STRUCTURAL EQUATION MODEL OF SUSTAINABLE-ORIENTED ATTRIBUTES INFLUENCING THE PROJECT MANAGEMENT PROCESS AND STRATEGY OF CONSTRUCTION PROJECTS

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Abstract

The sustainability orientation and introduction of sustainable practice in construction play a crucial role in mitigating the industry's negative global impacts (Lima et al., 2021). This study aims to propose a model of interrelationships among sustainable-oriented attributes of the project management process (PMP) involved in construction projects in the Vietnamese construction industry (VCI). The study adopted the PMP framework of ISO 21500:2012 as an initial model (International Organization for Standardization [ISO], 2012). We collected data on construction projects in Hanoi, the capital of Vietnam, using a questionnaire survey. We employed partial least squares structural equation modeling (PLS-SEM) to explore the interrelationships among the sustainable-oriented attributes of the PMP. The study results in a sustainable-oriented model of 24 attributes of the PMP. Eight relationships among sub-processes of the PMP involving construction projects in Vietnam are significant; meanwhile, the relationship between the implementing and controlling processes is not significant. This reflects a particular practice of the PMP in Vietnam. Research findings may benefit Vietnamese and foreign construction stakeholders. Stakeholders of construction projects in Vietnam and other countries can use findings to improve the PMP through measures affecting these identified attributes. Moreover, by making appropriate adjustments, we can apply the proposed model in this paper to other countries to gain insights into PMP involving construction projects.

Keywords: Project Analysis, Developing Country, Sustainability, Data Collection, Modelling

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1. INTRODUCTION

The construction industry is growing rapidly in developing countries, seen as a major driver of economic development, and the need for infrastructure to support economic growth. However, while contributing significantly to economic development, this sector must also address sustainability issues. Construction is one of the top three sectors contributing to global carbon emissions and a substantial increase in energy demand. Without strict management and a sustainability focus, construction activities can generate 40–50% of greenhouse gas emissions, consume 40% of natural resources, and emit large quantities of greenhouse gases and carbon dioxide (Yılmaz & Bakış, 2015).

In developing countries like Vietnam, research often concentrates on factors affecting the time, cost, schedule, and overall success or failure of construction projects, with little attention to sustainability or its orientation in project success. The factors that contribute to project success are also closely related to project management problems, which are found in other developing countries such as South Africa where projects do not comply with project management objectives and the main cause is the lack of management skills related to the emerging contractors in this country (Mavetera et al., 2015). Construction activities can lead to significant problems, such as resource intensiveness, environmental degradation, and negative impacts on public health. For effective project management, businesses and stakeholders must increase awareness and practice of sustainability in projects, from planning to monitoring and implementation. This approach aims to achieve benefits for all stakeholders transparently, fairly, and proactively. To guide future projects towards sustainability, it is crucial to identify attributes affecting the construction project management process (PMP). Sustainable activities can also help reveal the capacity of leaders to drive sustainable development effectively, while the 2030 agenda also encourages companies to move towards sustainability through their assessment of 17 Sustainable Development Goals (SDGs) (Nguyen et al., 2004; Le-Hoai et al., 2008; Mavi & Standing, 2018; Fathalizadeh et al., 2019; Pham et al., 2019; Pham & Kim, 2019; Sabini et al., 2019; Salah et al., 2023; Sicoli et al., 2024).

Research on sustainability in construction and project management has explored various approaches, including identifying barriers to sustainable integration in construction projects and the industry in developing countries. Studies often utilize methodologies like Leadership in Energy and Environmental Design (LEED) and Life Cycle Assessment (LCA) to assess sustainability. Typically, these studies employ surveys and interviews to identify barriers to sustainable practices in construction projects and to explore critical success factors (CSFs) that affect sustainability integration. However, structural implications have been less frequently addressed. The use of structural equation modeling (SEM) in research has focused on various issues without specifically addressing attributes or factors affecting the construction of PMP (Pham et al., 2019; Lima et al., 2021; Ametepey et al., 2015; Liu et al., 2020). Environmental challenges caused by construction projects lead to the need for sustainability-oriented models of PMPs (Shen et al., 2007; Sicoli et al., 2024). These models help project managers to effectively use resources and minimize construction waste (Silvius, 2017). Applying sustainability-oriented models in construction, PMPs may create long-term values and sustainable social benefits, improve stakeholder satisfaction, and encourage green construction (Stanitsas et al., 2021).

There are three objectives of the study, which are:

1) to identify the sustainability-oriented attributes of the PMP;

2) to explore the underlying interrelationships among these attributes of the PMP involving construction projects in Vietnam;

3) to propose a model of interrelationships among sustainable-oriented attributes of the PMP involving construction projects in the Vietnamese construction industry (VCI).

This model may enhance understanding of sustainable-oriented attributes of the PMP involving construction projects, then may help stakeholders of construction projects in Vietnam to raise the effectiveness of their projects.

The rest of the paper is structured as follows. Section 2 presents a summary of the literature review and factor synthesis. Section 3 deals with the questionnaire design, data collection, and data analysis methods. Section 4 summarizes and discusses the empirical findings. Section 5 concludes the research.

2. LITERATURE REVIEW

2.1. Project management processes

The definition of the PMP plays a key role in directing a study during the research process. The study adopts the concept of the standard ISO 21500:2012 as the definition of the PMP. According to ISO 21500:2012, the PMP of a project involves five sub-processes, which are initiating, planning, implementing, controlling, and closing (International Organization for Standardization [ISO], 2012).

The international standard ISO 21502 was born as a more updated version of ISO 21500. The new standards take a practice-based approach by describing, monitoring, and outlining for global application (Guida & Monassi, 2021).

