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Research Paper

Environmental management control systems and eco-capability: Catalysts for sustainable organisation performance

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Abstract

The Natural Resources-Based View (NRBV) and dynamic capability theory are used to support the investigation of the relationship between Environmental Management Control System (EMCS), eco-capability and sustainability performance, which is a major aim of this study within Malaysia's Environmental Sensitive Industry (ESI) context. This study employed a quantitative approach using survey questionnaires and obtained valid responses from 142 respondents. Subsequently, the data were analysed using Partial Least Squares (PLS) modelling with Reflective Formative Type II, Mode B higher-order construct. This study highlights the importance of EMCS implementation as a package of control, including planning, cultural, cybernetic, reward and incentive and administrative control. Furthermore, eco-capability is identified as a significant complementary mediator between EMCS and sustainability performance. The findings have offered both theoretical insights and practical implications, especially in the Asian business region. It advances literature by empirically validating the strategic role of EMCS in driving sustainability through eco-capability. The result can provide valuable guidance for managers in various industries that seek a competitive advantage through sustainability control initiatives and assist policymakers in developing supportive regulatory frameworks.

Keywords: Environmental Management Control System (EMCS), Eco-capability, Sustainability performance, Environmentally Sensitive Industry (ESI).

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Introduction

As sustainability issues become more visible, organisations actively pursue strategies that balance environmental, social and economic goals. These initiatives are now recognised as a global requirement and a key driver of competitive advantage (Trollman and Colwill, 2021). Consequently, organisations are proactively seeking effective management control systems that integrate sustainability into their main business operation (Rehman et al., 2021).

EMCS can play a critical role in translating sustainability strategies into operational practices, including product and process design, cost control and performance evaluation in ESIs. It has been shown that EMCS directly improve sustainability performance when organisations are using systematic tracking of environmental cost, which can support strategic decision-making and manage resources efficiently (Crutzen et al., 2017; Henri and Journeault, 2010; Wijethilake et al., 2017). EMCS should be implemented holistically to maintain long-term competitiveness (Hennig et al., 2023; Jasch, 2006; Pramono et al., 2023). In practice, some organisations tend to use combinations of controls, some of which are complex (Guenther et al., 2016).

Several studies suggest that researchers need to analyse EMCS as a package rather than analysing them separately to get a better understand on the effectiveness of EMCS practices and outcomes (i.e., Chenhall, 2003; Grabner and Moers, 2013; Lueg and Radlach, 2016; Malmi and Brown, 2008). Therefore, this study adopts the MCS package framework proposed by Malmi and Brown (2008), which comprises five interrelated elements, namely planning, cultural, cybernetic, reward and incentive and administration. By focusing on how these components work together, this research provides empirical evidence on their collective impact on sustainability in ESIs. This study also extends existing knowledge by examining the mediating role of eco-capability in the relationship between EMCS and the sustainability outcome of ESIs in Malaysia in respond for holistic assessment. The aim is to provide contextual insights into how EMCS and eco-capability can strengthen organisational performance.

The interrelationship between EMCS, eco-capability and sustainability performance could be further explained by embedding the theory of NRBV and dynamic capabilities. NRBV emphasise how firms can obtain a competitive advantage through the acquisition of and control over resource use, thereby generating wealth for the firm (Helfat et al., 2007). Firms always rely on their resources and their ability to exploit them to gain a competitive advantage (Hart 1995; Wernerfelt 1984). In the context of this study, the term eco-capability refers to a firm's human, business and technological resources (Powell and Dent-Micallef, 1997). The Firm needs to align EMCS and eco-capability to be powerful and reliable, with strategic decisions made to ensure that it remains competitive (Hart, 1995). Specifically, the firm's ability to control its environmental exercise relies on the ability of its human, business and technological resources.

Empirical studies that examine the association of the EMCS package and eco-capability among multiple ESIs in Malaysia are still limited. The previous studies have examined this mechanism in isolation within single-industry settings such as manufacturing (Edirisinghe et al., 2024; Henri and Journeault, 2008; Rehman et al., 2018); hospitality industry (Daromes and Ng, 2023), construction (Rehman et al.,2021), and oil and gas

(George et al., 2016), offering limited generalizability. This narrow focus leaves an important gap in understanding how EMCS and eco-capability interact across different industrial contexts. By extending the analysis to four major ESIs: manufacturing, plantation, oil and gas and construction, this study manages to provide wider empirical evidence of the robustness and consistency of the relationship between EMCS, eco-capability and sustainability performance. In doing so, it strengthens the theoretical generalisation across industrial boundaries and offers practical insights into cross-sectoral sustainability strategies.

The discussion on literature review, hypothesis development and research methods is presented in the following sections. Followed by findings and discussion, as well as the limitations and future directions of the study. The final section of this paper presents how this study's framework and findings provide some practical implications and suggestions for Asian businesses.

Literature Review

From a sustainability perspective, the NRB theory was introduced by Hart (1995), which explains how organisations can leverage their environmental resources to gain a competitive advantage. This theory suggests that sustainability performance is closely linked to how effectively firms manage natural resources. By exercising these practices, firms can foster innovation, enhance efficiency and support long-term organisational success. This perspective is relevant for ESIs, where business competitiveness is closely tied to responsibility and accountability for the resources used and the impact on the environment and society. Therefore, ESIs must possess eco-capability to ensure that they can manage resources well and translate environmental goals into tangible outcomes. Drawing from NRBV and dynamic capability theory, this concept refers to the synergy between human resources, business workflows, and technological systems (Powell and Dent-Micallef, 1997; Teece et al., 1997). By integrating these elements, firms can embed environmental considerations into their core business operations, so that they can proactively respond to both challenges and opportunities.

NRBV and eco-capability leverage the sustainable competitive advantage through an organisation's ability to evolve in a dynamic environment. The NRBV emphasises the strategic value of environmental resources while eco-capability provides the necessary dynamic capabilities. EMCS operationalise the strategic vision of NRBV and the adaptive capacities of eco-capability. EMCS, encompassing planning, cultural, cybernetic, reward and incentive, and administration dimensions (Malmi and Brown, 2008), translates these principles into actionable organisational practices. Collectively, NRBV, eco-capability and EMCS form a coherent framework for achieving a sustainable competitive advantage. NRBV establishes why environmental resources are strategically important, eco-capability provides the adaptive strength to use them, and EMCS ensures their effective implementation and controls. Strengthening these capabilities allows firms to align their resources with the NRBV concept and improve EMCS functionality in achieving managerial performance and contributing to long-term competitiveness (Rotzel et al., 2019).

