INSIGHT INTO TECHNOLOGICALLY VIGILANT LEADERSHIP: SMART SUSTAINABLE CIRCULAR SUPPLY CHAIN MANAGEMENT IN THE ECONOMIC CONTEXT OF INDUSTRY 6.0

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Abstract

The emergence of Industry 6.0 presents both opportunities and problems for environmental sustainability. Emerging technologies, like artificial intelligence (AI), the Internet of Things (IoT), and blockchain, can improve energy efficiency, maximize resource utilization, and decrease consumption. Conversely, the energy-intensive characteristics of these technologies may result in elevated electricity consumption and increased carbon dioxide emissions if not handled responsibly. In this context, the senior leadership of the relevant organizations plays a pivotal role in facilitating the removal of adoption barriers during the early phase of migration to new technologies. This study proposes a model grounded in resource-based theory and stakeholder theory that examines the relationship between technologically vigilant leadership (TVL) and smart sustainable circular supply chain management (SSCSCM) within the context of Industry 6.0, mediated by the effectiveness of the management accounting information system (EMAIS). This study further delves into the moderating influence of inclusive green growth policy (IGGP) on these relationships. This study assessed the suggested model by partial least squares structural equation modeling to examine the statistical data obtained from a convenience and snowball sample of accountants in small and medium enterprises. The empirical findings indicated a positive correlation between TVL and SSCSCM. This relationship was partially mediated by EMAIS. IGGP positively moderated the connections among TVL, SSCSCM, and EMAIS. These significant insights would assist policymakers in formulating enhanced TVL mechanisms to capitalize on the benefits of EMAIS and therefore fortify SSCSCM.

Keywords: Circular Economy, Environmental Management Accounting, Industry 6.0, Smart Supply Chain, Vigilant Leadership

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1. INTRODUCTION

Sustainability has become a prominent issue in politics, industry, and science over the past two decades (Karuppiah et al., 2024). The global manufacturing sector is confronted with an unprecedented challenge: reconciling economic growth with urgent environmental and societal needs (Alam et al., 2025). Traditional linear production models, which are defined by a "take–make–dispose" approach (Dinda, 2020), are no longer viable in the face of increasing resource depletion (H. Liu, Alharth, et al., 2022), increasing refuse generation (Mihai & Minea, 2021), and the effects of climate change (Yang et al., 2023). In particular, the integration of sustainability-related topics into supply chain management has become a high–volume and swiftly expanding research area (Amir et al., 2023). The circular economy, which replaces linear resource flows with restorative cycles (Morseletto, 2020), has been catalyzed by the necessity to transition to more sustainable systems (Cagno et al., 2021). Green supply chains, closed-loop supply chains, reverse supply chains, sustainable supply chains, and, most recently, circular supply chains, have all been the consequence of this evolution (Jain et al., 2025). The latter addresses concerns such as recycling, reuse, and the zero-waste ideal by integrating circular thinking, which is founded on the circular economy framework, into supply chain management (Carissimi et al., 2023). Circular supply chain management (Hazen et al., 2020) is, in particular, central to the circular economy. This approach strategically integrates practices such as circular product design (Burke et al., 2021), circular procurement (Qazi & Appolloni, 2022), cleaner production, and end-of-life management (Lahane et al., 2020).

Sufficient technological integration and support, such as Industry 6.0, are necessary for the circular supply chain to reach its maximum potential, in addition to scientific and technical advancements. This symbiotic relationship enables organizations to optimize resource use, minimize waste, and improve material recovery and reuse throughout the product lifecycle. Industry 6.0 is a paradigm that, according to scholars, encompasses a considerably broader perspective than any of the previous industrial revolutions (Chourasia et al., 2022). Madsen et al. (2025) anticipate that Industry 6.0 will incorporate new levels of innovation and build upon the digital infrastructure of Industry 4.0 and the human-centric enhancements of Industry 5.0. It is important to note that Industry 5.0 continues to depict humans and robots coexisting on the shop floor. However, Industry 6.0 anticipates a phase in which cognitive machines autonomously manage numerous processes, with humans providing strategic guidance (directly or indirectly through cognitive interfaces) rather than hands–on control (Madsen et al., 2025). In this study, smart sustainable circular supply chain management (SSCSCM) denotes the integration of circular economy principles and Industry 6.0 technologies inside supply chain management.

In order to achieve this, the organizational structure must undergo a significant transformation, and the management must be prepared for a fundamental paradigm shift (Abu Afifa & Nguyen, 2023). The management accounting system is a critical component of organizational strategy, as it provides managers with information that is essential for the translation of anticipated behaviors and outcomes. Organizations employ the management accounting system to enhance system quality and organizational performance by leveraging all available resources, both within and outside of their business environment (Abu Afifa & Saleh, 2022). Unfortunately, although emerging technologies, like artificial intelligence (AI), the Internet of Things (IoT), and blockchain, can improve energy efficiency, maximize resource utilization, and decrease consumption (Nyiwul & Koirala, 2024), the energy-intensive characteristics of these technologies may result in elevated electricity consumption and increased carbon dioxide emissions if not handled responsibly (Vu, 2025). In this regard, it is crucial for organizations to change their leadership styles to those that are equipped with a specific set of skills and expertise to meet the demands of the digital business environment. This leadership transformation will enable the firms to establish a thriving digital environment and acquire a competitive edge. Leaders are instrumental in the establishment of a digital work environment by eliminating obsolete structures and implementing new business models. Gao et al. (2024) define "vigilant leadership" as the actions of a leader that are intended to motivate individuals to focus on potential obstacles and to respond to unforeseen setbacks. Technologically vigilant leadership (TVL) in this research can be interpreted as a leadership style that prioritizes proactive awareness and responsiveness to technological changes and threats, building upon the suggestion of Gao et al. (2024).