Researchers have continuously made significant efforts to apply partial least squares SEM (PLS-SEM) to various aspects of construction projects like identifying factors of cost performance, the relationship between causes and effects of poor communication, project control system, and so on (Chou & Yang, 2012; Chou & Ngo, 2014; Memon & Rahman, 2014; Hair et al., 2017; Elizar et al., 2017; Sinesilassie et al., 2019; Alaloul et al., 2020; Chidambaram & Tamilmaran, 2020; Gamil & Abd Rahman, 2023; Unegbu et al., 2022; Ishtiaq et al., 2023; Muñoz-Peña et al., 2023; Batra, 2025; Le & Sutrisna, 2024; Bello et al., 2024). The literature suggests that the application of PLS-SEM to the PMP of construction projects has received minimal attention (Mavi & Standing, 2018; Mirhosseini et al., 2022). Therefore, there is a shortage of studies and findings relating to sustainable-oriented attributes of the PMP involving construction projects, particularly in countries with transition economies, like Vietnam.

2.2. Interactions among project management processes of construction projects

This study adopts interactions among PMPs in ISO 21500:2012 as a conceptual model of sustainable-oriented attributes among the PMPs of construction projects in Vietnam. The ISO 21500:2012 project management model comprises five key processes: initiating, planning, implementing, controlling, and closing (Zandhuis & Stellingwerf, 2013). This standard plays a key role in ensuring the same process among project stakeholders, thereby minimizing errors in the PMP of construction projects.

Moreover, ISO 21500:2012 may help managers evaluate work quality and align employee efforts with organizational goals (Bakator et al., 2017). The integration of project management standards, including ISO 21500 and sustainability aspects, is crucial for enhancing the effectiveness of construction projects in the long-term view (Mavi & Standing, 2018; Kristinsdóttr et al., 2014; Subaie et al., 2023; Varajão et al., 2017).

Implementing the project management model under ISO 21500:2012 in developing countries like Vietnam faces significant challenges, especially when combined with sustainability principles. Several factors hinder its widespread adoption, including limited awareness and education about the standard, along with financial and infrastructural constraints (Drob & Zichil, 2013; Bakator et al., 2017). Successful implementation of ISO 21500:2012 necessitates investment in training, organizational changes, and government resource allocation (Varajão et al., 2017). Additionally, cultural norms that favor traditional management tools and a focus on short-term goals over long-term sustainability objectives further complicate its adoption (Takagi & Varajão, 2022). Although ISO 21500:2012 provides general guidance, it lacks specific emphasis on sustainability and methods for adapting the standard to local and organizational contexts (Bakator et al., 2017). These issues underscore the need for tailored approaches to effectively integrate ISO 21500:2012 into construction PMPs in Vietnam and other developing countries (Abdelkhalik & Azmy, 2022; Zandhuis & Stellingwerf, 2013). Therefore, seeking a proper model of interrelationships among sustainable-oriented attributes of the construction PMP plays a key role in applying ISO 21500:2012 to construction projects in Vietnam, a country with a transition economy.

2.3. Sustainability in project management of construction projects

Sustainability refers to the ability to maintain or support a process continuously over time (Jeronen, 2013; Yeung, 2023; Owusu-Wiredu, 2024; Sun, 2024; Suhardjo et al., 2024). Moreover, sustainability represents a very significant value in the construction industry today, and it is also being heavily integrated into project management with different approaches (Stanitsas et al., 2021). Sustainability comprises three constructs: 1) economic, 2) social, and 3) environmental (Jeronen, 2013; Emas, 2015). Moreover, sustainability was mainly referred to only in terms of environmental factors, seemingly ignoring the interactive relationship between the three factors of economy, society, and environment (Figueiredo et al., 2021). Sustainable development is also considered various goals of a study in Thailand. Economic sustainability requires you to carefully consider the whole life cycle of goods (Jeronen, 2013; Office of Sustainability, n.d.). Social sustainability can be characterized as consuming resources of human society more slowly than these resources are naturally renewed, discharging less waste than assimilating natural systems without degrading, or without depending upon other sources for most basic requirements of humans (Office of Sustainability, n.d.). In general, social sustainability can be applied to societies of any country. Environmental sustainability ensures that humans continue to have the resources to meet all needs (Hussen, 2012; Office of Sustainability, n.d.). Environmental sustainability principles can be applied to any system size, which involves a small home garden in a country (Banihashemi et al., 2017). Sustainability plays a crucial role in ensuring responsible utilization of natural resources, the minimum of waste, pollution mitigation, the use of renewable energy, and the implementation of ecological practices (Office of Sustainability, n.d.).

Sustainability in construction project management emphasizes minimizing the environmental impact of construction projects in their phases and improving the effective utilization of resources throughout the lifecycle of a construction (Silvius, 2017; Nikolić et al., 2016). Reducing waste, responsible utilization of natural resources, and encouraging environmentally friendly materials are typical practices of applying sustainability in construction projects (Hussen, 2012; Opoku et al., 2019). There are several aspects of sustainable construction in practice, which are the implementation of green practices in the designing, bidding, and building phase of a construction project (Nikolić et al., 2016), the use of recycled materials (Banihashemi et al., 2017), water resource preservation, and responsible water consumption (Opoku et al., 2019). In other words, sustainability in construction not only creates environmentally friendly buildings, but also efficiency in economics (Banihashemi et al., 2017; Opoku et al., 2019). Moreover, there have been many studies about sustainability in various industries in the past five years (Nigri et al., 2020; Akomea-Frimpong et al., 2022; Asogwa et al., 2022).