EMCS and Eco-Capability

The EMCS package is a comprehensive management control mechanism that helps firms to formulate, monitor, and control the implementation of environmental initiatives systematically (Malmi and Brown, 2008). There are five dimensions of EMCS, i.e., planning, cultural, cybernetic, reward and incentive, and administrative controls. Each dimensions reflect the importance of organisation structure and behaviour, which can contribute to the effectiveness of environmental management resources. The EMCS package approach is increasingly being used in research to support a sustainability framework, specifically research with the aims of understanding its roles in sustainable development and organisational performance (Bresciani et al., 2022; Rehman et al., 2021; Trollman and Colwill, 2021).

Referring to the EMCS framework developed by Malmi and Brown (2008), it starts with planning to infuse sustainability into the organisation's strategy, followed by cybernetic controls that act like a fitness tracker to keep tracking on meeting the environmental goals through continuous feedback from the various stakeholders. Rewards and incentives play a significant role in motivating employees to keep the momentum going and stay engaged with the company. Firms need to cultivate a culture of environmental consciousness and, through cybernetic control, could provide feedback to close the gaps and make continuous improvement in eco-capabilities. Lastly, administrative control established the roles and structure needed for the effective implementation of eco-capabilities. Firms need to perceive that these controls could create a strategic advantage, as Rotzel et al. (2019) confirm that the EMCS package significantly enhances managerial performance.

In line with NRBV and dynamic capability, organisations are required to create unique and non-replicable resources. This highlights the critical roles of human expertise, technology investment and business strategy. When the organisation empowers environmental experts to invest in green technology, it fosters a culture of innovation that is difficult for competitors to copy.

By harmonising EMCS with broader business strategy, firms can transform environmental protection from a standalone obligation into a core driver of efficiency. The organisation's ability to systematically manage and control it environmentally resources will influence the development and strengthening of its eco-capabilities (Nuhu et al., 2019). Furthermore, building up an organisation's capabilities can lead to better sustainability performance and a stronger market position (Rehman et al., 2021). Therefore, the following hypothesis is proposed to assess whether these findings apply in the context of the Malaysian ESI industry:

H1 There is a positive relationship between EMCS and eco-capability.

EMCS and Sustainability Performance

EMCS packages represent a key mechanism through which an organisation can improve management effectiveness, while improving sustainability performance (Crutzen et al., 2017; Rotzel et al., 2019). In Malmi and Brown (2008), all five dimensions in the MCS package positively influence the sustainability performance of the firms. The planning dimension integrates environmental considerations into organisational strategies, influencing decision-making to improve sustainability performance. Cybernetic control enables continuous improvement through feedback loops. This could enhance the organisation's agility in addressing evolving economic, environmental and social challenges. Ultimately, reward and incentive dimensions encourage sustainable practices among employees in meeting the goals of the organisation. Then, the administrative dimension establishes a structural framework for effective sustainability implementation, streamlining efforts to achieve cohesive outcomes. Lastly, the cultural aspect can be encouraged by applying sustainability values in daily practices in the organisation. Hence, EMCS, through its dimensions, become a comprehensive driver to enhance sustainable performance.

In relation to NRBV, EMCS contributes to organisational capabilities, leading to sustainable competitive advantage and superior performance (Henri, 2006; Wijethilake et al., 2017). It manages and communicates strategic priorities, instructs managers to assess critical areas, and stimulates economic and environmental performance through efficient resource management (Henri, 2006). Additionally, EMCS positively impacts social performance, reflecting an organisation's responsibilities to various stakeholders. Thus, the following hypothesis is proposed:

H2 There is a positive relationship between EMCS and sustainability performance.

Eco-Capability and Sustainable Performance

According to Grant (1991), a firm's capabilities consist of resources that work together to achieve organisational performance and gain a competitive advantage. Besides, the firm's performance can be improved if the top management is capable of providing strong support to minimise the environmental issues using cutting-edge technologies (Gabler et al., 2015). Eco-capability reflects the strengths within an organisation that cares about its environmental activities (Ortas et al., 2015). In order to minimise pollution and promote innovation, a variety of resources, including financial, technological, human capital and physical assets, are essential. For example, financial capacity enables the purchase of cutting-edge anti-pollution machinery.

Employee and stakeholder involvement in reducing resource consumption and waste enhances financial performance, market share, profit, and return on investment (Wong, 2013). Managing technology resources to prevent pollution and improve product stewardship also boosts competitiveness (Hofmann et al., 2012). Innovations and eco-friendly systems reduce costs and improve environmental performance (Rasit et al., 2020).

Firms that consider all sustainability aspects (environmental, economic and social) show stronger performance (Mat Yusoh et al., 2023; Rehman et al., 2018). Although eco-capability has been shown to positively influence firm performance, this relationship remains underexplored within the context of Malaysia's ESIs. Thus, this study predicts that eco-capability may significantly enhance the sustainability performance of Malaysian ESI companies. Based on the above discussion, the following hypothesis is developed:

H3 There is a positive relationship between eco-capability and sustainability performance.

The Mediating Effect of Eco-Capability on EMCS and Sustainability Performance

The empirical evidence on the mediating role of eco-capability on EMCS and sustainability performance is still not many. Unique and dynamic capabilities allow the development of a competitive advantage that will foster improvements in environmental and economic performance (Henri and Journeault, 2010). Similarly, Bresciani et al. (2023) found that the green dynamic capabilities act as a significant mediator between environmental MCS packages, perceived environmental uncertainty and green performance. Meanwhile, Rehman et al. (2021) found that the relationship between ecological sustainability and sustainable performance is significantly moderated by organisational capabilities. These studies provide some evidence on the roles of capabilities as a mediator between EMCS and sustainability performance.

Subsequently, Lin and Wu (2014) combined the dynamic capabilities view with RBV, and the results demonstrated a coherent consideration of both resources. It is also shown that dynamic capabilities effectively mediate sustainability performance in competitive environments. Further, firms do not only compete in product markets, but they also compete to create organisational, operational, and technological capabilities that will provide them with an advantage in those product markets (Pisano 2015).

