

Unveiling How Internal Control Foster Sustainable Green Innovation Ecosystem: Mediating Role of Environment Management Accounting Data Analytics

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Abstract

This study constructs and validates a theoretical framework that focuses on the correlation between internal control systems (ICS) and the sustainable green innovation ecosystem (SGIE). Furthermore, it aims to investigate the role of environmental management accounting data analytics (EMADA) as a mediator in the relationship between ICS and SGIE. The current study utilized a methodological approach consisting of three components namely a literature review, expert interviews, and a self-administered survey. The study used structural equation modeling to analyze the proposed model, which was constructed using statistical data gathered from a cross-sectional survey of 583 accountants working in public sector organizations (PSOs). The acquired observations underscored the interdependence and mutual reinforcement of the proposed dimensions. These observations provided guidance for PSO leaders to recognize and take advantage of chances to enhance their effectiveness in the green innovation implementation journey. They also helped in developing strong strategies to efficiently steer their digital transformation process. The work's detailed findings were crucial in enabling policymakers to establish rules and regulations linked to digitalization and green innovation.

Keywords: Big data; Ecosystem; Environmental management accounting; Green innovation; sustainable development.

1. Introduction

The ongoing escalation in worldwide energy requirements sustains unsustainable business practices that have a detrimental impact on climate change (Iroegbu et al., 2020; Ojo & Baiyegunhi, 2021). As a consequence, the public sector organizations (PSOs) continue to be burdened with the need to address the escalating pollution of land, air, and water. As a result, green innovation is a feasible strategy that advances economic growth and environmental

protection (Cui et al., 2023). PSOs in emerging markets place significant emphasis on and actively encourage innovation (De Vries et al., 2018). Therefore, even a seemingly insignificant advancement within this category of institution can result in significant outcomes or repercussions that extend beyond its confines (Edler & Yeow, 2016). Regrettably, within a complex environment, green innovation may face obstacles stemming from factors such as the unpredictability of cost inputs, the intensity of research and development endeavors (Fernando & Wah, 2017), the demands imposed by multiagent collaboration, the varying degrees of technological expertise (Liao, 2018), and the imperative to align green business strategies with financial goals (Somlai, 2022). By effectively implementing the complete green innovation process, organizations face considerable obstacles when attempting to maximize their internal capabilities and resources. Concerning to this, the sustainable green innovation ecosystem (SGIE) provides a structure for analyzing multiagent collaboration in the PSO's sustainable management. The SGIE, an innovation ecosystem, endeavors to create more favorable conditions that promote green innovation in a sustainable manner. Nonetheless, this entails the application of environmental management techniques and the utilization of digital technology (Demirel & Kesidou, 2018).

Environmental management accounting data analytics (EMADA), refers to an accounting information system that utilizes big data to effectively identify, collect, utilize, and analyze both physical information regarding the movement of water, energy, and materials, as well as financial information regarding environmental costs, savings, and profits. The primary objective of EMADA is to furnish management with accurate information regarding the real environmental expenses associated with their organizational operations, as well as to pinpoint potential chances for reducing expenditures.

Significantly, the rapid expansion of innovation on a global scale has resulted in a wide array of pressing demands regarding the application of management control techniques (Tu et al., 2022). The implementation of an internal control system (ICS) is generally acknowledged as a method or framework for directing, supervising, and managing an organization in pursuit of a particular goal.

This phenomenon has necessitated a reevaluation and the development of a comprehensive comprehension of the emerging ecosystem so that the PSO, which is an SGIE, can maximize its potential and guarantee green innovation. In light of the paucity of established scholarly literature on the subject regarding the potential impact of ICS on promoting SGIE, the primary objective of this study is to investigate how ICS can contribute to the development of the SGIE via EMADA. Additionally, opportunities for theoretical and practical contributions to this field are brought to light by the investigation. In addition, this gap in theory gives rise to the following research questions that are thought-provoking and require further investigation.

RQ1. *To what extent does ICS illustrate an influence on SGIE?*

RQ2. *Does EMADA mediate the association between ICS and SGIE?*

The present investigation was groundbreaking in that it specifically sought to contribute to the

current state of knowledge regarding the green innovation ecosystem. Despite receiving several calls for further investigation (e.g., Fan et al., 2022; Oliveira-Duarte et al., 2021; Yi & Zhang, 2022; Yu et al., 2022), the green innovation ecosystem has received limited attention in academic literature (Li & Shi, 2022), and there is a dearth of quantitative studies that specifically examine it within the domain of management (Rosa et al., 2023).

Additionally, the results of this study made a scholarly contribution to the field of green innovation ecosystems by demonstrating that the successful formulation and operationalization of SGIEs are contingent upon the effectiveness of ICS. The majority of environmental management accounting-related research has been conducted in the private sector (Gunaratne & Lee, 2021; Nyakuwanika et al., 2021). Empirical evidence indicated that organizations adopted environmental management accounting narratives due to the perceived advantages in terms of financial and environmental performance. Nevertheless, the existing body of evidence has been inadequate to support the notion that environmental management accounting practices have been widely adopted by local administrations, especially in developing nations (Mukwarami & van der Poll, 2024). In this regard, the other contribution pertained to EMADA and involved obtaining a deeper understanding of potential avenues through which PSO could enhance the capabilities of SGIE establishment and operationalization by leveraging EMADA's effectiveness. By doing so, the current study contributes to the growing corpus of knowledge concerning the implementation of environmental management accounting in PSOs, particularly in developing countries.

The entire investigation proceeds as follows. The current study begins with an explanation of the research motivation and orientation, followed by a review of the relevant literature in Section 2. This review provides theoretical background and conceptualization. Section 3 delineates the interpretation of the research paradigm and the formulation of hypotheses. The discussion of research methodology is presented in Section 4. In Section 5, a summary of the obtained observations, discussions, and implications are provided. Section 6 concludes with a comprehensive analysis of the inherent limitations and constructive suggestions for future research.