2.4. Sustainable-oriented attributes of construction project management processes

In this study, attributes influencing each stage of the PMP involving construction projects are features or qualities considered to be good or useful to all sub-processes of the PMP involving construction projects. Social sustainability emphasizes the promotion of human rights and freedoms, with a focus on human development (Banihashemi et al., 2017). Environmental sustainability involves protecting biodiversity, using renewable resources, limiting the consumption of non-renewable resources, minimizing harmful environmental impacts, and preserving historical and cultural heritage (Salah et al., 2023). Environmental sustainability is reflected in energy consumption, waste management, water consumption, material usage, noise, ecological assessments, sustainable natural resource usage, sustainable stakeholder management principles, and environmental reporting (Yılmaz & Bakış, 2015; Fathalizadeh et al., 2019; Martens & Carvalho, 2017; Stanitsas et al., 2021). Economic sustainability in construction projects refers to practices, such as return on investment (ROI), financial performance, economic and political stability, capital budget, investment plans, and stakeholder engagement in the PMP of construction projects (Hussen, 2012; Moshood et al., 2024). Sustainability in construction and project management has been explored in many studies from various perspectives and contexts (see Table 1).

Few studies directly address the attributes influencing each stage of the PMP, particularly with a focus on sustainability. Most existing research primarily examines the challenges, difficulties, and barriers that projects and PMPs encounter (Alwaly & Alawi, 2020; Ogunde, 2017). Moshood et al. (2024) pointed out these attributes as knowledge, occupational skills, and safety attributes. Other authors (Guinan, 2025; Ma, 2011; Marcelino-Sádaba et al., 2015; McBride, 2016) indicated that the initiating stage involves critical attributes such as human resources, scope determination, and implementation tools. The findings of these studies aim to fill the gap by exploring how specific attributes influence each stage of the PMP, thereby providing a more detailed understanding of their impact on project outcomes. In the planning management process, several attributes play crucial roles, including managers, engineers, bidding processes, tools, political and legal constraints, and stability (Misnan et al., 2024). During the implementation phase, key attributes include supplier selection, implementation resources, understanding stakeholders, and communication (Banihashemi, 2017; Shen et al., 2007; Zhong et al., 2018). The attributes impacting each stage of the PMP were reported by Lindahl and Ryd (2007).

Reviews of scientific publications on sustainability in construction project management highlight a critical gap: the exploration of the interrelationships among sustainability-oriented attributes. Previous research often pays little attention to the complexity and interrelations among these sustainability-oriented attributes, particularly in construction project management. This fragmented approach leads to a poor understanding of how these attributes mutually influence and then impact project outcomes. Therefore, it is necessary to develop appropriate models that describe the interrelations among sustainability-oriented attributes in the construction PMP, enabling stakeholders to integrate sustainability strategies into construction project management.

The roundtable of five experts and literature review resulted in a list of 33 preliminary attributes (see Table 1).

Table 1. Sustainability-oriented attributes of the project management process

PMP	*Coding*	*Attributes of PMP*	*References*
Initiating	*I1*	Human resource selection	Marcelino-Sádaba et al. (2015), Guinan (2025), and Ma (2011)
	I2	Active participation of stakeholders	
	I3	Knowledge and awareness	
	I4	The connection between strategies and sustainable management	
	I5	Ecosystem efficiency	
	I6	Exchange in environmental reporting on sustainability	
Planning	*P1*	Procurement and bidding process	Misnan et al. (2024), Shen et al. (2007), Zhong et al. (2018), and Banihashemi (2017)
	P2	Efficiency of bidding	
	P3	Planning resources and materials	
	P4	Developing products/services that pay attention to social sustainability	
	P5	Scope of work, constraints	
	P6	Political and legal stability	
	P7	Communicate with parties in social reporting	
	P8	Environmental assessment	
	P9	Design project specifications and techniques	
Implementing	*IP1*	Modern technology and methods	Shen et al. (2007), Banihashemi (2017), and de Almeida Vittori Ferreira et al. (2024)
	IP2	Contractor's right to perform	
	IP3	Project resources (people, machinery, capital)	
	IP4	Knowledge and awareness	
	IP5	Minimize water and noise pollution	
	IP6	Waste management	
Controlling	*C1*	Control methods	Zhong et al. (2018), Yong and Mustaffa (2013), and Banihashemi (2017)
	C2	Progress status	
	C3	Status of expenses	
	C4	Powers and abilities of managers	
	C5	Monitoring methods	
	C6	Responsible labor practices for sustainable development	
	C7	Troubleshooting, effective coordination of supervision	
Closing	*CS1*	Troubleshooting issues related to sustainable development	Dinsmore and Cabanis-Brewin (2018), Mavi and Standing (2018), Cerne and Jansson (2019), and Stanitsas et al. (2021)
	CS2	Coordination between parties	
	CS3	Committed to meeting the SDGs	
	CS4	Public acceptance	
	CS5	Experience in sustainable management	

3. RESEARCH METHODOLOGY

3.1. Questionnaire design and data collection

There are several methods to collect data and then complete research objectives. These methods are the questionnaire survey, interviewing experts, triangulation, case studies, and so on. The questionnaire survey has been selected for this study because of the convenience of data collection in Vietnamese conditions. The questionnaire was developed and administered to individuals who had direct involvement in the implementation of construction projects in Hanoi, Vietnam's capital, which is renowned for its rapid infrastructure development. This step aimed to validate the proposed model. The questionnaire comprised questions synthesized from previous studies in the field.

The initial attributes believed to impact the PMP were compiled from document reviews and presented to a panel of five professionals with significant experience in construction projects. Through face-to-face discussions, these experts meticulously examined and reviewed the attributes. They were then tasked with eliminating unnecessary attributes and categorizing unclassified ones into stages of project management, aligning them with appropriate sustainability criteria based on their practical insights. This process resulted in 33 attributes grouped into five sub-processes of the PMP.

The questionnaire comprised two sections. The first section focused on the impact level of attributes influencing the sustainability-oriented PMP in construction projects in Hanoi, Vietnam. Participants were individuals who had been actively involved in at least one recent project from the initiation to the closing phase. They were asked to assess the extent of these attributes at each stage of the PMP using a five-point Likert scale, where 1 indicated "very low impact" and 5 indicated "very high impact". The study selects the five-point Likert scale because it is easier to judge than the seven-point Likert or another scale (Tripathi & Jha, 2018). The second part of the questionnaire collected the profile of respondents.

