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Unearthing the Interplay between Organisational Resources, Knowledge and Industry 4.0 Decision Support Tools to achieve Sustainability and Supply Chain Wellbeing

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Abstract

Due to increasing supply chain disruptions and stakeholder demands for more environmentally friendly business models, managers are searching for ways to ensure sustainability and supply chain performance. We propose supply chain well-being (SCWB) as a new concept that offers a more comprehensive way of managing supply networks. Similarly, the opportunities for SCWB and sustainable business performance (SBP) are facilitated through the application of Industry 4.0 (I4.0) data-driven analytical decision support systems (ADSS). In this context, our study examined the role of ADSS in fostering SBP and SCWB by integrating the theoretical perspectives stemming from organisational information processing theory (OIPT), Resource-Based View (RBV) and the Knowledge-Based View (KBV). Our conceptual model was tested on 350 Vietnamese manufacturing SME managers using covariance-based structural equation modelling. The findings highlight the importance of understanding how tacit resources are generated, stored, and analysed for effectively leveraging I4.0 decision support tools. This paper contributes to the existing literature in several ways. First, we extend the supply performance literature by proposing SCWB as a more comprehensive approach to managing supply chain networks. We also show how ADSS can be absorbed by SMEs and extend the OIPT literature by elucidating the role of knowledge sharing, generation, and analysis for information processing capabilities. The findings offer policymakers, technology providers and practitioners to focus on information processing fit for achieving SBP and SCWB.

Keywords: Industry 4.0; Analytical Decision Support Systems; Circular Economy, Sustainability; Supply Chain Wellbeing, Knowledge Based View; Organisational Information Processing; Green Operations

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Abstract

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1. Introduction

The disruptive events in the last decade have accentuated the importance of Small and Medium-sized Enterprises (SMEs) in economic performance as they facilitate value creation and employment generation proficiencies (OECD, 2016; 2020; WTO, 2020; Ndubisi et al., 2021). Disruptions also pose significant challenges for SMEs due to the limited available resources, market scope, complexity, and survival rate (Bartik et al., 2020; Paul, 2020; Klein and Todesco, 2021). For instance, Melynk et al. (2021) found that disruptions significantly impacted SMEs, especially smaller ones (1-49 employees). SMEs' survival rate in the UK after the first three years was less than 40%, before the pandemic with a decline of about 6.5% thereafter (ONS, 2021). The EU has had similar figures, with a failure rate of about 44% over five years in 2016 (Eurostat, 2019) and Vietnam at 61% (Rand and Tarp, 2020). These disruptions have also increased the vulnerabilities of SMEs supply chains increasing calls more ways to enhance sustainable business performance and SC performance (Rakshit et al., 2021).

SMEs tend to be less involved with environmental management practices and performance, especially in developing economies. Environmental initiatives are often perceived as expensive by SMEs, even when cost-cutting advantages are highlighted to them (Malesios et al. 2020; Shibin et al. 2020). The importance of SMEs in economic development, especially during periods of structural transformation, thus increases the need to understand how sustainable performance and supply chain well-being can be achieved. Tenets of sustainable performance (SBP) suggest that harmonising the financial, social, and environmental purposes of delivering business activities can enhance value maximisation geared toward sustainability (Moore and Manning, 2009; Chardine- Baumann and Botta-Genoulaz, 2014; Hussain et al., 2018 Kamble et al. 2020). Sustainable outcomes in SMEs depend on their ability to adequately balance economic growth, the environment's safety, and social progress (Zaid et al., 2018).

Supply chain performance in SMEs is also important for profitability especially due to the alarming rate of disruptive events (Arend and Wisner, 2005; Rossetti and Choi, 2008; Lui et al., 2021). Although several strategies have been proposed to strengthen SMEs supply chains performance including AI driven resilience (Dey et al. 2023), these strategies are frequently unit focused and do not consider supply chain performance from a holistic perspective. Measuring the performance-related aspects of a unit within a supply chain is a difficult challenge, owing to the intricate relationships between the members defined by the supply chain strategy used. Also, traditional SC performance metrics are considered narrow and do not consider emerging issues including sustainability and economic performance (Bayraktar et al. 2020; Kuhnen et al. 2022; da Silva et al., 2022). To this end, we propose the concept of supply chain well-being (SCWB) defined *as the assessment of the overall health of the SC*. The core elements include the economic performance of the focal firm and its suppliers, resilience, due diligence, and SC partnerships. As such, we argue that to effectively assess the performance of a supply chain, considerations need to be given these core elements. SCWB integrates several facets of supply chain performance to support the increased call for research (Ivanov, 2018; Jabbarzadeh et al., 2018; Bag et al., 2021; Negri et al., 2021; Weiland, 2021).

Industry 4.0 has demonstrated to be successful in providing several benefits to businesses of business benefits such as operational optimisation and value chain optimisation. SMEs are being transformed by employing I4.0 technologies such as AI-powered decision support tools (Ulas, 2019; Hansen and Bøgh, 2021; Drydakis, 2022). The research indicates the benefits of employing AI powered solutions in SMEs include obtaining a competitive edge and enhancing sustainable business performance through intelligence gathering, underpinned by its decision-making capabilities (Chan et al., 2018; Behaldi et al., 2021; Kumar and Kalse, 2021; Dyrdakis, 2022). I4.0-enabled analytical decision support systems (ADSS) as an AI-based application have been conceptualised to benefit firms in several ways, including the capacity to tackle multifaceted decision environments and enhance performance outcomes (Gunasekaran et al., 2017; Zhu et al., 2018). ADSS is an expert AI-powered application tasked with decision-making through knowledge simulation and reasoning (Fertier et al., 2020). Given the prevalence of disruptive events, it is pertinent to establish ADSS for dynamic operations in SMEs. Moreover, the evolution of AI in the form of novel generative AI models (such as ChatGPT and Bard) will open transformative opportunities for SMEs across the world

(Budhwar et al., 2023), irrespective of the sector and size of the organisation, both innovating and disrupting supply chain mechanisms and practices (Ritchey et al., 2023).

Due to the complexities and costs involved in adopting I4.0 enabled tools, it is pertinent to understand how to successfully integrate these technologies within SMEs for enhanced sustainable and supply chain wellbeing outcomes. There are limited studies that provide a holistic theoretical framework to support this discourse. Some studies consider I4.0-enabled tools; tangible and implicit resources capable of facilitating sustainable practices and supply chain performance (Dubey et al., 2019; Nandi et al., 2020; Shibin etal. 2020; Bag et al., 2021). However, some of these studies fail to consider the effective harnessing of skills and knowledge transfer mechanisms (Baadallah et al., 2021; Chatterjee et al., 2021). Lopes de Soussa Jabbour et al. (2018) demonstrated the need for knowledge to successfully integrate I4.0 tools in enhancing circular economy practices. Thus, if organised effectively, tacit resources such as information and knowledge can enhance business performance. In this context, Industry 5.0 (I5.0) a relatively new term and emerging concept coined by the European Commission which complements Industry 4.0 frameworks. The literature is also scanty on how SMEs measure the successful absorption of I4.0 enabled tools. To this end, we argue that the absorption of I4.0 enabled tools (ADSS) requires understanding the fit between the organisation's resources and its processing requirements (Chatterjee et al., 2021). It simply indicates that an organisation's ability to satisfy its requirements through available resources improves performance by understanding the needs for the information processing systems.

In view of this, we propose a comprehensive theoretical framework that integrates the resource-based view (RBV), the knowledge-based view (KBV) and the organisational information processing theory (OIPT). The aim is to demonstrate how SMEs can harness their resources and knowledge-sharing capabilities to achieve SCWB and SBP through industry 4.0 (ADSS) tool. By this, we contribute to the literature by evaluating the conditions for ADSS adoption and its role in enhancing sustainable SCWB and SBP. This study shows that SCWB and SBP are hierarchal, involving decision-making capabilities and sustainable operations. It entails understanding how organisational resources, knowledge, and capabilities (stemming from I5.0) are critical for creating value from I4.0 ADSS adoption. We argue that organisational resources and knowledge capabilities enhance the use of ADSS, which can be effectively used through adequately processing information. Our study contributes existing literature by addressing the following research questions:

1. What are the drivers of ADSS adoption for SMEs engaged in manufacturing activities?
2. What is the role of ADSS in enhancing sustainable business performance (SBP) and supply chain well-being (SCWB) for SMEs engaged in manufacturing activities?

The originality of this study in operations and supply chain (SC) management literature stems first from our attempt to provide a comprehensive approach towards the application of industry 4.0 (ADSS) in SBP and SCWB. Second, we provide a theoretical model grounded in the integration organisational information processing theory (OIPT), resource-based view (RBV) and the knowledge-based view (KBV) to explain how SME's can adequately harness the dividends I4.0 (ADSS) tools and its impact on the supply chain process. The study also introduces the concept of supply chain well-being (SCWB) as a more comprehensive approach to managing supply chain networks and provides an integrated framework that shows how SBP and SCWB can be achieved through ADSS. The findings from this study extend studies on SMEs by elucidating the role of knowledge-sharing capabilities in enhancing ADSS absorption. It highlights the importance of knowledge generation and analysis in building information processing capabilities. The findings will help policymakers, technology providers and supply chain specialists to focus on information processing fit to achieve the desired outcomes of SBP and SCWB.

The paper is structured as follows. In the literature review section (2), we model SCWB and SBP capability relationships. We also review the extant literature on the theoretical underpinnings supporting antecedents of analytical decision support systems and the outcomes to facilitate SCWB SBP. The research hypothesis is developed in Section Three based on the reviewed literature. The findings and results are presented in Sections four and five, respectively. In Section Six, we discuss our findings' theoretical and managerial implications. We draw our conclusion in Section Seven and provide agendas for future research.

2.Theoretical Background and Literature

Existing literature on ADSS in manufacturing SMEs provides limited knowledge of direct and indirect contributions to supply chain well-being (SCWB) and sustainable business performance (SBP). Also, considering that managers implementing these technologies must understand the possible outcome of their decision-making activities. The dividends of I4.0 decision support systems (ADSS) are beginning to receive significant attention in the operations management literature (Trunk et al., 2020). Hinged on recent discourse (Dubey et al., 2020), we argue that the contribution of organisational resources and knowledge sharing is critical to developing ADSS in SMEs. Similarly, SMEs' ability to process the information generated through ADSS is critical in efficiently developing supply chain well-being (SCWB) in complex and uncertain environments. As such, we integrate three theoretical lenses to form the foundation of our theoretical model. We draw insights from the resource-based view (RBV) to empirically examine the relationship between organisational tacit resources (skills, experiences and ideas) and ADSS absorption. The knowledge-based view (KBV) explains the link between knowledge storage, retrieval and transfer and ADSS; while the organisation information processing theory (OIPT) is used to argue that while resources and knowledge transfer are required for building ADSS adoption, its absorption and impact is mediated by understanding the fit (Chatterjee et al. 2021). Our underpinning theories and model are discussed below, and our hypotheses developed.

2.1. Resource-based view (RBV)

Tenets of resource-based view (RBV) argue that organisations can achieve superior performance by harnessing their resources and capabilities (Barney, 1991; Barney et al., 2001; Barney and Clark, 2007; Gunasekaran et al., 2017). These resources should be simultaneously valuable (V), rare (R), imperfectly imitable (I) (Barney et al., 2001; Sirmon et al., 2011). To this end, resources refer to tangible and intangible assets, including physical, human, and technological, that organisations possess or control to create value and grow (Barney et al., 2001). Similarly, the RBV strategy suggests that organisations focus on creating value that directly impacts their performance (Lonial and Carter, 2015). Value creating activities include supply chain (SC) strategies, sales, operations, technical know-how and services (Lepak et al., 2007), and value offerings include providing quality products. Based on the RBV, these activities and offerings are rooted in how organisations select and structure their resources for competitive advantage. Resource combinations offer great potential for competitive advantage and stimulate value for resource commitment (Hunt and Davis, 2012; Carter et al., 2017).

