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Digital Resilience in High-Tech SMEs: Exploring the Synergy of AI and IoT in Supply Chains

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Abstract:

This study investigates the transformative interaction among digital resilience (DR), Internet of Things-oriented supply chain practices (IoTP), AI-driven innovative practices (AIDIP), and sustainable supply chain performance (SSCP) in the context of the dynamic capability view (DCV) theory. Using empirical data from 293 high-tech SMEs in China that have adopted IoT and AI practices and analyzing it through partial least squares structural equation modeling (PLS-SEM), the results show that DR has a significant effect on IoTP and AIDIP improvement, which in turn positively influences SSCP. Notably, IoTP has a positive impact on operational efficiency and environmental sustainability, whereas AIDIP is also vital to resource optimization and predictive analytics. Moreover, SCD moderates the relationship between DR and IoTP, which amplifies the effectiveness of digital practices in dynamic environments. These findings have major implications for integrating digital technology with adaptive capacities in improving supply chain resilience (SCR), efficiency, and sustainability. However, since the sample is limited to Chinese high-tech SMEs with confirmed adoption of IoT and AI practices, the generalizability of the findings to other firm sizes or geographies should be approached with caution. The current research thus fills the gap between theory and practice and provides managers and policymakers with actionable insights while prescribing a robust framework for navigating the complexities of contemporary supply chain management.

Keywords: Digital Resilience, Internet of Things-Oriented Supply Chain Management Practices, AI-Driven Innovative Practices, Supply Chain Dynamism, Sustainable Supply Chain Performance.

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1 Introduction

In the modern era of fast technological strides and integrated world markets, building resilience and sustainability in supply chain management has been a strategic imperative for organizations to gain an advantage in the competitive market space (Susitha et al., 2024). Ali et al. (2023), emphasized that integration of digital sustainability strategies with supply chain management is increasingly affected by global uncertainties and disruptive technological changes. So, it is quite understandable that contemporary supply chains are confronted with increased complexity (LeBaron, 2021). These findings increase this complexity, propelled by consumer expectations, decreasing product life span, globalization's vast implications, and the disruptive aspects triggered by global uncertainties. Those disruptions also include public health crises, in other words, outbreaks, geopolitical tensions, and even natural disasters (Lund et al., 2020).

Such a disruptive impact raises the question of how different entities can build the capabilities to become resilient to major shocks. For instance, the COVID-19 pandemic highlighted significant vulnerabilities such as supply chain disruptions that impacted suppliers (Harland, 2021), cybersecurity breaches targeted businesses (Pranggono & Arabo, 2021) and governments, and socioeconomic disparities adversely affected health outcomes (Rai, 2020). Building on these challenges, the increasing reliance on digital data as a critical resource highlights the significance of digital technologies (Zhao et al., 2023), giving rise to the concept of digital resilience (DR). DR encompasses the ability to leverage digital technologies to absorb significant shocks, adapt to disruptions, and transition to a new, stable state (Tim & Leidner, 2023).

The case of “just-in-time” supply chains underscores the contrast between digital transformation and DR (Neway, 2024). Pre-pandemic strategies prioritized efficiency through low-cost suppliers and minimal inventory, but the COVID-19 pandemic exposed their fragility with disruptions from demand shocks, supply bottlenecks, and inflation (Rajzer, 2024; Schulz, 2022). This vulnerability has become more critical in light of persisting geopolitical tensions, such as the Russia-Ukraine conflict and the Gaza-Israel dispute, which have disrupted international trade routes, supply chains, and the availability of critical raw materials (Althaqafi, 2024). As a result, organizations are moving toward resilience-driven strategies aimed at better managing supply variability, price instability, and broader social, political, and environmental upheavals (Azadegan & Dooley, 2021; Ciravegna et al., 2023).

To achieve this resilience, the integration of technologies such as the Internet of Things (IoT) oriented supply chain management practices (IoTP) and Artificial Intelligence (AI) driven innovative practices (AIDIP) into the operations of a supply chain represents a transformative approach that enables smarter, more adaptive, and efficient systems (Ghobakhloo et al., 2023). Integration of IoT and AI technologies has brought about a sea change in the functioning of supply chains by rendering significant efficiency and transformative benefits (Belhadi, Mani, et al., 2024; Hastig & Sodhi, 2020; Sundarakani et al., 2021). IoTP, such as real-time tracking, automated inventory control, and predictive maintenance, improves transparency, streamlines logistics, and reduces waste, enabling cost-effective and seamless supply chain processes (McDonald, 2024). At the same time, AI helps in predicting risks, reduces problems (Riahi et al., 2021), and aids in creating analytical models to find areas that can be better (Ni et al., 2020).

According to Bloomberg (2020), Alibaba’s cloud-based, AI-powered supply chain systems allow small and medium-sized enterprises (SMEs) to adapt to changing customer needs and find new avenues using advanced data analysis. It can, therefore, also enhance strategic decision-making and hence cause one to think about how this helps with innovation and long-term success in gaining an advantage in supply chain management (Akter et al., 2022).