A total of 640 survey questionnaires were distributed to individuals working at construction enterprises and contractors in Hanoi. The questionnaires were distributed directly, and responses were collected on the spot. To enhance credibility and response rates, initial conversations were held with respondents, allowing them to share stories about their actual projects before completing the questionnaire and providing their opinions. Out of the 640 questionnaires distributed, 230 respondents were willing to answer and return the questionnaire. However, 14 questionnaires were discarded due to inappropriate response levels, such as incomplete or inappropriate answers, or identical responses to all questions. This left 216 valid responses, resulting in a response rate of 77.72%. Appropriate sample sizes for most studies relating to PLS-SEM fall between 30 and 500 respondents, ensuring adequate representation and statistical reliability (Memon et al., 2020). This study adopts the suggested sample size for factor analysis, ranging from 100 to over 1,000 (Mundfrom et al., 2005). Therefore, 216 responses can be considered as the appropriate size for PLS-SEM analysis in this context.

Among the 216 valid responses, the majority (55.6%) of respondents are investors. This implies that findings may be considered from the viewpoint of the owners. Construction contractors represented 16.7% of the valid responses, followed by contractors providing consulting and design services. The respondents demonstrated substantial experience in the construction industry, with 66.7% reporting over 10 years of experience, resulting in an acceptable level of data reliability.

Regarding awareness and application of sustainability concepts, 35.6% of respondents were aware of the concept of sustainability in project management but had not applied it in practice. Additionally, 31.9% of respondents were familiar with ISO standards but had not applied them in practical management, indicating that the concepts of sustainable construction project management and ISO-based PMPs are primarily theoretical and lack practical application in the context of Vietnam.

In terms of project types, most respondents (47.7%) indicated involvement in apartment projects, with other project types including mixed projects and office buildings. Private capital was predominant, with projects typically ranging from VND 250–500 billion in scale.

3.2. Data processing method

The research methodology employed in this paper encompasses several analyses aimed at assessing the impact of attributes on the construction PMP. Specifically, exploratory factor analysis (EFA) and PLS-SEM methods are utilized. PLS-SEM is chosen for its ability to maximize the variance explained in the dependent variable(s) and its flexibility in meeting necessary assumptions, making it particularly suitable for exploratory research with less developed theory (Hair et al., 2014; Hair et al., 2017).

The research framework follows a step-by-step approach, including identifying attributes, gathering survey data, collecting and analyzing data, and providing recommendations. To ensure the reliability of the scale used in the initial survey, Cronbach's alpha coefficient is employed. Subsequently, EFA with varimax rotation is conducted to explore and group the elements into constructs. These constructs are then subjected to PLS-SEM to elucidate the interrelationships and assess the impact of these attributes on the construction of PMP.

The results yield groups of attributes aligned with the stages of the construction PMP in Vietnam, oriented towards sustainable development. These findings are compared with the original model based on the concept of ISO 21500:2012, aiming to offer recommendations for managers overseeing construction projects in Vietnam.

4. RESULT AND DISCUSSION

4.1. Results of exploratory factor analysis

Cronbach's alpha coefficient has been used to validate the reliability of the five-point scale (Hair et al., 2014). Hair et al. (2017) argued that a scale ensuring unidirectionality and achieving reliability should reach Cronbach's alpha threshold of 0.7 or higher. A higher coefficient indicates greater reliability. Additionally, another indicator utilized to evaluate the scale's reliability is the corrected item-total correlation (CITC). This value represents the correlation between each observed variable and the rest of the scale. A stronger correlation indicates better reliability. Moreover, Cristobal et al. (2007) suggest removing elements with a CITC less than 0.3. Consequently, factor *I1* in the Initiating group is eliminated due to a CITC of 0.262. The Cronbach's alpha coefficient results are 0.799, 0.911, 0.875, 0.869, and 0.843 for attributes in the initiating (*I*), planning (*P*), implementing (*IP*), controlling (*C*), and closing (*CS*) sub-processes, respectively. These results confirm the reliability of the measurement scale in questionnaires. The remaining attributes are 32.

EFAs are utilized to estimate the remaining attributes, with the reliability of each factor checked through commonality. During this evaluation, three attributes, namely *I2*, *C7*, and *C6*, are eliminated due to commonalities < 0.5 or loading attributes > 0.5 out of two attributes. Therefore, there are only 29 attributes to perform EFA. The commonality of the remaining attributes is all greater than 0.5, indicating the reliability of the construction model in this study. EFAs are conducted using principal component analysis and Promax rotation. The significance of Bartlett's test (p = 0.000) and a Kaiser–Meyer–Olkin (KMO) index value of 0.798 confirm that the data is suitable for factor analysis.

All attributes with loadings greater than 0.5 are considered to contribute to the explanation of factor groups. These five factor groups collectively explain 63.7% of the total variance in the data, surpassing the recommended threshold suggested by Hair et al. (2017).

Based on 29 sustainable-oriented attributes associated with the construction PMP, five sub-processes are identified: 1) *I*, 2) *P*, 3) *IP*, 4) *C*, and 5) *CS*.