Based on the above discussions, this study proposes eco-capability as a mediator in the relationship between EMCS and sustainability performance. Therefore, the following hypothesis is formulated:

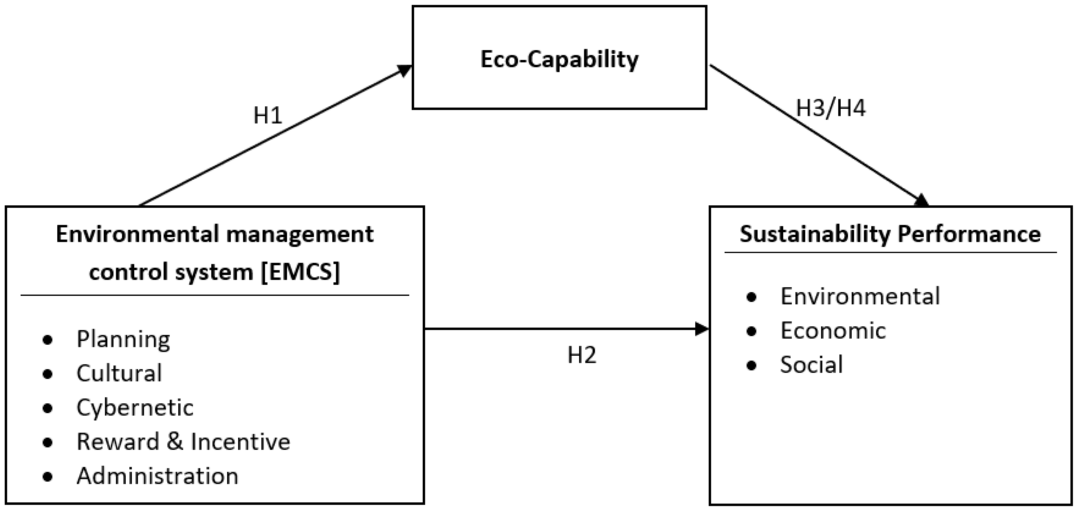
H4 Eco-capability mediates the relationship between EMCS and sustainability performance.

Conceptual Framework

Referring to Figure 1, the conceptual framework for this study was developed based on the hybrid conceptual framework developed by Hart (1995), Powell and Dent-Micallef (1997), Malmi and Brown (2008), Henri and Journeault (2010), and Wagner and Schaltegger (2004).

The EMCS dimensions are based on the formation of five types of control (planning, cultural, cybernetic, reward and incentive, and administrative control). It could act as a driver in controlling and monitoring greening activities, and it is expected to positively impact on the sustainability performance. Another essential point, the implementation of EMCS, is to ensure that resources are utilised effectively and efficiently to reach the organisation's goals, while eco-capability aims to transform the resources into valuable offerings that will ensure the competitiveness of the organisation. The presence of a specific firm's capability, such as human resources skills, business resources supported using advanced technology, may facilitate and enforce the implementation of EMCS on the greening process initiatives. Sustainability performance is measured by economic, environmental, and social dimensions.

Figure 1: Conceptual framework



Methodology

Sampling Population and Size

The sampling frame of this study was derived from large-sized companies in manufacturing, oil and gas, plantation, and construction industries, which are known to heavily consume natural resources and pose substantial environmental risks (Deegan et al., 2002; Wilmshurst and Frost, 2000). Additionally, these companies often incur significant environmental expenditures that can influence firm value and investor return (Clarkson et al., 2013; Ferreira et al., 2010). Moreover, there is a notable research gap regarding the application of EMCS in these sectors within the Malaysian context. The study also focuses on large firms as prior research suggests they are more likely to adopt proactive environmental strategies due to their scale, greater visibility, and capacity to invest in sustainable technologies (Aragón-Correa et al., 2008; Crutzen et al., 2017; Essid and Berland, 2018). Besides, large, listed companies tend to prioritise environmental reputation and are more likely to disclose environmental initiatives compared to unlisted companies (Sarumpaet, 2005).

In this study, the size of the companies is determined based on sales turnover, which exceeds RM50 million or has 200 full-time employees or more for manufacturing; sales turnover which exceeds RM20 million or at least 75 full-time employees for oil & gas and plantation industries; and G7 companies with project values above RM10 million for the construction industry (CIDB 2017). A total of 3886 companies were identified as the sampling frame. G*power statistical software was employed to determine the minimum required sample size for PLS-SEM as suggested by Hair et al. (2022). Based on the desired statistical power of 95% and effect size (R^2) of 0.15, and a 5% significance level, the analysis suggested a minimum of 107 responses. Therefore, the obtained sample size of 142 valid responses exceeds this threshold and is considered statistically adequate for conducting PLS-SEM and drawing reliable conclusions.

The stratified random sampling technique is used in this study to ensure proportional representation across industries. For example, the manufacturing sector comprised 23.7% of the population (921 out of 3886 firms), resulting in a sample of 230 firms

(23.7% of 972). The same proportional approach was applied to the construction, oil & gas and plantation sectors. Within each spectrum, every 4th company on the list was selected. Based on this method, a total of 972 questionnaires were distributed, and 142 valid responses were received and used for the data analysis.

Data Collection

This study employs a quantitative approach. A questionnaire survey was used as the primary data collection tool and was distributed to the heads of accounts or persons in charge of environmental accounting practices within the sampled organisations. This study collected data using self-administered questionnaires (i.e., delivered by hand, post and email). Pre-test of the survey instrument was conducted to allow the researcher to check the clarity of directions to the respondents and flow of the questions to improve the comprehension of the instrument. Besides, with the aim of lessening the potential for errors and deficiencies, a pilot study was conducted over a representative convenience sample of 15 ESI companies.

The questionnaire comprised three sections with a total of 16 questions pertaining to 82 items. Section A, consisting of six questions, focused on respondent profiles, ensuring their knowledge of the companies for reliable responses. Section B, addressing the EMCS adapted from Malmi and Brown (2008), consists of five questions with 27 items. A seven-point Likert scale ranging from 1 (not at all) to 7 (to a great extent), respondents had to indicate the extent to which their companies are integrating environmental concerns in their strategic planning, performance measurement system, budget, culture, reward, and administration as a control mechanism. While eco-capability consists of one question with nine items, which were adapted from Powell and Dent-Micallef (1997) and Gabler et al. (2015). A seven-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree) requires the respondents to indicate their opinion about the companies' capabilities to support their environmental control practices. Section C, centered on sustainability performance, featured three questions with 40 items, which were adapted from Wagner and Schaltegger (2004) and Henri and Journeault (2010). Environmental performance involved 12 items measuring the reduction of environmental impacts, economic performance included 13 items assessing competitive benefits from environmental practices, and social performance encompassed 15 items gauging corporate social sustainability on social performance. A seven-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree) requires the respondents to rate the extent of their agreement on the companies' environmental activities having a positive impact on the sustainability performance.