More importantly, there is an ongoing debate over the efficacy of government innovation policies in relation to digital transformation and sustainable transformation. Inclusive green growth is a long-term development approach that emphasizes economic advancement, social equity, human welfare, and energy efficiency (Wu et al., 2024). Inclusive green growth policy (IGGP) denotes tactics and actions that foster economic expansion while guaranteeing environmental sustainability and social inclusion. IGGP assists small and medium-sized enterprises (SMEs) in initiating, expanding, and evolving by directly offering capacity-building management support and indirectly enhancing the economic, regulatory, and institutional framework to better accommodate SME requirements. This will facilitate the green growth of SMEs, promoting their expansion. Government policies are widely recognized for enhancing transformation performance. Not all businesses benefit from adopting digital technologies; only those with advanced digital capabilities — specifically, the proficiency to effectively leverage digitally pertinent infrastructure, resources, and platforms to attain entrepreneurial objectives — can realize these advantages (Heredia et al., 2022). Companies must consistently allocate resources to operations management and finance (Huikkola et al., 2022) and pursue governmental support to enhance their digital capabilities (Warner & Wäger, 2019). Nevertheless, the extent of impact and the fundamental mechanisms by which the government enhances company capacity, sustainable transformation, and digital transitions remain little explored. The integration of leadership's function in digital transformation and sustainable transformation is inadequately addressed in the literature, especially within small and medium-sized firms in

developing nations. The concept of vigilant leadership is not novel; nonetheless, TVL remains inadequately incorporated into literature and is still in its infancy. Investigating these pathways represents an urgent gap that necessitates resolution. Therefore, the current research aims to bridge these research gaps by tackling the research questions as follows.

RQ1: What is the effect of TVL on SSCSCM?

RQ2: Does the effectiveness of the management accounting information system (EMAIS) act as a mediator in the relationship between TVL and SSCSCM?

RQ3: Does IGGP act as a moderator in the relationships between TVL, EMAIS, and SSCSCM?

Numerous contributions are offered for both the academic literature and the practical understanding of these topics. Concerning theoretical significance, this study seeks to examine the impacts of TVL on SSCSCM inside SMEs, a relatively underexplored area that serves as the central research challenge of this work. By analyzing the direct and indirect correlations between TVL and SSCSCM, we offer a conceptual and quantitative explanation of how SMEs in emerging economies can rely on both TVL and management accounting information system, which subsequently facilitate the attainment of SSCSCM. For decades, leadership has been a cognitive construct that has been essential to the field of management sciences. It has undergone continuous development, successive modifications, and adaptations to the changing conditions of business operations and organizational transformations (Organa et al., 2024). Leadership is a critical component of the current economic environment (Organa & Sus, 2023). This study offers a pioneering contribution by quantitatively analyzing the mediating role of EMAIS in the relationship between TVL and SSCSCM, thus enhancing the developing, albeit still incipient, body of literature at the convergence of management accounting and the circular economy (Aureli et al., 2025).

Research on the influence of management accounting information systems and their role in achieving the Sustainable Development Goals (SDGs) has just lately started to appear in accounting literature. The majority of current studies are generally theoretical (Larrinaga & Garcia-Torea, 2022), and the scant study on the role of accounting in the circular economy mostly comprises literature reviews (Di Vaio et al., 2023). This study emphasizes IGGP's significant moderating function in the correlations between TVL, EMAIS, and SSCSCM. Inclusive green growth is considered a critical approach to achieving sustainable growth, which is a prerequisite for high-quality development (Xu et al., 2024). This establishes a foundation for future research on IGGP amid the current digital and sustainable transformations. Regarding practical significance, a comprehensive examination of the outcomes would assist practitioners by elucidating methods to identify and capitalize on growth opportunities facilitated by digital technology. Moreover, government officials and key policymakers are urged to emphasize innovation and cultivate an effective environment that facilitates the implementation of new technologies and processes via IGGP.

The rest of this research is structured as follows. Section 2 provides the conceptual framework and theoretical foundations, as well as the development of hypotheses. Section 3 describes the research methodology used. Section 4 presents and discusses the research outcomes and implications. Section 5 addresses the limitations of the research and offers suggestions for future studies.

2. LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

2.1. Theoretical underpinning

Resource-based view emphasizes the management of resources to improve performance, whereas stakeholder theory underscores the influence of industry norms on organizational practices. The resource-based view and stakeholder theory align in multiple respects, indicating robust connections between the two. Stakeholder theory can enhance the resource-based view through diverse concepts, such as collaboration, sustainability, or human resources (Freeman et al., 2021). As asserted by Luthra et al. (2022), the resource-based view highlights that an organization's competitive advantage relies on its essential resources and capabilities, while stakeholder theory elucidates that stakeholder integration can lead to innovative business models, enabling the attainment of sustainable objectives through the amplification of substantial resources. These principles indicate that an organization's performance is contingent upon its relationships with relevant stakeholders (Luthra et al., 2022). Through integration into an organization's economic model, stakeholders may become a fundamental component of the organization's resources, encompassing production and patronage. Furthermore, although individuals do not represent resources, they are stakeholders contributing resources (Freeman et al., 2021). These concepts are pertinent to the adoption of Industry 6.0, wherein organizations significantly rely on their leadership; employees' competencies for the development or implementation of digital technologies.

The resource-based view enhances the understanding of how a firm's intangible and tangible resources contribute to attaining and sustaining competitive advantage (Zahra, 2021). Resources are defined as factors considered as a firm's strengths or weaknesses, encompassing experienced staff, efficient procedures, brand names, or internal technology expertise (Wernerfelt, 1984). The resource-based view emphasizes the strategic importance of enterprises using their valuable, rare, imperfectly imitable, and non-substitutable resources to achieve and maintain competitive advantage. L. Liu et al. (2023) underscored the importance of digital platform skills in augmenting enterprises' capacity to procure both internal and external resources by optimizing the potential of digital technologies. In both instances, by utilizing existing or cultivating internal resources and enhancing them with new technologies, companies can generate significant assets that bolster their competitiveness.

Stakeholder theory, grounded in socio-political accounting, underscores the necessity of considering social, environmental, institutional, and political contexts to understand the economic aspects of organizations (Deegan & Blomquist, 2006). Nearly four decades ago, Freeman (1984) defined

a stakeholder as any individual or group that can influence or be influenced by an organization's attainment of its objectives. This conceptualization serves as a cornerstone in the evolution of stakeholder theory, which centers on an organization's management of its interactions with important stakeholders, including employees, consumers, communities, suppliers, and financiers (Freeman & Phillips, 2002). This study corresponds with the viewpoint of stakeholder theory, which asserts that companies cater to stakeholder requirements for strategic advantage (Raimo et al., 2023). Many scholars have examined the role of stakeholders on supply chain sustainability as well as contact with stakeholders, to increase sustainability performance (Gimenez & Tachizawa, 2012).

