Journal of Innovation & Knowledge 10 (2025) 100689

Contents lists available at ScienceDirect

Journal of Innovation & Knowledge

journal homepage: www.elsevier.com/locate/jik

Sustainable entrepreneurship and knowledge management: Role of green information technology in building sustainable entrepreneurial ecosystems

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ARTICLE INFO

JEL Codes:
O10
D83

Keywords:
Knowledge creation
Knowledge transfer and storage
Application and use of knowledge
Green information technology
Sustainable entrepreneurship

ABSTRACT

Using green management practices to build sustainable entrepreneurship is both effective and challenging for growing businesses. Meanwhile, knowledge management has proven to be a critical part of contemporary business practices. Thus, there is a growing demand for socially and environmentally aware behaviour as a part of existing strategies for dealing with the effects of such practices in the realm of sustainable entrepreneurial ecosystems. This study adopts a dimensional view of the knowledge-management model and its effect on sustainable entrepreneurship in Malaysia. We also include green information technology (GIT) acceptance in the model to examine its moderating effect on the proposed model. Partial least-squares structural equation modelling is used to explore the connections among variables. The results reveal that knowledge creation and transfer have a significant and positive relationship with sustainable entrepreneurship. However, the application and use of knowledge have insignificant effects on sustainable entrepreneurship. We also find that GIT acceptance significantly moderates the relationship between knowledge creation, knowledge transfer and storage, and sustainable entrepreneurship. By contrast, it insignificantly moderates the association between the application and use of knowledge and sustainable entrepreneurship. Our findings can help those involved in sustainable entrepreneurship development to more effectively utilise knowledge creation, GIT acceptance and adoption, and knowledge application and use.

Introduction

Sustainability is widely recognised as a fundamental overhaul at the global scale. Businesses, particularly small and medium-sized enterprises (SMEs), play a significant role in the radical alteration of sustainability (Al-Swidi et al., 2024). Consequently, SMEs, especially those in the manufacturing sector, face immense pressure to address socio-environmental dilemmas given their intrinsic status within industrial boundaries. This is because manufacturing SMEs contribute significantly to atmospheric contamination, with evidence suggesting they are responsible for 64 % of total pollution levels (Behjati, 2017). Additionally, SMEs' industrial activities account for approximately 38 % of carbon emissions, making them a substantial source of environmental deterioration (Hertwich, 2021). Reports on manufacturing SMEs also reveal that they greatly contribute to economic development. However, it has also been substantiated that the SME sector, manufacturing in particular, is responsible for resource depletion, pollution, and waste generation at the global level (Ndubisi et al., 2021). Thus, promoting sustainability among SMEs is of paramount concern for both researchers and practitioners, making it imperative to sketch the role of SMEs in sustainability to devise efficient strategies (Mendes et al., 2022).

Malaysia faces severe sustainability issues that threaten its fragile ecosystem. In light of such issues, analysts have downgraded the projected growth of the Malaysian manufacturing sector, voicing serious concerns. Considering the anticipated weaker figures and subdued performance, one of Malaysia's institutions, Kenanga Investment Bank Bhd, issued a 2023 growth projection for Malaysia's manufacturing index of 5 % to 2.4 %. The situation has become more critical, given that

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https://doi.org/10.1016/j.jik.2025.100689
Received 16 October 2023; Accepted 7 March 2025
Available online 3 April 2025

<20 % of Malaysia's business sector has pledged to support sustainability initiatives. At the same time, half of Malaysia's businesses do not have the budget for such activities (Zailani, 2024). As with other developing economies, Malaysia's SME sector has attracted attention owing to its essential role in economic growth (Tehseen et al., 2023). According to Baskaran et al. (2023), SMEs' entrepreneurial activities are crucial for promoting inclusive growth through innovation. In this regard, Malaysia's government has promoted entrepreneurship through various policies. Despite these well-intentioned efforts, the outcomes for SMEs have not been satisfactory. Thus, the success of Malaysian businesses depends heavily on entrepreneurial resources. This has led to the evolution of a contemporary approach in the business environment in which entrepreneurs are encouraged to focus on sustainable ecosystems (Turek et al., 2023). A sustainable entrepreneurial ecosystem in the manufacturing industry focuses on business and social values. Without sustainable practices, manufacturing will not be able to protect the environment or sustain profitability (Bakar, 2020; Bakar et al., 2020). Malaysian entrepreneurs can use their entrepreneurial competencies and resources to offset the shortcomings of institutional support. Entrepreneurial ecosystems have also received significant attention in recent years, as firms, governments, and communities have come to recognise the potential of integrated structures, policies, processes, and programs that encourage entrepreneurial activity to promote productivity, innovation, and employment. Various local ecosystem projects have been introduced around the world, particularly in advanced and middle-income economies. The participation of different stakeholders is considered a factor for successfully creating an entrepreneurial ecosystem (Habib et al., 2020; Remeikienė et al., 2022). Global surveys have revealed growing concerns related to entrepreneurial ecosystems, as both leaders and the public now face pressure to encourage economic growth by supporting entrepreneurial activities in their regions. An entrepreneurial ecosystem consists of a complex multilevel infrastructure. The regional field level comprises stakeholders such as government agencies, political decision-makers, and industry associations (Wawryszuk-Misztal, 2021; Wysocka, 2021). Firm-level infrastructure accommodates new startup activities that activate innovative regional development. Such activities are often transmitted across firms because of shared knowledge and resources, offering services to entrepreneurial entities such as venture capitalists and patent law firms. At the individual and group levels, individual bodies are involved in micro-level activities that regulate firm-level outcomes. Focusing on the micro level is important for investigating the entrepreneurial activities that lead to the generation of new ventures (Boczkowska et al., 2022; Nguyen et al., 2021). It is important to note, however, that entrepreneurs with insufficient knowledge can be staid, indifferent, and unproductive, creating additional hurdles to acquiring competencies (AlKoliby et al., 2024). Thus, knowledge sharing is crucial for firms as it helps them achieve a sustainable competitive edge (Bloem & Salimi, 2023). Abbas and Sagsan (2019) suggested that knowledge-management processes, such as acquisition, dissemination, and application, are crucial for sustainable entrepreneurship. The knowledge-management model is considered an important component in achieving this goal. However, developing a knowledge-management model is a complicated process that requires a supportive entrepreneurial ecosystem. Knowledge creation is considered the initiating point of the knowledge-management model and is classified into three aspects: process, volume, and results. Process concerns the stages in which creative, innovative knowledge is generated. Regarding volume, knowledge generation is calculated by assessing the extent to which existing knowledge is significantly expanded upon. In terms of results, knowledge generation focuses on value-added aspects. These aspects are inseparable from the innovation concept (Grimsdottir & Edvardsson, 2018; Ying et al., 2022). Researchers have suggested that knowledge transfer in firms is important for quick responses that can facilitate transformation, innovation, and competitive success. In a knowledge-based emerging society, an organisation's ability to transfer knowledge is considered a key factor in its performance. Knowledge transfer is now at the top of many companies' agendas, as knowledge is important for achieving and retaining competitive advantage. Knowledge is asymmetrically transferred to any organisation. However, if knowledge is not sustained, then knowledge transfer will not have adequate value for businesses. Companies that store knowledge but cannot use it waste their assets and ignore opportunities to achieve competitive advantage (Centobelli et al., 2022; Zhao & Li, 2021). Thus, the interaction between knowledge transfer and storage is important for the successful implementation of a knowledge-management model. Knowledge application is defined as the proper use of knowledge, which combines newly generated knowledge with feasible assets to integrate business activities, functions, and processes and improve the firm's outcomes. Knowledge application also considers integrating specific knowledge into a firm's activities and processes to achieve sustainable performance and knowledge strategy (Kordab et al., 2020; Paraschiv et al., 2021). All of these knowledge-management processes play important roles in organisations.