Table 2. Results of exploratory factor analysis

Variable	*Content*	*Component*				
		1	*2*	*3*	*4*	*5*
P3	Planning resources and materials	0.840				
P4	Develop products/services that pay attention to social sustainability	0.833				
P2	Efficiency of bidding	0.823				
P5	Scope of work, constraints	0.772				
P1	Procurement and bidding process	0.753				
P7	Communicate with parties in social reporting	0.743				
P6	Political and legal stability	0.701				
P8	Environmental assessment	0.643				
P9	Design project specifications and techniques	0.563				
IP4	Knowledge and awareness		0.809			
IP2	Contractor's right to perform		0.790			
IP5	Minimize water and noise pollution		0.773			
IP1	Modern technology and methods		0.760			
IP3	Project resources (people, machinery, capital)		0.730			
IP6	Waste management		0.653			
CS4	Public acceptance			0.760		
CS2	Coordination between parties			0.752		
CS3	Committed to meeting the SDGs			0.708		
CS5	Experience in sustainable management			0.651		
CS1	Troubleshooting issues related to sustainable development			0.555		
C3	Status of expenses				0.851	
C2	Progress status				0.823	
C1	Control methods				0.783	
C4	Powers and abilities of managers				0.708	
C5	Monitoring methods				0.606	
I6	Exchange in environmental reporting on sustainability					0.786
I5	Scope of work, constraints					0.771
I3	Knowledge and awareness					0.714
I4	The connection between strategies and sustainable management					0.693

4.2. Results of partial least squares structural equation modeling

4.2.1. Model conformity assessment

The standardized root mean square residual (SRMR) index serves as a goodness-of-fit indicator for the PLS-SEM model and helps in assessing parameter deviation within the model (Henseler et al., 2014). Model suitability is determined based on the value of the SRMR coefficient. If the SRMR coefficient is less than 0.08, the model is considered suitable. However, if the SRMR coefficient is less than 0.1, the model can still be accepted (Hu & Bentler, 1999).

Table 3. Results of model fit with research data

Index	*Saturated model*	*Estimated model*
SRMR	0.077	0.082

Table 3 results display a saturation pattern SRMR of 0.077, indicating an excellent model fit as it falls below the threshold of 0.08. However, the estimated model SRMR coefficient of 0.082, while slightly higher, remains within an acceptable range according to Hu and Bentler (1999), although it does not demonstrate optimal relevance. Despite this, the model can still be utilized effectively without significant impact (Hair et al., 2014).

4.2.2. Evaluation of the convergence value of the scale

To assess the convergence value of attributes, the outer loading weight should ideally exceed 0.7 and converge on the factor represented by the scale (Henseler et al., 2009). Additionally, the average variance extracted (AVE) should be greater than 0.5 to ensure satisfactory convergence values for attributes (Hair et al., 2014).

The results in Table 4 indicate that items *C1*, *IP1*, *P1*, *P2*, and *P8* have outer loadings below 0.7, which does not meet the criterion for satisfactory convergence according to Henseler et al. (2009). Therefore, these attributes should be excluded from the model in subsequent analyses. However, the remaining items exhibit outer loadings greater than 0.7, indicating satisfactory convergence. Furthermore, the AVE of the attributes is greater than 0.5, meeting the criterion for convergence of attributes as per Hair et al. (2014).

Table 4. Outer loading and average extracted variance

Items	*AVE*	*C*	*CS*	*I*	*IP*	*P*
C1	0.632	0.689				
C2		0.821				
C3		0.846				
C4		0.846				
C5		0.762				
CS1	0.614		0.768			
CS2			0.859			
CS3			0.735			
CS4			0.762			
CS5			0.788			
I3	0.872			0.783		
I4				0.83		
I5				0.775		
I6				0.786		
IP1	0.606				0.555	
IP2					0.824	
IP3					0.827	
IP4					0.811	
IP5					0.823	
IP6					0.795	
P1	0.573					0.572
P2						0.688
P3						0.812
P4						0.86
P5						0.825
P6						0.804
P7						0.787
P8						0.679
P9						0.743

After removing elements *C1*, *IP1*, *P1*, *P2*, and *P8*, further tests are conducted. The discriminant validity of the factor scale in the model is evaluated based on the heterotrait-monotrait (HTMT) ratio of correlations proposed by Henseler et al. (2015). When the HTMT coefficients are less than 0.85, it indicates that the two attributes are different from each other (Henseler et al., 2015).

Table 5. Heterotrait-monotrait ratio

	C	*CS*	*I*	*IP*	*P*
C					
CS	0.649				
I	0.378	0.587			
IP	0.298	0.498	0.517		
P	0.335	0.489	0.369	0.395	

The results in Table 5 indicate that all HTMT coefficients are less than 0.85, meeting the criterion proposed by Henseler et al. (2015). This suggests that the attributes are differentiated from each other, satisfying the prerequisite for proceeding with the subsequent steps in the study.

4.3. Structure model and hypothesis

After evaluating the model's suitability and the convergence value of the scale, hypotheses regarding causal relationships between groups of attributes are formulated, as depicted in Figure 1. Nine hypotheses are proposed to construct a hypothesis structure model, with arrows in the model reflecting the direction of the influence hypothesis.

The PMBOK's mission-based ISO 21500:2012 outlines a comprehensive PMP that encompasses *I*, *P*, *IP*, *C*, and *CS* stages. The development of the ISO 21500:2012 standard stems from companies' persistent quest for understanding why certain projects thrive while others falter. This standard aims to establish an internationally recognized framework applicable to a wide array of customized projects (Kristinsdóttr & Möller, 2014; Varajão et al., 2017). Therefore, the first four hypotheses are as follows:

H1: Initiating has a positive influence on planning.

H2: Planning has a positive influence on implementation.

H3: Implementing has a positive impact on controlling.

H4: Controlling has a positive influence on closing.

The control process within project management is deemed pivotal and independent, as it not only oversees the entire course of the project but also regulates individual groups of processes. Moreover, a study on the integration of the ISO 21500:2012 project management model suggests that the control process interacts with the initiating, planning, and implementing stages. In this context, the theory of "gate control between process groups" is frequently employed, with a "gate" signifying a decision point at the conclusion of each stage. These decision points serve to evaluate whether the project can progress to the subsequent stage or group of processes (Takagi & Varajao, 2022). Building upon these insights, the following relevant theories are proposed:

H5: Planning has a positive influence on controlling.