Data Analysis

The PLS-SEM is used as a statistical tool to assess latent variables in the measurement model and test multiple relationships of latent variables in the structural model simultaneously (Hair et al., 2022). Accordingly, PLS-SEM is useful for models with complex structures, including those with numerous latent variables, multiple indicators, and higher-order constructs (Becker et al., 2012; Hair et al., 2022; Wetzels et al., 2009). SPSS version 29 was used for data screening and preliminary analysis, while the statistical program of SmartPLS 4 was employed to analyse the measurement model and structural model (Ringle et al., 2024).

This study adopted a higher-order model, also referred to as a hierarchical component model (HCM). Specifically, a Reflective-Formative Type II, Mode B model was employed. In this structure, all the first-order constructs are reflective, while the second-order constructs (EMCS, eco-capability and sustainability performance) are formative. The repeated-indicator approach was employed, whereby all indicators of the first-order constructs were assigned to the respective second-order constructs. In this approach, when the arrows point from indicators to the second-order constructs, the model is classified as Mode B (Becker et al., 2012).

Measurement Model Assessment

There are four established criteria for evaluating a reflective construct in the measurement model to ensure that the quality requirements are met. Firstly, the indicator reliability of all the item loading values should be more than 0.708 (Hair et al., 2022). Then, internal consistency was assessed through composite reliability (CR) and Cronbach's alpha, with acceptable thresholds of 0.70 and above. Next, convergent validity was examined via average variance extracted (EVA), where values exceeding 0.50 indicated that the constructs adequately captured the variance of their indicators. Lastly, discriminant validity was assessed using the Heterotrait-Monotrait (HTMT) ratio, where HTMT values below 0.85 demonstrated sufficient discriminant validity (Hair et al., 2022).

Hair et al. (2022) and Becker et al. (2012) have recommended a process to validate the formative second-order constructs. Specifically, multicollinearity was assessed using VIF values, ensuring all indicators had VIFs below the acceptable threshold of 5.0. The significance and relevance of formative indicator weights were examined using bootstrapping (10,000 resamples). Non-significant indicators were evaluated for their outer loadings to assess their potential contribution to content validity, retaining only those with theoretical justification or substantial loadings.

Structural Model Assessment

The structural model was examined to test the hypothesised relationship among the constructs, following the procedures recommended by Hair et al. (2022), which involved a few key steps. First, collinearity in the structural model was evaluated using the variance inflation factor (VIF), indicating no multicollinearity issues as all VIF values were below the threshold of 5.0. Second, the structural path coefficients were analysed to assess the strength and direction of the hypothesised relationships. This was followed by bootstrapping with 10,000 subsamples to test the statistical significance of the path coefficients (p-values), ensuring the relationships were not due to random chance. Third, the structural model's explanatory power was assessed using the R^2 values of the endogenous constructs, indicating the proportion of variance explained by exogenous constructs. Lastly, the effect sizes (f^2) were calculated to determine the impact of each exogenous construct on the endogenous variables. These steps collectively provided a comprehensive evaluation of the structural model's validity and its ability to support the proposed theoretical framework.

Results

Respondents' Profile

Table 1 presents the profiles of the respondents. From this table, 54% of the respondents were accountants, 9% were project managers, and 19% were senior management. Thus, most of the respondents who answered the questions were from the managerial level. In addition, most of the respondents (73%) had over six years of experience, indicating their strong capacity to provide reliable and informed feedback for this study.

Table 1 also showed that the returned questionnaires represented the four types of industries in the ESIs, i.e., 32% in manufacturing, 22% from oil and gas, 30% from construction, and 17% from the plantation industry. Most of the companies (56%) have been in their respective industry for at least 16 years. Meanwhile, 17% have been in the industry for 11-15 years, and the remaining have been operating for 1-10 years. The average years of cooperation of the companies appear to reflect the significance of the considerable stability and maturity in the respective industries, hence, technically sufficiently reliable as a chosen sample for this study.

Subsequently, the companies' annual sales data indicates that 46% have sales in the range of RM 51 million and above, 11% with sales of RM 31-50 million, 13% have sales of RM 21-30 million, and the remaining 30% have annual company sales of RM 1-20 million. Therefore, it indicates that most of the companies (70% out of 142 companies recorded sales of at least RM 21 million) are very experienced in the industry and have well-established returns

Table 1: Respondents' profile

	Measures	Frequency (n=142)	Percentage (%)
Position	Accountant	76	54
	Project Manager	13	9
	Senior Management	27	19
	Others	26	18
Working Experience	1-5 years	38	27
	6-10 years	34	24
	11-15 years	30	21
	16 years above	40	28
Industry Type	Manufacturing	45	32
	Oil & Gas	31	22
	Construction	42	30
	Plantation	24	17
Industry Experience	1-5 years	11	8
	6-10 years	27	19
	11-15 years	24	17
	16 years above	80	56
Sales	1-20 million	42	30
	21-30 million	19	13
	31-50 million	16	11
	51 million and above	65	46
No of Employees	Less than 74	35	25
	Between 75-200	27	19
	Between 201-500	31	22

Measures	Frequency (n=142)	Percentage (%)
Between 501-1000	19	13
1001 and above	30	21

Assessment of the Measurement Model

The measurement items for first-order constructs (planning, culture, cybernetic, reward, administration, eco-capability, economic, environmental and social performance), which are reflective, were assessed for reliability as well as convergent and discriminant validity.

Firstly, the indicator reliability of all the item loading values should be more than 0.708 (Hair et al., 2022). Items with loading less than 0.708 should be deleted. Table 2 summarised that all items loading fall between 0.70 to 0.94, suggesting a larger shared variance between a construct and its indicators. Then the significance of the path coefficients was tested using a bootstrapping method (10,000 resamples) as suggested by Hair et al. (2022). The result indicates that all the critical t-values for the one-tailed test are more than 1.64 at a $p<0.05$ significance level (Hair et al., 2022). According to Hair et al. (2022), the CR range between 0.6 and 0.70 is acceptable; meanwhile, 0.7 to 0.9 is satisfactory. As shown in Table 2 and Table 3, all first-order constructs displayed a composite reliability of 0.60 to 0.93; thus, it meets the internal consistency level.