2.2. Conceptual respects

2.2.1. Smart sustainable circular supply chain management

The capability of a circular economy emphasizes the incorporation of techniques that support the "3-R" principles: recycle, reduce, and reuse (Matarneh et al., 2024). In conjunction with the circular economy, Industry 6.0 has recently acquired prominence as a method to deliver sustainable outcomes and minimize human-machine contact, facilitating the implementation of sustainability measures. Industry 6.0 signifies a new era, marked by the convergence of technologies including artificial intelligence, the internet of things, blockchain, and quantum computing (Kaur et al., 2024). Industry 6.0 technologies can implement the "smart concept", possessing significant potential to enhance circular economy principles. A smart sustainable circular supply network is engineered for flexibility and adaptability, effectively addressing supply chain issues and disturbances. Supply chains must evolve to align with the current industrial revolution, termed Industry 6.0 and the circular economy, to maintain competitiveness, respond proactively, and enhance sustainable resource management capabilities, thereby yielding environmental, social, and economic benefits. The integration of Industry 6.0 and the circular economy into the supply chain may facilitate the attainment of SDGs. Industry 6.0 technologies introduce the "smart concept", facilitating the creation of a flexible and versatile smart sustainable circular supply chain that enhances responsiveness, transparency, and sustainable collaboration. In this study, SSCSCM denotes the integration of circular economy principles and Industry 6.0 technologies inside supply chain management. In this context, the four SSCSCM practices are circular product design, circular procurement, cleaner production, and end-of-life product and waste management.

2.2.2. Technologically vigilant leadership

Leadership, as a cognitive construct, has been integral to management sciences for decades, undergoing ongoing development, successive modifications, and adaptations to the evolving conditions of business operations and organizational transformations (Organa et al., 2024). Leadership is an essential aspect in the contemporary economic landscape (Organa & Sus, 2023). It entails the process of making pivotal decisions and fostering requisite motivation among the organization's personnel. The Latin origin of "vigilance" is "*vigilia*", indicating two interconnected facets: wakefulness and watchfulness (Lewis & Short, 2002). The notion of vigilance was introduced into business research by Day and Schoemaker (2004, 2009). Based on the standpoint of Gao et al. (2024), "vigilant leadership" as leader actions aimed at encouraging people to concentrate on prospective obstacles and to react to unforeseen setbacks. Extending on the recommendation of Gao et al. (2024), TVL in this research can be understood as a leadership style that emphasizes proactive awareness and responsiveness to technological changes and threats.

2.2.3. Effectiveness of the management accounting information system

Management accounting information systems are equivalent to general information systems (Kaplan, 1984). The management accounting information system is defined as a crucial component of an organizational structure, meant to govern, motivate, assess performance, and convey the organization's goals to facilitate information participation and feedback (Jones, 1985). Management accounting systems have significantly evolved to accommodate new technical and environmental conditions (Chenhall & Moers, 2015) and have become the increasingly essential tools for facilitating managers' decision-making processes (Soobaroyen & Poorundersing, 2008). The management accounting information system experienced numerous modifications in the last decade of the 20th century due to significant technological advancements, compelling most businesses to innovate their accounting systems to acquire high-quality and timely accounting information (Saleh & Al–Nimer, 2022). Technology can affect the characteristics of management accounting systems (scope, timeliness, integration, and aggregation) within an organization to align with evolving business operations (Ghasemi et al., 2019). The effectiveness of a management accounting information system is described as the degree to which the system aids in attaining organizational objectives by delivering high–quality information that helps managerial decision–making and elevates business performance. The EMAIS can only be realized if each characteristic of the system (scope, timeliness, integration, and aggregation) attains effectiveness.

2.2.4. Inclusive green growth policy

Inclusive green growth integrates ecological conservation, social fairness, and sustainable development, serving as a crucial mechanism for advancing eco-civilization construction and sustainability (Zhang et al., 2022). Government policies are crucial in accelerating the promotion of green growth and achieving SDGs. According to Nakku et al. (2020), government assistance programs are designed to assist SMEs in surmounting financial and non-financial obstacles to enhance performance. IGGP denote tactics and actions that foster economic expansion while guaranteeing environmental sustainability and social inclusion. IGGP assists SMEs in initiating, expanding, and evolving by directly

offering capacity-building management support and indirectly enhancing the economic, regulatory, and institutional framework to better accommodate SME requirements. This will facilitate the green growth of SMEs, promoting their expansion.

2.3. Hypotheses development

Industry 6.0 prioritizes renewable energy, machine autonomy, interplanetary resource exploitation, aerial platforms, biological upgrades, and quantum regulation, offering substantial advancements and novel prospects (Das & Pan, 2022). The integration of Industry 6.0 and the circular economy within the supply chain may facilitate the attainment of SDGs. The emergence of Industry 6.0 presents both opportunities and problems for environmental sustainability. Emerging technologies, like artificial intelligence, the Internet of Things, and blockchain, can improve energy efficiency, maximize resource utilization, and decrease consumption (Nyiwul & Koirala, 2024). Conversely, the energy-intensive characteristics of these technologies may result in elevated electricity consumption and increased carbon dioxide emissions if not handled responsibly (Vu, 2025). In this context, the senior leadership of the relevant organizations plays a pivotal role in facilitating the removal of adoption barriers during the early phase of migration to new technologies (Mora Cortez & Johnston, 2018; Asif et al., 2020). Leaders exhibit a robust dedication to vigilance by continually observing technological developments and prospective risks. Technologically vigilant leaders are change-driven, emphasizing the promotion of transformation through the articulation of a persuasive future vision and demonstrating readiness to act swiftly when necessary. The first hypothesis in the current research is conjectured as follows.

H1: TVL directly and positively impacts SSCSCM.

A management accounting system is a valuable asset for the efficient operation of an organization (Campos et al., 2023). To better plan, monitor, and control the various organizational activities, optimize the use of resources, support decision-making, and evaluate performance, management accounting systems could gather, process, and analyze non-accounting, financial, and operational accounting data, both internal and external. Presently, the ongoing technological advancement has resulted in an increasing number of studies emphasizing the integration of accounting systems with technological innovations that facilitate the transition of financial accounting into management accounting (R. Liu, Wang, et al., 2022). The management accounting information system is essential for assessing risk, reducing uncertainty in managerial decision-making, and aiding in risk management activities (Abu Afifa & Saleh, 2022). TVL employs accounting data to convey expectations, empowering people to determine their own methods of execution. Moreover, supervisors with a technologically vigilant style will employ accounting information in their engagements with subordinates to create and manage systems; they often advocate for and delegate decision-making responsibilities to their subordinates. The hypothesis in the current research is conjectured as follows.