Analytic decision support system (ADSS) as part of an organisation's resource portfolio, when used in isolation, may not meet the criteria of RBV. Similarly, SMEs do not possess the resources for huge investments without considering the return on investments. However, limited studies have considered the impact of resource combinations on technological absorption. Some studies suggest that decision-making tools serve as strategic resources for organisations. Although RBV facilitates resources to achieve a competitive advantage (Gunasekaran et al., 2017), it does not explain how these resources are harnessed to enhance SCWB and SBP. It also fails to explain how knowledge generated are stored and shared to enable competitive advantage.

2.2 Knowledge-Based View (KBV)

Our study is also anchored on the knowledge-based view of the firm (KBV), which posits that organisations should be examined through their knowledge capabilities (Grant 1996; Eisenhardt and Santos, 2002). We considered the KBV an appropriate theory because it explains how organisations exist based on their ability to transfer knowledge (Bloom et al., 2014) effectively. From this perspective, knowledge is masked as information and know-how where an organisation's capacity to generate and transmit this knowledge can produce a competitive advantage (Chen et al., 2020). Thus, through KBV, organisations are conceptualised as brooders and initiators of knowledge (Chowdhury et al., 2022). Frequently combined with RBV, KBV has been widely applied in existing studies to identify organisations' aims in adopting digital technologies and the effect on their performance (Apraci, 2017; Di Vaio et al., 2020; Upadhyay and Kumar, 2020). Although these studies have focused on organisational resources, cultures, and technology acceptance, in these instances, KBV fails to capture the structure in which knowledge sharing facilitates decision-making capabilities.

Existing literature on KBV recognises knowledge sharing as critical in generating value capable of enhancing firm performance (Hansen et al., 1999). From this perspective, the categorisation strategy in knowledge sharing involves housing knowledge in accessible databases for reuse over time by members of the organisation. Analysing requires translating stored data into decision-making capabilities. Thus, ADSS will propel knowledge sharing propagation across the organisation through codification and analysing to promote decision-making capabilities. It should be noted here that from this perspective, knowledge and the appropriate structures required to facilitate knowledge sharing needs to be constructed to achieve value. Yet not every organisation possesses the capacity to organise knowledge effectively. Thus, organising knowledge can provide unique resources leading to sustainable business performance and supply chain well-being.

2.3 Organisation Information Processing Theory (OIPT)

Organisation information processing theory offers an insightful theoretical lens to understanding the absorption capacity of ADSS in facilitating business performance and supply chain well-being (SCWB). OIPT view organisations as information processing systems that carry out activities to effectively make decisions regarding complex tasks when faced with uncertainties (Eqelhoff, 1991; Mandler, 2002; Trentin et al., 2011; Srinivasan and Swink, 2017). From this perspective, organisations are characterised as open systems that strive to create value through curbing uncertainties in their decision-making processes (Galbraith, 1973). Thus, in information processing roles, managers must decide why they require data, the type of inputs required to generate the data, how these data are processed, knowledge, information and decision-making process (Hefner et al., 2021). The dimensions of OIPT include information processing capabilities, information processing requirements, and the fit between the two. Therefore, it is pertinent for organisations to understand all dimensions (Galbraith, 1973; Zhu et al., 2018).

An organisation's information processing requirements refer to the required information necessary to make decisions capable of achieving objectives (Prekumar et al., 2005). It implies the need for organisations to make decisions. With the call for SMEs to embrace CE practices and green operations as avenues to facilitate business performance and SC well-being within our study, we represent these as information processing requirements. On the other hand, information processing abilities are defined as the ability of organisations to collect, store, analyse, and communicate information to support decision-making (Tushman and Nadler, 1978). The digitalisation of business firms has given precedence to using technologies that collect and store vast amounts of data. These technologies allow organisations to capitalise and compete with their information processing capabilities. Managing such data and the ability to translate the data into insightful decision making requires advanced capabilities (Dubey et al., 2020). Given this, ADSS and its antecedents are recognised as information processing capabilities. OIPT also emphasises the fit between capabilities and requirements. It simply implies that an organisations' ability to meet its requirements enhances performance. For instance, it adopts an AI-related technology to enhance CE operations in a highly volatile environment. OIPT would posit that the information processing capabilities be matched with its requirements to mitigate uncertainties (Trunk et al., 2020). Organisations can enhance information processing capacity through investment in related information processing technologies (Srinivasan and Swink, 2017). Extant literature has used OIPT to demonstrate the advantages of information processing technologies in manufacturing operations, including efficient decision-making and resilience (Zhu et al., 2018; Dubey et al., 2020). However, OIPT posits that information processing abilities and associated outcomes may be affected (Chen et al., 2015; Zhu et al., 2018; Hefner et al., 2021). Several studies have used OIPT in collaboration with RBV to examine sustainable business performance. They are, however, saddled with mixed findings and do not consider the position of knowledge sharing capabilities for decision making. For instance, Sharma et al. (2021) used OIPT from an RBV lens to examine how digital technologies enhance the sustainable performance of manufacturers and found a mediated effect. Belhadi et a., (2021) examined the capabilities of AI tools in determining supply chain dynamism and resilience within an information processing system. Their study showed that AI's dividends on performance were a short-term and long-lasting impact on SCD; exploiting the full potential of AI capabilities was essential.

2.4 Supply chain well-being (SCWB)

We define supply chain well-being (SCWB) as assessing the overall health of the SC. Its critical elements include economic performance, sustainability, resilience, due diligence, and SC partnerships. One of the significant challenges of managing SCs is the presence of dynamic structures where the intersection of several elements of risk management, economic efficiency, circularity and sustainability is required (Ivanov, 2018). Extant research has demonstrated that organisations include sustainability elements in managing their SCs (Nair et al., 2015). Within these settings, they argue for the importance of sustainability for business continuity- a vital element of SC resilience (Tukamuhabwa et al., 2015; Ham et al., 2020).

SC resilience and sustainability have several overlapping elements (Chan et al., 2017; Ivanov, 2018). The globalisation of SCs has made its network structures critical to economic performance. It directly contributes to employment, access, and distribution of natural resources, which are the basic tenets of sustainability (Negri et al., 2021). Thus, in considering sustainable SC, managers focus on designing resilient SCs from an environmental, political, and societal perspective (Meinlschmidt et al., 2018; Jabbarzadeh et al., 2020; Negri et al., 2021). Further, understanding the economic environment in which SCs operates has not been considered hitherto (Ding et al., 2016). Economic performance has been suggested to reduce environmental externalities and includes government policies. The discussion around due diligence is also pertinent to the SCWB agenda. Although the pillars of sustainability emphasise aspects of due diligence, certain elements have not been considered within the supply chain discourse. SC due diligence refers to structures' organisations set up to prevent and remedy human rights risks and their impact (Hofmann et al., 2018). It includes tax compliance of your suppliers, exploitation, fraud, and corruption. Thus, it ensures designing the supply chain to mitigate issues that may arise with conflict minerals. Therefore, irrespective of how resilient a SC is, the inability of organisations to actively ensure the legitimacy of labour within their supply chain signals the absence of well-being.

Managing networks within SC are also essential to achieving SCWB. However, the literature on SC resilience suggests the role of collaborative practices, including trust, in facilitating networks and partnerships (Tukuhambwa et al., 2015; Dubey et al., 2020a; Yaroson et al., 2021). Within SCWB parlance, this element goes beyond SC resilience relationships to understand how networks are formed, the risks SC partners are exposed to, network nodes are formed, and the implications of supplier partnerships given sustainability agenda and interconnected economic performance. Given the above, we argue that the above elements are essential for the effective supply chain management. Yet existing literature generally considered them independently. In line with the survivability agenda of SCs (Ivanov, 2020), we advocate for SC well-being, a comprehensive approach to managing SCs. Here the focus transcends the capacity of SCs to anticipate and mitigate disruptions but the inclusion of sustainable production, supplier selection, environment performance consideration, due diligence and building SC sustainable partnership.

2.5. Sustainable business performance (SBP)

Sustainable business performance (SBP) refers to the integration of sustainable practices of an organisation (economic, social, and environmental performance) (Carter and Rogers, 2008; Chardine- Baumann and Botta-Genoulaz, 2014; Hussani et al., 2018; Kamble et al. 2020). Here economic performance entails the organisation's capacity for improvement financially that propels its position against its competitors (Zaid et al., 2018). The organisation's capacity for environmental safety refers to its ability to minimise waste, decrease carbon emissions, and reduce hazardous and toxic ingredients (Gong et al., 2018). Social improvements refer to the firm's reputation, its products and/service offerings from the perspectives of stakeholders, including employees, customers, and the public (Sharma et al., 2021). There is an increasing interest in how SMEs can attain SBP. There is, however, limited empirical evidence to help managers. Therefore, our study extends the existing literature by providing empirical evidence on the link between the factors facilitating SBP in SMEs.

2.6. Research Contribution

The increasing interest in employing Industry 4.0 enabled decision support systems (ADSS) to meet sustainable development goals linked with developing government initiatives in SMEs prompted this study. More specifically, there was a need to improve responsible material usage and lessen the environmental and societal effect of SMEs' operations (MacArthur 2013 and 2015). The link between I4.0 technology CE practices, risk management, supply chain dynamism and green operations on long-term company success has been described and, in many cases, objectively verified in the literature. However, research concentrating on SMEs' commercial operations (contributing negatively to the environment, not individually) especially in developing markets are limited. There is also no defined yardstick for measuring supply chain performance.

Given existing literature, we consider the information processing capabilities of ADSS by examining its antecedents and impact on SCWB through CE practices, green operations, risk mitigation and SC robustness. We use RBV in this paper to demonstrate the absorption of ADSS as a valuable resource that impacts SBP and SCWB. Thus, organisational resources and knowledge sharing mechanisms support the assimilation of ADSS, which facilitates CE practices, risk management strategies, green operations, and supply chain robustness. This in turn impacts SCWB. The organisation information processing theory also assesses the match between information processing requirements stemming from green operations, CE practices, risk management, supply chain dynamic and information processing capabilities as ADSS.

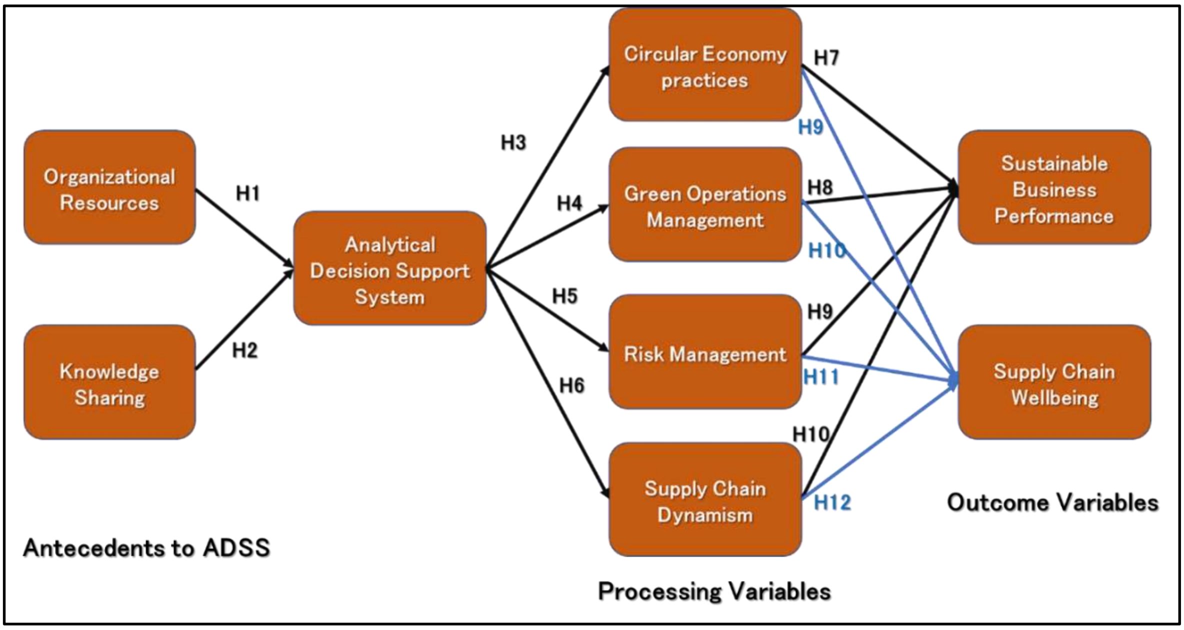

Figure 1 Theoretical Model
(blue lines signify the relationship to SCWB, differentiating it from SBP)

2.7. Theoretical model

We first determine the antecedents of ADSS by examining the role of organisations' resources and knowledge sharing capabilities. We also examine the information processing activities through circular economy practices, green operations, risk management and SC robustness. This study focuses on supply chain well-being and sustainable business performance as outcomes of the fit between ADSS and information process activities. In addition, we control for organisation size. A summary of the constructs is provided in Table 1.