Convergent validities were assessed using AVE according to the suggestions by Hair et al. (2022). AVE for EMCS dimensions in this study is within the range of 0.68 to 0.74, indicating high values of AVE. Whereas, for other constructs, i.e., eco-capability and sustainability performance, the AVEs are between 0.60 to 0.80. The results indicate that the AVE enlightens more than 50% of the variance among the scale indicators. In other words, the 0.5 threshold indicator satisfies the criterion of convergent validity.

Table 2: Summary of construct reliability and validity

First Order Construct	Second Order Construct	Items	Loadings	Cronbach's alpha	t-Statistics	CR	AVE
	EMCS						
Planning				0.89		0.92	0.70
		Plan_a	0.81		28.22		
		Plan_b	0.89		49.41		
		Plan_c	0.82		24.63		
		Plan_d	0.87		39.69		
		Plan_e	0.79		23.2		
Cultural				0.90		0.93	0.72
		Cult_a	0.83		23.25		
		Cult_b	0.89		46.44		
		Cult_c	0.86		33.2		
		Cult_d	0.85		35.83		
		Cult_e	0.81		23.97		
Cybernetic				0.90		0.93	0.68

First Order Construct	Second Order Construct	Items	Loadings	Cronbach's alpha	t-Statistics	CR	AVE
		Budgt_a	0.84		26.98		
		Budgt_b	0.73		16.92		
		Pms_a	0.86		39.84		
		Pms_b	0.85		33.43		
		Pms_c	0.88		44.4		
		Pms_d	0.78		20.46		
Reward				0.91		0.93	0.73
		Rwd_a	0.82		29.49		
		Rwd_b	0.81		25.28		
		Rwd_c	0.90		59.34		
		Rwd_d	0.84		28.41		
		Rwd_e	0.89		52.62		
Administration				0.88		0.92	0.74
		Adm_a	0.85		28.21		
		Adm_b	0.85		31.69		
		Adm_c	0.89		38.31		
		Adm_e	0.84		30.75		
	Eco-Capability						
Human				0.84		0.92	0.80
		Cap_a	0.87		27.19		
		Cap_b	0.93		31.42		
		Cap_c	0.88		29.65		
Business				0.87		0.91	0.76
		Cap_d	0.86		25.86		
		Cap_e	0.85		29.16		
		Cap_f	0.90		27.56		
Technology				0.86		0.92	0.79
		Cap_g	0.88		33.61		
		Cap_h	0.87		30.02		
		Cap_i	0.91		35.93		
	Sustainability Performance						
Environmental				0.94		0.95	0.61
		Env_a	0.70		9.86		
		Env_b	0.76		13.96		
		Env_c	0.72		12.73		
		Env_d	0.77		12.19		
		Env_e	0.82		16.03		
		Env_f	0.78		13.89		
		Env_g	0.83		15.78		
		Env_h	0.86		16.64		
		Env_i	0.80		15.41		
		Env_j	0.79		16.08		
		Env_k	0.81		17.3		
		Env_l	0.71		12.56		

First Order Construct	Second Order Construct	Items	Loadings	Cronbach's alpha	t-Statistics	CR	AVE
Economic				0.94		0.95	0.60
		Econ_a	0.70		12.64		
		Econ_b	0.75		15.39		
		Econ_c	0.78		17.19		
		Econ_d	0.75		17.69		
		Econ_e	0.82		19.93		
		Econ_f	0.78		17.74		
		Econ_g	0.82		19.26		
		Econ_h	0.78		17.51		
		Econ_i	0.78		19.02		
		Econ_j	0.76		14.25		
		Econ_k	0.73		13.45		
		Econ_l	0.84		21.25		
		Econ_m	0.78		17.92		
Social				0.93		0.94	0.61
		Soc_a	0.74		12.28		
		Soc_b	0.72		13.34		
		Soc_f	0.73		10.91		
		Soc_g	0.80		18.78		
		Soc_h	0.74		8.97		
		Soc_i	0.80		15.91		
		Soc_k	0.76		14.17		
		Soc_l	0.78		14.16		
		Soc_m	0.85		17.14		
		Soc_n	0.79		14.32		
		Soc_o	0.84		18.48		

Note: Five items were deleted (budg_c, Soc_c, Soc_d, Soc_e and Soc_j) due to low loading <0.708

Discriminant validity was evaluated using the heterotrait-monotrait ratio of correlations (HTMT) as proposed by Henseler et al. (2015) within the multitrait-multimethod matrix. This method assesses discriminant validity by estimating the true correlation between distinct, well-measured constructs. HTMT value should be less than 0.85 (HTMT.85) or 0.90 (HTMT.90) (Henseler et al., 2015). As shown in Table 3, all results meet the HTMT.90 threshold value. The confidence interval in this study also did not contain a value of one, thus indicating that the discriminant validity requirement had been fulfilled. Thus, we can conclude that the measures used in this study exhibit sufficient validity and reliability.

Table 3: Discriminant validity (HTMT)

	Plan	Cultural	Cyber	Reward	Admin	HR	BR	TR	Econ	Env
Plan										
Cultural	0.856									
Cybernetic	0.822	0.784								
Reward	0.674	0.671	0.786							

	Plan	Cultural	Cyber	Reward	Admin	HR	BR	TR	Econ	Env
Admin	0.827	0.731	0.854	0.793						
HR	0.667	0.557	0.724	0.689	0.706					
BR	0.724	0.570	0.825	0.744	0.759	0.883				
TR	0.753	0.664	0.802	0.830	0.753	0.821	0.829			
Economic	0.577	0.465	0.550	0.536	0.524	0.493	0.589	0.601		
Environmental	0.588	0.558	0.589	0.530	0.560	0.476	0.556	0.620	0.587	
Social	0.636	0.522	0.572	0.489	0.562	0.479	0.616	0.566	0.750	0.595

Formative Hierarchical Component Model

In this study, EMCS, eco-capability and sustainability performance are the higher-order components specified as formative, as suggested by Bedford et al. (2016) and Santos and Brito (2012). The formative constructs are multidimensional; hence, the indicators do not necessarily strongly correlate, and internal consistency tests are not relevant for formative. According to Becker et al. (2012), the relationship between lower-order constructs and higher-order constructs is signified by the path coefficients. The path coefficient value should be more than 0.10 (Andreev et al., 2009). Accordingly, the critical t-value for a one-tailed test is 1.64 at a $p<0.05$ significance level (Hair et al., 2022).