2. Literature Review

Contingency theory. Because of its foundational notions in organizational literature, contingency theory—discovered in 1950 by researchers from Ohio State University (Nohria & Khurana, 2010)—was utilized in studies centered on organizational difficulties (Sausser et al., 2009). Building on the perspectives of contingency theory, it was generally agreed that many factors determine an organization's structure. These factors include, but are not limited to, the following: the nature of the organization's work, market conditions, culture, the external environment, and technology. An organization's specific operational context determines whatever accounting procedures it chooses to implement, according to the contingency theory (Phan et al., 2017). Thus, there is no one best way to keep financial records; rather, what constitutes an appropriate system of accounting is contingent upon factors specific to each organization, including its structure, technology, and external factors (Otley, 1980). To be

productive, organizations must adapt to their changing circumstances (Donaldson, 2001). According to Chang and Deegan (2010), organizations may implement environmental strategies and accounting procedures in response to perceived environmental unpredictability. This helps them stay effective when faced with changing circumstances.

Environmental management accounting data analytics. Environmental management accounting, viewed through a management accounting lens, integrates cost and financial accounting to reduce environmental impact and risks while minimizing expenses related to environmental protection (Bresciani et al., 2023). In the current research, EMADA, refers to an accounting information system that utilizes big data to effectively identify, collect, utilize, and analyze both physical information regarding the movement of water, energy, and materials, as well as financial information regarding environmental costs, savings, and profits. The primary objective of EMADA is to furnish management with accurate information regarding the real environmental expenses associated with their organizational operations, as well as to pinpoint potential chances for reducing expenditures.

Internal control system. According to Schaeffer (2014), ICS is a framework that encompasses analysis, strategies, processes, procedures, and policies. Members of the company's board of directors and other employees carry it out. By controlling potential threats and assuring the organization's objectives, ICS aims to improve operational efficacy and efficiency (Michelon et al., 2015). This is carried out in a way that complies with all applicable laws and regulations, is organized, ethical, cost-effective, and accountable (Sari et al., 2017). Furthermore, ICS is designed to safeguard resources from being lost, misused, or damaged (Sari et al., 2017).

Sustainable green innovation ecosystem. Academics have taken a keen interest in the concept of an innovation ecosystem ever since Moore (1993) first presented the term, and numerous additional scholars have since discovered comparable concepts (Adner, 2017). One way to create a green innovation ecosystem is to combine organizational green innovation with an innovation ecosystem. The green innovation ecosystem is one lens through which to view the challenges of multi-agent interaction in the context of sustainable management. As defined in this study, SGIE is an innovation ecosystem that strives to cultivate a sustainable environment for green innovation.

Internal controls, a crucial component of modern organizational infrastructure, were initially developed to reduce the probability of managerial fraud. Ma et al. (2022) suggested that implementing a robust system of internal controls can significantly enhance an organization's strategic management, information exchange, and operational operations. Additionally, this will aid in mitigating systemic risks inside the organization's operations and innovation endeavors. Organizations can make well-informed decisions about green innovation projects by incorporating procedures for scientific risk assessment, consultation, and oversight. By doing this, it reduces the occurrence of innovation choice failures caused by agency-related issues and safeguards established companies against losses associated with innovation risks. Ma et al. (2022) argue that improved internal controls can drive advancements in green inventions. Furthermore, studies have indicated that implementing efficient internal control systems

enhances an organization's ability to engage in technological innovation. Additionally, investors are more inclined to invest larger amounts of money into an organization's innovation initiatives when its control measures are of higher quality (Vasilev et al., 2017). As such, the first hypothesis can be posited as follows.

Hypothesis 1 (H1). *ICS is likely to significantly and positively impact SGIE.*

The digital economy has brought about an increase in the level of risk associated with data transmission and storage (Xiwen et al., 2021). As a result, an analysis was conducted on the internal controls that the accounting information system had established in order to protect against network security threats, computer infections, and hackers. There is no doubt that the improvement of information system quality and dependability is a direct result of implementing effective internal control measures (Laudon & Laudon, 2012). For internal and external objectives, an effective ICS can assist EMADA to determining, gathering, analyzing, minimizing, and managing environmental-related costs. Additionally, the greater the effectiveness of an organization's ICS, the more likely it is that EMADA will be able to assist the organization in fulfilling its environmental responsibilities and explicitly recognize the economic benefits of enhanced environmental and economic performance. As such, the second hypothesis can be posited as follows.

Hypothesis 2 (H3). *ICS is likely to significantly and positively impact EMADA.*

Building on the perspectives of Qian et al. (2018), an organization's internal management tool for addressing its environmental burden and traditional practices is environmental management accounting. According to Zhou et al. (2017), environmental management accounting is a way for businesses to get the data they need to enhance their financial and environmental performance. Better environmental performance is a clear result of environmental management accounting (Asiaei et al., 2021; Erauskin-Tolosa et al., 2020). Implementing environmental management accounting can improve production efficiency, decrease waste, and cut costs and energy (Schaltegger, 2018). Additionally, Nkundabanyanga et al. (2021) verified that environmental performance disclosure is positively impacted by environmental management accounting.

Innovations in technology have the potential to bring about greener business practices (Alraja et al., 2022). In order to gain an edge over the competition and manage operations from a distance, technological advancements have made it possible to make better use of limited resources (El-Haddadeh, 2020). Sustainable green transformations rely heavily on technological developments (Effendi et al., 2020). Technological advancements have reduced waste and made green activities sustainable (Wang et al., 2021).

Therefore, the EMADA implementation would enable PSO to improve and enhance transparency regarding their environmental expenses and enhance their ability to make environmentally conscious decisions and improve their performance, ultimately leading to sustainable development. As such, the third hypothesis can be posited as follows.