Green information technology (GIT) is considered pivotal for sustainable entrepreneurship, as it helps stakeholders disseminate information through computer resources in an eco-friendly manner (Sani et al., 2020; Uddin et al., 2015). The role of GIT has gained prominence in recent years owing to climate change and the energy crisis (Ribeiro et al., 2021). GIT is viewed as a technological solution that addresses users' and developers' concerns regarding environmental problems (Radu, 2016). Although firms optimise their resources through GIT, in the context of SMEs, it is still viewed as a complex concept (Baggia et al., 2019; Mory-Alvarado et al., 2023). It is worthwhile, then, to consider the moderating role of GIT acceptance between knowledge management and sustainable entrepreneurship. Therefore, building on the existing literature, this study explores the proposed framework in the context of Malaysia's manufacturing sector. This work could help entrepreneurs and stakeholders transfer or disseminate knowledge through GIT acceptance to build sustainable entrepreneurship. This study extends existing knowledge by examining the acceptance of GIT practices and their moderating role in the relationship between knowledge management and sustainable entrepreneurship. This research also responds to recent calls for more in-depth contextual evidence regarding sustainable entrepreneurship and digitalisation (George et al., 2021; Holzmann & Gregori, 2023). In this way, we reveal sustainable entrepreneurship's existing knowledge-management dimensions in the Malaysian SME context, making the evidence more accessible to practitioners and businesses. This study highlights the roles of knowledge creation, knowledge transfer and storage, knowledge and application, and knowledge use in sustainable entrepreneurial ecosystems. In doing so, this study fills a gap related to the transformation of sustainable entrepreneurship practices in Malaysian manufacturing SMEs.

The rest of this paper is organised as follows. Next, we review the literature, which is followed by the methods and data collection. We then present and discuss the findings. Finally, we discuss the study's theoretical and managerial implications, followed by the conclusions.

Literature review

Theoretical framework

Audretsch and Keilbach (2007) introduced the knowledge spillover theory of entrepreneurship (KSTE) as an extended version of endogenous theory. This theory draws attention to the roles played by entrepreneurs, who are regarded as vessels of knowledge diffusion throughout the process of knowledge capitalisation (Audretsch & Belitski, 2015). As knowledge has been conceptualised differently in the literature, KSTE emphasises codified knowledge forms (Ghio et al., 2015; Qian & Acs, 2015). Meanwhile, Audretsch and Keilbach (2011) emphasised that knowledge can also materialise through specialised individuals based on the information available in a region. Interestingly,

tacit knowledge has sparked researchers' interest in recent years, with an emphasis on the role of entrepreneurs as sources of knowledge (Ghio et al., 2015; Antonelli et al., 2022).

Lattacher et al. (2021) argued that entrepreneurial activities depend on either new or existing forms of knowledge, which help to further promote economic growth. This argument is justified by the proposition that the KSTE lens is applicable to various industrial and institutional contexts. The KSTE perspective illustrates how utilised knowledge can be underestimated, underscoring the significance of entrepreneurs' collaboration with the external environment. In addition, in the digital era, where knowledge exchange is rapid, the slightest negligence can pose challenges, as it might affect a firm's productivity and innovation and hinder the possibilities for new knowledge, which is crucial for entrepreneurs to capitalise on (Obschonka & Audretsch, 2020). This explains the important roles of key enabling technologies and information and communications technology (ICT) (Carree et al., 2019; Khalil & Belitski, 2020). Here, technology and knowledge are regarded as mutual information drivers through which entrepreneurs can identify novel opportunities. This allows entrepreneurial firms to align themselves with continuous changes in the external environment. Hence, using this theoretical lens to explain the knowledge-management process in sustainable entrepreneurship underscores the importance of knowledge sharing in promoting sustainable practices. This framework also encapsulates the idea that by handling knowledge effectively, sustainable entrepreneurs can more easily reap the benefits of technological advancements by accepting GIT and promoting sustainable practices. In addition, embracing GIT allows entrepreneurs to effectively handle knowledge-management processes, subdue functional costs, and integrate businesses with sustainable objectives. In summary, GIT acceptance amplifies the entrepreneurial ability to utilise knowledge-management processes to produce sustainable actions.

Knowledge management

Since knowledge management emerged as a concept, it has attracted the interest of policymakers and researchers given its significance for uplifting organisations' ability to build competitive advantage (Martins et al., 2019). The knowledge-management process is a systematic mechanism that aims to translate tacit knowledge into explicit knowledge, covering both internal and external knowledge transfers. Darroch's (2005) framework also explains this process in terms of knowledge acquisition and dissemination, where its efficacious use benefits organisations. Studies also suggest that the knowledge-management process is based on four interconnected phases: knowledge generation, knowledge storage, knowledge transmission, and knowledge integration (Abbas & Sağsan, 2019). Gaviria-Marin et al. (2019), meanwhile, categorised the process into three structured and coherent dimensions. These include knowledge production, which encompasses knowledge generation and acquisition. Then, knowledge integration, which covers knowledge dissemination, retention, and application, reflects the preservation and implementation of knowledge. However, implementing knowledge management involves various barriers, either in the form of environmental or institutional obstructions or human impediments (Oliva & Kotabe, 2019). By contrast, knowledge-management practices shape organisational abilities by enabling the flow of expertise, which further helps firms achieve sustainable goals (Alkathiri et al., 2024). In other studies, knowledge management has been viewed as a planned process in which firms use knowledge to shape business performance. In light of the above, this study explores the knowledge-management process by considering three dimensions: knowledge acquisition, knowledge dissemination, and knowledge application. Knowledge acquisition is "obtaining information from multiple resources" (AlKoliby et al., 2022). Knowledge dissemination is "gathering, conveying and distributing the information" (Lee et al., 2013). Knowledge dissemination also involves two aspects: knowledge sharing and knowledge culture. Knowledge sharing refers to offering knowledge, whereas a knowledge culture involves gathering knowledge from stakeholders (Attia & Salama, 2018). Knowledge application, also known as knowledge responsiveness, prepares firms to enhance vigorous information that could help create a competitive advantage while tapping the opportunity to improve business functions (Darroch, 2005; Lee et al., 2013).