After running the bootstrapping method (10,000 resamples) as suggested by Hair et al. (2022), the indicator validity for the higher-order constructs is summarised in Table 4. All the path coefficients are shown as significant ($p <0.05$). Table 4 also indicates that all the formative first-order constructs of this study range from 1.83 to 3.57, showing that no multicollinearity issue has arisen in this study, as indicated by Hair et al. (2022), if VIF is greater than five, it implies a high collinearity.

Table 4: Indicator validity for the higher-order construct

Second-order construct	Path	β^2	T-Statistics	p-value	VIF
EMCS	Plan -> EMCS	0.231	19.254	0.000	3.38
	Cultural -> EMCS	0.213	21.058	0.000	2.82
	Cybernetic -> EMCS	0.278	23.849	0.000	3.44
	Reward -> EMCS	0.231	17.128	0.000	2.43
	Admin -> EMCS	0.190	20.506	0.000	3.16
Eco Capability	HR -> Eco-Capability	0.354	25.584	0.000	2.66
	BR -> Eco-Capability	0.365	32.475	0.000	3.55
	TR -> Eco-Capability	0.375	28.320	0.000	3.57
Sustainability Performance	Economic PMC -> Sustainability PMC	0.420	20.535	0.000	2.26
	Environmental PMC -> Sustainability PMC	0.354	15.531	0.000	1.83
	Social PMC -> Sustainability PMC	0.389	16.053	0.000	2.33

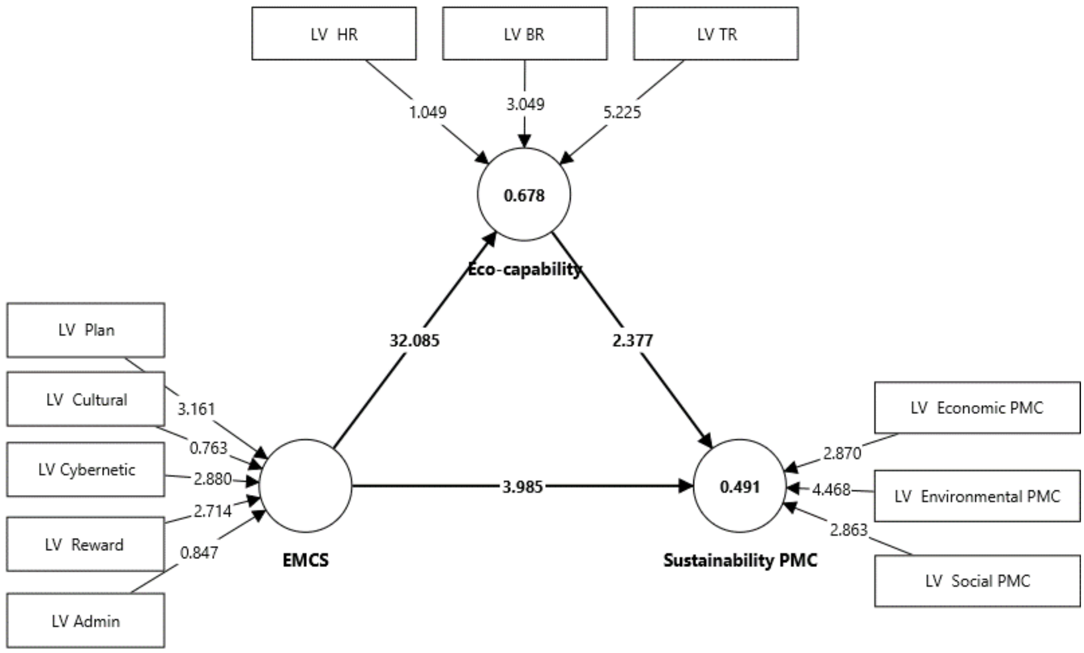
Note: p-value = <0.05

Assessment of the Structural Model

The structural model of this study was assessed through the coefficient of determination (R^2), path coefficient (β), and effect size (f^2).

The explanatory power of the structural model was determined by examining the coefficient of determination (R^2 values) (Hair et al., 2022). Specifically, the amount of variance in the endogenous constructs in this study (eco-capability and sustainability performance) is explained by the EMCS construct. Hair et al. (2022) stated that, R^2 values of 0.75, 0.55, or 0.25 for latent endogenous constructs in the inner model can be labelled as substantial, moderate, or weak, respectively. The results shown in Figure 2 indicate that the model is robust with 67.8% (R^2=0.678) of the variance in eco-capability explained by the first-order constructs, i.e., EMCS. Hence, the variance of eco-capability can be classified as moderate. The model also indicates a weak R^2 value (R^2=0.491), which means that the structural model only explains 49.1% of the variation in sustainability performance explained by EMCS.

Figure 2: Structural model of EMCS, eco-capability and sustainability performance



Next, the significance and relevance of the structural path were examined using t-values generated from a bootstrapping procedure with 10,000 resamples (Hair et al., 2022). Figure 2 also shows that three types of EMCS dimensions are significant. Plan (t= 3.161) is the strongest dimension that forms the EMCS, followed by cybernetic (t= 2.880) and reward (t= 2.714). These results point out that most companies in ESIs are applying these three out of the five types of control dimensions. However, cultural (t= 0.763) and administration (t= 0.847) are not significant, indicating that they are less practiced by the firms.

Subsequently, the following step is to examine the significance and relevance of the path coefficients. The dimension for sustainability performance, as shown in Figure 2, indicates that economic, environmental, and social performance are significant dimensions to form sustainability performance with t-values of 2.870, 4.468 and 2.863, respectively. Meanwhile, for the eco-capability dimension, only business resources (t=3.049) and technology resources (t=5.225) are significant; however, the human resources are an insignificant dimension for the eco-capability construct.

Referring to Table 5, the direct path relationships of EMCS on eco-capability (t=32.085, p<0.05) and EMCS on sustainability performance (t=3.985, p<0.05) are statistically significant, indicating that H1 and H2 are supported. The direct path of eco-capability on sustainability performance is also significant (t=2.377, p>0.05), thus H3 is also supported.