Hypothesis 3 (H3). *EMADA is likely to significantly and positively impact.*

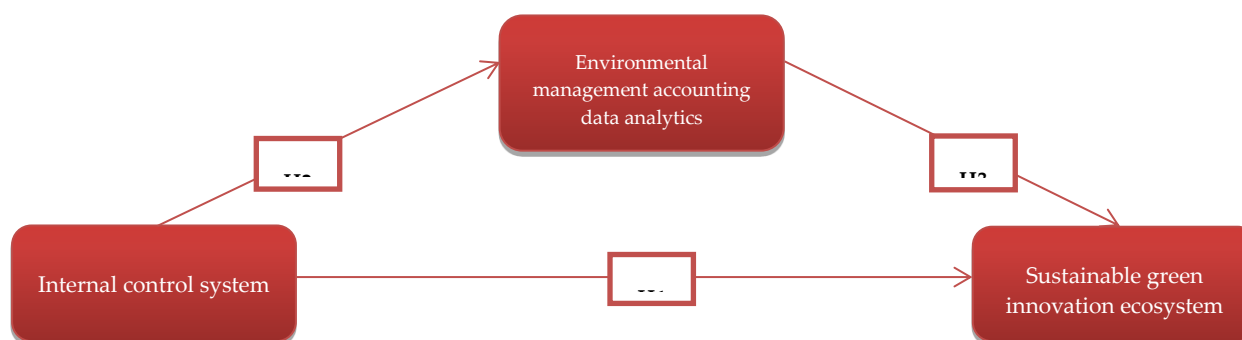


Figure 1. Hypothesized model

3. Research Method

Operationalization of research variables. Researchers are increasingly utilizing mixed-methodologies approaches to address the limitations of both qualitative and quantitative methods (Creswell & Creswell, 2018). This investigation made use of exploratory sequential mixed methods because, as stated by Agyeiwaah (2022), they are able to provide a comprehensive explanation of phenomena by moving beyond the limitations of a single method. In this study, a purposive sample technique was employed to choose the best informants from academics, working professionals, and public sector employees who were knowledgeable about the topic. Interviews were conducted using a semi-structured format in order to gather information from professionals and researchers in the fields of green innovation ecosystem, digital technologies, environmental management accounting, and internal control systems. Interviews were stopped when data saturation was reached or when no new information emerged. Due to the inability to extract any new material, this study was considered saturated after eight interviews.

In order to guarantee that the source and target documents were equivalent, a laborious back-translation technique was implemented. The questionnaire was initially written in English and subsequently translated into Vietnamese with meticulous care. A small-scale pilot test was conducted to conduct a preliminary evaluation of the measuring instruments prior to conducting a more extensive survey. The small-scale pilot survey, which employed a cohort of respondents that was readily obtained from the target demographic through PSOs, was completed by thirty individuals. All variables had Cronbach's alpha values that exceeded 0.6, which is considered satisfactory, as per Bujang et al. (2018). A five-point Likert scale was employed to assess responses, which varied from one (extremely disappointed) to five (extremely satisfied).

Environmental management accounting data analytics. The EMADA construct was conceptualized as a second-order aggregate of five first-order micro-foundational constructs – Environmental accounting information diagnostic analytics; Environmental accounting information predictive analytics; Environmental accounting information prescriptive analytics; Performance management information system; Digital risk management information system which were derived from those proposed by Almubaydeen et al. (2023); Chowdhury (2023); Tanbour and Nour (2024).

Digital Internal control system. The criteria for DICS in this examination were obtained from the research conducted by Xiwen et al. (2021). The scale used for assessment encompassed the following five core categories: control environment, risk assessment, control activities, information and communication, and monitoring.

Sustainable green innovation ecosystem. The measurement scale for GIE in this investigation was formulated using four items that were derived from those proposed by Fan et al. (2022), Zeng et al. (2022), and Alraja et al. (2022).

Target population and sampling procedure. The survey subjects of the research were accountants who were employed by PSOs in the southern region of Vietnam. The prediction was made by Zybery and Rova (2014) that the presence of accountants will be a necessary prerequisite for attaining effective outcomes due to the increasing prevalence of digital technologies. The present investigation utilized a combination of projectile sampling and convenience sampling techniques. The methodology's effectiveness in gathering data from the population to develop statistical conclusions was recognized. Gupta (2021) recommended that the sample size be between 5:1 and 20:1, with 5 and 20 designating the sample size for each individual item. A variety of data was gathered during the period of the middle of November 2023 to the beginning of May 2024. Following the screening and examination of the questionnaires, a final sample size of 583 cases was retained for analysis, with a data loss rate of 16.71 percent. The statistical data in this investigation was analyzed using SPSS 29.0 and SmartPLS 4.1.0.2. The comprehensive demographic data collected from this investigation is presented in Table 1.

Table 1. Demographic information

Respondent's Profile	Demographic Variables	Usable Responses	Weight (%)
<i>Gender of respondent</i>			
	Male	174	29.85
	Female	409	70.15
<i>Age of respondent</i>			
	30 – under 40	234	40.14
	40 – under 50	296	50.77
	Over 50	53	9.09
<i>Experience of respondent (years)</i>			
	10 - under 20	287	49.23
	20 - under 30	264	45.28
	30 - under 40	32	5.49
<i>Education</i>			
	Undergraduate	549	94.17
	Postgraduate	34	5.83

4. Finding and Discussion

Measurement model assessment. *Indicator and construct reliabilities.* The reliability of the measuring scales is also evaluated utilizing Cronbach's alpha, composite reliability (CR), and Dijkstra-Henseler rho as recommended by Hair et al. (2022). Cronbach's alpha, CR, and Dijkstra-Henseler rho values for each construct should be higher than the recommended cutoff value of 0.70 (Hair et al., 2022).

Convergent validity. The factor loading is the correlation between latent construct elements with a value greater than 0.7 (Hair et al., 2022). The average variance extracted (AVE) is evaluated in the subsequent phase. According to Hair et al. (2022), the hypothesized constructs should have AVEs that are greater than the minimally recommended value of 0.50, demonstrating the decent degree of convergent validity.

The necessary detail of reliability as well as convergent validity shown in **Table 2** demonstrates that this study achieves the reliability and vigor of the measurement model.