Discussing this notion further of supply chain dynamism (SCD) is described by the ability of the supply chains to adapt themselves to fast-changing conditions, be they internal or external (Ali et al., 2024). SCD significantly increases productivity by allowing smooth, real-time data exchange and a proactive approach to managing fluctuations and uncertainties (Bari et al., 2022). In dynamic supply chains, advanced sensing capabilities and data integration enable rapid adjustments to market demands, optimization of resource utilization, and the maintenance of competitiveness in the face of turbulent conditions.

On the other hand, to capture the environmental factors, the firms focus on promoting sustainable behaviors and engaging the employees to be more environmentally conscious towards better performance. In this context, sustainable supply chain performance (SSCP) refers to the harmonious integration of operational efficiency with a deep commitment to environmental, social, and economic responsibility, ensuring long-term sustainability. Technologies like blockchain and big data analytics are important for improving SSCP; however, more attention is being given to the effects of IoT-based supply chain practices and AI-powered innovations (Raut et al., 2021; Yousefi & Tosarkani, 2022) . These digital capabilities are adept at analyzing large datasets and generating data-driven insights (Li et al., 2024). They contribute to better use of resources, predicting changes in demand, and making the supply chain work better (Bhattacharya et al., 2024). The application of these advanced technologies can help companies make their operations smoother, reduce waste, and improve how they predict needs to reach better SSCP (Khan et al., 2021).

This study, therefore, seeks to fill important gaps that exist in current research by examining how DR, IoTP, and AIDIP work together in improving SSCP. It specifically checks how IoT and AI practices help in this process and how SCD affects them. So, we created the following research questions:

RQ1. How does DR influence IoTP and AIDIP, and how do these mediators subsequently impact SSCP?

RQ2. How does SCD moderate the relationship between DR IoTP and AIDIP?

RQ3. What is the role of DataFusion Smart technologies in enhancing the effectiveness of IoTP and AIDIP to achieve sustainable supply chain performance under varying levels of SCD?

This paper contributes to the theoretical advancement of DCV by extending its application to the domain of digital transformation and sustainability in supply chains. It also offers practical recommendations for managers and policymakers seeking to enhance supply chain performance through the strategic deployment of digital technologies. By bridging the gap between academic theory and real-world applications, this study provides a comprehensive framework for navigating the complexities of modern supply chain management, ultimately fostering resilience, efficiency, and sustainability.

2 Literature Review and Hypothesis Development

2.1 Dynamic Capability View (DCV) Theory

The DCV has become one of the most vibrant topics in the domain of strategic management and has even been referred to as ‘the new touchstone firm-based performance-focused theory’(Abdurrahman et al., 2024). Since the DCV first appeared in the scientific literature (Teece et al., 1997), several hundred studies have elaborated on this approach (Yuan & Pan, 2023). Similarly, the DCV theory provides a framework for understanding how firms adapt to rapidly changing environments, particularly in the context of IoT and AI adoption, long-term enterprise performance, and sustainable competitive advantage (Teece, 2014).

A study conducted by Foss and Mazzelli (2025) suggests that dynamic managerial capabilities, comprising dynamic strategy capabilities (the ability to develop adaptive strategies) and dynamic resource capabilities (the ability to reconfigure and allocate resources effectively), are crucial for managing the IoT era (Kawai, 2018). Additionally, empirical evidence shows that supply chain management (SCM) positively influences both DC and sustainability performance (Hinelo et al., 2024). Furthermore, dynamic and ambidextrous capabilities have been found to positively affect economic, environmental, and social activities in sustainable supply chain management (Belhadi et al., 2022). While economic and social activities contribute to both supplier and buyer performance, environmental activities' impact remains inconclusive (Javed et al., 2024).

It is especially helpful in explaining business model innovation across varied institutional and national contexts (Shiferaw & Amentie Kero, 2024). Hence, DCV thus provides a refined prism through which to analyze how firms orchestrate and reorganize resources to overcome truly dynamic and uncertain environments; it remains an important theoretical framework to advance the strategic management research agenda for enhancing SSCP and maintaining competitiveness.

In line with this theoretical foundation, we position DR, IoTP, and AIDIP as dynamic capabilities embedded within the firm's digital transformation efforts. DR reflects a firm’s ability to sense and respond to environmental turbulence by reconfiguring digital processes. IoTP represents an operational capability that allows firms to seize real-time data and optimize workflows across the supply chain. AIDIP, on the other hand, reflects the ability to transform supply chain processes through predictive analytics and innovation. Together, these capabilities enable firms to dynamically adjust and sustain performance in volatile environments.

By grounding these constructs in the sensing–seizing–transforming logic of DCV (Teece, 2014) , we build our conceptual model and hypotheses upon a theoretically integrated framework. This also clarifies the causal direction in our study: DR enables IoTP and AIDIP, which in turn influence SSCP. The directionality of relationships among DR, IoTP, and AIDIP is grounded in the DCV. In line with Teece's (2014) framework, this study conceptualizes DR as a foundational capability that enables organizations to sense environmental disruptions and digital opportunities. IoTP and AIDIP, by contrast, represent downstream capabilities, tools through which firms seize and transform operations in response to such sensing. This causal logic aligns with prior research where resilience capabilities precede technological adaptation and innovation (Aghazadeh et al., 2024; Belhadi et al., 2022). While it is plausible that digital practices like IoTP and AIDIP can enhance resilience over time, this model is rooted in the strategic management literature that positions DR as an enabler of proactive digital transformation, not merely an outcome of it.