H2: TVL directly and positively impacts EMAIS.

SSCSCM is a sophisticated methodology that amalgamates smart technology, sustainability tenets, and circular economy principles within supply chain management to foster more sustainable, efficient, and resilient supply networks. Based on the perspectives of Pieroni et al. (2019), companies must evolve from generating solely economic value to a comprehensive model of value proposition; engaging with a single actor to multiple stakeholders; and shifting from a firm-centric to a network-centric or ecosystem operational framework. Accordingly, implementing these modifications necessitates a robust management accounting system that facilitates managers' embrace of a sustainable circular business model (Elgie et al., 2021). The research conducted by Ahmad and Al-Shbiel (2019) demonstrated that a management accounting information system is essential for improving organizational performance. Businesses employ management accounting information systems as a framework to improve the collection, storage, and management of their financial data by providing managers with up-to-date information on internal operations (Muskat et al., 2021). Thus, a management accounting information system is a component of a system intended for the measurement and collection of financial and operational data, which aims to guide motivational behaviors and administrative actions to fulfill the organization's strategic objectives by enhancing and cultivating cultural values. Management accounting solutions are essential for promoting smart, sustainable, and circular supply chain management by delivering vital information, facilitating decision-making, and improving collaboration and performance throughout the supply chain. Admittedly, the amalgamation of management accounting information system with sophisticated technology enhances these advantages, rendering supply chains more efficient, transparent, and sustainable. The hypothesis in the current research is conjectured as follows.

H3: EMAIS directly and positively impacts SSCSCM.

SSCSCM is not merely an option, but a strategic necessity in the current highly competitive company environment. Improving productivity and efficiency is essential, and SSCSCM addresses this requirement through the utilization of advanced technology and automation. SSCSCM enhances efficiency by eliminating bottlenecks, reducing manual errors, and optimizing resource allocation. Strategic decision-making involves acquiring and analyzing relevant data, identifying key opportunities, evaluating potential risks, and ultimately determining the most effective approaches to attain future objectives (Alahmed et al., 2024). A crucial element of this rapid environment is real-time decision-making, and SSCSCM provides the essential capabilities through its real-time data analytics and insights, allowing enterprises to respond swiftly and decisively, thereby gaining a competitive advantage. Effective strategic decision–making necessitates meticulous evaluation of resources, capabilities, market trends, competitive dynamics, and other variables that could affect outcomes, alongside a comprehensive understanding of internal and external factors influencing the organization's capacity to attain its objectives (Ibeh et al., 2024; Alkhaldi et al., 2024). Leaders must utilize comprehensive and prompt information from management accounting systems to mitigate the risk of failures (Abu Afifa & Nguyen, 2023). Vigilant leadership is an influential technique that directs followers' focus towards prospective hazards and motivates them to adopt

preventive measures to mitigate those threats (Gao et al., 2024). A technologically vigilant leader is an essential figure inside an organization, possessing the knowledge, abilities, and experience to adeptly utilize digital technology to foster innovation, improve processes, and attain strategic objectives. The hypothesis in the current research is conjectured as follows.

H4: TVL indirectly and positively impacts SSCSCM through EMAIS.

Inclusive green growth is a sustainable development strategy that seeks to harmonize economic expansion, ecological integrity, and social equity, thereby addressing issues of environmental degradation and uneven economic development during industrialization (Qian & Ji, 2022). Inclusive green growth promotes economic advancement, social fairness, and sustainable production, closely aligning with the contemporary development philosophy characterized by innovation, coordination, sustainability, openness, and shared benefits (Zhang et al., 2022). Prior studies on governmental assistance have demonstrated its potential to yield various beneficial results at the organizational level, encompassing performance, globalization, innovation, entrepreneurial orientation, and capability enhancement (Buffart et al., 2020; Yi et al., 2021). IGGP seeks to reconcile economic development with the conservation of natural resources, the mitigation of climate change, and the advancement of environmental stewardship. Simultaneously, IGGP endeavors to guarantee that the advantages of growth are distributed equally among various socioeconomic groups, particularly marginalized communities. The government exerts significant influence on a firm's innovativeness by implementing laws and initiatives that promote the adoption of innovative projects. Governments can foster innovation through the provision of subsidies (Xia et al., 2022; Xinle et al., 2022). Policy support denotes the regulations and statutes that substantially facilitate the adoption of novel technology and innovative concepts. When support is plentiful, adoption generally occurs swiftly (Wong et al., 2020). The hypotheses in the current research are conjectured as follows.

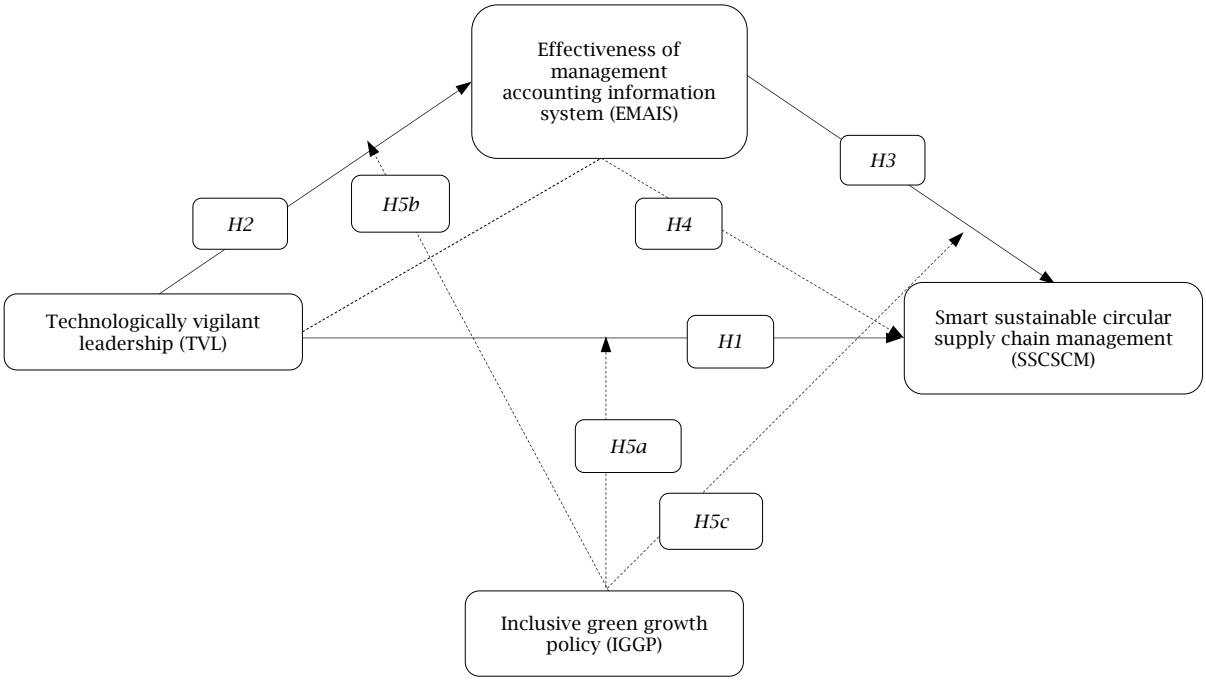
H5a: IGGP moderates the relationship between TVL and SSCSCM.