Table 2. Results summary of measurement model assessment

Constructs operationalization	and	Convergent validity		Construct reliability			Result
		Factor Loading s	AVE	Cronbach's Alpha	Composit e Reliabilit y	PA	
Environmental management accounting data analytics	EMADA						
Environmental accounting information diagnostic analytics	DA	0.822	- 0.69	0.781	0.876	0.782	Accepted
Environmental accounting information predictive analytics	PDA	0.834	- 0.71	0.805	0.888	0.809	Accepted
Environmental accounting information prescriptive analytics	PSA	0.836	- 0.71	0.802	0.887	0.804	Accepted
Performance	PM	0.847	- 0.73	0.823	0.898	0.82	Accepted

management information system		0.871	8			3	d
Digital risk management information system	DRM	0.829	- 0.70			0.78	Accepted
Internal control system	ICS	0.859	0	0.786	0.878	6	d
Control environment	COE	0.794	- 0.68			0.76	Accepted
Risk assessment	RA	0.850	1	0.765	0.868	7	d
Control activities	COA	0.845	- 0.75			0.83	Accepted
Information and Communication	IAC	0.882	0	0.834	0.903	4	d
Monitoring	MON	0.847	- 0.76			0.85	Accepted
		0.915	6	0.848	0.911	1	d
Green innovation ecosystem	GIE	0.799	- 0.70			0.79	Accepted
		0.878	7	0.792	0.882	5	d
		0.805	- 0.70			0.79	Accepted
		0.903	9	0.793	0.883	8	d
		0.741	- 0.57			0.75	Accepted
		0.795	7	0.756	0.848	7	d

Correlations and discriminant validity. As illustrated in **Table 3**, the discriminant validity meets the Fornell-Larcker requirement, which states that the square root of each construct's AVE must be greater than the correlation between a given construct and all others (Fornell & Larcker, 1981). This metric has drawn criticism since variance-based SEM techniques may overestimate factor loadings and underestimate structural model links (Henseler et al., 2015). The third criterion is consequently issued.

Table 3. Results summary of Discriminant validity using Fornell–Larcker process

	CO E	DR M	SGI E	CO A	MO N	LAC	PSA	RA	PDA	PM	DA
COE	0.871										
DRM	0.332	0.821									
SGIE	0.095	0.238	0.830								
COA	0.115	0.060	0.188	0.833							
MON	0.099	0.276	0.110	0.069	0.837						
LAC	0.139	0.321	0.229	0.092	0.150	0.838					
PSA	0.082	0.154	0.331	0.085	0.049	0.120	0.844				
RA	0.067	0.045	0.286	0.385	0.024	0.106	0.123	0.855			
PDA	0.171	0.206	0.341	0.135	0.184	0.112	0.080	0.112	0.842		
PM	0.082	0.274	0.129	0.005	0.066	0.159	0.122	0.130	0.136	0.862	
DA	0.132	0.231	0.285	0.165	0.081	0.174	0.153	0.249	0.207	0.105	0.755

Using the heterotrait-monotrait ratio (HTMT), the connections were estimated. As proposed by Henseler et al. (2015), it is the average of item correlations between constructs as opposed to within a single concept. The HTMT measurements should not exceed a threshold value of 0.9, according to Henseler et al. (2015). The HTMT statistic was drastically less than the recommended value of 0.90, as shown by the bootstrapping analysis results in **Table 4**, which validates the discriminant validity.

Table 4. Results summary for discriminant validity on Heterotrait–Monotrait ratio

	CO E	DR M	SGI E	CO A	MO N	LAC	PSA	RA	PDA	PM	DA
COE											
DRM	0.415										
SGIE	0.119	0.310									
COA	0.142	0.101	0.243								
MON	0.120	0.357	0.140	0.090							
LAC	0.171	0.413	0.291	0.121	0.192						
PSA	0.101	0.202	0.418	0.110	0.060	0.151					
RA	0.083	0.060	0.360	0.482	0.037	0.132	0.151				
PDA	0.209	0.265	0.435	0.170	0.231	0.139	0.100	0.138			
PM	0.098	0.346	0.163	0.037	0.094	0.195	0.151	0.157	0.186		
DA	0.168	0.305	0.373	0.208	0.112	0.223	0.195	0.312	0.267	0.134	

Structural model assessment. The structural model employed to evaluate the hypothesized relationships was illustrated in **Figure 2**.