Our theoretical model is presented in Figure 1.

Table 1 Defining constructs.

Construct	Definition	Authors
Organisational Resources	Based on the RBV, organisational resources refer to tacit resources including skills, competencies, technologies and capabilities.	Hun and Davis, 2012; Miklef and Gupta, 2021; Dubey et al., 2020; Bag et al., 2020; Gupta et al., 2020; Tseng et al., 2018
Knowledge Sharing	Based on the KBV, this construct measures the effective use of knowledge. It assesses how organisations store, transfer and use information capabilities to facilitate decision making.	Grant, 1996; Appelbaum, 1997; Arpaci, 2017; Bauer and Green1998; Kearns and Sabherwal, 2006, Blome et al. 2014; Wamba et al., 2020
ADSS	Following the OIPT, an I4.0 (ADSS) tool is an information processing resource. It combines decision support systems with computing, artificial neural networks (ANN), and intelligent agents, to provide powerful	Dey et al. 2023 ; Dubey et al., 2020 ; Bag et al., 2020 ; Gupta et al., 2020 ; Tseng et al., 2018 ;

	aids in solving difficult applied problems. They are often real-time, involve large amounts of distributed data, and benefit from complex reasoning.	
Circular Economy practices	CE practices involves the efficient use of material resources available by applying three basic principles: reduce, reuse, and recycle. In line with the OIPT framework, CE practices are information processing requirements. That is, I4.0 tools facilitate decisions making regarding CE practices.	Dey et al., 2020 and 2019 ; Saha et al., 2020 ; Bag et al., 2021 ; Soni et al. 2023 ; Wamba et al., 2023
Green Operations	Green operations are practices that contribute to the enhancement of environmental performance in companies' operations. In line with the OIPT framework, green operations are information processing requirements.	Dubey et al., 2020 ; Bag et al., 2020 ; Gupta et al., 2020 ; Tseng et al., 2018
Supply chain Dynamism	Supply chain dynamism is measured as a processing capability of ADSS. It is measured as the share of new products in relation to total revenue. It is the degree of the innovation frequency for products and service; and the innovation rate of operating processes	Lee et al., 2016; Inman and Green 2021; Braunscheidel et al., 2009; Bak et al., 2020; Belhadi et al. 2021; Queiroz et al., 2021
Risk Management	Risk management are practices used to mitigate reduce supply chain vulnerability and mitigate disruption impact. These practices such as identification, assessment, treatment and monitoring require decision making capabilities which can be enhanced using I4.0 decision support. Following the OIPT lens, RM strategies are information processing requirements.	Baz and Ruel, 2021 ; Yang et al., 2021 ; Ho et al., 2015 ;
Sustainable Business Performance	Sustainable performance is described as the alignment of financial, social, and environmental goals in the execution of core business operations to maximise value. In line with OIPT framework, SBP are outcomes of the fit between organisational resources and their information processing requirements	Dey et al., 2020 and 2019; Saha et al., 2020; Epstein and Roy, 2003
Supply chain Wellbeing	Assessing the overall health of the supply chain including economic performance, due diligence, sustainability, resilience and	Baz and Ruel, 2021; Wamba et al., 2021; Modgil et al., 2021a and

	partnerships. In line with OIPT framework, SCWB are outcomes of the fit between organisational resources and their information processing requirements	2021b; Weiland and Durach, 2021; Gu and Huo, 2021; Queiroz et al., 2021

3. Hypothesis development

3.1. Antecedents of analytical decision support systems (ADSS)

Consistent with RBV and KBV, we argue that antecedents of analytical decision support systems (ADSS) comprise two primary elements: organisational resources and knowledge sharing capabilities. The RBV perspective expresses the link between the value of organisational resources, capabilities, and competitive advantage (Barney et al., 2001; Barney and Clark. 2007). The value dimension of resources may include technology, workforce skills and the ability to harness these resources for desired outcomes. Workforce skills, data and leadership dimensions are categorised as organisation resources. They are termed as tacit resources as they cannot be seen but their actions felt.

The rise in digitalised business environments has lent itself to the knowledge of AI-application tools as tacit knowledge (Zhang et al., 2009; Yu et al., 2018). These skills are mainly programming, and data analytical skills and are deemed complex resources as it requires the coordinated effort of the workforce to harness its potential success. Also essential for the execution of ADSS are tangible resources such as data warehouses and infrastructure, cloud computing and data visualisation tools (Soriano et al., 2012; Dubey et al., 2019). This study argues that tacit knowledge (ADSS skills and techniques) are resources that provide a competitive advantage. To effectively reap the dividends of ADSS requires the ability to organise knowledge, identify accessible databases for employees and translate the knowledge generated into useable information for decision making. It is particularly relevant in SMEs due to their limited knowledge and concerns about understanding returns associated with these technologies (Moosmayer et al., 2020). We contend that harnessing the dividends of ADSS is dependent on the organisation's resource capacity and knowledge sharing abilities.

Given these arguments derived from the literature, we hypothesise the following:

H1: Organisational resources will significantly impact ADSS in SMEs.

H2: Knowledge sharing will significantly impact ADSS in SMEs

3.2. The link between analytical decision support systems (ADSS) and information processing requirements

Industry 4.0 (I4.0) tools such as ADSS contributions to SMEs' growth are gaining ground in the extant literature due to their desire to strategically compete using technology (Denicolai et al., 2021). ADSS as an AI-enabled tool has been seen to enhance CE practices (Khan et al., 2020; Awan et al., 2021; Bag et al., 2021; Edwin-Cheng et al., 2021), green operations (Wong et al., 2011; 2020), risk management strategies and SC dynamism (Belhadi et al., 2021). Researchers argue for optimising resources for CE practices by integrating AI-enabled tools in manufacturing operations, where knowledge sharing is required to achieve this (Bag et al., 2020; Charles et al. 2023). ADSS can be used to link information and material flow for circularity through recycling, reuse, and remanufacturing (Zeiss et al., 2021). Edwin-Cheng et al. (2021) showed that AI-powered tools as an information process capability supported firms' decision making towards circularity. Therefore, we employ an overarching theoretical lens centred on the organisation information processing theory (OIPT), where the resource-based view (RBV) and the knowledge-based view (KBV) explain the capabilities elements of information processing systems (Barney,1991; Barney and Clark, 2007).

H3: ADSS will significantly impact CE practices

Green operations (GO) practices are complex business decisions that entail greening an organisation's operational strategies in manufacturing, quality, logistics, and physical distribution for competitive performance (Famiyeh et al., 2018). These complexities are contingent on the nature and scale of businesses. The adoption of digital technologies (ADSS) can mitigate these challenges (Umar et al., 2022) by providing visibility and accurate data points for enhanced decision making.

H4: ADSS will significantly impact GO

Risk management strategies depend on multiple data points to make quick and adaptive decisions, which enhances the suitability for applying AI-powered technologies (Baryannis et al., 2019). It highlights the need for predefined communication conventions to facilitate knowledge-sharing capabilities for risk reduction (Sabahi and Parast, 2019; Zhang et al. 2023). Therefore, the processing capability of ADSS offers analytical tools to propel decision-making by analysing and monitoring potential threats (Dolgui et al., 2020). Consequently, the organisational capabilities of knowledge sharing are confirmed to enhance the capabilities of AI-powered tools, resulting in the early detection of risks (Belhadi et al., 2021). While there are many ways through which ADSS can be used in RM, the adoption is low and may be due to the absence of the ability to harness, store and process collected data for effective decisions. We expect a significantly positive influence of ADSS and RM.

H5: ADSS will significantly affect risk management strategies (RM)

Supply chain dynamism (SCD) entails the ability of supply chains to adjust in times of disruptive events (Weiland, 2020). It is measured as the variation rate in products or processes; the ability of organsiations to introduce new products (Lee et al., 2020; Benzidia et al., 2023). SCD is particularly relevant in ADSS as it influences the information sharing, quality and supporting technology (Zhou and Benton, 2007). The literature is extensive on the analytical capabilities of AI-powered tools in predicting the impact of disruptive SC events (Choi et al., 2018; Belhadi et al., 2021). Therefore, it suggests that organisations should improve their analytical capabilities to propel supply chain dynamism (SCD) by effectively harnessing their knowledge capabilities, thus strengthening existing information processing capabilities (Wong et al., 2020).

H6: ADSS will significantly affect supply chain dynamism

3.3. Outcomes of information processing capabilities

The OIPT theory posits that achieving desired outcomes requires organisations to match their information processing capabilities with their requirements (Trentin et al., 2011). We contend that achieving desired outcomes is dependent on the organisation's ability to understand how ADSS can effectively meet its requirements. This study categorises ADSS as information processing capabilities while circular economy (CE) practices, green operations (GO), risk management (RM) and supply chain dynamism (SCD) are classified as requirements.

CE practices facilitate the loopback of resources into the SC for more extended periods, and a key execution strategy is the successful selection of suppliers. Tenets of sustainability also suggest CE as a condition for meeting sustainable performance (Geissdoerfer et al., 2017) and resilience (Hussain and Malik, 2020). However, CE practices are plagued with several challenges, including capital costs, complexities in the supply chain, absence of collaboration, longer lead times, and insufficient information and skills (Jaeger and Upadhay, 2020). These challenges can be tackled using I4.0 enabled tools (Tseng et al., 2018; Nascimento et al.,2019, Agrwal et al., 2021; Gupta et al., 2021). ADSS supports sound decisions concerning investment costs, supplier selection and collaboration through enhanced visibility and information sharing (Dev et al., 2020; Belhadi et al., 2021). These activities enhance business performance, and as such, we hypothesise that

H7: CE will significantly influence SBP

Although the effectiveness of CE practices in achieving resilience is still at the nascent stage, it has gained momentum (Ivanov and Dolgui, 2020; Sarkis et al., 2020) and may be required as a yardstick for SCWB. For instance, Nascimento et al. (2019) demonstrated that AI-powered technologies could facilitate CE contributions to sustainable performance through remanufacturing. Nandis et al. (2021) found a significant relationship between AI-powered tools and CE to enhance resilience. Belhadi et al. (2021) found machine learning big data and fuzzy logic programming promising AI-powered tools for enhancing SC resilience by providing a decision support tool framework. Therefore, combining ADSS with CE practices could facilitate resilience (Fahinma et al., 2019). Thus, decision-making tools powered by AI (ADSS) are positioned to facilitate decisions on resilience and SCWB by adequately managing and utilising organisational resources so that the capabilities match the requirements, thereby influencing the desired outcome. To this end, we propose that:

H11: CE has a significant influence on SCWB

The environment dynamics and the pressure for firms to manage operations responsibly have moved towards green operations (Cherrafi et al., 2017; Siegel et al., 2019). In this context, green operations, entails reconfiguring organisations' operations to ensure the use of environmentally friendly resources. It has emerged as significant in the sustainability agenda (Wong et al., 2012). Evidence suggests a positive link between green operations and the sustainability agenda (economic, social, and environmental) (Cherrafi et al., 2017). The argument is that green operations (GO) provide processes to curb environmental damages caused by the various stages of production while satisfying the demand of stakeholders. For instance, Omar et al. (2022) found that by using industry 4.0 techniques, green operations enhanced the sustainable business performance of a sample of 234 manufacturing firms. Thus, honing organisational resources through its information processing capabilities could successfully enhance GO for sustainable business performance. Given the above, we hypothesise that:

H8: GO will significantly influence SBP

We also propose the importance of GO in SCWB. The contention here is that operational strategies focused on green operations would ensure consistency in supplier selection (Omar et al., 2022) for enhanced resilience and economic performance (Khan et al., 2021). Yu et al. (2021) showed that organisations could mitigate adverse disruptions and enhance business performance through GO by using resources effectively. Some studies have found an insignificant effect of GO on the social aspects of sustainability (Zaid et al., 2018; Khan et al., 2021). They explained that some aspects of GO, such as green purchasing and procurement, may be external to the current business environments, limiting organisations' control. It may suggest the importance of a close supplier network relationship in GO and SCWB. To this end, we propose that:

H12: GO has a significant influence on SCWB

Risk management (RM) strategies are often employed to evaluate and tackle risks cost-effectively (Wu and Blackhurst, 2009). These strategies involve identification, assessment, analysis, treatment and monitoring (Giannakis and Papadopoulos, 2016). The literature on investigating the link between risk management strategies (RM) and sustainable business performance (SBP) remains scanty (Krysiak, 2009; Giannakis and Papadopoulos, 2016). In most cases, RM is considered an element of sustainability as monitoring risk related to sustainability improves the sustainability agenda by eliminating the consequences of brand image or shareholder value. In other instances, RM is related to SC risk, focusing on cost minimisation, enhanced operational efficiency, improved responsiveness, and tackling complexity (Giannakis and Papadopoulos, 2016). Thus, higher levels of RM strategies enhance SBP. Empirical evidence includes the works of Shafiq et al. (2017), who investigated this nexus and demonstrated that when the perceived risk was high, there was more excellent monitoring of sustainable practices leading to SBP. Beske and Seuring (2014) explored the sustainability dimension to include risk management and proactivity. It, therefore, suggests a relationship between the variables, and so we propose that:

H9: RM will significantly SBP

Although there are no empirical studies linking RM strategies and SCWB, elements of SCWB, including resilience and sustainability, are wrought with mixed results. For instance, Wong et al. (2020) showed that SC resilience significantly contributed to RM. The authors argue that firms facing disruptions should enhance SC resilience for improved RM strategies. On the other hand, El-baz and Ruel (2021) showed that RM strategies enhanced SC resilience. The internal cognitive abilities developed through AI-powered decision-making tools regarding RM strategies' issues enhance resilience strategies, sustainability, and performance (Kamalahmadi and Parast, 2016; Wong et al., 2020; Belhadi et al., 2021). It may suggest a significant impact of RM on SCWB. We, therefore, hypothesise that:

H13:RM significantly influences SCWB

In measuring SCWB, due diligence entails effectively managing SCs to mitigate the issues relating to conflict materials (Smit et al., 2020). We argue that higher SCD increases SCWB through various routes. For instance, Wantao et al. (2019) found a positive impact of SC dynamics on resilience in examining the relationship between SC dynamics and resilience. Yu et al. (2019) also found a positively significant link between SCD and the financial performance of 241 Chinese companies. Their findings indicated that higher levels of SCD increased SBP and SCWB through improved resilience strategies.

Furthermore, Hoffmann et al. (2018) showed that compliance, commitment, and analysis were critical in implementing due diligence in SCs. Higher levels of SCD behaviours may reduce learning and collaborative practices, which influences SCWB. Existing studies also show that AI-powered tools facilitate supply chain resilience (Belhadi et al., 2021a)

H10:SCD will significantly influence SBP

H14: SCD significantly influences SCWB

4. Methodology

We utilized a primary survey-driven approach to validate the conceptual model (Figure 1) derived from our literature review, which integrates theoretical perspectives from RBV, KBV, and OIPT. This methodology is frequently used in existing studies that investigate the adoption of new innovations and their effects on organizations, employees, and other stakeholders within the supply chain. Considering the prevalent use of perception-based surveys in fields like operations, supply chain management, information management, and strategic management, we deemed this method suitable for addressing the research questions presented in our study.

4.1 Sample Selection

Vietnam stands out as one of the most rapidly advancing middle-income economies on a global scale, having an annual GDP growth rate of 7% over the last decade. Data from the World Bank reveals that the nation's per capita GDP surged roughly 2.7 times from 2002 to 2020. Furthermore, poverty levels have sharply declined, moving from over 32% in 2011 to currently under 2%. Impressively, Vietnam's economy demonstrated considerable resilience during the COVID-19 crisis, marking it as one of the rare nations — not just in Southeast Asia, but globally — to report positive GDP growth amidst the pandemic. With a vision set firmly on achieving a high-income developed status by 2035, the government, decision-makers, and a vast majority of enterprises (99% being SMEs) are channelling their efforts towards this goal. As per the Vietnamese General Statistics Office's 2020 report, SMEs constitute over 97% of all enterprises, providing employment to 60% of the nation's workforce. These SMEs predominantly operate in sectors such as trade, motor vehicle and household goods repair, manufacturing (with a notable emphasis on the food and beverage industry), and construction, as indicated by studies from Nguyen et al. (2020) and Dinh and Nguyen (2018).

Small and medium-sized enterprises (SMEs) form the backbone of the Vietnamese economy. Understanding the dynamics and decision-making processes within these SMEs can provide valuable insights into the larger industrial landscape of Vietnam. According to the practitioners' literature, government policymakers and the Vietnamese Chamber of Commerce have acknowledged the importance of implementing green and digital practices within the SMEs (98% of all enterprises in Vietnam) to develop closed-loop green supply chain. In this regard, the government has introduced several initiatives and reforms such as carbon pricing tools to reduce greenhouse gas emissions, carbon tax for businesses and economic incentives for low carbon businesses (VNT 2019; CEV, 2018). Vietnam Green Growth Strategy (VGGS) seeks to expedite economic transformation. Its core objectives are to utilize natural resources wisely, minimize greenhouse gas emissions by embracing and implementing advanced technologies, enhance infrastructure to boost overall economic efficiency, address climate change challenges, aid in poverty alleviation, and steer the nation towards sustainable economic growth. Additionally, the national strategy for environmental protection 2030, seeks to minimis the rising trends of pollution and environmental degradation, address pressing environmental concerns, progressively enhance and rejuvenate environmental quality, halt the loss of biodiversity, and proactively bolster our ability to respond to climate change.

The manufacturing sector in Vietnam is core to its economy. The manufacturing output in Vietnam for 2022 reached \$101.22B, marking a 12.3% rise from 2021. In 2021, the output stood at \$90.13B, which was an 8.59% growth from 2020. In 2022, Vietnam's manufacturing sector accounted for 24.76 percent of the country's total GDP. Additionally, Vietnam has become a leading destination for international investment, particularly in labour-intensive manufacturing, due to a blend of distinct advantages. These encompass its competitive labour costs, well-developed infrastructure tailored for exports, and a strategic geographical position along crucial trade routes, which makes it a attractive location of supply chain diversification (McKinsey, 2023). Moreover, the Vietnamese government has introduced the National Digital Transformation Programme, set for 2025 with a vision extending to 2030. This program encourages businesses to integrate cutting-edge technologies like AI, analytics, and IoT-based systems, enhancing their productivity, operational efficiency, and competitive edge. The goal of this digital initiative is for Vietnam to secure a place among the top 50 nations in the UN's ICT Development Index by 2025, e-government index be among the four leading countries in Southeast Asia, and placed among the top 40 countries on the Global Cybersecurity Index of the International Telecommunication Union.

As per the MIT Technology Review's Green Index rankings, which evaluate 76 global economies towards a green and low-carbon economy, Vietnam stands at 52nd for Climate Policy effectiveness, 70th due to its elevated carbon emissions, and 12th for implementing environmentally sustainable practices (Green Index, 2021). These positions indicate that while policies and initiatives exist to foster a sustainable, low-carbon economy, their adoption by business entities seems inconsistent, and their effectiveness appears lacking. For this study, we included the process intensive SMEs in Vietnam, whose business activities and practices contribute to environmental degradation and pollution, according to the UN climate change report (UN 2018), and therefore most likely to benefit from I4.0-driven CE practices. Vietnam is actively striving to incorporate Industry 4.0 solutions into its manufacturing sector. Given the country's focus on transitioning to more advanced manufacturing processes and integrating digital technologies, it becomes an apt location to study the impact of ADSS in SMEs, and how the digital transformation ca be achieved. While much of the existing literature focuses on more developed economies, there is a dearth of research focusing on emerging markets like Vietnam. The role of tacit resources, knowledge sharing, generation, and analysis could be different in Vietnam compared to Western countries, offering a distinct perspective on how ADSS tools can be effectively leveraged. The Vietnamese government has been pushing for technological and sustainability advancements in its industries. Understanding the role of ADSS in enhancing supply chain and business performance can guide policymakers in tailoring initiatives that drive businesses towards sustainability. Therefore, our study in the Vietnamese context enriches the body of knowledge and provides nuanced insights applicable to other emerging markets.

4.2 Research Design and data collection

A survey was administered to collect data from operations managers in Vietnamese SMEs from process-intensive sectors such as construction, manufacturing, agriculture and production systems for two reasons: (1) these sectors are the backbone of the economy in the sense that they contribute more than 60% to the GDP, a major source of employment for the current workforce, and practice both process and technological innovation; (2) they also are the sectors where CE adoption is critical to enhancing the sustainable performance of the enterprises by reducing waste (responsible management of waste generation and disposal through lean management practices) and optimise the usage of raw virgin materials and consumption (through closed loop supply chain practices), and ensuring the long-term viability and competitive edge of their operations.; (3) These sectors actively engage in both process and technological innovation, constantly striving to evolve and improve their operations, which will play a pivotal role in sustaining the livelihoods of a significant portion of the workforce; (4) As global emphasis on sustainability grows, stakeholders, including consumers, investors, and regulatory bodies, expect businesses, especially in these sectors, to adopt sustainable practices. Meeting these expectations is essential for business continuity and growth; (5) Embracing digitalisation and sustainable practices, offers these businesses a competitive advantage, setting them apart in the market and potentially leading to increased business opportunities and profitability;(6) As government ad policymakers tighten environmental regulations and digital transition, businesses in these sectors will be at the forefront of compliance requirements and urgent ned to evolve. Proactively adopting I4.0 and sustainable practices can help them stay ahead of regulatory changes and avoid potential penalties or operational disruptions.

Table 2 Description of data

Items	Key Figures
Target Sample Size	500
Incomplete responses	95
Unusable responses	55

Response validation criteria (Checking the internal response consistency)	Non-meaningful response to subjective questions; time is taken to complete the survey (not less than the threshold of 15 minutes); inconsistent responses to reverse coded items; contradictory responses to the same item rephrased and asked twice at different intervals within the survey (without changing the meaning and interpretation of the original item);
Eligible Responses	350 (sample adequacy statistically tested and is greater than the required sample), and in line with the recommendations proposed in Sideridis et al. (2014)
Managerial Role	All [business operations manager]
Years of employment (mean)	6.2 years
Years of managerial experience	3.8 years
Sectors	Manufacturing: 24% Construction:22% Agriculture: 36% Other production and similar (Oil & Gas, Transport, Industrials, Basic Materials, etc): 18%
SME Using ADSS	Average number of years: 4.4
SME Using CE	Average number of years: 5.2
Size of the organisation	Small (10-49 employees): 85% Medium (49-199 employees):15%

The survey comprised of various statements (proxies) measuring the key constructs of the study using a 5-point Likert scale (1 = completely disagree; 2 = disagree; 3 = neither agree nor disagree; 4 = agree; 5 = completely agree). The survey was piloted with a selected set of ten SMEs managers not participating in the final study by conducting a focus group. The SMEs' managers had more than ten years of experience working in the same organisation. The pilot employed a Delphi protocol, and four iteration rounds to ensure that the participants reached a consensus on the statements used to measure the constructs. The protocol also ensured that all participants would present their views and discuss the proxies because of the constructs used in the study to reach an agreement.