Sustainable entrepreneurship

Sustainable entrepreneurship has attracted research attention because of its philosophy, which proposes that organisations can simultaneously become profitable and sustainable while contributing social value (Muñoz et al., 2018). Thus, sustainable entrepreneurship can be considered a distinctive approach that can blend the three pillars of sustainability—namely, attention to economic, environmental, and social needs. In this regard, various interrelated concepts such as eco-entrepreneurship and green entrepreneurship have emerged (Strydom et al., 2021). However, the distinction between these concepts is often presented in the form of literal definitions that fail to capture the nuanced differences. While green entrepreneurship supports initiatives to minimise environmental harm, eco-entrepreneurship aims to improve public welfare based on social challenges (Hoogendoorn et al., 2019). It is also claimed that sustainable entrepreneurship is an effective approach for simultaneously acknowledging environmental and social issues (Diepolder et, al., 2021). This concept has been scrutinised in tandem with factors such as the triple bottom line, the circular economy, and entrepreneurial ecosystems (Bertello et al., 2022; Del Vecchio et al., 2021). Such work highlights the significance of sustainable entrepreneurship for attaining competitive advantage and utilising extensive knowledge. Initially, sustainable entrepreneurship was viewed only as an entrepreneurial activity related to environmental issues (Elkington, 1998). However, with recent developments, the concept has evolved in terms of scope and now intersects with the triple bottom line approach (Natividade et al., 2021). Based on this idea, Hockerts and Wüstenhagen (2010) defined sustainable entrepreneurship as "the discovery and exploitation of economic opportunities through the generation of market imbalances that initiate the transformation of a sector toward an environmentally and socially more sustainable state." Sustainable entrepreneurship was further conceptualised by Shepherd and Patzelt (2011), who advocated nature preservation, community support, and plausible opportunities for gaining profits in the future. However, profit is not based solely on financial gain but also on non-financial gains, thus generating individual, social, and organisational benefits. These two explanations are considered appropriate for defining sustainable entrepreneurship because they consider all aspects of sustainability. To date, however, there is not a universally accepted definition of sustainable entrepreneurship, as some still perceive it as a green, environmental, or sustainability-driven initiative (Mendes et al., 2022). Studies also suggest that despite the revamping activities of large and small enterprises, SMEs' approaches to sustainability are distinctive compared with those of large enterprises owing to financial constraints (Kostakis & Tsagarakis, 2022). Hence, this makes the subject more appealing, further warranting a consideration of all aspects of sustainability.

Knowledge management and sustainable entrepreneurship

Audretsch et al. (2020) suggested that acquisition, utilisation, distribution, and application are the key elements of knowledge management, also known as the key enablers of sustainable business. Pham et al. (2019) argued that knowledge management helps firms acquire external information that helps them maintain sustainable goals. Similarly, Singh et al. (2021) argued that knowledge dissemination within and outside of organisational boundaries allows firms to implement sustainable initiatives more successfully and be equipped with innovative methods that make the process easier. Various studies have provided evidence for the important association between the knowledge-management paradigm

and sustainable entrepreneurship principles. For example, Durst and Zieba (2020) scrutinised knowledge-management practices and the organisational capacity to maintain sustainable performance. Their study revealed that, although knowledge is a critical aspect of corporate sustainability, it can be risky if not managed efficiently. Similarly, another study revealed that knowledge management enhances business sustainability while supporting green innovation (Abbas & Sağsan, 2019).

Fores and Fernandez-Yañez (2023) argued that knowledge management encompasses all facets of knowledge, including knowledge acquisition, storage, processing, dissemination, and application. Antunes and Pinheiro (2020) also regarded knowledge management as a comprehensive approach that helps firms manage knowledge, especially those eager to increase organisational creativity and efficiency. It has also been argued that knowledge management plays a significant role in various dimensions of sustainability. Migdadi (2022) suggested that the knowledge-management process is the main instrument of organisational excellence. Thus, firms must decide which knowledge to retain, develop, or scrap considering sustainability needs (Trivedi & Srivastava, 2022). Studies also suggest that sustainable entrepreneurship is nurtured by successfully acquiring and utilising knowledge (Abbas & Khan, 2023; Al-Swidi et al., 2024). It has been proposed, moreover, that knowledge management and sustainable entrepreneurship have a strong relationship because knowledge is a critical resource that also plays a critical role in sustainable performance (Shahzad et al., 2020).

The success of any firm can be calculated based on the ability to transfer knowledge from one firm to another. Hence, knowledge transfer provides companies with competitive advantage (Qinqin et al., 2023). Highlighting the significance of knowledge transfer in organisational success, Hamdoun et al. (2018) noted that knowledge transfer helps organisations transfer knowledge from one person, owner, or place to another. Knowledge transfer helps entrepreneurial firms utilise innovative and sustainable practices in their manufacturing processes. Sharing and transferring the latest knowledge helps firms remain up-to-date according to market demand. With firms facing immense global pressure, they must integrate sustainable and environmental activities into their manufacturing processes. In addition, knowledge application is considered an organisational response or acknowledgement of operational changes via strategy and technology, as well as the ability to take advantage of them to create new services and products. Hamdoun et al. (2018) noted that knowledge application is a key source of innovative competencies for firms, thus enhancing the sustainability of organisations. Organisations can reveal or introduce new procedures to enhance their economic and social performance by integrating knowledge. Considering stakeholder interests, dynamic companies integrate new knowledge and use environmentally friendly activities to create a sustainable entrepreneurial environment (Tran-Thi-Thanh & Nguyen-Thi-Phuong, 2023). This allows organisations to create environmentally friendly products using minimal resources, which helps entrepreneurial firms benefit the environment and the firm itself.

H1. Knowledge acquisition positively influences sustainable entrepreneurship.

H2. Knowledge dissemination positively influences sustainable entrepreneurship.

H3. Knowledge application positively influences sustainable entrepreneurship.

GIT as a moderator

As ICT continues to advance in all areas of human activity, GIT has become a pressing global issue (Dezdar, 2017). Meanwhile, organisations are obligated to shift toward green technologies owing to concerns about social and environmental responsibility. Thus, GIT acceptance is an essential parameter for firms to implement superior yet cost-effective methods to improve sustainability (Ribeiro et al., 2021). The effective and efficient utilisation of IT is crucial for protecting the environment and society, and technology plays a significant role in organisational productivity. Thus, it is challenging for organisations to adopt models and practices that can integrate IT practices to contribute to new business models. GIT and green information system (GIS) concepts have emerged to synchronise sustainable resources with economic policies that benefit the environment, society, and firms (Sani et al., 2020). In general, GIT and IS are viewed as organisational needs that minimise the negative effects of technology on the environment. In recent years, the acceptance of GIT and IS has become paramount because of the prominence of sustainability principles. Singh and Sahu (2020) noted that while GIT has been defined and conceptualised in various ways, there is no universally accepted definition. While some studies have viewed GIT and GIS in similar contexts, others have separated the concepts by making certain distinctions. Others, meanwhile, view GIT as a part of GIS and use the terms interchangeably (Brooks et al., 2010; Mithas et al., 2010). Malhotra et al. (2013), for instance, unified the concepts, claiming they serve a common purpose. By contrast, Loeser (2013) distinguished between the scope of GIT and GIS, referring to GIT as "a measure and initiative that lowers the negative environmental impact of manufacturing, operations, and the disposal of IT equipment and infrastructure."