H5b: IGGP moderates the relationship between TVL and EMAIS.

H5c: IGGP moderates the relationship between EMAIS and SSCSCM.

All the aforementioned hypotheses and variables are illustrated in Figure 1:

Figure 1. Research model and hypotheses



Source: Authors' elaboration.

3. RESEARCH METHODOLOGY

3.1. Measurement scale development

A cross-sectional design was employed, and a structured questionnaire was created to systematically assess how TVL promotes SSCSCM within the context of Industry 6.0. This study employed established and verified measures from prior research, utilizing five-point Likert scales from 1 (strongly disagree) to 5 (strongly agree). The measurement items were first translated into Vietnamese and then translated back into English by two proficient translators. Both versions were examined for discrepancies during the translation process to guarantee conceptual comparability with the original English sources (Paulraj et al., 2017). Five academic experts and three industry professionals were interviewed to execute content analysis. Following the implementation of modifications based on expert recommendations, we commenced a preliminary testing phase with 15 managers who acted as both evaluators and participants. We adjusted and enhanced the survey to produce the definitive version based on their feedbacks.

Measures for TVL were adapted from Gao et al. (2024). Measures for IGGP were adapted from Heshmati et al. (2019), Dufrénot (2023), and Zhang et al. (2022). Measures for EMAIS, which comprised of broad scope, timeliness, aggregation, and integration, were adapted from Soobaroyen and Poorundersing (2008), Zaleha Abdul Rasid et al. (2014), and Mazi and Ebere (2019). Measures for SSCSCM, which comprised circular product design, circular procurement, cleaner production, end-of-life product and waste management. More concretely, measures for circular product design were adapted from Zhu et al. (2011), den Hollander et al. (2017), Kayikci, Kazancoglu, Gozacan-Chase, et al. (2022), and Kayikci, Kazancoglu, Lafci, et al. (2022). Measures for circular procurement were adapted from Carter and Carter (1998), Zhu et al. (2011), Zhu et al. (2013), Kayikci, Kazancoglu, Gozacan-Chase, et al. (2022), and Kayikci, Kazancoglu, Lafci, et al. (2022). Measures for cleaner production were adapted from Sousa-Zomer et al. (2018), Zeng et al. (2010), Kayikci, Kazancoglu, Gozacan-Chase, et al. (2022), and Kayikci, Kazancoglu, Lafci, et al. (2022). Measures for end-of-life product and waste management were adapted from Carter and Ellram (1998), Hsu et al. (2013), Kayikci, Kazancoglu, Gozacan-Chase, et al. (2022), and Kayikci, Kazancoglu, Lafci, et al. (2022).

3.2. Sampling and data collection

The research utilized data obtained from a survey of prospective respondents from SMEs. The survey sample comprised accountants selected from SMEs across various industries and regions in Vietnam. Before doing the survey, participants were informed of the study's aims and their rights to refuse participation or withdraw at any time. The researchers confirmed that this study adhered to ethical standards for human subjects and that the identity and confidentiality of the participants were preserved throughout the investigation. Targeted questionnaires were distributed to accountants of SMEs to collect empirical data utilizing a combination of convenience and snowball sampling methods. The sample size conformed to the "10 times rule" methodology, a commonly utilized approach for establishing the minimum sample size in PLS-SEM. This method was based on the principle that the sample size should be a minimum of ten times bigger than the highest number of links among latent variables in either the inner or outer model (Sarstedt et al., 2022). The survey was conducted offline from August 2024 to January 2025. A response rate of 73.14% yielded 512 valid responses for the empirical analysis. Table 1 included a comprehensive summary of the demographic data collected throughout the survey.

Table 1. Demographic characteristics of survey respondents

Items	*Frequency*	*Percentage*
Gender of respondent		
Male	277	54.10
Female	235	45.90
Age of respondent		
30–under 40	126	24.61
40–under 50	279	54.49
Over 50	107	20.90
Experience of respondent (years)		
10–under 20	166	32.42
20–under 30	248	48.44
Over 30	98	19.14
Education		
Undergraduate	495	96.68
Postgraduate	17	3.32

Source: Authors' elaboration.