The pilot study played a pivotal role in our research by aiding us to: (1) Refine Proxies: We gained insights into the appropriateness of the proxies used in our research. This helped us fine-tune the language presenting these proxies and decide on a refined set of proxies to accurately gauge the constructs depicted in our model. Additionally, it opened avenues to potentially introduce new proxies based on feedback; (2) Clarify Terms: We verified that the terminologies and phrases used in our statements were lucid and unequivocal, ensuring that respondents comprehended them without any misinterpretation; (3) Establish Inclusion/Exclusion Criteria: Through our discussions, we validated the inclusion and exclusion criteria for the respondents and their respective business sectors. This was essential to ensure that our model would be applicable and relevant in the real-world context of the country, aligning with the nation's classification and representation of SMEs; (4) Validate Constructs: We ensured that the constructs used in our study resonated with the actual business practices in Vietnam. We found, for instance, that the majority of Vietnamese SMEs do engage with analytical decision support systems and lean into green management practices that align with the Circular Economy (CE) philosophy.; (5) Capture Contextual Nuances: Interacting with the group provided a rich understanding of cultural, economic, and industry-specific nuances, which are paramount for the effective application of any model in a region-specific context; Bridge Theory and Practice: The discussions helped bridge the gap between theoretical constructs and practical implementations, ensuring our research findings would be not just academically sound but also practically applicable.

The survey employed rigorous screening questions at the outset to ensure that all respondents met the following criteria: (1) Possessed 3-5 years of managerial experience within the same organisation, ensuring a thorough knowledge of the existing organisational strategies, processes, and performance measures; (2) Were familiar with the organisation's resource allocation and knowledge management strategies, particularly in adopting and utilizing analytical decision-support systems (ADSS); (3) Had an in-depth understanding and practical experience of implementing, using, and maintaining practices related to ADSS in a business operations context; (4) Regularly participated in senior management strategy meetings, ensuring they were informed about the company's overarching strategies, objectives, and priorities; (5) Were acquainted with the CE principles and practices in place at their organisation and understood the implications for business sustainability, operational performance, and resilience; Worked in an organisation that had integrated CE practices into its operational processes, symbolizing a commitment to lean and green philosophies for sustainability; Were in organisations that employed ADSS—including analytical tools, AI-driven systems, and other digital computational tools—to capitalize on data-driven decision-making; Were affiliated with organisations having a robust digital data management platform and strategy, aiming to aggregate data gathered from various sources; Were associated exclusively with SMEs; Played a pivotal role in the decision-making process regarding the adoption of new technologies; Had a track record of attending or undergoing training programs related to ADSS and sustainability practices, suggesting their proactive role in staying updated.

The reasons for conducting the study with managers are: (1) Decision-Making Insight: Managers are typically at the forefront of decision-making processes. Their insights can reveal how data analytics directly influence choices that affect sustainable business performance; Operational Oversight: With their comprehensive view of organisational operations, managers can provide a detailed perspective on where and how analytics drive efficiency and sustainability; Strategic Perspective: Managers can elucidate how data analytics aligns with the strategic goals of an organisation, especially those related to sustainability; Breadth of Experience: Their multifaceted roles expose them to various facets of the business, from operations to strategy to HR. This breadth can offer a holistic view of the impacts of ADSS; Change Management: Managers often are involved in change management initiatives. Their experience can highlight how data analytics facilitates transitions to more sustainable business practices; Evaluation and Feedback: Managers are usually involved in the evaluation of new tools and systems, making them apt respondents for feedback on the practical benefits and challenges of ADSS in the context of achieving SBP and SCWB. Stakeholder Communication: Managers often communicate with external stakeholders, such as investors or partners. Their insights can reveal how ADSS impact these external perceptions and relations in the context of SBP and SCWB initiatives and practices. Risk Management: Given their role in assessing and mitigating risks, managers can provide valuable insights into how data analytics can predict, highlight, or manage digital transformation and sustainability-related risks; Resource Allocation: Understanding where and how resources (both human and capital) are allocated can shed light on the importance and impact of ADSS in driving sustainability initiatives; Training and Development: Managers often identify training needs making them keenly aware of knowledge gaps, and sources that can be most beneficial for sustainable growth.

The data captured was analysed using the Partial Least Square-Structural Equation Modelling (PLS-SEM) technique which is popular in the business and management domain to test and analyze the relationships between observed variables (indicators) and latent variables (constructs) in a theoretical model grounded in the literature, and using quantitative data captured to measure the variables (Hair et al., 2021). Unlike multiple regressions which can handle one dependent variable at a time, PLS-SEM can handle multiple interrelated dependent relationships, analysing several regression equations simultaneously. PLS-SEM is adept at modelling constructs that aren't directly observable but are inferred from other observed variables (proxies used to measure them), similar to the ones used in our research. SEM also provides various indices (like the Chi-square, RMSEA, CFI, and others) that help in determining how well the conceptual model fits the observed data, i.e., the validity of the model. SEM also integrates confirmatory factor analysis (CFA), allowing for the validation of measurement models before proceeding to test the structural model (Ringle et al., 2020). In the context of our study, SEM is suitable because it allows for the modelling of complex interrelationships between antecedents to ADSS, and its potential impact on SBP and SCWB.

We introduced a manipulation to ensure that the study worked effectively, i.e., respondents read the study objectives and answered the survey correctly. This check provides confidence on the design of the study. The manipulation check took the form of multiple-choice questions, asking participants to: (a) identify the context of the study; (b) stakeholders of the study; (c) meaning of ADSS; (d) industry being studied. We found a robust and statistically significant correlation between the choices made by participants and the expected responses. This indicates that the research study interpreted by the participants as intended. Respondents answering any one of the questions wrong, were deemed unsuitable to be included in the final analysis. To ensure that the respondents were attentive to the instructions provided, read them, and answered the survey thoughtfully, we had introduced one reverse scaled statement in selected constructs, same statement rephrased and asked twice, open ended question requiring respondents to insert specific terms in the text box, and calculating response time (threshold set to 10-12 minutes based on a pilot conducted before the experiment). After imposing the attention check, responses collected from 350 participants were deemed suitable for further analysis (Table 2).

After administering the manipulation checks, we shifted our focus to assessing the equivalences within our sample to ensure that there aren't substantial differences in participants' baseline understanding and perceptions about ADSS, CE, sustainable business performance and SCWB, that could influence the outcomes of the study. We carried out a Chi-squared test for independent samples to assess the differences in knowledge, awareness, and understanding among participants across various age groups and years of experience. For each test criteria (e.g., ADSS knowledge), during the screening process, we selected participants, who scored either a 4 (very good knowledge) or 5 (excellent knowledge). Therefore, 4 x 2 contingency table was set-up for df =3. Our analysis revealed no statistically significant discrepancies in these areas ($p > 0.05$). This consistency suggests that participants exhibited a uniform baseline of knowledge and comprehension, ensuring that their responses were not skewed by varied levels of familiarity or expertise. Such a homogeneity in participant understanding is crucial as it allows us to attribute observed effects more confidently to the phenomenon being studied, rather than to individual differences in background knowledge.

For this study, we have followed the definition of SMEs put forward by the Vietnamese National Assembly (Law 04/2017/QH14 – SME law), i.e., employing not more than 200 employees, total turnover does not exceed VND100 billion (for current and preceding year), and are registered with the state social insurance scheme. The purpose of the inclusion criteria was to select respondents with first-hand knowledge and the capacity to make decisions that could deliver meaningful information for analysis. The age of the organisations may influence innovation within the organisations, as it is linked with the availability of tangible and intangible resources (Wei et al., 2014), and this variable has been controlled in several existing studies through statistical measures and purposive sampling. In this study, we have used a final inclusion criterion (5 < SMEs age < 10) based on the input obtained in the focus group. The purpose was to sample organisations with similar economic characteristics and strategic alliances to implement and practice digital innovation and green practices, which could deliver meaningful information for analysis (Table 1). This will also ensure that the organisations have adopted ADSS and CE in their business processes (which is more recent, i.e., does not go beyond ten years)

5. Findings

5.1 Sampling Adequacy

The sample size (350 managers) used to validate the model was found to be adequate based on the recommendations in Wolf et al. (2013) and Sideridis et al. (2014) and similar studies reported in the literature. Furthermore, statistical analysis conducted using R with the aid of the software package semTools showed that a sample size of 246 (less than 350) will achieve desired statistical power (highly significant results). Furthermore, the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy for the model showed that the sample size is excellent for conducting SEM analysis (0.97). Bartlett's test rejected the null hypothesis, indicating that the constructs are suitable for SEM analysis to examine the causal relationships. To evaluate sample adequacy, we also utilized the G* power tool, conducting an F-test for linear multiple regression using a Fixed Model with R^2 deviation from zero, like the approach from Queiroz 2021a (refer to Table 2). This test determined a required sample size of 153 for a medium effect size of 0.15, an alpha value of 0.05, and a power set at 0.80, considering the seven predictor constructs in our model. Our sample size of 350 confirms the adequacy for validating our results. The chosen parameters and subsequent results align with the guidance offered by Kang, 2021, and Hair et al., 2013.

Table 2: G*Power parameters and output

Test Family: F tests

Statistical Test: Linear multiple regression: Fixed model, R2 deviation from zero.

Type of power analysis: A priori: Compute required sample size.

Input Parameters	Effect size f2 = 0.15 α err prob = 0.05 Power (1-β err prob) = 0.95 Number of predictors = 7
Output	Noncentrality parameter λ = 22.95 Critical F = 2.0732820 Numerator df = 7 Denominator df = 145 Total sample size = 153 Actual power = 0.9503254

5.2 Reliability and Construct Validity.

To ensure procedural accuracy, we began by validating the content through preliminary testing, crafting straightforward and clear statements. We highlighted the anonymity and confidentiality of participants' responses on the survey's introductory page to minimize potential biases driven by social desirability. The indicators for each construct were neither grouped nor labelled to further reduce potential respondent biases, as recommended by Parkhe (1993). Additionally, we employed reverse coding by using both positive and negative wording for the indicators, which helped in verifying the survey and in counteracting biases of agreement or disagreement.

We assessed the reliability of the constructs using Cronbach’s alpha, as suggested by Bollen (1989). Table 4 displays robust Cronbach alpha values exceeding 0.8, signifying the scales' high reliability. To confirm the proxy items' construct validity, we adhered to guidelines from Mackenzie et al. (2011), Schmiedel et al. (2014), and Chen and Paulraj (2004). We employed Exploratory Factor Analysis (EFA) using principal component analysis to gauge initial construct validity as per Chen and Paulraj (2004). This choice was rooted in our decision to derive the number of constructs and their corresponding proxies from existing literature. Consequently, we opted to devise a fresh measurement scale for our conceptual model instead of relying on pre-existing ones. Any proxies that cross-loaded across multiple dimensions were excluded, and we iteratively performed the PCA to achieve a robust factor structure. We have also used Herman’s single factor test by performing confirmatory factor analysis (CFA), loading all the proxies relevant for the study (obtained after the PCA) to a single dimension and examining the variance value proportion. The results of this analysis showed that the common methods variance (CMV) is 0.39, which is less than the threshold value (0.5) reported in the literature. Therefore, we consider that the potential impact of CMB calculated using CMV to be non-substantial.