This study focuses on GIT acceptance, and we argue that in the sphere of ICT, environmental preservation is based on the genesis of hardware and software engineered to reduce environmental harm; hence, it is classified as a radical innovation. Meanwhile, refining pre-existing technological frameworks is another way to address environmental issues; this is called incremental innovation (Radu, 2016). Emerging concepts such as GIT (or green ICT) aim to reduce the ecological footprint of ICT in the development and utilisation of applications that promote sustainability (Harnischmacher et al., 2020). Murugesan et al. (2008) described the concept as a systematic approach that involves "designing, manufacturing, using, and disposing of computers, servers, and associated subsystems—such as monitors, printers, storage devices, and networking and communications systems—efficiently and effectively with minimal or no effect on the environment." Watson et al. (2008) emphasised energy efficiency and equipment utilisation when defining GIT. In addition, Watson et al. (2008) attempted to distinguish the concept from GIS, explaining that "green IT is all about transmitting, processing or storing information," whereas GIS represents an "integrated set of software that utilize IT to support societal, individual or organizational goals" (Anthony, 2020; Chen & Roberts, 2024). Other studies, such as Molla (2009), view GIT as "an organization's ability to systematically apply environmental sustainability criteria (such as pollution prevention, product stewardship, use of clean technologies) to the design, production, sourcing, use, and disposal of the IT technical infrastructure as well as within the human and managerial components of the IT infrastructure" (Mustonen, 2024; Onimbo, 2020). Likewise, Andreopoulou (2012) conceptualised GIT/ICT as "design technique, construction technique, the function of the information diffusion technique to achieve optimal environmental governance, and the approach is also about optimization and improvement of the organization's operational processes without hindering its progress in use of technology" (Karabasevic et al., 2021). Thus, given the various definitions of GIT and its distinction from GIS, it is essential to understand how GIT can mitigate ICT's adverse effects on the environment or how IS can be indirectly used to support other business initiatives to minimise the ecological footprint. This distinction highlights the unique characteristics of GIT, which firms adopt to contribute to environmental protection. Nevertheless, it is apparent that the concept of GIT emphasises the technology itself and its efficiency in reducing a firm's ecological footprint, which is what this study largely focuses on, following Anthony (2020), Waston et al. (2008), and Radu (2016).

In the context of sustainable entrepreneurship, GIT plays a crucial

role in disseminating information within and outside of organisations, and it is perceived as a practice that makes eco-friendly use of technological resources (Uddin et al., 2015). Given the current environmental crisis, GIT acceptance has become more prevalent as it is based on the bottom-line concept of sustainability. Unlike conventional business strategies, it mainly focuses on the sustainable feasibility of IT-based solutions (Ribeiro et al., 2021). With GIT acceptance, the optimal use of ICT can improve a firm's sustainable performance and operations. According to recent studies, GIT sheds light on the strategic use of IT and aligns business objectives with sustainable practices to bring about changes in operational business cycles. Thus, this study seeks to determine the mediating role of GIT acceptance between knowledge-management practices and sustainable entrepreneurship. GIT gives firms the ability to systematically implement sustainability criteria. GIT acceptance acknowledges two overarching and correlated objectives. First, it prepares businesses to reduce harmful effects by limiting their carbon emissions. Second, GIT acceptance helps businesses manage their environmental footprint, suggesting its prominent role in building sustainable practices with the help of knowledge management. As argued in recent studies, knowledge acquisition can be enhanced by accepting GIT (Sahoo et al., 2023). Researchers also suggest that with GIT acceptance, organisations are encouraged to build sharing hubs relevant to environmentally friendly technologies, focusing on a deeper understanding of sustainability constraints (Alkathiri et al., 2024; Wang et al., 2024). When GIT is embedded in an organisation's foundational principles, it can help businesses disseminate environmental knowledge across departments, promoting shared and unified awareness of and commitment to green goals. Further, implementing such knowledge, fortified by GIT acceptance, allows organisations to efficiently utilise green technologies and practices to address the complexities of practical operations (Polas et al., 2023). Thus, knowledge management, including knowledge acquisition, dissemination, and application, with the support of GIT, is expected to advance sustainable entrepreneurship and facilitate such ventures in initiating green innovative practices to achieve further goals.

Since this study selects SMEs to assess this relationship, it is important to note that various SMEs have introduced significant changes to embrace digital technology so that their businesses can be floated. Especially in the wake of the pandemic, such sharp changes emerged with the aim of maintaining economic stability. Studies have revealed that organisations had the opportunity to emerge from the pandemic by accepting IT-based strategies through which they could achieve their desired goals. Based on the scenario and the overall discussion, GIT has the potential to act as a moderator to keep knowledge flowing to support sustainable entrepreneurship. Thus, we hypothesise the following:

H4. GIT acceptance moderates the positive relationship between knowledge acquisition and sustainable entrepreneurship.

H5. GIT acceptance moderates the positive relationship between knowledge dissemination and sustainable entrepreneurship.

H6. H4: GIT acceptance moderates the positive relationship between knowledge application and sustainable entrepreneurship.

Method

This study explores knowledge creation, transfer, and storage, as well as the application and use of knowledge in sustainable entrepreneurship. We identify a moderating effect of GIT in Malaysian firms. We adopt a questionnaire from prior literature, taking six items for knowledge acquisition from Darroch and McNaughton (2002). Knowledge dissemination is measured using five items from Darroch and McNaughton (2002). The application and use of knowledge is based on 11 items from Ode and Ayavoo (2020). We measure GIT acceptance using four items from Mishra et al. (2014) because it is the most suitable scale based on the definition of Watson et al. (2008): "Green IT is all about transmitting, processing or storing information." Sustainable entrepreneurship is measured using 10 items from Nhemachena and Murimbika (2018).