Table 5: Summary of Hypothesis Testing

Hypothesis	Path	t-value	*p*-value	Result
H_1	EMCS -> Eco-capability	32.085	0.000	Supported
H_2	EMCS -> Sustainability performance	3.985	0.000	Supported
H_3	Eco-capability -> Sustainability performance	2.377	0.009	Supported

The next step is to evaluate the effect size of the structural model to measure the impact of the selected predictor construct on the R^2 values of an endogenous construct. Referring to Table 6, the analysis revealed that EMCS has a significant and strong effect on eco-capability (β=0.823, f^2=2.102); meanwhile, the effect size of the relationship between EMCS on sustainability performance is medium (β=0.452, f^2=0.130), thereby supporting the hypothesis. However, the effect size of the relationship between eco-capability and sustainability performance is small (β=0.279, f^2=0.049). The results revealed that the selected predictor constructs have a different effect size on the R^2 values of an endogenous construct.

Table 6: The Assessment of *f*-squared (f^2)

Relationship	β^2	f^2	Effect size
EMCS -> Eco-capability	0.823	2.102	large
EMCS -> Sustainability performance	0.452	0.130	Medium
Eco-capability -> Sustainability performance	0.279	0.049	small

The Mediating Effect of Eco-Capability on EMCS and Sustainability Performance

The H4 hypothesis is to test the mediating effect of eco-capability on the relationship between EMCS and sustainability performance. Table 7 shows that EMCS is statistically significant on eco-capability (t=32.085, p<0.05), and there is a significant direct path of EMCS on sustainability performance (t=3.985, p<0.05). The indirect path of eco-capability on sustainability performance also indicated a significant result (t=2.377, p>0.05. Referring to Table 8, the result of the 95% bootstrapped CI lower limit is 0.068 with an upper limit of 0.385, which indicates that there is no zero in between. This means that eco-capability is a complementary mediation in this relationship (Preacher and Hayes 2008). According to Zhao et al. (2010) and Nitzl et al. (2016), When the direct and indirect effects are both significant and point in the same direction, it indicates the existence of a complementary mediation effect.

Table 7: Result of the Mediating Effect

	Path	Indirect Effect	STD dev	T-Value	Lower Limit (5%)	Upper Limit (95%)
H4	EMCS -> Eco-capability-> Sustainability performance	0.230	0.098	2.353	0.068	0.385

Discussion

The study found that EMCS appeared to be significantly influencing sustainability performance. The findings are in line with findings by Daromes and Ng (2023) and Rehman et al. (2021). Through systematic policies, organisations are able to align their strategies with environmental goals. This process builds a work culture that values performance and rewards, thereby motivating employees to work harder and increasing core values in the organisation. Thus, the comprehensive EMCS package not only improves sustainability performance but also offers a competitive advantage through more optimal resource management.

The first dimension of the EMCS framework is planning. It is the strategic base that helps firms to identify and use resources in a way that gives them a clear competitive advantage (Barney, 1991). In line with Rotzel et al. (2019), their findings have demonstrated that a firm's environmental strategic plans correlate positively with environmental management performance, indicating that proactive planning leads to stronger managerial outcomes. Another critical EMCS dimension, cybernetic control, supports this positive relationship by supplying essential data for strategic planning and performance management (Searcy, 2012). By integrating budgeting and performance systems, managers make decisions based on evidence from the real-time data (Perego and Hartmann, 2009; Schaltegger and Burritt, 2010). Then, the organisation can successfully motivate the employees by using a well-structured reward system to meet high-level sustainability goals.

Contrarily, another dimension of EMCS, which is cultural and administrative control, did not reach statistical significance. This indicated that green practices have not yet been successfully normalised within the organisations' daily lives. Notwithstanding the implementation of structural controls, environmental values appear to be only partially developed and inconsistently reflected across the workforce. Fraj et al. (2013) also argued that the introduction of environmental culture alone is insufficient to cultivate eco-capabilities. Besides, Akano et al. (2024) highlighted the cultural barrier issues where environmental responsibility is commonly viewed as an external obligation rather than a fully internalised priority throughout the organisations. Accordingly, Goebel and Weißenberger (2017) and Chenhall et al. (2015) believed that cultural controls should ideally anchor organisational values and administrative effectiveness.

Organisations tend to utilise different types of control, including both formal and informal controls, which align with accounting practices (Bedford and Malmi, 2015). It is confirmed by Strauss et al. (2013), who claimed that organisations tend to focus on using certain controls that are relevant to their context and needs. Moreover, Chenhall (2003) also claimed that not all control mechanisms are feasible in statistical models. ESIs that successfully integrate administrative and cultural controls can more easily adapt to changes in regulations, market trends, and stakeholder expectations (Abdel-Maksoud et al., 2021). This adaptability can give ESIs a competitive advantage in an eco-conscious global market. Therefore, when administrative and cultural controls are shown as less impactful in this study, it might be valuable under different circumstances. Collectively, all five dimensions (plan, cultural, cybernetic, reward and administrative) could create a robust and adaptive environmental management system.

Consequently, our statistical analysis indicates that eco-capability plays a substantial mediating role between EMCS and sustainability performance, suggesting that EMCS alone may not directly contribute to improved sustainability outcomes unless combined with strong eco-capabilities. A well-developed EMCS, supported by human, business, and technology resources (eco-capability), enhance competitive advantage (Gabler et al., 2015; Powell and Dent-Micallef, 1997). The integration of these resources enables consistent and effective implementation of environmental controls, facilitating green management initiatives (Hofmann et al., 2012). By strengthening firms' ability to control, measure and integrate environmental objectives into operational processes, eco-capability shifts environmental concern from a compliance cost into a source of strategic advantage (Gabler et al., 2015). This aligns with the NRBV concept, where the combination of environmental objectives with business strategy can create sustainable competitive advantages (Hart, 1995).

Technological capability also has been found to positively influence firm performance. Consistent with Felsberger et al. (2022), found that European manufacturing firms investing in and utilising digital technologies strengthened their competitive positions. In a complex and rapidly evolving business environment, firms must continually enhance their capabilities and resources to adapt to the changes in technology and its impact on business performance. However, not all technological advancements uniformly affect inter-firm performance. In this study, the impact of eco-capability on sustainability performance is less direct, with technological improvements contributing more to cost-efficiency and firm performance. Ultimately, effective environmental control depends on achieving a balance between developing dynamic capabilities and pursuing sustainable competitive advantage.