4. RESEARCH ANALYSIS

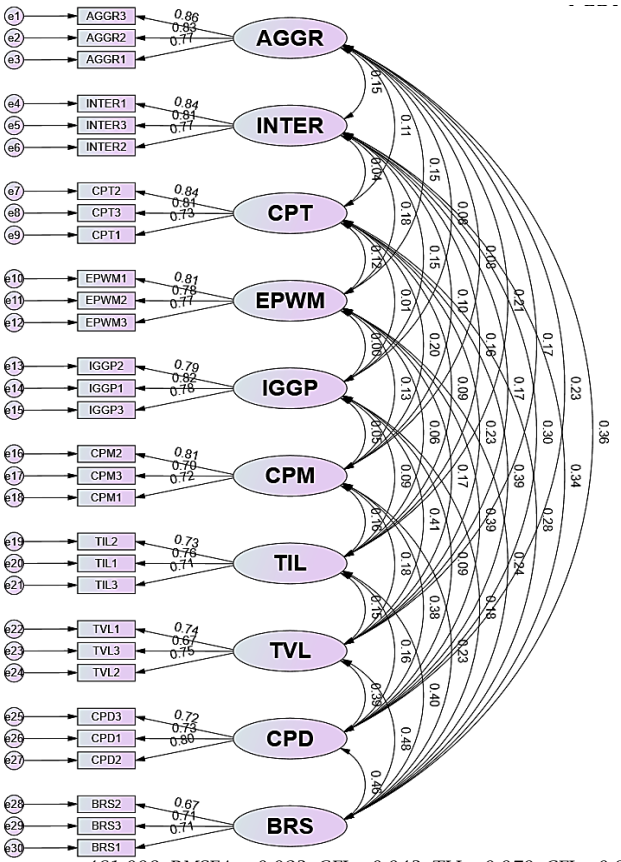
4.1. Common method bias

Common method bias (CMB) arises when identical respondents supply data for both independent and dependent variables, potentially exaggerating connections. Procedural and statistical procedures were adopted to resolve CMB. Respondent anonymity and question randomization were implemented to mitigate social desirability and response pattern biases. Ensuring anonymity enhances involvement. Ultimately, a pilot test was executed to enhance the survey prior to its comprehensive distribution. The Harman one-factor technique was used and highlighted that the first factor explained around 15.769% of the variance, which was below the 50% criterion. The variance inflation factor (VIF) scores, which ranged from 1.000 to 2.460, were lower than the recommended cutoff of 3.3. According to Kock (2015), these values highlighted that CMB did not pose any substantial problems in the sample. In a nutshell, there was no apparent presence of CMB in our study.

4.2. Model fit

The confirmatory factor analysis (CFA) was conducted using the maximum likelihood technique, and the support of AMOS 28.0. The CFA outcomes were influenced by five main indices, namely the chi-square/df ratio, goodness-of-fit index (GFI), comparative fit index (CFI), Tucker-Lewis index (TLI), and root mean square error of approximation (RMSEA). All indicators for model fitness of the proposed model in Figure 2 adhered to the specific criteria recommended by Kline (2023), rendering the model acceptable across all aspects. Consequently, the chi-square/df was 1.281 (≤ 3), RMSEA was 0.023 (< 0.080); GFI was 0.943 (> 0.9), CFI was 0.983 (> 0.9), TLI was 0.979 (> 0.9).

Figure 2. CFA result



Note: Chi-square/df = 1.281; Chi-square = 461.098; RMSEA = 0.023; GFI = 0.943; TLI = 0.979; CFI = 0.983; Df = 360; P = 0.000.
Source: Authors' elaboration.

4.3. Measurement model

Table 2 demonstrated the reliability and convergent validity of the construct. Cronbach's alpha (α), composite reliability (rho_c), and composite reliability (rho_a) were utilized to assess the constructs' reliability. Hair et al. (2024) advised that a threshold exceeding 0.70 was deemed appropriate for Cronbach's alpha (α) and composite reliability (rho_c). Dijkstra and Henseler (2015) asserted that a threshold of over 0.70 was deemed acceptable for composite reliability (rho_a). Additionally, outer loading and average variance extracted (AVE) methods were utilized to assess convergent validity. AVE threshold over 0.50 and outer loadings surpassing 0.7 were considered appropriate for subsequent investigation.

In this research, Cronbach's alpha (α) values fluctuated from 0.740 to 0.860, and the composite reliability (rho_c) values fluctuated from 0.852 to 0.914, which were greater than 0.7 (Hair et al., 2024). Alternatively, the composite reliability (rho_a) values were assessed, and the values of the constructs fluctuated from 0.741 and 0.888, which were greater than 0.7 (Dijkstra & Henseler, 2015). In this research, the outer loadings of each item fluctuated from 0.798 to 0.899, which was greater than 0.7. The AVE values of the constructs in the current investigation fluctuated from 0.658 to 0.781, which were more than 0.5. Significantly, Table 2 demonstrated that all constructs in this investigation had above the established minimum threshold values.

Table 2. Results summary of construct reliability and convergent validity

Constructs and operationalization	*Convergent validity*		*Construct reliability*			*Result*
	Factor loadings	*AVE*	*Cronbach's Alpha*	*Composite reliability (rho_c)*	*Composite reliability (rho_a)*	
Technologically vigilant leadership (TVL)	0.807–0.832	0.675	0.760	0.862	0.760	Retained
Effectiveness of the management accounting information system (EMAIS)						
Broad scope (*BRS*)	0.798–0.826	0.658	0.740	0.852	0.741	Retained
Timeliness (*TIL*)	0.822–0.854	0.694	0.780	0.872	0.785	Retained
Aggregation (*AGGR*)	0.869–0.899	0.781	0.860	0.914	0.860	Retained
Integration (*INTER*)	0.853–0.888	0.768	0.849	0.908	0.854	Retained
Smart sustainable circular supply chain management (SSCSCM)						
Circular product design (*CPD*)	0.834–0.858	0.709	0.795	0.880	0.798	Retained
Circular procurement (*CPM*)	0.813–0.862	0.698	0.783	0.874	0.784	Retained
Cleaner production (*CPT*)	0.849–0.883	0.753	0.836	0.901	0.836	Retained
End-of-life product & waste management (*EPWM*)	0.858–0.868	0.747	0.830	0.898	0.831	Retained
Inclusive green growth policy (IGGP)	0.807–0.894	0.750	0.838	0.900	0.888	Retained

Source: Authors' elaboration.

This research assessed discriminant validity employing the Fornell–Larcker criterion (Table 3) and the Heterotrait–Monotrait ratio (HTMT) (Table 3). Table 3 unequivocally demonstrated that all bolded values along the diagonal, indicative of the square root of AVE values, exceeded the inter-construct correlation values. This satisfied the Fornell-Larcker criteria (Fornell & Larcker, 1981). This study also utilized the HTMT approach to assess discriminant validity, as provided by Henseler et al. (2015). Table 3 indicated that all HTMT values in this investigation remained below the 0.85 threshold, hence affirming the discriminant validity among the constructs.