Adopted instrument details

Items	Statements	Sources
Knowledge Acquisition		
KNA1	"My organisation values employees' attitudes and opinions."	Darroch and McNaughton (2002)
KNA2	"My organisation has well-developed financial reporting systems."	
KNA3	"My organisation is sensitive to information about changes in the market place."	
KNA4	"My organisation has a science and technology human capital profile."	
KNA5	"My organisation works in partnerships with international customers"	
KNA6	"My organisation gets information from market surveys."	
Knowledge Dissemination		
KND1	"In my organisation, market information is freely disseminated."	Darroch and McNaughton (2002)
KND2	"In my organisation, knowledge is disseminated on the job."	
KND3	"My organisation uses specific techniques to disseminate knowledge."	
KND4	"My organisation uses technology to disseminate knowledge."	
KND5	"My organisation prefers written communication."	
Application and Use of Knowledge		
AUKN1	"The organisation can locate and apply knowledge to changing competitive conditions."	Ode and Ayavoo (2020)
AUKN2	"The organisation has processes for using knowledge in the development of new products/services."	
AUKN3	"The organisation has processes for using knowledge to solve new problems."	
AUKN4	"The organisation has processes for applying knowledge learned from experience."	
AUKN5	"The organisation takes advantage of new knowledge."	
AUKN6	"The organisation uses knowledge to improve efficiency."	
AUKN7	"The organisation makes knowledge accessible to those who need it."	
AUKN8	"The organisation quickly applies knowledge to critical competitive needs."	
AUKN9	"The organisation quickly links sources of knowledge to solving problems."	
AUKN10	"The organisation has processes for applying knowledge learned from mistakes."	
AUKN11	"The organisation uses knowledge to adjust its strategic direction."	
Green IT Acceptance		
GIT1	"My organisation intends to consider GIT when buying new hardware."	Mishra et al. (2014)

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(*continued*)

Items	Statements	Sources
GIT2	"My organisation intends to consider GIT when buying new software."	
GIT3	"My organisation will consider GIT depending on the type of ICT usage."	
GIT4	"My organisation intends to consider GIT depending on the place of its ICT usage."	
Sustainable Entrepreneurship		
SEN1	"My organisation helps enhance the environmental image of the local community."	Nhemachena and Murimbika (2018)
SEN2	"My organisation helps reduce overall negative environmental effects in the local community."	
SEN3	"My organisation helps enhance the protection and conservation of natural and environmental resources in the local community."	
SEN4	"My organisation has managed to create employment for others.	
SEN5	"In comparison with competitors, my organisation has introduced more new products/services."	
SEN6	"Compared with competitors, my organisation made more changes and improvements to existing products/services."	
SEN7	"Compared with competitors, my organisation's profits have continued to grow."	
SEN8	"In my organisation, rapid growth this year is a dominant goal.	
SEN9	"Steady growth and stability in my organisation this year is its primary concern."	
SEN10	"My organisation actively engages in the search for large business opportunities."	

We collected data from manufacturing firms. The sample targeted only employees in managerial/supervisory positions or top management. Demographic criteria were carefully selected to ensure that the sample was aware of technical concepts such as GIT and knowledge management. Knowledge of these concepts was considered essential because without specific knowledge and awareness, respondents could not comprehend the questions, leading to inconclusive findings. We used the random sampling technique for this study. Both physical and virtual settings were used to reach out to the participants; 517 questionnaires were distributed across these domains. We received 315 valid questionnaires, for a ratio of 60 %. SPSS and partial least squares (PLS) are applied to assess the integrity of the proposed model. Specifically, we employ structural equation modelling (SEM) through the PLS approach to assess the framework. The PLS-SEM method has garnered attention in management and entrepreneurship studies (Hair et al., 2017). The entire model is based on two sub-models: measurement and structure. The measurement model ensures the reliability and validity of the constructs, and the structural model supports hypothesis testing. PLS is chosen because of its effectiveness in complex models consisting of various constructs and paths (Hair et al., 2017). Further, this approach does not require normally distributed data; hence, it is considered more flexible. PLS is proficient in handling multicollinearity issues as it can provide reliable findings even in cases of high multicollinearity (Hair et al., 2017, 2020).

Descriptive statistics are used to determine the features of the quantitative dataset. Convergent analysis is also conducted to determine the association between the variables. Moreover, the heterotrait-monotrait (HTMT) ratio is determined (values should be <0.85) (Hair et al., 2020) (see Fig. 1).

Results

Table 1 presents the descriptive statistics. The total number of respondents is 315. The results show that the mean values for GIT, KNA, SEN, and AUKN are 3.1222, 3.1241, 2.1108, 3.1314, and 3.2815, respectively. However, the standard deviation for each variable is more significant than 1, except for KND (SD= 0.91285). Therefore, no outliers are observed.

KBT is performed to determine the suitability of the collected data for factor analysis. The KMO value is 0.901, which indicates that the sample is adequate for further analysis, as shown in Table 2. The significance value is 0.00, showing a positive outcome.

Factor loadings

First, we evaluate the validity of the model. We assess items with loadings following the guidelines of Hair et al. (2016), who note that loadings of <0.6 should be removed to reach the threshold of reliability and validity. As all items meet the criteria, no items are removed. Table 3 also shows that no cross-loading or duplicate loading are observed in the data for any item. The factor-loading results are significant.

Construct validity results

We test the validity of the constructs through discriminant and convergent validity, which are subtypes of construct validity. Discriminant validity demonstrates that theoretically unrelated variables are not correlated. Table 4 shows that discriminant validity among the variables is established, as demonstrated by the diagonal shape formed (Table 5 and Fig. 2).

The results reveal that knowledge acquisition and dissemination have a significant and positive link with sustainable entrepreneurship, because the p-values are <0.05; thus, H1 and H2 are supported. These findings suggest that firms become more innovative and sustainable by acquiring and disseminating knowledge. Knowledge management helps firms to leverage the best green practices, which further optimises their resources, increases market competitiveness, and transforms them into more sustainable entities. However, the application and use of knowledge has an insignificant association with sustainable entrepreneurship ($p > 0.05$), as shown in Table 6; thus, H3 is rejected. These results imply that implementing knowledge is not as easy as it might seem because it requires a strategic approach. Without continuous application, firms might lose their ability to accept change, which is essential for keeping up with the dynamic environment of sustainable entrepreneurship.

Table 7 and Fig. 2 show that GIT significantly moderates the association between knowledge acquisition and sustainable entrepreneurship and knowledge dissemination and sustainable entrepreneurship ($p < 0.05$); H4 and H5 are supported. These results suggest that GIT solutions double the effect of knowledge acquisition and dissemination on sustainable entrepreneurship. Hence, firms must accept and integrate them into their core principles to optimise resource efficiency. However, there is insignificant moderation in the association between the application and use of knowledge and sustainable entrepreneurship ($p > 0.05$), thus rejecting H6 (see Fig. 3). This suggests that GIT acceptance might be helpful in the initial stages of the knowledge-management process; however, additional factors must be considered for successful implementation to achieve sustainable entrepreneurship.