The capacity of management to effectively monitor, control, and incentivise green practices, alongside the development of eco-capability, is essential for reputational enhancement and improved sustainability performance (Lin and Wu, 2014; Pramono et al., 2023). Further, Bresciani et al. (2022) found that green dynamic capabilities serve as a critical mechanism mediating the relationship between the EMCS package, perceived environmental uncertainty, and green performance. Our findings extend this by showing that Malaysia ESIs' eco-capability not only enhances environmental responsiveness but also strengthens organisational resilience, allowing firms to take proactive initiatives. For example, ESIs adopting carbon reduction targets or renewable energy transition that are both environmentally and economically sustainable. In volatile markets, organisations are advised to build successive advantages by addressing evolving environmental demands (Barreto, 2010; Felsberger et al., 2022). Firms that leverage eco-capability were reported to have stronger market and financial performance (Gabler et al., 2015).

To conclude, eco-capabilities play a significant role in driving sustainability performance, particularly within Malaysian ESIs. These capabilities provide firms with the resources and resilience needed to navigate uncertainty and take on courageous environmental initiatives. Together, a well-structured EMCS package and eco-capability enable firms to achieve sustainable competitive advantages by balancing environmental, economic, and social performance goals.

Limitation and Future Research

Despite offering valuable insights into the relationship between EMCS, Eco-capability and sustainability performance, several limitations should be acknowledged. In particular, the findings are derived from a sample of the Malaysian ESI industry, which may constrain the generalisability of the results. The regulatory frameworks, cultural norms and environmental priorities could be different in other regional contexts. Nevertheless, careful consideration was given to the measurement instruments employed, as self-reported survey data are inherently subject to potential measurement error and social desirability bias, particularly when addressing sensitive issues such as environmental responsibility.

Next, other contextual or organisational factors, such as leadership commitment, environmental policy or market competition, are not included in the analysis. Finally, the use of a cross-sectional research design constrains the ability to draw causal conclusions. This is because it measures organisational behaviour and performance at a single point in time rather than observing changes over time. The longitudinal studies could be more relevant for future research as they could provide deeper insights into the dynamic evolution of EMCS practices and their long-term impact on sustainability outcomes. Addressing these limitations could help to strengthen the validity, reliability and applicability of the findings across broader contexts in future research.

Practical Implications for Asian Business

This study explores the dynamic interaction between EMCS, eco-capability, and sustainability performance in Malaysia, suggesting valuable insights for businesses across Asia. In the context of Asian businesses, the application of EMCS will be more effective when firms apply the control system in a package rather than in isolation, specifically for ESIs in the Asian region (Chenhall et al., 2003; Malmi and Brown, 2008). The following discussion suggests how businesses in a specific industry can strategically apply the EMCS package holistically to achieve better environmental management outcomes.

Survival in the modern manufacturing industry is very challenging due to the intense competition in the Asian market. Thus, operational efficiency must now coexist with strict environmental compliance. To achieve this, firms can no longer rely on static goals. Firms must align their long-term planning with cybernetic tools that monitor resource usage in real-time. Effective rewards and incentives must be employed to encourage green practices within the organisations. They can cultivate a culture that promotes sustainability values among employees. Structured administration further reinforces sustainability compliance and supports continuous improvement. Ultimately, these EMCS practices contribute to better organisational performance (Rehman et al.,2018) and satisfy the intensifying demand of stakeholders (Abrams et al., 2021; Edirisinghe et al., 2024).

The construction industry faced similarly steep challenges, given its reputation for heavy material waste and high emissions levels. Construction companies in the Asian region can use the EMCS package, which provides a roadmap for elevating project sustainability (Rehman et al., 2021). In this context, planning can facilitate the integration of green design and efficient resource allocation from the early design phase of the project. Cybernetic tools allow firms to monitor environmental impacts throughout the construction process. Yet for these standards to stick, reward systems must be in place to motivate personnel, supported by administrative control that keeps project-level environmental compliance on track (Saka et al., 2021). Perhaps, most importantly, fostering a culture of environmental accountability ensures that these values are shared by everyone within the organisation.

In the Asian oil and gas industry, where environmental risks and public scrutiny are high, an integrated EMCS approach can significantly enhance resilience (George et al., 2016). Strategic planning is essential to align operations with national decarbonization goals, while cybernetic control facilitates the monitoring of emission and safety achievements. Meanwhile, administrative control can be shared with the employees to enhance their accountability for environmental activities, thus creating a strong concern for sustainability in high-risk contexts.

Consequently, the nature of the plantation industry is associated with land use management, biodiversity conservation and community engagement (Morgans et al., 2018), which also requires a holistic application of EMCS. Strategic planning and control play a critical role in steering sustainable land management and reforestation initiatives. Cybernetic controls support effective resource allocation and enable systematic performance evaluation. Additionally, the reward system can promote environmentally responsible practices among field workers (Abrams et al., 2021). This is further reinforced by administrative controls that ensure strict compliance with global certification schemes such as the Sustainable Palm Oil Roundtable (RSPO) (Morgan et al., 2018). Finally, cultural control strengthens stakeholder engagement by fostering a shared commitment to environmental stewardship among workers and local communities.

The management of diverse firms in the Asian region might consider using this framework by following these steps: First, firms need to assess the current maturity level of EMCS adoption through internal audits, paired with industry benchmarking to highlight specific gaps and strengths. From there, management must narrow the focus on the environmental risks to their sector, whether there is waste management in the factory or biodiversity loss in the plantation. Once these risks are clearly identified, the various dimensions of EMCS can be strategically aligned to mitigate them. Finally, the most important step is investing in human and technological capital. Without building these internal capabilities, the framework remains a theoretical exercise rather than a functional success.

Finally, it can be concluded that planning and cybernetic control can reduce operational risks, while reward systems and cultural control play a role in motivating the adoption of sustainable behaviour throughout the organisation. Contrarily, administrative control provides an important formal structure to enforce compliance and increase accountability. Accordingly, building eco-capability by investing in human and technical expertise is essential. Lastly, continuous monitoring allows firms to respond dynamically to environmental pressures as well as to regulatory changes. Maintaining competitiveness by integrating sustainability into core business operations is crucial.

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