Table 3. Results summary of discriminant validity

Fornell–Larcker process									
	AGGR	***BRS***	***CPD***	***CPM***	***CPT***	***EPWM***	***IGGP***	***INTER***	***TIL***
AGGR	**0.884**								
BRS	0.297	**0.811**							
CPD	0.198	0.356	**0.842**						
CPM	0.067	0.182	0.315	**0.835**					
CPT	0.105	0.216	0.323	0.185	**0.868**				
EPWM	0.130	0.183	0.313	0.103	0.093	**0.864**			
IGGP	0.070	0.141	0.079	0.032	0.014	0.001	**0.866**		
INTER	0.131	0.276	0.241	0.086	0.031	0.145	0.130	**0.876**	
TIL	0.172	0.304	0.124	0.131	0.081	0.052	0.070	0.133	**0.833**
Heterotrait–Monotrait ratio									
	AGGR	***BRS***	***CPD***	***CPM***	***CPT***	***EPWM***	***IGGP***	***INTER***	***TIL***
AGGR									
BRS	0.371								
CPD	0.239	0.463							
CPM	0.082	0.239	0.399						
CPT	0.124	0.274	0.393	0.228					
EPWM	0.153	0.234	0.382	0.130	0.112				
IGGP	0.079	0.174	0.094	0.047	0.037	0.023			
INTER	0.152	0.346	0.292	0.106	0.046	0.173	0.143		
TIL	0.210	0.398	0.162	0.166	0.097	0.074	0.082	0.158	

Source: Authors' elaboration.

4.4. Structural model

The VIF values for all constructs in the current research were below the threshold of 3.3, showing that collinearity did not alter the estimations (Kock, 2015). Subsequently, the significance and relevance of the interconnections inside the structural model were evaluated. The significance was evaluated by employing a bootstrapping with 10,000 resamples and utilizing the percentile bootstrapping technique as the mechanism for determining the confidence interval.

Direct effect: Building on the bootstrapping results in Table 4, *SSCSCM* was confirmed to be influenced by *TVL* (β = 0.284; t-value = 6.581; p-value = 0.000) and *EMAIS* (β = 0.268; t-value = 6.473; p-value = 0.000). Similarly, *TVL* was validated to exhibit a substantial and positive impact on *EMAIS* (β = 0.361; t-value = 8.496; p-value = 0.000). Consequently, *H1–H3* were empirically supported.

Indirect effect: The mediating effect of *EMAIS* was assessed. The indirect impact of *TVL* on *SSCSCM* through *EMAIS* was initially assessed for its significance. The relationship between *TVL* and *SSCSCM* was partially mediated by *EMAIS*, as the direct effect of *TVL* on *SSCSCM* was also supported (β = 0.284; t-value = 6.581; p-value = 0.000), and the indirect effect was significant (β = 0.097; t-value = 5.145; p-value = 0.000) (Hair et al., 2024). As a consequence, the results suggested partial mediation.

Moderating effect: This study evaluated the moderating effect of *IGGP* on the relationships among *TVL*, *EMAIS*, and *SSCSCM*. The statistical results shed light on the fact that *IGGP* favorably moderated the direct effect of *TVL* on *SSCSCM* (β = 0.196; t-value = 4.741; p-value = 0.000), and *TVL* on *EMAIS* (β = 0.245; t-value = 6.585; p-value = 0.000). Furthermore, *IGGP* significantly moderated the direct effect of *EMAIS* on *SSCSCM* (β = 0.153; t-value = 3.445; p-value = 0.001). Consequently, *H5a–H5c* were empirically supported.

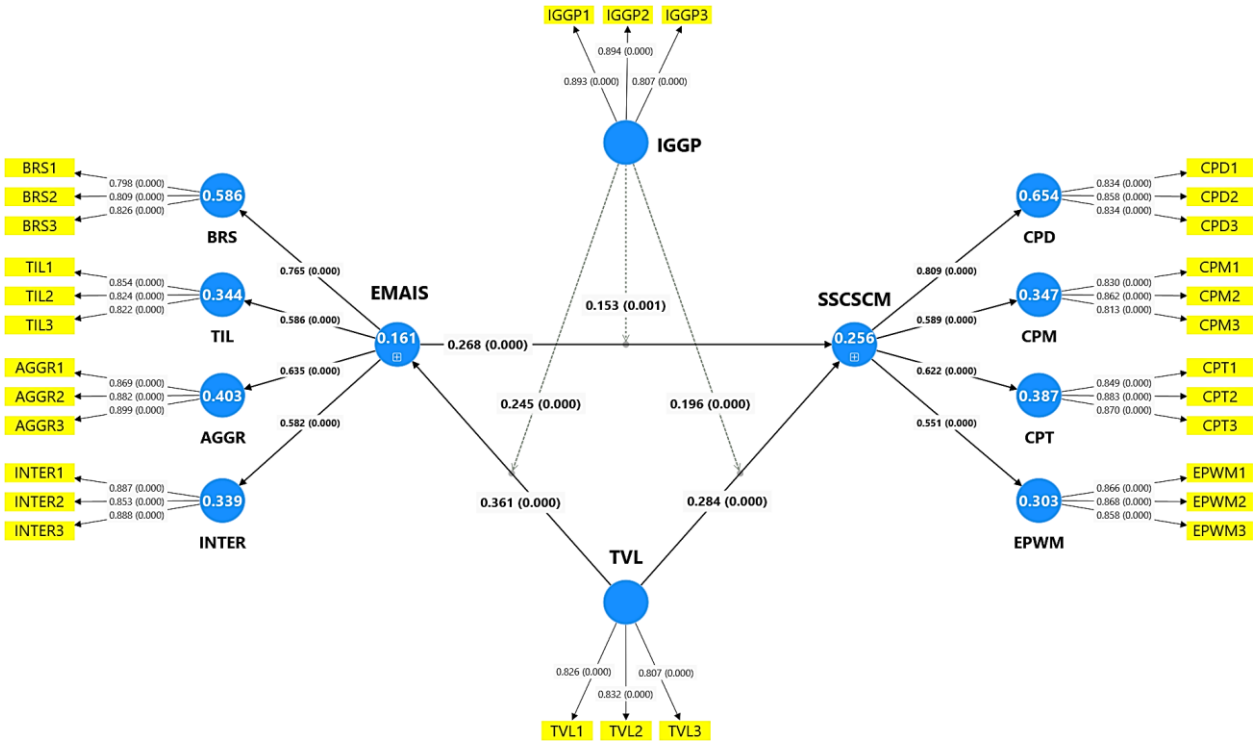
The R^2 values were 0.256 for *SSCSCM* and 0.161 for *EMAIS*. The score of f^2 in Table 4 put an accent on the fact that *TVL* and *EMAIS* demonstrated small impacts on *SSCSCM* (0.074 and 0.079, respectively). Likewise, *TVL* illustrated a small impact on *EMAIS* (0.129). The Q^2 values were 0.073 for *SSCSCM* and 0.044 for *EMAIS*, which were above zero.