Discussion

Our results demonstrate the positive role of knowledge acquisition in sustainable entrepreneurship. Knowledge acquisition plays a significant role in enhancing the sustainability of entrepreneurial firms. Consistent

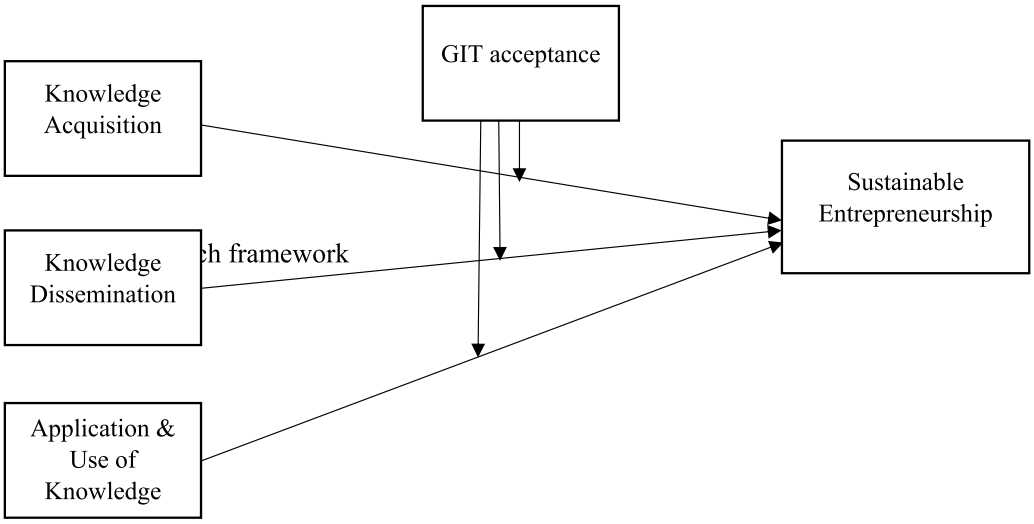

Fig. 1. Research framework.

Table 1
Descriptive statistics.

	N	Mean	Std. Deviation	Kurtosis
	Statistic	Statistic	Statistic	Statistic
GIT	315	3.1222	2.07378	−0.213
KNA	315	3.1241	1.11251	−0.462
KND	315	2.1108	.91285	−0.345
SEN	315	3.1314	1.01612	−0.215
AUKN	315	3.2815	1.11513	−0.356

Table 2
KBT.

KMO Measure of Sampling Adequacy.		.901
Bartlett's Test of Sphericity	Approx. Chi-Square	13,739.1 91
	Df	769
	Sig.	.00

with the literature, firms need appropriate resources to create and acquire new knowledge and enhance sustainability. Ordieres-Meré et al. (2020) and Wach et al. (2022) supported this hypothesis, noting that firms that can innovate and update their knowledge acquisition will help their industry minimise resource waste by implementing sustainable practices. Our findings also align with Bashir and Farooq (2019), who noted that knowledge creation and acquisition boost firms' sustainable activities. Manufacturing is a prominent sector in Malaysia, making it important for all firms, and especially entrepreneurs, to acquire knowledge that will help them follow environmentally friendly processes.

The results show a significant effect of knowledge dissemination on sustainable entrepreneurship. As discussed above, knowledge dissemination helps employees and organisations solve any crises faced by firms in innovative ways. This is supported by Tajpour et al. (2022), who noted that organisations that can disseminate knowledge can achieve sustainable outcomes by encouraging the sharing of novel ideas. Entrepreneurs with well-suited knowledge are also better positioned to invest in green products and services to achieve sustainability. Kordab et al. (2020) also suggested that knowledge should not be stored and organised so that the firm's values are secured from loss; these firms obtain advantages by improving the efficiency of their activities and enhancing their sustainable performance. Thus, knowledge dissemination plays a significant role in entrepreneurial firms and positively affects the sustainable ecosystem (Turek et al., 2023).

Table 3
Cross-loadings.

	KNA	KND	GIT	AUKN	SEN
KNA1	0.834				
KNA2	0.647				
KNA3	0.624				
KNA4	0.744				
KNA5	0.693				
KNA6					
KND1		0.742			
KND2		0.718			
KND3		0.699			
KND4		0.693			
KND5		0.713			
GIT1			0.882		
GIT2			0.828		
GIT3			0.810		
GIT4			0.822		
AUKN1				0.708	
AUKN2				0.727	
AUKN3				0.625	
AUKN4				0.722	
AUKN5				0.719	
AUKN6				0.865	
AUKN7				0.798	
AUKN8				0.736	
AUKN9				0.769	
AUKN10				0.678	
AUKN11				0.756	
SEN1					0.811
SEN2					0.810
SEN3					0.702
SEN4					0.824
SEN5					0.769
SEN6					0.639
SEN7					0.766
SEN8					0.801
SEN9					0.798
SEN10					0.758

Table 4
Discriminant and convergent validity.

	Cronbach	CR	AVE
KNA	0.923	0.940	0.723
KND	0.948	0.959	0.795
AUKN	0.905	0.933	0.778
GIT	0.862	0.907	0.708
SEN	0.877	0.916	0.731

Table 5
Heterotrait-monotrait ratio.

	AUKN	SEN	KND	KNA	GIT
AUKN					
SEN	0.370				
KND	0.423	0.397			
KNA	0.857	0.227	0.677		
GIT	0.890	0.891	0.510	0.452	

Our results show that knowledge application and use have an insignificant effect on sustainable entrepreneurship. Contrary to the literature, these results imply that, although knowledge application promotes innovation, its effect on SEN might take longer to become evident. In addition, depending on the context, external factors such as the market situation and regulatory framework might subdue the effectiveness of knowledge application. Additionally, the contribution of knowledge applications can be overshadowed by broader ecosystem dynamics. Meanwhile, contradictions in prior evidence suggest that knowledge application partially mediates corporate sustainability and quality management, emphasising the negative effect of knowledge application on sustainable entrepreneurship in the context of this study (Abbas, 2020). However, Rusu et al. (2022) and Vainauskienė et al. (2022) suggested that knowledge application creates competencies for firms and enhances their economic performance. Martins et al. (2019) noted that knowledge can be used to enhance firms' sustainability. By contrast, our data, collected from Malaysian manufacturing firms, indicated that proper and efficient knowledge and applications in firms cannot significantly affect the entrepreneurial ecosystem.

Our findings confirm that GIT acceptance is a potential moderator that strengthens the relationship between knowledge acquisition and sustainable entrepreneurship; this is consistent with the existing literature on sustainable technologies. Prior studies of GIT view it as an environmentally friendly technological practice, encouraging firms to better implement acquired knowledge to achieve sustainable entrepreneurial goals (Fernando et al., 2019). This moderating effect aligns with the proposition that GIT allows firms to use more efficient resources with low operational costs synced with sustainable principles. The results also show that GIT acceptance enhances a firm's environmental and technological knowledge, especially when combined with knowledge acquisition. This also shapes sustainable entrepreneurial behaviour and addresses the market's need for green solutions. The findings also support existing evidence that infusing GIT enables firms to implement knowledge successfully, building a sustainable competitive edge in eco-centric markets (Qinqin et al., 2023).

