, 12,	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12,	3, 4, 5, 6, 7, 8, 9, 10, 11, 12,	1

Table 6. Reduced Conical Matrix (CM).

Strategies	3	4	5	6	7	8	9	10	11	12	2	1	Driving Power	Level
S3	1	1	1*	1*	1*	1*	1	1	1*	1*	0	0	10	1
S4	1*	1	1	1*	1*	1*	1*	1	1*	1*	0	0	10	1
S5	1*	1*	1	1	1	1	1*	1*	1*	1*	0	0	10	1
S6	1*	1*	1*	1	1*	1*	1	1	1*	1	0	0	10	1
S7	1	1*	1*	1	1	1*	1*	1*	1	1*	0	0	10	1
S8	1	1	1*	1	1	1	1	1	1*	1	0	0	10	1
S9	1*	1	1	1*	1	1*	1	1	1*	1*	0	0	10	1
S10	1*	1*	1	1*	1	1*	1*	1	1*	1*	0	0	10	1
S11	1	1	1	1	1*	1	1	1	1	1*	0	0	10	1
S12	1	1	1	1*	1	1*	1	1	1*	1	0	0	10	1
S2	1*	1	1	1	1	1	1	1	1	1	1	0	11	2
S1	0	0	0	0	0	0	0	0	0	0	1	1	12	3
Dependence Power	12	12	12	12	12	12	12	12	12	12	2	1		
Level	1	1	1	1	1	1	1	1	1	1	2	3		

The results are visually presented in the driving–dependence graph (Figure 2), which classifies the strategies into four categories: Autonomous, Dependent, Linkage, and Independent variables. Notably, no strategies were classified in Quadrant I (Autonomous variables) or Quadrant II (Dependent variables), indicating that all strategies either play a foundational role or are highly interconnected. The analysis revealed that two strategies—S1: Developing NZC Procurement Strategies and Policies and S2: Establishing NZC Procurement Standards—exhibited high driving power but low dependence, thus positioning them in Quadrant IV (Independent variables). These two strategies serve as fundamental enablers that influence the rest of the system and should therefore be prioritised during initial policy development and strategic planning stages.

In contrast, the remaining ten strategies (S3 to S12) were situated in Quadrant III (Linkage variables), characterised by both high driving and high dependence power. This indicates a dynamic and sensitive system where any modification in one strategy may substantially affect the others. These include strategies related to green finance, smart procurement platforms, pilot practices, infrastructure, stakeholder capacity and awareness, coordination, green materials, technology development, and design planning. The absence of autonomous or purely dependent variables suggests a strongly integrated strategy network, reinforcing the need for coordinated and systemic implementation efforts.

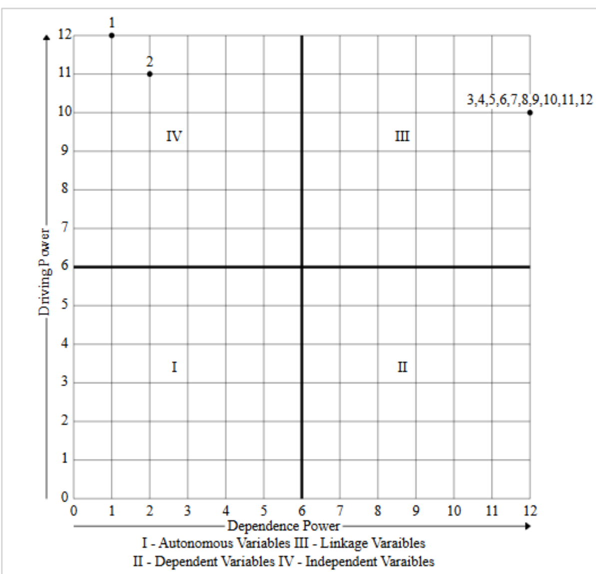

Figure 2. MICMAC analysis result.

To clarify the structural interrelationships among the twelve NZC procurement strategies, Interpretive Structural Modelling (ISM) was conducted. The resulting hierarchical model, as depicted in Figure 3, reveals three distinct levels of strategic influence and dependency. At the foundational Level III, S1 (Developing NZC Procurement Strategies and Policies) emerges as the primary driver. It exhibits no dependence on other strategies but exerts a direct influence on S2 (Establishing NZC Procurement Standards), which occupies the intermediate Level II. S2, in turn, exerts control over all remaining ten strategies, which reside in the topmost Level I.