Table 4 Construct reliability

Constructs	Codes	**alpha**	**CR**	**AVE**
Organisational resources	ORGS	0.895	0.902	0.537
Knowledge Sharing	KDS	0.902	0.914	0.569
Analytical decision support system	ADSS	0.897	0.905	0.546
Circular Economy Practices	CEP	0.878	0.89	0.536
Green Operations	GOP	0.905	0.91	0.592
Risk Management	RM	0.85	0.851	0.535
Supply Chain Dynamism	SCD	0.917	0.924	0.676
Sustainable Performance	SUP	0.904	0.92	0.622
Supply Chain Wellbeing	SWB	0.926	0.942	0.664

Given the different types of SMEs included in the study, consideration was given to the industry type as a control variable. After running the analysis, this variable did not show any significant relationships with the constructs and the changes in the standardised regression weights were 0.003 or less. Hence, the model presented in Figure 1 does not include the control variable for parsimony. All the items loading to the constructs had coefficients above 0.7, which is considered acceptable in the field (Queiroz and Fosso-Wamba, 2019).

5.3. Convergence and Discriminant Validity

We assessed the convergent validity of each dimension by computing the average variance extracted (AVE) from individual proxy loadings, as determined in the confirmatory factor analysis. Discriminant validity for each factor was derived using scale composite reliability coefficients (SCR), calculated from the AVE values. As illustrated in Table 5, the diagonal of the matrix presents the square root of the AVE for the primary constructs. With an AVE exceeding 0.5 and a CR surpassing 0.7 (as depicted in Table 3), these metrics fall within acceptable bounds, signifying the constructs' validity as per established literature. Furthermore, the square root of the AVE surpasses all inter-construct correlations, indicating robust discriminant validity, consistent with the guidelines from Chen and Paulraj (2004).

Table 5 Inter-construct correlations

	ORGS	KDS	ADSS	CEP	GOP	RM	SCD	SUP	SWB
ORGS	**0.732**	0.624	0.594	0.675	0.628	0.628	0.742	0.695	0.772

KDS	0.624	**0.754**	0.672	0.726	0.725	0.694	0.664	0.626	0.715
ADSS	0.594	0.672	**0.738**	0.715	0.648	0.628	0.746	0.728	0.774
CEP	0.675	0.726	0.715	**0.732**	0.625	0.679	0.742	0.684	0.765
GOP	0.628	0.725	0.648	0.625	**0.769**	0.659	0.764	0.783	0.727
RM	0.628	0.694	0.628	0.679	0.659	**0.731**	0.719	0.704	0.679
SCD	0.742	0.664	0.746	0.742	0.764	0.719	**0.822**	0.763	0.784
SUP	0.695	0.626	0.728	0.684	0.783	0.704	0.763	**0.788**	0.761
SWB	0.772	0.715	0.774	0.765	0.727	0.679	0.784	0.761	**0.814**

Before hypothesis testing, it's crucial to tackle potential endogeneity concerns, as emphasized by various researchers like Abdallah et al. (2015), Guide and Ketokivi (2015), and Kock (2022). To understand the causal dynamics of our variables, we employed the nonlinear bivariate causality direction ratios (NLBCDR) method proposed by Kock (2015). Our analysis produced a value of 0.87 for the NLBCDR, surpassing the deemed acceptable threshold of 0.7. This result supports the assertion that our proposed variables are free from endogeneity.

5.4. Goodness of fit

The assessment of the model proposed and fit of the data is tested using goodness-of-fit measures, which are presented in Table 6. Typical thresholds include goodness-of-fit index coefficients (GFI), Tucker-Lewis Index (TLI), and comparative fit index (CFI) with good fit for values above 0.9 (Malesios et al., 2018, Doll et al., 1994), and root mean square error of approximation (RMSEA) values below 0.08 (Hair et al., 2013). The $\chi 2$ /df ratio is advised to be under 3 (Kamble et al., 2018).

Table 6 Goodness-of-fit of the SEM model

	CFI	GFI	TLI	RMSEA	$\chi 2$ /df ratio
Model	0.912	0.904	0.907	0.031	2.047

5.5. SEM results

The standardised estimates from the SEM analysis are presented in Figure 2. The continuous lines with coefficients show significant relationships. The results of the hypothesis are presented in Table 7

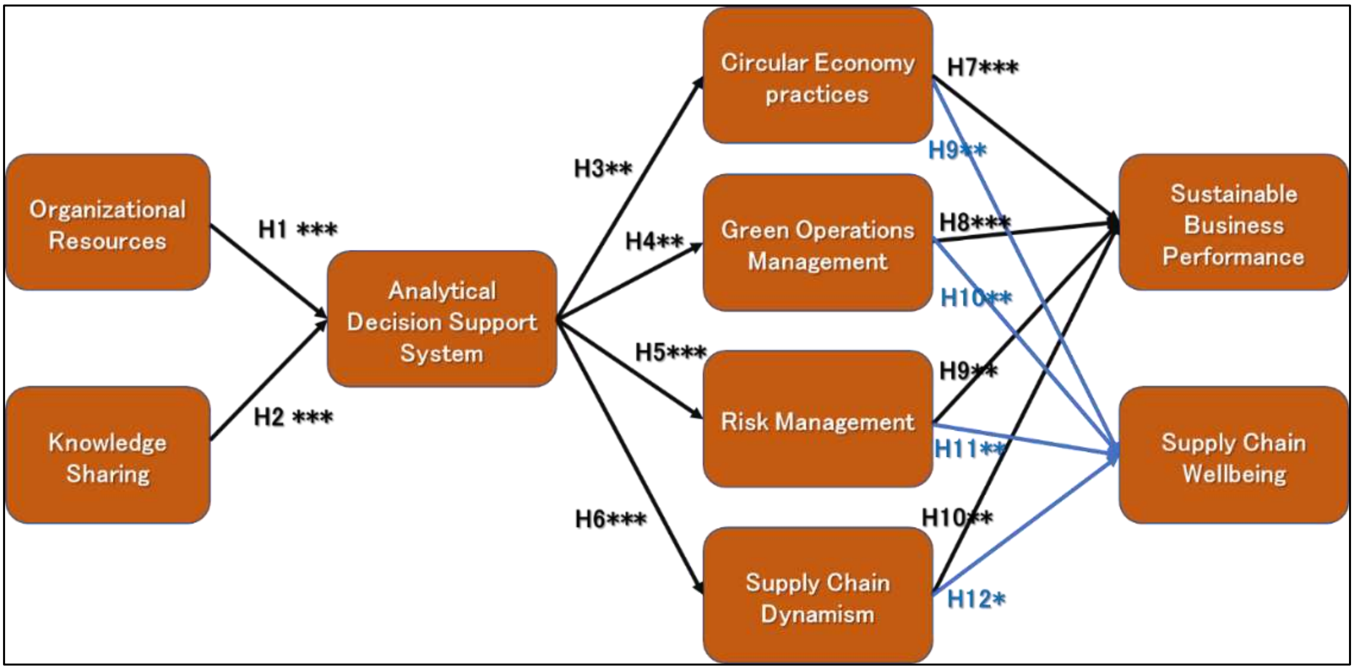

Figure 2: SEM Model Path analysis results (blue lines signify the relationship to SCWB, differentiating it from SBP)

Table 7: Hypothesis outcomes

Hypothesis	**Relationship tested**	**Beta Value**	**Significance (p value)**	**Outcome**
1	ORGS >> ADSS	0.481	0.001	Accepted
2	KDS >> ADSS	0.414	0.001	Accepted
3	ADSS >> CEP	0.372	0.001	Accepted
4	ADSS >> GOP	0.329	0.001	Accepted
5	ADSS >> RM	0.370	0.001	Accepted
6	ADSS >> SCD	0.485	0.001	Accepted
7	CEP >> SUP	0.295	0.001	Accepted
8	GOM >> SUP	0.249	0.001	Accepted
9	RM >> SUP	0.185	0.01	Accepted
10	SCD >> SUP	0.159	0.01	Accepted
11	CEP >>SWB	0.384	0.01	Accepted
12	GOP >> SWB	0.329	0.01	Accepted
13	RM >> SWB	0.475	0.01	Accepted
14	SCD >> SWB	0.174	0.05	Partially accepted

6. Discussion

This study integrated the RBV, KBV and OIPT to provide a comprehensive framework that examined the contribution of the I4.0 decision support tool (ADSS) in enhancing SBP and SCWB. Through the OIPT lens, we argued that understanding the antecedents of ADSS (organisational resources and knowledge capabilities) and its need (CE practices, risk management, SC dynamism and green operations) within an organisation is critical to its impact on SBP and SCWB. Our findings indicate that ADSS influences SCWB and SBP in SMEs if the information process capabilities are adequately matched with the information processing requirements. The starting point is identifying the antecedents of ADSS, as these constitute the organisations' information processing capabilities (Lenka et al., 2017; Hefner et al., 2021; Raj and Jeyaraj, 2022). These antecedents are organisational resources and knowledge-sharing capabilities. Our findings corroborate the study by Raj and Jeyaraj (2022), who highlighted the importance of expertise and absorptive capacity in enhancing industry 4.0 (ADSS) tools. These imply that the successful application of ADSS requires workforce skills and the capability to organise information generated for efficient decision-making (Hefner et al., 2021; Wantao et al., 2022; Modgil et al., 2023).

In line with OIPT, understanding organisations' information processing requirements (why ADSS is required) is essential. The literature highlights the role of I4.0 in enhancing circular economy practices (CE), risk management strategies (RM), green operations (GO) and supply chain dynamism (SCD) (Bag et al. 2021; Benzidia et al. 2023; Zhang et al. 2023). The argument is that ADSS can link information and foster firms' decision-making capabilities. Our findings support this as we find positive links between ADSS and CE (β =0.372, $P \leq 0.001$), RM (β =0.329, $P \leq 0.001$), GO (β =0.370, $P \leq 0.001$) and SCD (β =0.485, $P \leq 0.001$). It thus implies that ADSS are important for CE, RM, GO and SCD. Therefore, efficiently organising resources by SMEs, including storing, retrieving and transferring information for ADSS, led to enhanced CE practices, risk management strategies, green operations and supply chain dynamics.

We also show a 'fit' between organisations' processing capabilities and their requirements. Our findings confirm these assertations to show that leveraging the information processing capabilities of ADSS contributes to SBP and SCWB. Organisational processing requirements include establishing CE practices, redesigning operations, establishing sustainable risk management strategies and SC dynamism. A 'fit' between capabilities and requirements produces SBP and SCWB. However, understanding the nature of knowledge and the process required to transform learning is critical (Behaldi et al., 2021). Thus, CE practices powered by ADSS are essential in developing SCWB. Since sustainability is an important element of SCWB, if SME managers engage in aspects of CE practices such as remanufacturing or recycling, steps are being taken to strengthen the triple bottom line and SCWB. A positive link between CE practices to SCWB also demonstrates the importance of CE in promoting resilience (Nandi et al., 2021) and partner networks. Our findings also indicate a link between ADSS, SBP and SCWB to answer our second research question. In line with OIPT (Eqelhoff, 1991; Mandler, 2002; Trentin et al., 2011; Srinivasan and Swink, 2017), SBP and SCWB are outcomes of the fit between organisations' information processing capabilities and their requirements. Our findings, however, differ from the study by Qader et al. (2022) who found resilience as a mediator between I4.0 and supply chain performance.

The current environmental business challenges advocate for organisations' investment in capabilities that facilitate scanning and learning the environment for rapid adjustments during disruptions. Our findings partially support the hypothesis of a significantly positive link between SCD and SCWB at (p=0.05). The significant positive effect provides new insights into the influence of the external business environment on SCWB. It indicates that a better understanding of SCD directly affects the implementation of SCWB through resilience (Lee et al., 2016, Yu et a., 2019) due to diligence and supplier relationships. Therefore, to achieve SCWB, recognising the external environment's inherent functions and possible triggers is imperative. Our findings also suggest that through harnessing the capabilities of ADSS, SCD contributions to SCWB can be achieved. It implies that if ADSS is not adequately absorbed, it may not deliver the contributions of SCD to SCWB. Our findings thus extend the study by Yu et al. (2019), who posit higher dynamism in enhancing resilience.