The results also demonstrate the positive moderating role of GIT acceptance between knowledge dissemination and entrepreneurial sustainability. We conclude that GIT acceptance plays a significant role in making firms sustainable (Heredia et al., 2022). Green technology will help organisations share or transfer knowledge, which will enable individuals and organisations to learn more sustainable practices. Furthermore, knowledge without storage is useless for any organisation; thus, green technology will support firms in storing knowledge. Data analysis has shown that entrepreneurial manufacturing firms require green technology for proper knowledge application and storage to

Table 6
Direct effects.

Parameter			Estimate	t-stat	P
SEN	<—	KNA	.202	2.201	.028
SEN	<—	AUKN	.146	1.092	.275
SEN	<—	KND	.528	6.109	.000

Table 7
Indirect effects.

Parameter			Estimate	t-stats	P
ZSEN	<—	ZGITXAUKN	−0.027	0.241	.627
ZSEN	<—	ZGITXKNA	.167	1.973	.010
ZSEN	<—	ZGITXKND	.191	2.678	.007

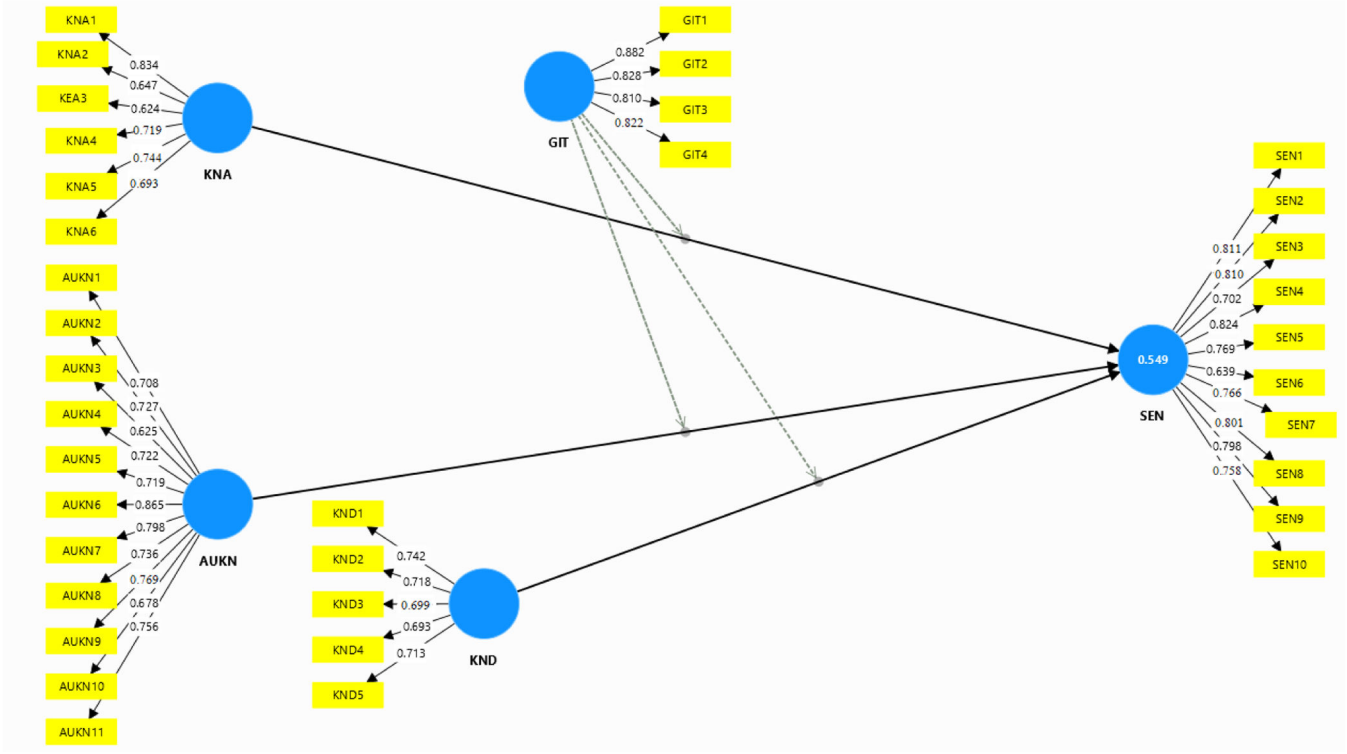

Fig. 2. Measurement model assessment.

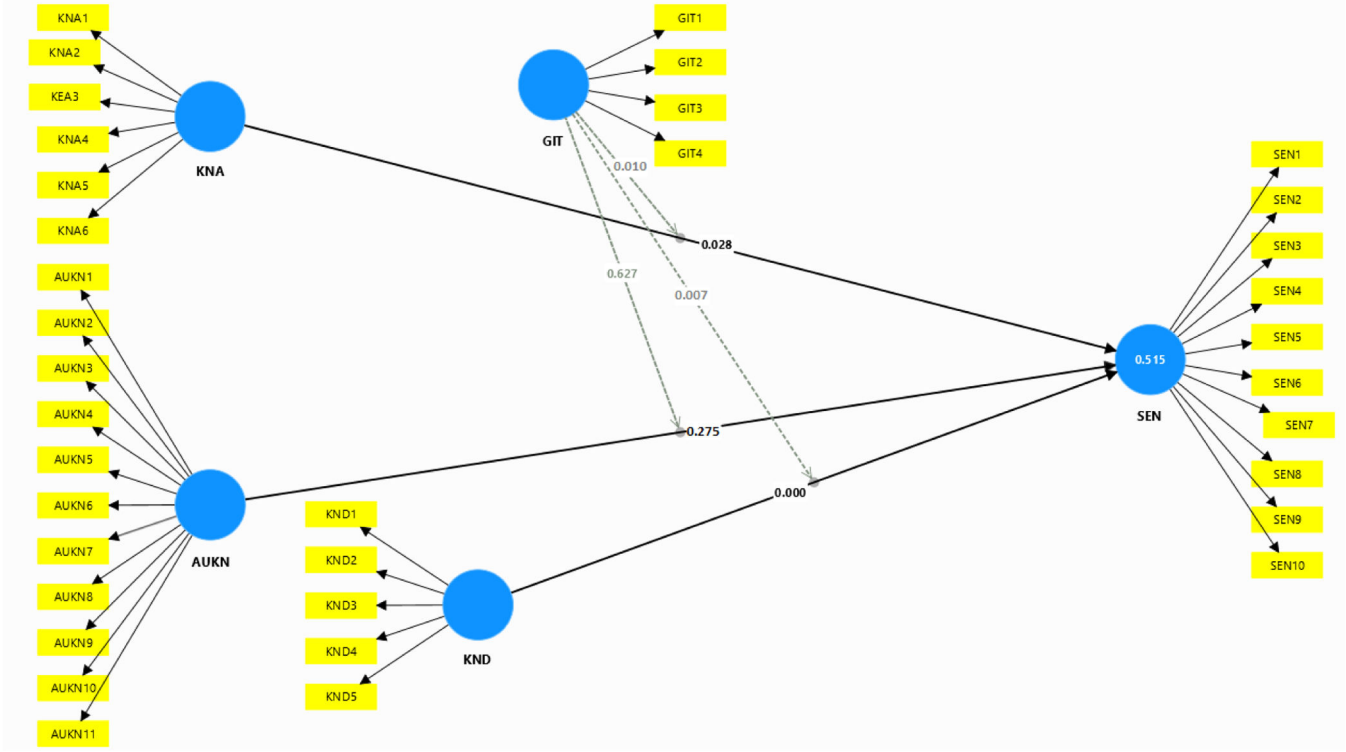

Fig. 3. Structural model assessment.

minimise negative effects on the environment (Chien, 2023).