These Level I strategies—including green finance (S3), smart procurement platforms (S4), pilot practices (S5), urban and socioeconomic infrastructure (S6), stakeholder capacity (S7), inter-agency coordination (S8), green materials (S9), technological innovation (S10), stakeholder awareness (S11), and design integration (S12)—are characterised by high dependence and low driving power. Some of them (e.g., S4–S5, S6–S7) also show bidirectional relationships, indicating mutual reinforcement.

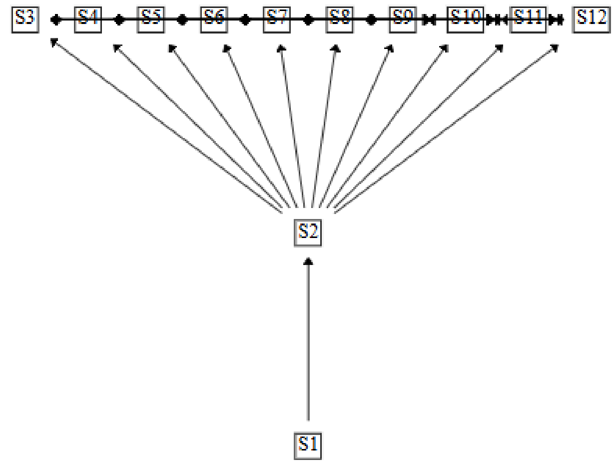

Figure 3. Final MICMAC model.

This model illustrates a logical flow from policy formulation to standardisation and operational implementation, suggesting that effective deployment of strategies at Levels I and II is contingent on strategic governance and regulatory foundations at Level III. These findings support the assertion that without clear national direction (S1) and institutional standardisation (S2), operational strategies may lack coherence, efficiency, and alignment with net-zero targets.

The ISM hierarchy thus offers critical insights for policy planners, emphasising the need for a tiered approach in NZC procurement reforms—beginning with governance and cascading down to execution-level strategies.

5. Discussion and Policy Implications

To effectively implement Net-Zero Carbon (NZC) procurement strategies in the built environment, it is essential to align national and subnational policies with international best practices and emerging regional trends. Developed countries such as the United Kingdom and Australia have demonstrated how embedding NZC targets into public procurement frameworks can drive systemic change. For instance, the UK mandates carbon reduction reporting in public tenders through Policy Procurement Notice PPN 06/21, while Australia's "Net Zero in Government Operations Strategy" integrates low-emission standards across building and transport procurement portfolios [20], [21]. Similarly, the European Union's Green Public Procurement (GPP) programme promotes lifecycle carbon assessments and sector-specific benchmarks, providing a comprehensive foundation for sustainable procurement [22].

These global experiences underscore several strategic policy directions for emerging economies. First, NZC procurement goals should be institutionalised within national climate frameworks to provide long-term regulatory certainty. Second, measurable carbon performance standards and lifecycle assessment tools must be incorporated into procurement criteria to guide market behaviour. Third, leveraging procurement to stimulate green markets—particularly for low-carbon steel, cement, and green building materials—is crucial for achieving deep decarbonisation, as evidenced by the GPP Pledge initiative's potential to reduce emissions by over 80% by 2050 [23]. Fourth, financial instruments such as green bonds, concessional loans, and blended finance are necessary to de-risk innovation and scale private sector participation. Fifth, capacity-building among public sector actors and enhanced stakeholder collaboration are foundational enablers, as seen in Oslo's climate budgeting model and Switzerland's procurement pilots [24].

Finally, integrating NZC procurement with circular economy objectives can enhance both environmental and economic outcomes, as highlighted in Australia's Circular Economy Plan, which uses public procurement to stimulate secondary material markets [25]. By adopting a multi-dimensional policy framework that combines regulation, finance, institutional capacity, and innovation, governments—particularly in Southeast Asia—can accelerate the adoption of NZC procurement and contribute meaningfully to global decarbonisation efforts.

6. Conclusions

The purpose of the paper is to present an analysis of the Interpretive Structure Model (ISM) and the Cross-Impact Matrix Multiplication Applied to Classification (MICMAC) as a tool to classify the specific importance of the key strategies to advancing Net-Zero Carbon procurement (NZCP) and their relationships. The hierarchical relationship between the twelve NZCP strategies helps to propose solutions to promote Net-Zero Carbon Building development in the Vietnamese construction industry more closely and more effectively. These main NZCP strategies are grouped into 03 large groups containing 12 sub-NZCP strategies, which are identified through survey results from eight Net-Zero Carbon Building strategies experts. The results showed that the cluster "Drivers", including S1 Developing NZC Procurement Strategies and S2 Policies and Establishing NZC Procurement standards, has the strongest impact on advancing Net-Zero Carbon procurement in Vietnam.

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