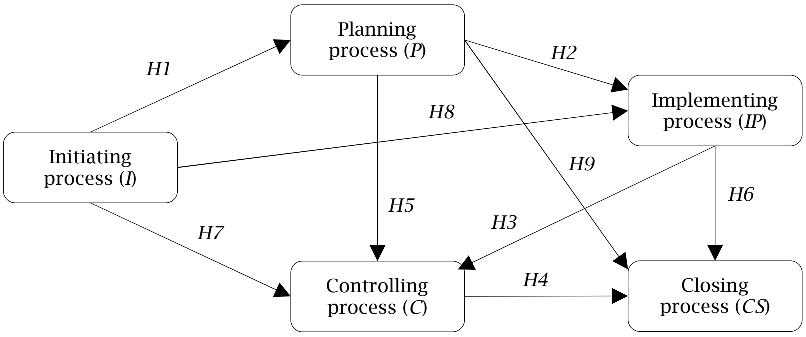
H6: The implementation has a positive influence on the closing.

H7: Initiating has a positive influence on controlling.

H8: Initiating has a positive influence on implementing.

H9: Planning has a positive influence on closing.

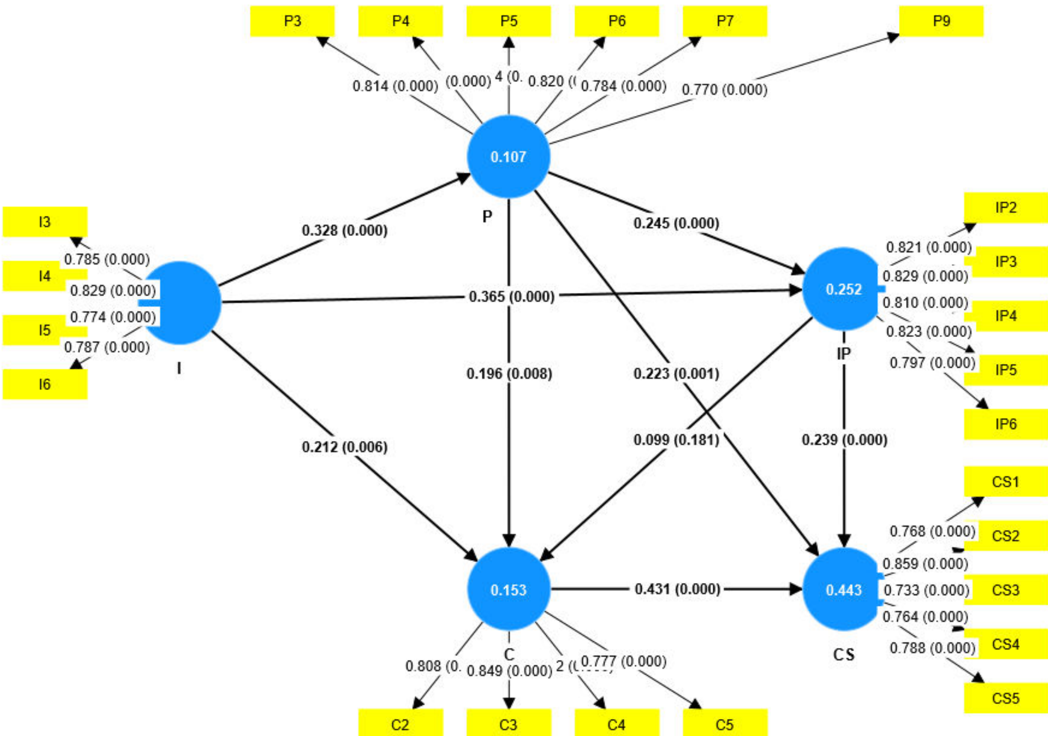
Figure 1. Hypothesis structure model



4.4. Discussion of the interrelationship between stages of the project management process

Partial least squares structural equation modeling confirms all hypotheses in the structural model with p-values less than 0.05, with the exception of *H3*, which postulates a relationship between the *IP* and *C* stages (see Table 7 and Figure 2). PLS-SEM posits positive relationships for all hypotheses *H1*, *H2*, *H4*, *H5*, *H6*, *H7*, *H8*, and *H9*. Findings also posit no relationship between the *IP* and *C* stages because of the p-value of 0.181, which is greater than 0.05. In other words, the stage *IP* does not have a significant effect on stage *C*. Indeed, the lack of evidence supporting the relationship between *IP* and *C* suggests that while *C* serves as a pivotal step in the process, its influence may not always be directly attributable to *IP*. In practical terms, it's plausible that many projects may undergo concurrent management of implementation and control phases. This finding resonates particularly well within the context of Vietnam's construction project management practices, especially concerning sustainability attributes.

Figure 2. Model test results with no intermediate variables



Research on controlling outcomes of transport infrastructure investment projects in Vietnam has highlighted deficiencies in establishing adequate monitoring mechanisms during project implementation (Le, 2021). Furthermore, both public and private projects in Vietnam encounter various limitations, such as budget and time deviations, and challenges in environmental control and timely decision-making processes during implementation (Thương & Tuyên, 2022). These issues underscore the need for better integration and consistency between different project management stages, particularly between implementation and downstream control, to enhance overall project outcomes and sustainability practices.

The results from Table 7 underscore the significance of various attributes in influencing the dependent variable. Notably, *H4* (*C* to *CS*) demonstrates the strongest effect, indicating that the *C* process significantly impacts the *CS* stage of the project. This highlights the critical importance of thorough project *C* measures before project closure to mitigate errors, aligning with previous research findings.