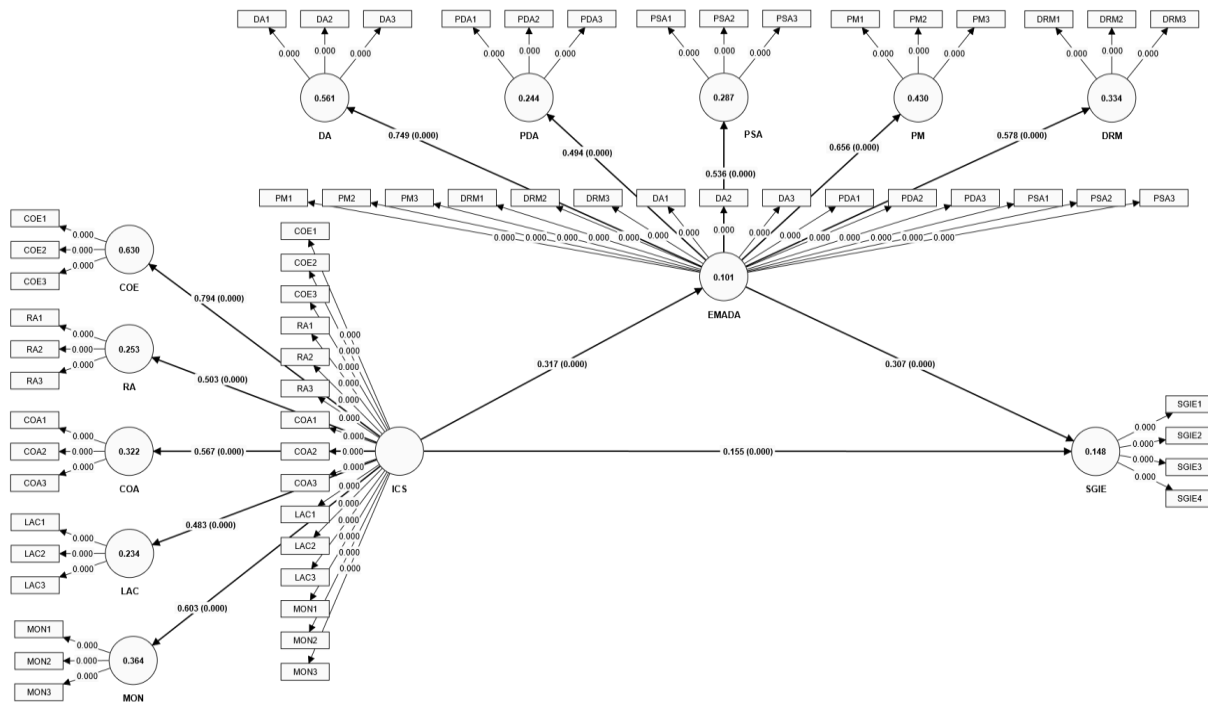


Figure 2. Diagram of structural model extracted from SmartPLS 4.1.0.2

All inner variance inflation factor (VIF) values were much below the critical threshold value of 3, indicating no significant collinearity issues (Hair et al., 2022). Through the utilization of path coefficients and R^2 values, Hair et al. (2022) assessed the structural model's fit. The value of R^2 for EMADA was 0.101 and 0.148 for SGIE. As shown in **Table 5**, the f^2 effect size results for each variable indicated that the significance varied from small to medium. Rested on the bootstrap outcomes (percentile bootstrapping, two-tailed test, 0.05 significance level, with 10,000 resamples) in **Table 5**, ICS impacted EMADA ($\beta = 0.317$; t -value = 8.185; p -value = 0.000) and SGIE ($\beta = 0.155$; t -value = 4.185; p -value = 0.000) in a substantial and positive manner. In the same vein, EMADA impacted SGIE ($\beta = 0.307$; t -value = 8.244; p -value = 0.000) in a substantial and positive manner. In this regard, H1-H3 were accepted. Given that the direct effects of ICS on SGIE were also supported and that the indirect effects were considerable (t -value = 5.871; p -value = 0.000), it was determined that EMADA partially mediated the association between ICS and SGIE (Hair et al., 2022). As a result, the findings indicated partial mediation.

Table 5. Results summary of hypotheses acceptance

Relevant path	Path coefficient	SE	95% Confidence interval	VIF	t-value	p-value	Result
<i>Direct effect</i>							
ICS → EMADA	0.317	0.039	[0.238 0.391]	1.000	8.185	0.000	Accepted
ICS → SGIE	0.155	0.037	[0.081 0.226]	1.112	4.185	0.000	Accepted
EMADA → SGIE	0.307	0.037	[0.230 0.376]	1.112	8.244	0.000	Accepted
<i>Indirect effect</i>							
ICS → EMADA → SGIE	0.097	0.017	[0.068 0.133]	-	5.871	0.000	Accepted
R²	R²_{EMADA} = 0.101; R²_{SGIE} = 0.148						
f²	f²_{ICS ⇒ EMADA} = 0.112; f²_{ICS ⇒ SGIE} = 0.025; f²_{EMADA ⇒ SGIE} = 0.099						

The results reported in **Table 6** of the PLS_{predict} study (Shmueli et al., 2019) showed that the linear model (LM) achieved a much lower root mean square error (RMSE) than the partial least squares structural equation modeling (PLS-SEM) for almost all items. In addition, when the cross-validated predictive ability test (CVPAT) outlined in the studies by Sharma et al. (2023) was applied, it was found that the LM had a lower average loss compared to the PLS-SEM. Alternatively, PLS-SEM may be more effective than the naive indicator average (IA) prediction benchmark for both PLS_{predict} and CVPAT. As a result, the model acquired a certain level of predictive capacities, enabling it to meet the IA criteria. However, it fell short of meeting the more cautious LM criterion.

Table 6. Predictive model assessment

Construct	Item	PLSpredict			CVPAT	
		Q ² _{predict}	RMSE PLS- SEM	LM RMSE	IA average loss difference (p value)	LM average loss difference (p value)
DA	DA1	0.072	1.071	1.081	-0.073 (0.000)	-0.035 (0.022)
	DA2		1.184	1.195		
	DA3		1.304	1.326		
PDA	PDA1	0.031	1.270	1.300	-0.040 (0.012)	-0.066 (0.000)
	PDA2		1.433	1.450		
	PDA3		1.257	1.286		
PSA	PSA1	0.061	1.117	1.128	-0.060 (0.000)	-0.023 (0.188)
	PSA2		1.157	1.165		
	PSA3		1.171	1.183		
PM	PM1	0.005	1.036	1.047	-0.004 (0.773)	-0.019 (0.180)
	PM2		0.942	0.953		
	PM3		1.021	1.028		
DRM	DRM1	0.007	1.147	1.157	-0.009 (0.592)	-0.012 (0.579)
	DRM2		1.261	1.270		
	DRM3		1.291	1.287		
GIE	GIE1	0.060	0.999	1.011	-0.042 (0.002)	-0.020 (0.114)
	GIE2		1.031	1.040		
	GIE3		1.192	1.203		
	GIE4		1.171	1.175		
Overall					-0.155 (0.000)	0.347 (0.000)

Theoretical implication. Consistent with the researchers' expectations, the analysis of the results highlighted the potential utility of ICS in improving the design and implementation of SGIE. This scholarly endeavor may, to the best of researchers' knowledge, be the initial to offer novel and substantial insights into the exceedingly distinct impacts of ICS on SGIE. Undoubtedly, the integration of a resilient internal control system can substantially bolster the strategic management, information exchange, and operational activities of an organization (Ma et al., 2022). Moreover, it mitigates the frequency of innovation selection failures resulting from agency-related concerns and protects well-established organizations from financial losses linked to innovation volatility.

As anticipated by the researchers, EMADA was emphasized to illustrate a partial mediating effect on the relationship between SGIE and ICS. Based on the researchers' knowledge, this is the initial academic inquiry that illuminates the novel and critical comprehension of the extraordinarily distinctive effects of EMADA on the interrelation between ICS and EMADA.

In addition to identifying opportunities for cost reduction, environmental management accounting aims to furnish management with sufficient information regarding the tangible environmental expenses associated with their organization's operations. Alternatives to traditional management accounting practices, which are criticized for incorporating environmental expenses into general overhead accounts and neglecting to monitor the actual environmental costs and benefits of an organization, are environmental management accounting practices (Gunarathne & Lee, 2015). Consequently, the implementation of environmental management accounting by organizations would enhance environmental performance and decision-making, thereby promoting sustainable development, and increase the transparency of their environmental costs (van der Poll, 2022). By capitalizing on the statistical properties and interrelationships that are intrinsic in various data sources and utilizing big data analytics to address operational and decision-making challenges, decision makers employ big data analytics to develop strategies that enhance organizational performance via innovation, competitiveness, and value generation (de Camargo Fiorini et al., 2018). Taken together, EMADA implementation would enable organization to achieve the sustainable development. To put it differently, PSOs have a greater chance of succeeding in the formulation and operation of SGIEs, when the ICS gains greater efficiency and efficacy during the EMADA implementation process.