Existing studies have examined the relationship between CE practices and some aspects of SCWB (Bag et al., 2019; Nandi et al., 2020; Sarkis et al., 2020). We adopt a comprehensive approach to measure SCWB and confirm a significantly positive link between CE practices and SCWB. Our findings suggest that CE practices provide possibilities for building supplier networks, economic performance and resilience while promoting sustainability. It requires acknowledging the role of suppliers' networks, due diligence, and collaborative practices and closing the loop of SCs to remain responsive amidst uncertainty (Dev et al., 2020). In line with the OIPT, the positive relationship between CE practices and SCWB reflects the fit between firms' processing capabilities (ADSS) and their desired outcomes. Thus, the impact of CE practices on SCWB can be achieved by leveraging internal resources and knowledge-sharing capabilities and supplier networks.

ADSS absorption capabilities further strengthen CE practices' impact on SCWB. It aligns with existing studies that advocate using AI-powered tools to enhance CE practices (Bag et al., 2020; Wilts et al., 2021). Our findings confirm these assertions to show that leveraging the information processing capabilities of ADSS contributes to SBP and SCWB. It can be achieved by investments in information processing capabilities such as ADSS (Baryannis et al., 2019). Thus, CE practices powered by ADSS are essential in developing SCWB. Since sustainability is a critical element in SCWB, if managers engage in aspects of CE practices such as remanufacturing or recycling, steps are being taken to strengthen the triple bottom line and SCWB. A positive and significant link between risk management (RM) strategies and SBP highlights improved internal cognitive skills and knowledge-sharing capabilities (Kamalahmadi and Parast, 2016; Belhadi et al., 2021). It illustrates the importance of information collaboration tools in risk reduction by using ADSS for data collection and analysis for effective decision-making. A critical perspective is a cognitive skill demonstrated through knowledge-sharing abilities and the capacity to harness organisational resources.

Our findings also show a significantly positive relationship between GO and SBP. It aligns with existing studies (Khan et al., 2021; Omar et al., 2022), where authors have elaborated on how GO enhances business performance through product quality, reputation and sales. Yu et al. (2021) showed that organisations could effectively use resources to mitigate risks and improve business performance through GO. Also, the positive influence of GO on SCWB depicts close relationships with the supplier network (Khan et al., 2021), proactive due diligence strategies, enhanced resilience approaches and economic performance (Dev et al., 2021). In addition, we found a partially positive and significant effect of SCD on SCWB. We may suggest a short-term impact as SCD is cyclical and occurs in shorter wavelengths (Weiland, 2020). Our findings are consistent with studies conducted by Wamba et al. (2020). Behladi et al. (2021) demonstrate the value of SCD in developing SCWB. However, existing studies suggest that the relationship between SCD and SWB may be non-linear, and its impact may be felt when disruptions occur. It may also indicate that due to the cost implications (Weiland, 2020) required for SCD, careful attention should be given to SCWB. Existing studies advocate using AI-powered tools to enhance CE practices (Bag et al.,2020; Wilts et al., 2021).

6.1 Theoretical Implications

The role of I4.0 enabled tools (ADSS) have in enhancing business outcomes is increasing in the operations and supply chain management literature. What is less understood is how these tools are successfully integrated to achieve sustainable performance and supply chain wellbeing especially in SMEs. In this study, a comprehensive theoretical framework is adopted to explain the process of integration and offers several theoretical implications.

First, the positive link between organisational resources, knowledge (drawn from RBV and KBV) and ADSS based our findings, establishes the antecedents of ADSS adoption. It implies that for SMEs to successfully adopt ADSS, there is a need to harness resources including skills and knowledge sharing mechanisms These insights imply that Vietnamese SMEs need to develop both technical and non-technical capabilities and knowledge creation, co-creation, dissemination, and evolution mechanisms, simultaneously within their organisations for effective and swift adoption of ADSS. This will lead to data-driven decision-making (by leveraging contemporary big data analytics and AI-based tools).

Second, our findings demonstrate that understanding the requirements for ADSS adoption is critical to its successful integration. Requirements in this case include CE practices, green operations, risk management strategies and supply chain dynamism. As such implementation of ADSS will help to influence green business practices, processes and operations efficiently, dynamically and with suitable risk mitigation strategies. These results imply that the superior computational and predictive ability of ADSS will facilitate dynamic decision-making within SMEs' supply chains. The notion of dynamic decision-making will help SMEs maintain agility in their operational processes and, at the same time, embed lean and green practices within these processes. For example, CE practices and green operations will drive lean management, just-in-time philosophy in the production, logistics and other operational processes, and flexible reconfiguration. In contrast, proactive risk management practices will leave SCs less vulnerable to disruptions and unprecedented events, increasing business competitiveness and productivity, resulting in resiliency. Since the SC is a complex system, ADSS can simplify operations by solving problems faster and more accurately while simultaneously handling large volumes of data, facilitating proactive risk management and dynamic decision-making in the supply chain to anticipated problems.

Third, our research introduces a novel avenue within the Operations and Supply Chain Management (OSCM) and broader management literature, by emphasizing the idea of Supply Chain Wellbeing (SCWB). This novel concept captures a more holistic understanding of supply chains, representing a blend of supply chain robustness, resilience, transparency, stakeholder/partner relationships, and supply chain diligence. Supply Chain Resilience, capability ensures that supply chains can maintain operations during times of crisis and uncertainty, minimizing the impact of such events and facilitating a rapid return to the pre-disruption state. It highlights the ability of a supply chain to withstand and recover from various shocks, be they environmental, political, or economic. In contrast, the concept of SCWB extends beyond mere resilience. While resilience is about reactive capabilities – responding and adapting to crises – SCWB is more encompassing. It focuses on the proactive assessment of the health of the entire supply chain ecosystem. By understanding Supply SCWB, ad how ADSS can help to monitor and strategize SCWB, we can gain insights into the current strengths, weaknesses, and capabilities of supply chain, and where strategic interventions are required. This comprehensive understanding encompasses various functionalities of supply chain management and respective stakeholders. For instance, transparency in the SCWB is concerned about the visibility across the supply chain, ensuring all parties are informed and can anticipate potential issues. Robustness touches on the inherent strength and sturdiness of the supply chain, ensuring its ability to function under a variety of conditions without significant degradation. Relationships with partners and stakeholders delve into the mutual trust, cooperation, and collaborative strategies which ensure a harmonious and effective supply chain network. Lastly, supply chain diligence highlights the meticulous care and conscientiousness in managing and overseeing the supply chain operations. In essence, wellbeing ensures SC is operating optimally, sustainably, and harmoniously in the first place. By introducing the idea of SCWB, our study suggests that for a truly sustainable and effective supply chain, organizations must move beyond mere resilience and invest in understanding and enhancing the overall wellbeing of their supply chain.

Finally, our research reveals a positive relationship between CE, GO, RM, SCD and SBP and SCWB. It demonstrates that adequately matching information processing capabilities (organisational resources, knowledge and ADSS) and its requirements (CE practices, GO, RM and SCD) enhances SBP and SCWB. These findings underline the intricate interplay between information processing capabilities – encapsulated by organizational resources, knowledge, and the Analytical Decision Support System (ADSS) – and the ensuing requirements brought about by practices in CE, GO, RM, and SCD. What emerges is a clear picture where aligning these information processing capabilities with the aforementioned practices leads to enhancements in both SBP and SCWB. At the heart of this relationship is the pivotal role played by ADSS. This system doesn't simply act as a tool; it serves as a catalyst, orchestrating and harmonizing various business and supply chain activities. The study unveils a hierarchical connection, showing that the pathway from Industry 4.0 ADSS to achieve SBP and eventually SCWB is tiered. This shifts the narrative around ADSS from being tools to being catalysts in the drive towards sustainable business and SCWB. By establishing the interconnectedness between CE, GO, RM, SCD, SBP, and SCWB, this study provides a holistic framework that integrates diverse aspects of business and supply chain management. Therefore, our study bridges potential gaps in the literature, offering a more comprehensive understanding of how different elements come together. The revelation that the relationship between I4.0 decision support tools, SBP, and SCWB is hierarchical adds depth to our comprehension of these processes. This contributes a layered perspective to the discourse, emphasizing the cascading influence of decisions made at every level.

6.2 Practical Implications

The findings of this research have several implications for managers. For instance, the study established the importance of resources, skills, knowledge sharing mechanisms and infrastructure for ADSS adoption. It implies that SMEs must create mechanisms that will facilitate the sharing, storing and evolution of knowledge about the use of ADSS. This will allow employees better understand the system's context of use, abilities, and limitations. The knowledge-sharing mechanism should also help create new knowledge that will help enhance the functionalities and capabilities of ADSS, better understand management strategies and initiatives, thus developing an optimal human-machine interface in the business environment.

It also highlights the importance of data management strategy. Data is a crucial ingredient due to the value of outputs from the ADSS depends on the types of input, their quality, relevance to the business question, objective and outcomes envisaged. The data management strategy differs from digital readiness assessment (organisational capabilities) in the sense that the former requires input on the following aspects, irrespective of the technology being used: mapping the relation between the availability of data and business case; mapping the volume and formats of data available to the algorithmic needs; understand the data ownership and governance strategy. The strategy should also consider (1) new data collection methods to collect data, which may be possible because of automation and drive new use-cases; (2) effectively and efficiently creating a data repository to digitise all the data.

Similarly, adopting ADSS will impact teams, individual employees, and consumers, which needs to be identified, understood, managed, and communicated across the department. Firstly, integrating design thinking and agile methodology will make these people an integral part of the development team and help them understand the strategic application of ADSS. Secondly, it will be essential to instil a data-driven culture within the organisation, where technology is used as a driver to augment human tasks and intelligence rather than completely replacing them; Thirdly, skills development of the current workforce prepare for the future hybrid workforce where ADSS and human beings will work side by side, and articulating the role and responsibilities of the employees in this new model, clearly and concisely is necessary.

The efficacy of ADSS deployment depends not just on the mere introduction of technology but also on the synergy between the technology and its human users. Central to this synergy is the role of tacit experience within organizations. Unlike explicit knowledge that can be easily documented, tacit knowledge is rooted in actions, experiences, emotions, values, and insights, making it challenging to formally articulate. For instance, an employee with years of hands-on experience using an ADSS and its variants might possess intuitive insights and knowledge nuances about the system, which aren't necessarily articulated in manuals or training documents. Such implicit knowledge or know-how, derived from prolonged engagement and understanding of the technology, is invaluable. It ensures a smoother technology-employee interface, streamlines troubleshooting, and can lead to innovative ways to optimize the technology. From the KBV perspective, such tacit knowledge is regarded as a pivotal asset, and underscores that a firm's competitive advantage isn't just rooted in its tangible assets but significantly in its knowledge reservoir. In the context of ADSS, tacit AI experience becomes an indispensable facet of this knowledge reservoir. By tapping into the reservoir of tacit knowledge, organizations can bridge potential gaps between technology and its users. This not only ensures optimal utilization of the technology but also fosters a collaborative environment where technology and humans cohesively work towards shared objectives.

7. Conclusion and Future Directions

This study was motivated by the increased interest to adopt Industry 4.0 enabled decision support systems (ADSS) to achieve sustainable development goals aligned with evolving government strategies in SMEs. More specifically was the need to enhance responsible consumption of materials and reduce the impact of SMEs' business practices on the environment and society (MacArthur 2013 and 2015). Existing literature has reported and, in many cases, empirically demonstrated the impact of I4.0 technologies and CE practices on sustainable business performance. They have examined the relationships between lean management practices, sustainable-oriented innovation, market pressure, digital readiness, government initiatives and information dissemination (related to the CE business model and cases). However, studies focusing on SMEs' business activities (contributing negatively to the environment, not individually), adoption maturity in emerging economies, and organisational capabilities' role in adopting analytical decision support systems have been less researched.