Following closely, *H8* (*I* to *IP*) exhibits the second strongest impact, emphasizing the crucial role of the *I* process in project management. The *I* phase lays the foundation for subsequent stages and significantly influences the outcomes of *IP* management and specific project planning. This finding is consistent with prior research, which highlights the pivotal role of the initiating process (Varajão et al., 2017). All proposed ideas and project charters serve as guiding principles for subsequent project stages, providing a framework for effective management practices.

The significance of planning management is evident in the impact coefficients of *H2* and *H9*, which are 0.245 and 0.223, respectively. *P* requires precision and meticulousness, serving as the input for *IP*. During the *CS* phase of the project, it is imperative to review how closely the project adhered to the plan. However, the role of control in the context of sustainability research with project management in Vietnam appears less clear, as indicated by the lower coefficients in the model for *H3*, *H5*, and *H7*.

While *H1*, *H2*, and *H4* align with previous theories regarding the sequential process of project management, the impact of sustainability attributes alters the PMP, particularly in the Vietnamese context, where the relationship between *IP* and *C* does not hold. Additionally, the role of intermediate variables is evaluated, revealing that attributes *I* and *P* influence *CS* through intermediaries. Factor *I* exerts an effect on attributes *C* and *IP* through an intermediate variable, with the largest impact coefficient observed for *I* on *CS* at 0.317, indicating the strongest impact of *I* on *CS* through intermediate attributes.

Table 6. Total indirect effects

Relationships	*Original sample (O)*	*Sample mean (M)*	*Standard deviation (STDEV)*	*T-statistics (|O / STDEV|)*	*P-values*
I → C	0.109	0.114	0.041	2.632	0.009
I → CS	0.317	0.330	0.047	6.809	0.000
I → IP	0.080	0.083	0.026	3.073	0.002
IP → CS	0.043	0.044	0.033	1.309	0.191
P → C	0.024	0.026	0.021	1.136	0.256
P → CS	0.154	0.158	0.041	3.784	0.000

One of the key distinctions between the sustainability attributes of PMP in Vietnam and previous studies is the absence of a clear correlation or relationship between the *IP* stage and the *C* stage of construction PMP, while findings resulting from other countries clearly show such a relationship (Fathalizadeh et al., 2019; Mirhosseini et al., 2022; Moshood et al., 2024; Misnan et al., 2024). This seems strange. However, the circumstances of the VCI can help us to explain this finding. Construction projects in Vietnam depend heavily on foreign and government orders. Therefore, these projects are required to conform to laws and governmental decrees in construction. However, Vietnamese legislation in construction only focuses on regulations and rules at every step of the project, whereas it ignores relationships between factors in the implementation and control stages. As a result, poor or no relationships between the *IP* stage and the *C* stage are understandable in the Vietnamese context.

Table 7. Path coefficient

Hypotheses	*Original sample (O)*	*T-statistics (|O / STDEV|)*	*P-values*	*Significant*
C → CS	0.431	5.911	0.000	Yes
I → C	0.212	2.763	0.006	Yes
I → IP	0.365	5.760	0.000	Yes
I → P	0.328	5.054	0.000	Yes
IP → C	0.099	1.338	0.181	No
IP → CS	0.239	3.602	0.000	Yes
P → C	0.196	2.670	0.008	Yes
P → CS	0.223	3.191	0.001	Yes
P → IP	0.245	3.698	0.000	Yes

4.5. The proposed model of sustainable-oriented attributes of the PMP involving construction projects in Vietnam

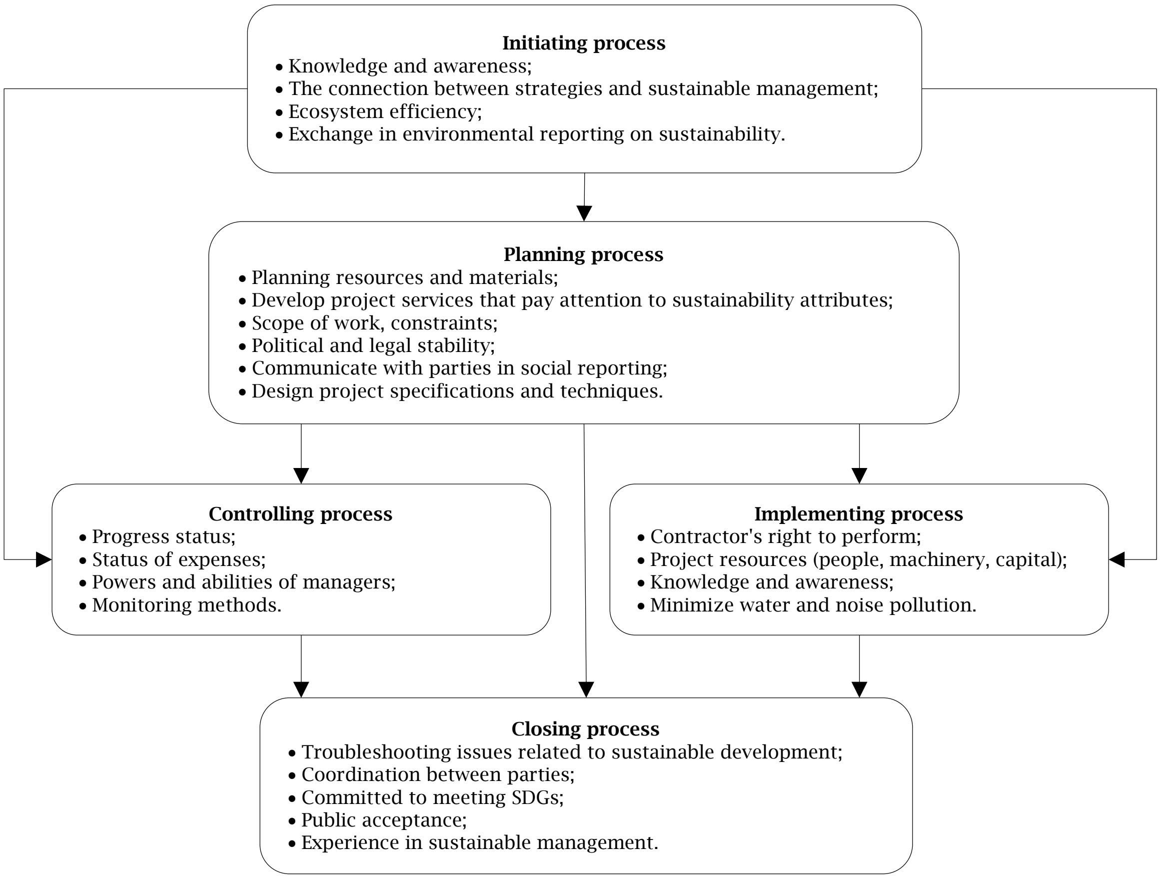
Based on the findings from the PLS-SEM analysis, a model of sustainable-oriented attributes of PMPs involving construction projects in Vietnam is proposed (see Figure 3). This model encompasses the five stages of project management along with their associated 24 attributes, having arrows denoting the direction of influence. The proposed model serves as a tool for examining and preliminarily assessing sustainability at each sub-process of the PMP.