Practical implication. Expanding upon the managerial perspectives, the findings from the current research yielded several valuable insights that can be implemented. Adapting the internal control environment to new technology must be a top priority. Second, to take EMADA's benefits into account, PSO accounting operations need to be digitalized to provide accurate and timely data. As a result, running the possible EMADA solutions simultaneously is highly advised. Among these resolutions are the following: the installation of infrastructure and technology to improve communication between industries; the distribution of sufficient funds and cutting-edge tools to revolutionize accounting procedures; and the promotion of greater participation of accounting personnel in the planning and creation of accounting information systems within the framework of digital transformations. A growing sense of unease should be addressed towards accounting staff continuing education programs and training that is connected to EMADA. Furthermore, these competences may be acquired by cooperative conversations with other ecosystem members. Last but not least, to make sure this type of organization can last, government agencies should provide rules about digitalization-related accounting processes and principles of internal control. There needs to be a stronger focus on resolutions that increase protections for data and information and bring more attention to the risks of careless actions, given that laws should control the release of digitalization tools to avoid their misuse and abuse.

5. Conclusion

The continuing academic effort in an immature area of study confronted some unavoidable restrictions, while highlighting notable results. This investigation was limited to a certain region of Vietnam, which was its main limitation. Due to its lack of external validity, this study should not be interpreted as drawing broad conclusions. Therefore, future research may compare and

contrast the current study's findings in a variety of national and cultural settings. The informants for this study were chosen using a combination of snowball sampling and a convenience approach due to time and budget constraints. These findings may be extrapolated to provide comprehensive solutions for management in future studies that use systematic sampling to get a large sample. The population from which the sample organizations were selected is another limitation that limits the research findings' applicability. To be more specific, declarative data was used for the analysis's deployment. The accountants' perspectives may have been influenced by their own biases, yet the poll results were nonetheless quite informative. Both the veracity of the informants' claims and their self-assurance in relaying the information were open questions. It is possible to address these concerns by conducting similar study with staff and departments from different organizations. Also, the parameters were no longer dynamic but inert because cross-sectional data analysis was used. The paradox of this research is that the interrelationships among the variables were malleable and open to change. These findings could serve as a foundation for more in-depth longitudinal investigations that could probe and provide more theoretical knowledge.

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References

- Adner, R. (2017). Ecosystem as structure: An actionable Construct for strategy. *Journal of Management*, 43(1), 39-58. doi: 10.1177/0149206316678451.
- Agyeiwaah, E. (2022). An Exploratory Sequential Mixed Methods Design: A Research Design for Small Tourism Enterprises in Ghana. In: Okumus, F., Rasoolimanesh, S.M. and Jahani, S. (Ed.) *Advanced Research Methods in Hospitality and Tourism*, Emerald Publishing Limited, Bingley, pp. 25-45.
- Almubaydeen, T.H., Shabayek, N.O.A.A., Al-Ramahi, N.M., alkabbji, R., Kanan, M. (2023). The Impact of the Characteristics of Accounting Information Systems on the Quality of Integrated Reports in the Industrial Companies Listed on the Amman Stock Exchange. In: Hannon, A., Mahmood, A. (eds) *Artificial Intelligence, Internet of Things, and Society 5.0. Studies in Computational Intelligence*, vol 1113 (pp. 533-544). Springer, Cham.
- Alraja, M.N., Imran, R., Khashab, B.M., & Shah, M. (2022). Technological Innovation, Sustainable Green Practices and SMEs Sustainable Performance in Times of Crisis (COVID-19 pandemic). *Information Systems Frontiers*, 24, 1081–1105. doi: 10.1007/s10796-022-10250-z.
- Asiaei, K., Bontis, N., Alizadeh, R., & Yaghoubi, M. (2021). Green intellectual capital and environmental management accounting: natural resource orchestration in favor of environmental performance. *Business Strategy and the Environment*, 31(1), 76-93. doi: 10.1002/bse.2875.
- Bresciani, S., Rehman, S.U., Giovando, G., & Alam, G.M. (2023). The role of environmental

management accounting and environmental knowledge management practices influence on environmental performance: mediated-moderated model. *Journal of Knowledge Management*, 27(4), 896-918. doi: 10.1108/JKM-12-2021-0953.

Bujang, M. A., Omar, E. D., & Baharum, N. A. (2018). A review on sample size determination for Cronbach's alpha test: A simple guide for researchers. *The Malaysian Journal of Medical Sciences: MJMS*, 25(6), 85–99. doi: 10.21315/mjms2018.25.6.9.

Chang, H. C., & Deegan, C. (2010). Exploring factors influencing environmental management accounting adoption at RMIT University. In *Sixth Asia Pacific Interdisciplinary Research in Accounting Conference (APIRA2010)* (pp. 1–39). Sydney

Chowdhury, E.K. (2023). Integration of Artificial Intelligence Technology in Management Accounting Information System: An Empirical Study. In: Abedin, M.Z., Hajek, P. (eds) *Novel Financial Applications of Machine Learning and Deep Learning. International Series in Operations Research & Management Science*, vol 336 (pp.35-46). Springer, Cham.

Creswell, J., & Creswell, J. D. (2018). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches* (5th ed.). Los Angeles, CA: Sage publications.

Cui, R., Wang, J., & Zhou, C. (2023). Exploring the linkages of green transformational leadership, organizational green learning, and radical green innovation. *Business Strategy and the Environment*, 32(1), 185-199, doi: 10.1002/bse.3124.

de Camargo Fiorini, P., Roman Pais Seles, B. M., Chiappetta Jabbour, C. J., Barberio Mariano, E., & de Sousa Jabbour, A. B. L. (2018). Management theory and big data literature: From a review to a research agenda. *International Journal of Information Management*, 43, 112–129. doi:10.1016/j.ijinfomgt.2018.07.005

De Vries, H., Tummers, L., & Bekkers, V. (2018). A stakeholder perspective on public sector innovation: why position matters. *International Review of Administrative Sciences*, 84(2), 269–287. doi: 10.1177/0020852317715513.