This study's results show that GIT acceptance has an insignificant moderating role in knowledge application, use, and sustainable entrepreneurship. There are several reasons for this. It could be attributable to a lag in GIT implementation, as GIT systems cannot be fully and immediately incorporated into business operations. Hence, organisations take time to realise their potential effectiveness in strengthening the relationship, leading to insignificant findings. In addition, if entrepreneurs do not harness GIT's potential, it might be useless, even if they intend to implement GIT practices. In addition, if GIT acceptance is in the nascent phase in a particular region or sector, then its lower adoption is more likely to minimise its effect on the relationship between knowledge management and sustainable entrepreneurship (Dat et al., 2022; Hutasuhut et al., 2022). Also, if organisations have sustainable knowledge but cannot use it properly through GIT practices, that knowledge might not offer the same benefits (Dvorský et al., 2023).

Implications

In light of these findings, this study offers meaningful theoretical implications by using KSTE to explain the relationship between knowledge-management practices, GIT acceptance, and sustainable entrepreneurship. Since our findings align with the theoretical proposition, GIT acceptance can enhance the effectiveness of the knowledge-management process by providing a conducive environment for promoting sustainable knowledge. This knowledge further refines sustainable entrepreneurial models. Since the findings reveal the influence of contextual factors on GIT acceptance, knowledge spillover can be expanded if entrepreneurs fully recognise the genuine role of GIT acceptance in shaping the knowledge-management process. With this expansion, firms could incorporate other digital tools that promise sustainable entrepreneurship. This research also has significant implications for the sustainability literature. Governments, NGOs, organisations, and other regulatory bodies seek to design, implement, and integrate strategies and policies that minimise negative effects on the environment. Since businesses have massive effects on economic growth, there is a need to integrate such policies or activities into operations for greater environmental sustainability. Firms face tremendous pressure to deal with environmental crises, and guidelines are needed to tackle these issues. In this study, the importance of the knowledge-management model and GIT for sustainable development helps establish guidelines for industrialists, policymakers, and governments. This study highlights the positive role of knowledge-management processes, such as knowledge acquisition, dissemination, use, and application, in the entrepreneurial ecosystem. Firms that use this model can implement sustainable policies in their operations. This study can guide policymakers in developing policies related to sustainable entrepreneurship using effective knowledge creation, GIT, and knowledge use. This study also suggests that firms with GIT can encourage and motivate the adoption of environmentally friendly policies. We determine that industries utilising green technology enhance their knowledge-management process. These processes help industries tackle environmental crises and encourage the proper utilisation of resources to deal with the depletion caused by increased population growth.

Conclusion

Economic crises, unemployment, natural disasters, poverty, and climate change are at the top of the sustainability agenda. However, the actions of entrepreneurial firms are associated with negative social effects, climate change, and global warming. This study, therefore, focuses on sustainable entrepreneurship in SMEs. In our study, the role of the knowledge-management model is analysed in terms of sustainable entrepreneurship. The results indicate that knowledge acquisition and dissemination have positive effects on firms' sustainability. This indicates that knowledge creation in firms helps them add more information to existing knowledge or replace existing information, because it allows organisations to learn more about sustainability and has positive effects on them. Moreover, our results indicate that knowledge transfer and storage positively affect entrepreneurial firms' sustainability. This

implies that knowledge transfer occurs between individuals or groups of people, which helps them share and transfer knowledge and green ideas to make their firms more sustainable. Furthermore, knowledge application and use are insignificant for making organisations sustainable. In conclusion, knowledge without application or proper use is useless; thus, it is important that entrepreneurial firms properly apply and use knowledge primarily related to sustainability to make them environmentally friendly. Moreover, the moderating role of GIT acceptance is analysed in terms of knowledge creation, knowledge transfer and storage, knowledge application and usage, and sustainable entrepreneurship. The findings suggest that GIT acceptance positively moderates the relationship between knowledge creation and sustainable entrepreneurship. Green technology stimulates the knowledge-creation process in firms so that employees and management focus more on green or sustainable activities, thereby eradicating negative effects on the environment. GIT acceptance also influences the relationship between knowledge transfer and storage and sustainable entrepreneurship. Green technology allows entrepreneurial firms to share and store their green knowledge, and through sharing and transferring, industries can implement more environmentally friendly operations. Furthermore, GIT acceptance insignificantly moderates the application and use of knowledge and sustainable entrepreneurship. It has been argued that knowledge has no benefit if it is improperly applied or used. With the acceptance of GIT, firms are encouraged to use knowledge applications properly in their processes to become environmentally friendly. To make entrepreneurial firms sustainable, it is important that organisations focus on knowledge management and green technology. These insights highlight the need to balance knowledge-management strategies, which is possible only through continuous acquisition and dissemination. Without it, its transformative effects limit sustainable entrepreneurial growth. Furthermore, with the acceptance of GIT's role in a firm's sustainable operations, the benefits of knowledge acquisition and dissemination can be amplified. However, this might not always ensure successful implementation because the presence of other factors might share the burden of effective utilisation.

Limitations and future research

Owing to time and resource constraints, this study has several limitations that can serve as guidance for future researchers. First, it only considers manufacturing SMEs in Malaysia, which limits the generalisability of the findings. The scope of this study should be extended by considering a diverse set of economies with one end goal—a more thorough understanding of the model. In addition, this study considers GIT acceptance as a moderator. Moderators such as GIS can be used in future research to contrast the findings regarding whether the technology itself is sufficient to support a sustainable agenda or whether GIS broadens the horizon, as is evident in the literature. This study considers only three dimensions of knowledge-management processes. In the future, more variables, such as knowledge protection and security, should be added to the framework of sustainable entrepreneurship to analyse the overall effect of the knowledge-management model. In addition, other sets of variables should be considered as mediators, such as individuals' personality traits or absorptive capacity, as they play a significant role in implementing effective knowledge-management processes.

CRediT authorship contribution statement

Muhammad Sadiq: Formal analysis, Data curation, Conceptualization. **Thuy Dung Pham Thi:** Software, Methodology, Investigation. **Chi Minh Nguyen:** Writing – review & editing, Writing – original draft, Visualization. **Hai-Dung Do:** Visualization, Validation, Supervision, Project administration.

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