Managers can leverage this model to implement and evaluate sustainability measures across distinct stages, involving contractors, investors, and construction units to ensure alignment with these attributes. Moreover, adopting this model can aid in supporting enhancements and ensuring the attainment of construction objectives.

By utilizing the sustainable-oriented model, stakeholders can readily identify processes and pinpoint underlying causes and constraints contributing to slow progress, misaligned goals, and other project-related challenges. For instance, to attain sustainability objectives, managers should ensure stakeholder engagement, formulate a sustainability strategy, and devise management solutions to address sustainability issues while maintaining ongoing stakeholder communication to capture timely information. Moreover, in the situation of poor project planning or unclear project planning, the proposed model plays a key role in tracing overlooked attributes during the PMP of construction projects. The proposed model may help project managers to tackle problems of their construction projects at the root causes, thereby facilitating more effective project management practice.

Specifically, practitioners, like construction project managers, can use these findings to improve the effectiveness of construction projects at every stage through measures that influence sustainability-oriented attributes. For instance, the *I4* factor suggests that stakeholders should actively participate in the initial stages of construction projects to align sustainability goals with project objectives. Furthermore, the factor *CS3* suggests that construction practitioners should prioritize sustainable materials in their projects and subsequently demonstrate their commitment to sustainability.

Figure 3. The sustainable-oriented model of attributes influencing the PMP of a construction project



5. CONCLUSION

The final structural model, including 24 significant attributes, has been proposed through PLS-SEM. The analysis highlights the significant influence of the *C* stage on the *CS* stage, confirming the importance of attributes in the project *C* stage before the project *CS* stage. Interestingly, the study found that the *IP* stage has no relationship with the *C* stage, which aligns with the Vietnamese context, where *IP* often adheres strictly to the original plan. Consequently, the role of control becomes integrated into the implementation process itself, leading to an indistinct impact between these two stages.

The findings of this research may significantly contribute to the field of construction project management, enhancing the understanding of team interaction within the ISO 21500 PMP, particularly when sustainability-driven attributes are integrated. The findings of this study can be leveraged by construction companies to enhance their project management practices, leading to more efficient and sustainable project outcomes. By adopting the identified sustainability-oriented attributes, companies can reduce costs associated with project delays and rework, thereby improving their profitability. Furthermore, the emphasis on control before project closure can minimize financial risks and ensure that project deliverables meet quality standards. This study can provide a comprehensive framework based on ISO 21500:2012, adapted for Vietnamese conditions, serving as a practical case study for students. Instructors in universities can use the findings to teach students about the importance of sustainability in project management and the specific practices that can enhance project outcomes. The identified relationships among PMP attributes can be used to develop problem-solving exercises and project simulations. The insights from this research can inform policymakers about the current state of sustainable practices in the VCI. By highlighting the gaps and potential areas for improvement, this study can support the development of regulations and policies that promote sustainability in construction projects. Policymakers can use these findings to encourage the adoption of sustainable project management practices, providing incentives for companies that implement such practices. The paper can serve as a reference for policymakers advocating for stronger sustainability incentives. This advocacy can lead to more robust policies that promote long-term sustainability in the construction industry, benefiting society. The paper can raise awareness among stakeholders, encouraging a demand for sustainable construction practices. As people become more informed about the benefits of sustainable-oriented project management, there could be increased support for sustainable projects from developers and contractors.

However, despite achieving its objectives, the study has some limitations. Firstly, it does not consider construction projects of varying scales or in different locales with diverse policy mechanisms. Secondly, as it is conducted in the context of Vietnam, the findings may lack generalizability across different geographical regions. Nonetheless, the study aims to shed light on the reciprocal relationship between construction PMPs, serving as a reference for similar studies in other developing nations. Additionally, the attributes examined within each process group may not be exhaustive, rendering the proposed research framework imperfect for evaluating the construction PMP of varied sizes and types.

This study adds to the body of knowledge in construction project management by identifying key sustainability-oriented attributes and their interrelationships within the PMP. Future research can build on these findings by exploring the applicability of the identified attributes in different contexts and regions. Researchers can also investigate the long-term impacts of adopting these practices on project success and sustainability outcomes. Additionally, the study provides a validated structural model that can be used as a foundation for further empirical studies in the field.

Sustainability-driven attributes in construction PMP are not only helpful in addressing environmental challenges of construction projects, but they are also sources of a crucial strategy to gain long-term value for stakeholders. Sustainable practices in construction projects can improve the adaptability and social responsibility of project stakeholders, while also promoting a safe environment for future generations.

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