We developed a conceptual model to build upon the existing research and further extend these works. We validated it with 350 Vietnamese operations managers. Our findings showed that organisational (tangible and intangible) resources and knowledge-sharing mechanisms will influence analytical decision support systems adoption. We also found that such systems will positively impact CE, green operations, risk management and SC dynamism, which is essential to enhance sustainable business performance and SC wellbeing. Therefore, our work provides an initial step for researchers to understand how internal organisational capabilities and knowledge management can be combined to understand and examine antecedents influencing ADSS adoption in practice, resulting in organisationally valued outcomes.

SC wellbeing is a new concept introduced in our study that warrants further investigation. Future studies should focus on understanding the relationship between SC wellbeing and each dimension of sustainable business performance (economic, environmental and social). Furthermore, internal organisational factors (beyond technical infrastructure and digital platforms) influencing SC wellbeing should be examined to better understand the managerial responsibilities in this context. Such empirical insights will equip managers with information to develop strategies that will help create a collaborative and conducive working environment for adopting and managing circularity in business models. Case studies should be conducted to better understand the antecedents influencing SC wellbeing and its impact on SC due diligence (an emerging topic in operations management, while research has been chiefly outlined from a human rights perspective). Future studies should also focus on understanding the direct relationship between ADSS (I4.0 technologies) and SC wellbeing, which will help to understand the type of data sources, analytical frameworks, technology integration and computational algorithms required to enhance SC wellbeing. In summary, we recommend the following to critically study ADSS and its impact on SCWB further extending our conceptual model:

1. By exploring the multifaceted nature of SCWB, breaking down its various components and dimensions, it is essential to conduct a through analysis of how SCWB aligns with and impacts each dimension of sustainable business performance: economic, environmental, and social.
2. Understanding the role of management and leadership in shaping SCWB and facilitating its adoption and integration into daily operations across the supply chain operations.
3. Conducting studies that dive into what responsibilities managers should shoulder when considering SCWB, and examining how managerial decisions, strategies, and actions can foster or hinder the growth and adoption of SCWB.
4. Undertaking case studies to gain nuanced insights into the factors that precede and influence SCWB, and explore how SC due diligence, currently viewed largely from a human rights lens, intersects with SC wellbeing.

5. Conducting empirical studies to critically understand, how different data sources, analytical methodologies, technology integration practices, and computational algorithms impact SCWB.
6. Understanding how SCWB can be quantified systematically by organisations to better understand what can be optimised and how, clearly identifying the role of ADSS in such optimisation decisions and strategies.
7. Investigating the challenges faced by organizations to integrate ADSS into their existing systems and how these affect SCWB, especially how the cultural context of an organization or region affects the adoption of ADSS to ascertain the differential impact on SCWB.
8. Revealing the relationship between SCWB and supply chain resilience, and how SCWB can either enhance/diminish supply chain resilience in specific contexts and situations by using ADSS, and variability of such elements across different sectors and organisations of different sizes in the supply chain ecosystem.

Regarding limitations, the sample studied in our research may limit the generalisability of results. Although purposive sampling and inclusion criteria employed in our study have increased the internal validity of our investigation, this strategy may often determine external ecological validity, i.e., in other geographical locations and industrial sectors. We acknowledge that generalizability is a recurring issue in all survey-based research (including ours), which can be addressed by conducting more empirical investigations across the globe in other business sectors, which will aid in comparing the results (further contributing to the research in this area). However, while comparing these results emerging from different contexts and samples, recommendations and implications stemming from the findings should be applied cautiously to ensure ecological validity and replicability. he study was cross-sectional, capturing data at a single point in time. This may not account for changes in perspectives or shifts in trends over time. A longitudinal study might yield different or more profound insights regarding changes in SCWB and SBP over a prolonged period. Constructs like SCWB and sustainable business performance are multifaceted. While our study utilized certain indicators to measure these constructs, there might be other relevant indicators not captured, which could provide a more holistic view. The conceptual model validated in our study provides a pathway to further develop the research in this area, which will help organisations to improve their sustainable performance, technology capability and infrastructure, and change management, through evidence-based strategies conducive to the need of the organisations, sectors and their respective workforce.

Compliance with Ethical Standards

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Conflict of Interest:

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Ethical approval: All procedures (online survey) involving human participants were in accordance with the ethical standards of Aston University (Aston Business School) and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent: Informed consent was obtained from all individual participants included in the study at the pre-screening stage of the survey.

Data Availability Statement: The data that support the findings of this study may be available from the corresponding author upon reasonable request. The data are not publicly available due to [restrictions - containing information that could compromise the privacy of research participants].

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Appendix 1 Survey Instrument

Construct	Proxies measuring the construct	
Organisational Resources	• We have digital infrastructure to use decision support systems • We have human resources with suitable skills and competencies to use and implement DSS • We have a digital and data management strategy • My organisation has strong leadership to adopt and implement data driven green and lean practices	Miklef and Gupta, 2021; Dubey et al., 2020; Bag et al., 2020; Gupta et al., 2020; Tseng et al., 2018

	• My organisation has access to necessary knowledge knowledgebase to adopt and implement data driven green and lean practices • Specialised instructions and decision-making models are available to adopt and implement data driven green and lean practices • We integrate internal and external data with internal to facilitate high-value analysis of our business environment • We have explored or adopted cloud-based services for processing data and performing analytics • The organization has access to internal and external talent with the right technical skills to support digital implementation and tools • Our managers are able to understand business problems and to direct analytical initiatives to solve them • Our managers are capable of coordinating analytics-related activities in ways that support the organization, suppliers and customers • We are able to anticipate and plan for the organizational resistance to change • We are able to make the necessary changes in human resource policies for process re-engineering • In our organization we take bold and wide-ranging acts to achieve firm objectives • We have inter-departmental coordination and collaboration to collectively achieve business goals aligned to the priorities.	
Knowledge Sharing	• My organisation provides means and mechanisms to employees to share knowledge for digital analytics adoption • My organisation has means and mechanisms to store knowledge shared and disseminated among employees, for digital analytics adoption • My organisation has means and mechanisms to make knowledge accessible among employees, for digital analytics adoption	Grant, 1996; Appelbaum, 1997; Arpaci, 2017; Bauer and Green 1998; Kearns and Sabherwal, 2006, Wamba et al., 2020

	• My organisation has means and mechanisms to explore and experiment with the knowledge for digital analytics adoption • My organisation has means and mechanisms to apply knowledge in sandbox/pilot projects, for digital analytics adoption • My organisation recognises the importance of knowledge sharing within the teams for digital analytics adoption, integration and managing this change • My organisation has training programmes for employees' digital analytics education • My organisation has knowledge sharing workshops for employees' digital analytics education • My organisation has means and mechanisms for knowledge co-creation within teams in the context of technology adoption • I have attended training programmes through my organisation to gain digital analytics knowledge	
ADSS	Organisation has employed analytical decision support systems to • monitor and track products in the value chain • optimize resource utilization, e.g., using waste as a resource, optimal energy consumption • making decisions to support reuse and recycling practices • make green low carbon decisions • monitoring the environmental information (such as toxicity, energy used water used, air pollution) • attract new customers and understand their evolving needs • Making decisions related to business process reconfiguration (logistics/production • Understanding uncertainty in the dynamic market environment	Dubey et al., 2020; Bag et al., 2020; Gupta et al., 2020; Tseng et al., 2018
Circular Economy practices	• We work with clients/suppliers for ecological design of products/services • During the design stage we consider the possibility to reuse products after they have served their initial purpose	Dey et al., 2020 and 2019; Saha et al., 2020; Bag et al., 2021

	• We are using recycled materials as inputs in our processes • We have policy and practices in place to dispose machineries and equipment on time • We design our products for reuse, recycle and remanufacture • Manufacturing processes consider zero waste policy • Find ways to reintroduce end-of-life items into our supply chain or someone else's supply chain • Decrease the usage of non-recyclable raw materials in our processes	
Green Operations	• use renewable energy to reduce impact on environment • practices for reducing the consumption of energy in the production processes • employ just in time for eco-friendly forward and reverse logistics practices • practices to reduce impact on environment (water, air and noise pollution) • ensure that we use treatments and filtrations to extend the use of industrial resources (such as oils, acids, lubricants) • energy efficient manufacturing and production facilities • product designs consider eco-friendly manufacturing practises • replaced non-recyclable raw materials with renewable, recyclable or biodegradable inputs • rate our suppliers' compliances with environmental legislation	Dubey et al., 2020; Bag et al., 2020; Gupta et al., 2020; Tseng et al., 2018
Supply chain Dynamism	• Adapted SC processes to decrease lead times • Our operational processes can be easily reconfigured and optimised to cope up with uncertainties • Adapted SC processes to decrease new product • development cycle time • We have flexibility in planning and operations • We have flexibility in manufacturing / operations through layout and processes	Inman and Green 2021; Braunscheidel et al., 2009; Bak et al., 2020; Queiroz et al., 2021

	• We are able to satisfy evolving needs of consumers and trade partners in the context of environmentally friendly choices • Organization reacts immediately to incorporate changes into its manufacturing processes and systems • Production processes are flexible in terms of product models and configurations • Organization has the capabilities to meet and exceed the levels of product quality demanded by its customers • Organization has the capabilities to deliver products to customers in a timely manner and to quickly respond to changes in deliver requirements	
Risk Management	• We identify risks in our SC (short term and long term) • In the course of our risk analysis for all SC partners, we define early warning indicators • In the course of our risk analysis we analyse the possible impact of supply chain risks • In the course of our risk analysis, we classify and prioritize our supply chain risks • In the course of our risk analysis, we demonstrate possible reaction strategies • Supply chain risk management is an important activity in our company • In the course of our risk analysis, we evaluate the urgency of our supply chain risks • There is a systematic strategy to communicate the risk management plan to employees • My organisation performs period reviews of risks associated with physical and digital assets	Baz and Ruel, 2021; Yang et al., 2021; Ho et al., 2015;
Sustainable Business Performance	• We have reduced our manufacturing costs in recent years • We have increased average return on net assets from green products • We have reduced Inventory carrying cost. • We have reduced Cost of transportation and handling. • We have reduced business waste across our processes	Dey et al., 2020 and 2019; Saha et al., 2020; Epstein and Roy, 2003

	• We have improved compliance with environmental standards • We have decreased carbon emissions • We increased revenue from green products and practices • We have improved work safety in recent years • We have improved work environment in recent years • We have commitment from employees and managers towards incorporating environmental management We have created jobs to support the community and thus contributed to nation's entrepreneurial growth.	
Supply chain Wellbeing	• We are able to cope with changes brought by the supply chain disruption • We are able to adapt to the supply chain disruption easily • We are able to provide a quick response to the supply chain disruption • We are able to maintain high situational awareness at all • We are able to reconfigure business processes considering environmental issues to remain competitive in the market • We are able to trace and track the activities in our SC • We are able to maintain diligence in SC (e.g., ethical sourcing, environmentally certified suppliers). • We collaborate and cooperate with our stakeholders and partners to make SC efficient • We make stakeholders and partners an integral part of the decision-making process • We ensure to meet the needs of the consumers following ethical principles • We remain obedient to the government regulations and policies • We ensure that work practices in our SC is ethical (fair wages, fair labour and fair trade) • We assess third-party risk by understanding our firm's third-party universe.	Baz and Ruel, 2021; Wamba et al., 2021; Modgil et al., 2021a and 2021b; Weiland and Durach, 2021; Gu and Huo, 2021; Queiroz et al., 2021