Table 4. Results summary of hypotheses acceptance

Relevant path	***Path coefficient***	***SE***	***95% confidence interval***	***VIF***	***t-value***	***p-value***	***Result***
Direct effect							
TVL → SSCSCM	0.284	0.043	[0.197–0.366]	1.461	6.581	0.000	Supported
TVL → EMAIS	0.361	0.042	[0.273–0.442]	1.202	8.496	0.000	Supported
EMAIS → SSCSCM	0.268	0.041	[0.186–0.346]	1.225	6.473	0.000	Supported
Indirect effect							
TVL → EMAIS → SSCSCM	0.097	0.019	[0.063–0.137]	–	5.145	0.000	Supported
Moderating effect							
IGGP × TVL → SSCSCM	0.196	0.041	[0.116–0.277]	1.292	4.741	0.000	Supported
IGGP × TVL → EMAIS	0.245	0.037	[0.173–0.319]	1.091	6.585	0.000	Supported
IGGP × EMAIS → SSCSCM	0.153	0.044	[0.068–0.242]	1.145	3.445	0.001	Supported
R^2	R^2_{SSCSCM} = 0.256; R^2_{EMAIS} = 0.161						
f^2	$f^2_{TVL \Rightarrow SSCSCM}$ = 0.074; $f^2_{TVL \Rightarrow EMAIS}$ = 0.129; $f^2_{EMAIS \Rightarrow SSCSCM}$ = 0.079						
Q^2	Q^2_{SSCSCM} = 0.073; Q^2_{EMAIS} = 0.044						

Source: Authors' elaboration.

Figure 3. Structural model



Source: Authors' elaboration.

5. CONCLUSION

The statistical results indicate that TVL exerts a positive and statistically significant influence on SSCSCM. To our knowledge, this may be one of the few studies examining the influence of TVL on SSCSCM in SMEs in a developing country. This research enhances the existing literature on vigilant leadership (Day & Kruse, 2021; Gao et al., 2024; Mitson et al., 2024). TVL is crucial for firms to manage the intricacies of the digital era. It guarantees that executives are cognizant of technology improvements and are equipped to utilize these modifications for organizational accomplishment. This leadership approach cultivates a culture of perpetual learning, flexibility, and proactive management of technological risks and opportunities.

Consistent with the researchers' anticipations, EMAIS is confirmed to partially mediate the link between TVL and SSCSCM. To the best of the researchers' knowledge, this may be one of the few studies emphasizing the potential significance of EMAIS in assisting technologically vigilant leaders in managing smart sustainable circular supply chains. TVL frequently entails overseeing risks associated with the sustainability of the supply chain, including interruptions in the availability of sustainable resources, adherence to environmental standards, or fluctuations in the market. A management accounting information system can deliver significant risk management insights through predictive analytics, enabling the anticipation of potential risks in the circular supply chain and facilitating proactive measures for their mitigation. A management accounting information system can monitor resource flows across the supply chain, enabling leaders to oversee and manage the movement of materials, products, and waste. It aids in recognizing chances for minimizing material usage, repurposing products, or converting trash into new items, so guaranteeing that the supply chain endorses sustainable practices. A technologically vigilant leader can utilize this knowledge to make decisions that minimize waste and enhance resource circularity.

Furthermore, IGGP is revealed to positively modulate the links among TVL, EMAIS, and SSCSCM. To the researchers' knowledge, this study may be one of the few that underscores the potential significance of IGGP in enhancing technologically vigilant leaders' ability to effectively leverage management accounting information system for success in managing smart, sustainable circular supply chains. Based on the perspectives of Shobande et al. (2024), a circular economy is consistent with the tenets of inclusive green growth, fostering socially inclusive and environmentally sustainable economic development. IGGP is essential in developing smart, sustainable circular supply chain management by fostering green innovations, improving circular capabilities, offering regulatory support, and guaranteeing economic and social advantages.

The obtained findings of this research provide actionable advice for practitioners and policymakers in the implementation of SSCSCM. Our findings suggest that it is essential for companies to comprehend the influence of Industry 6.0 on the management of sustainable circular supply chains. In this context, SMEs must ascertain the capabilities and resources that facilitate the implementation of SSCSCM processes. Our research indicates that TVL and management accounting information system are critical tools and capabilities that facilitate SMEs in implementing smart sustainable circular supply chain practices. Practitioners and SME managers should promote

the cultivation of TVL skills within their organizations to monitor the environment for impending threats, avert potential issues, and stimulate ongoing improvement and innovation, all of which are essential for enhancing organizational readiness for change and ensuring sustained success. Consequently, SMEs must integrate training and coaching for their leaders' skill enhancement to effectively guide their organization's digital transformation process. The findings of this study indicate that SMEs can efficiently obtain valuable information to enhance SSCSCM, hence improving sustainable performance, by utilizing a management accounting information system. Therefore, SME managers must emphasize the establishment, growth, and enhancement of organizational learning capabilities by investing in resources and assets, while also heightening their understanding of the significance of the management accounting information system. To enhance the efficient and systematic learning of employees, managers should integrate, collaborate, and coordinate the knowledge and experiences gained from the implementation of the management accounting information system within the firm. They should also provide training sessions and apprenticeship programs that emphasize the attainment of comprehensive expertise in management, accounting, information systems, and digital technologies. Policymakers must assess the legislative and policy implications of inclusive green growth, ensuring that regulations promote rather than hinder organizational efforts to leverage digital technology for sustainable inclusive green growth.

Notwithstanding its theoretical and practical contributions, this work possesses numerous limitations. The research was mostly limited to SMEs in Vietnam, hence restricting the applicability of the findings to other countries. Future research should examine these findings across diverse types of SMEs and cultural contexts, particularly in regions with varying regulatory and economic conditions. The self-reliance-reported data from accountants may introduce biases. Thus, future studies may tackle this issue by employing multiple data sources and approaches, such as qualitative interviews or case studies, to gain deeper insights. The study's cross–sectional design recorded a singular instant, constraining causal inference. Future longitudinal studies are required to assess the influences of TVL, EMAIS, and IGGP on SSCSCM over time. Such studies might assess the long–term impacts of these components on SSCSCM and examine how SMEs transition to implement circularity initiatives for sustainable inclusive green growth achievement.

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