Demirel, P., & Kesidou, E. (2018). Sustainability-oriented capabilities for eco-innovation: Meeting the regulatory, technology and market demands. *Business Strategy and the Environment*, 28(5), 847–857. doi: 10.1002/bse.2286.

Donaldson, L. (2001). *The Contingency Theory of Organizations*. New York: Sage Publications, Inc.

Edler, J., & Yeow, J. (2016). Connecting demand and supply: The role of intermediation in public procurement of innovation. *Research Policy*, 45(2), 414–426. doi:10.1016/j.respol.2015.10.010.

Effendi, M. I., Sugandini, D., & Istanto, Y. (2020). Social Media Adoption in SMEs Impacted by COVID-19: The TOE Model*. *Journal of Asian Finance, Economics and Business*, 7(11), 915–925. doi: 10.13106/jafeb.2020.vol7.no11.915

El-Haddadeh, R. (2020). Digital innovation dynamics influence on organisational adoption:

The case of cloud computing services. *Information Systems Frontiers*, 22(4), 985–999. doi: 10.1007/s10796-019-09912-2

Erauskin-Tolosa, A., Zubeltzu-Jaka, E., Heras-Saizarbitoria, I., & Boiral, O. (2020). ISO 14001, EMAS and environmental performance: a meta-analysis. *Business Strategy and the Environment*, 29(3), 1145–1159. doi: 10.1002/bse.2422.

Fan, X., Shan, X., Day, S., & Shou, Y. (2022). Toward green innovation ecosystems: past research on green innovation and future opportunities from an ecosystem perspective. *Industrial Management & Data Systems*, 122(9), 2012–2044. doi: 10.1108/IMDS-12-2021-0798.

Farida, I., Mulyani, S., Akbar, B., & Setyaningsih, S.D. (2021). Implementation and Performance of Accounting Information Systems, Internal Control and Organizational Culture in the Quality of Financial Information. *Utopía y Praxis Latinoamericana*, 26(1), 222–236.

Fernando, Y., & Wah, W. X. (2017). The impact of eco-innovation drivers on environmental performance: Empirical results from the green technology sector in Malaysia. *Sustainable Production and Consumption*, 12, 27–43. doi: 10.1016/J.SPC.2017.05.002.

Fornell, C., & Larcker, D. F. (1981). Evaluating Structural Equation Models with Unobservable Variables and Measurement Error. *Journal of Marketing Research*, 18(1), 39–50. doi:10.1177/002224378101800104.

Gunarathne, N., & Lee, K.-H. (2021). The link between corporate energy management and environmental strategy implementation: Efficiency, sufficiency and consistency strategy perspectives. *Journal of Cleaner Production*, 293, 1–21. doi:10.1016/j.jclepro.2021.126082.

Gunarathne, N., & Lee, K.-H. (2015). Environmental management accounting (EMA) for environmental management and organizational change. *Journal of Accounting & Organizational Change*, 11(3), 362–383. doi: 10.1108/JAOC-10-2013-0078.

Gupta, A. K. (2021). Innovation dimensions and firm performance synergy in the emerging market: A perspective from Dynamic Capability Theory & Signaling Theory. *Technology in Society*, 64, 1–14. doi: 10.1016/j.techsoc.2020.101512.

Hair, J.F., Hult, G.T.M., Ringle, C.M., & Sarstedt, M. (2022). *A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM)* (3rd ed.). Thousand Oaks, CA: Sage.

Henseler, J., Ringle, C. M., & Sarstedt, M. (2015). A new criterion for assessing discriminant validity in variance-based structural equation modeling. *Journal of the Academy of Marketing Science*, 43(1), 115–135. doi:10.1007/s11747-014-0403-8.

Iroegbu, A. O. C., Sadiku, R. E., Ray, S. S., & Hamam, Y. (2020). Plastics in municipal drinking water and wastewater treatment plant effluents: challenges and opportunities for South Africa—a review. *Environmental Science and Pollution Research*, 27, 12953–12966. doi:10.1007/s11356-020-08194-5.

Kock, N. (2015). Common Method Bias in PLS-SEM. *International Journal of e-*

Collaboration, 11(4), 1–10. doi:10.4018/ijec.2015100101.

Laudon, K. C., & Laudon, J. P. (2012). *Management Information Systems Managing in the Digital Firm* (12th ed.). London: Pearson Prentice Hall.

Li, Y., & Shi, Y. (2022). Dynamic game analysis of enterprise green technology innovation ecosystem under double environmental regulation. *International Journal of Environmental Research and Public Health*, 19(17), 1-33. doi: 10.3390/ijerph191711047.

Liao, Z. (2018). Institutional pressure, knowledge acquisition and a firm's environmental innovation. *Business Strategy and the Environment*, 27, 849–857. doi: 10.1002/bse.2036.

Ma, X., Ock, Y.-S., Wu, F., & Zhang, Z. (2022). The Effect of Internal Control on Green Innovation: Corporate Environmental Investment as a Mediator. *Sustainability*, 14(3), 1-19. doi: 10.3390/su14031755.

Michelon, G., Bozzolan, S., & Beretta, S. (2015). Board monitoring and internal control system disclosure in different regulatory environments. *Journal of Applied Accounting Research*, 16(1), 138-164. doi: 10.1108/JAAR-03-2012-0018.

Moore, J. F. (1993). Predator and prey: A new ecology of competition?. *Harvard Business Review*, 71(3), 75-83.

Mukwarami, S., & van der Poll, H.M. (2024). Critical environmental management accounting practices influencing service delivery of growing cities in a developing economy: a review and conceptual framework. *Environment Systems and Decisions*, 1-30. doi: 10.1007/s10669-023-09960-9.

Nkundabanyanga, S.K., Muramuzi, B., & Alinda, K. (2021). Environmental management accounting, board role performance, company characteristics and environmental performance disclosure. *Journal of Accounting & Organizational Change*, 17(5), 633-659. doi: 10.1108/JAOC-03-2020-0035.

Nohria, N., & Khurana, R. (2010). *Handbook of Leadership Theory and Practice*. Boston: Harvard Business School Press.

Nyakuwanika, M., van der Poll, H.M., & van der Poll, J.A. (2021). A Conceptual Framework for Greener Goldmining through Environmental Management Accounting Practices (EMAPs): The Case of Zimbabwe. *Sustainability*, 13(18), 1-26. doi: 10.3390/su131810466.

Ojo, T. O., & Baiyegunhi, L. J. S. (2021). Climate change perception and its impact on net farm income of smallholder rice farmers in South-West, Nigeria. *Journal of Cleaner Production*, 310, 1-10. doi:10.1016/j.jclepro.2021.127373.

Oliveira-Duarte, L., Aparecida Reis, D., Fleury, A. L., Aparecida Vasques, R., Fonseca Filho, H., Koria, M., & Baruque-Ramos, J. (2021). Innovation ecosystem framework directed to sustainable development goal #17 partnerships implementation. *Sustainable Development*, 29(5), 1018–1036. doi: 10.1002/sd.2191.

- Otley, D. T. (1980). The contingency theory of management accounting: Achievements and prognosis. *Accounting, Organisations and Society*, 5(4), 413–428. doi: 10.1016/0361-3682(80)90040-9.
- Phan, T. N., Baird, K., & Su, S. (2017). The use and effectiveness of environmental management accounting. *Australasian Journal of Environmental Management*, 24(4), 355–374. doi: 10.1080/14486563.2017.1354235.
- Qian, W., Hörisch, J., & Schaltegger, S. (2018). Environmental management accounting and its effects on carbon management and disclosure quality. *Journal of Cleaner Production*, 174, 1608–1619. doi:10.1016/j.jclepro.2017.11.092.
- Rosa, F. S., Compagnucci, L., Lunkes, R. J., & Monteiro, J. J. (2023). Green innovation ecosystem and water performance in the food service industry: The effects of environmental management controls and digitalization. *Business strategy and the environment*, 32(8), 5459–5476. doi: 10.1002/bse.3430.
- Sari, N., Ghozali, I., & Achmad, T. (2017). The effect of internal audit and internal control system on public accountability: The empirical study in Indonesia state universities. *Technology*, 8(9), 157–166.
- Sauser, B. J., Reilly, R. R., & Shenhar, A. J. (2009). Why projects fail? How contingency theory can provide new insights – A comparative analysis of NASA's Mars Climate Orbiter loss. *International Journal of Project Management*, 27(7), 665–679. doi:10.1016/j.ijproman.2009.01.004.
- Schaeffer, M. S. (2014). *Internal Controls in Accounts Payable*. United State of America, US: Crystallus, Inc.
- Schaltegger, S. (2018). Linking Environmental Management Accounting: A Reflection on (Missing) Links to Sustainability and Planetary Boundaries. *Social and Environmental Accountability Journal*, 38(1), 19–29. doi:10.1080/0969160x.2017.1395351
- Sharma, P.N., Liengard, B.D., Hair, J.F., Sarstedt, M., & Ringle, C.M. (2023). Predictive model assessment and selection in composite-based modeling using PLS-SEM: extensions and guidelines for using CVPAT. *European Journal of Marketing*, 57(6), 1662–1677. doi: 10.1108/EJM-08-2020-0636.
- Shmueli, G., Sarstedt, M., Hair, J.F., Cheah, J.-H., Ting, H., Vaithilingam, S., & Ringle, C.M. (2019). Predictive model assessment in PLS-SEM: guidelines for using PLSpredict. *European Journal of Marketing*, 53(11), 2322–2347. doi: 10.1108/EJM-02-2019-0189.
- Somlai, R. (2022). Integrating decision support tools into businesses for sustainable development: A paradoxical approach to address the food waste challenge. *Business Strategy and the Environment*, 31(4), 1607–1622. doi: 10.1002/bse.2972.
- Tanbour, K.M., Nour, A.I. (2024). The Impact of Internal Auditing Activity on the Effectiveness of Digital Risk Management in Banks Registered on the Palestine Exchange. In: Khoury, R.E.,

Nasrallah, N. (eds) *Intelligent Systems, Business, and Innovation Research. Studies in Systems, Decision and Control*, vol 489 (pp.17-32). Springer, Cham.

Vasilev, V. L., Bakhvalov, S. I., Prikhod'ko, A. N., & Kazakov, A. V. (2017). Internal control in the system of innovation management in the modern business environment. *International Journal of Economic Research*, 14, 409-416.

Wang, K.-H., Umar, M., Akram, R., & Caglar, E. (2021). Is technological innovation making world “Greener”? An evidence from changing growth story of China. *Technological Forecasting and Social Change*, 165, 1-7. doi: 10.1016/j.techfore.2020.120516.

Xiwen, L., Xub, D., and Shiyu, S. (2021). Research on the Internal Control Problems Faced by the Financial Sharing Center in the Digital Economy Era—An example of Financial Sharing Center of H Co. Ltd. International Conference on Identification, Information and Knowledge in the internet of thing 2020. *Procedia Computer Science*, 187, 158–163. doi: 10.1016/j.procs.2021.04.047.

Yi, H., & Zhang, Q. (2022). Knowledge-sharing strategies of university-industry alliances promoting green technology innovation in ecosystems: Based on the utility of multichannel funding. *IEEE Access*, 10, 65728–65743. doi: 10.1109/ACCESS.2022.3184422.

Yu, X., Qi, Y., Yu, L., & He, Y. (2022). Temporal and spatial evolution of coupling coordination degree of industrial innovation ecosystem—From the perspective of green transformation. *Sustainability*, 14(7), 1-18. doi: 10.3390/su14074111.

Zeng, J., Chen, X., Liu, Y., Cui, R., & Zhao, P. (2022). How does the enterprise green innovation ecosystem collaborative evolve? Evidence from China. *Journal of Cleaner Production*, 375, 1-14. doi: 10.1016/j.jclepro.2022.134181.

Zhou, Z., Zhao, W., Chen, X., & Zeng, H. (2017). MFCA extension from a circular economy perspective: Model modifications and case study. *Journal of Cleaner Production*, 149, 110–125. doi:10.1016/j.jclepro.2017.02.049.

Zybery, I., & Rova, L. (2014). The role of the accountants in the framework of the modern technological developments and digital accounting systems. *European Scientific Journal*, 24, 30-48. doi: 10.19044/esj.2011.v24n0p%25p.

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