2.2 Digital Resilience and IoT-Oriented Supply Chain Management Practices

DR refers to the ability to adapt, recover, and thrive in the face of digital challenges and adversities. It encompasses the capacity to design, deploy, and use information systems to adjust to external shocks (Kohn, 2023). Recent research explores the role of digital technologies, particularly the Internet of Things (IoT), in enhancing supply chain resilience (SCRes) and performance (Qader et al., 2022).

SSRes refers to the broader capacity of the entire supply chain to withstand and recover from disruptions, encompassing both technological and operational strategies (Gaudenzi et al., 2023). IoT-based technologies positively impact supply chain integration, processes, and firm performance in agri-food supply chains (Yadav et al., 2023). IoT can improve SCRes by enhancing key enablers such as velocity, adaptability, and information sharing across the supply chain (Al-Talib et al., 2023).

While both concepts share common goals, DR is considered a subset of SSRes, specifically focusing on enhancing the technological adaptability of supply chains through digital tools. These technologies offer opportunities to redesign supply chains, reinforcing flexibility and improving product quality analysis (Udeh et al., 2024). By implementing IoT, companies can better monitor and control complex, geographically expanded supply chains, enabling faster and more effective responses to disruptions (Sanders, 2025).

According to DCV, firms with digital resilience are able to "sense" disruptions and opportunities, which enables them to seize digital technologies like IoT to improve operational agility. Thus, this study position DR as a higher-order dynamic capability which makes organizations feel digital risks and opportunities (a critical enabler of SSRes), improving the overall ability of the supply chain to manage disruptions through advanced digital practices (Qader et al., 2022; Shoomal et al., 2024). Therefore, we formulated the following hypothesis:

H1: DR significantly and positively impacts IoTP.

2.3 Digital Resilience and AI-Driven Innovative Practices

Recent research has also highlighted the role of AI in promoting DR and creativity (Atif & Qureshi, 2024). The adoption of AI has been found to predict digital innovation among technology firms, where digital resilience partially mediates this relationship (Aghazadeh et al., 2024). DR is enabled through information systems, whereby organizations are helped to resist the impact of exogenous disruptions and quickly recover from them (Boh et al., 2023).

AI usage behaviors, particularly routine and infusion use, can also increase individual DR via both task-focused and emotion-focused coping mechanisms (Hu et al., 2023). Maximizing the beneficial role of digital tools in fostering community resilience means it is very important that such tools are themselves resilient. This may be done with freely accessible and exchangeable data, compelling storytelling in visuals, and diverse sources (Tim et al., 2021; Wright, 2016).

Based on these findings, it is observed that digital resilience and AIDIP co-act to improve supply chain adaptability and recovery. This synergy has positive impacts on sustainable supply chain performance since it ensures resilience and competitiveness.

Dynamic capabilities theory suggests that resilient firms are more capable of transforming operations through advanced digital innovations such as AI. Hence, we developed the following hypothesis:

H2: DR significantly and positively impacts AIDIP.

2.4 IoT-Oriented Supply Chain Management Practices and Sustainable Supply Chain Performance

The Internet of Things (IoT) is revolutionizing supply chain management in terms of integration, visibility, and operational performance (Shoomal et al., 2024). Using IoT significantly enhances the effectiveness of the supply chain through real-time monitoring, inventory management, and resource optimization (Jum'a et al., 2024).

In the retail industry, IoT would enable automatic data capture and enhance visibility, thus sharing information and promoting cost efficiency, quality, delivery, flexibility, and firm sustainability (De Vass et al., 2021). IoT applications can be found in asset tracking, cold chain monitoring, and route optimization, addressing challenges around data security and interoperability (Sallam et al., 2023).

A framework for SSCM based on the four-stage architecture of IoT has been proposed, allowing for environmentally conscious decision-making across the supply chain (Rebelo et al., 2022). These developments show the important role of IoT in cultivating better practices in supply chain management and overall performance, hence serving useful insights to managers, researchers, and policymakers alike (Adeusi et al., 2024).

Henceforward, the IoTP became central to the enhancement of SSCP by improving integration, visibility, and decision-making. These innovations not only bring improvement in operational efficiency but also encourage environmentally sustainable and agile supply chains, which are very important for academics, administrators, and decision-makers in achieving sustainability goals. IoTP can be viewed as a seizing capability under DCV, enabling firms to respond efficiently to dynamic supply chain conditions and achieve sustainability goals. Hence, we came up with the following hypothesis:

H3: IoTP significantly and positively impacts SSCP.

3 AI-driven Innovative Practices and Sustainable Supply Chain Performance

Recent research demonstrates how important Artificial Intelligence (AI) is for better sustainable supply chain management (SSCM). Advanced information-processing skills make supply chains stronger and more effective with the use of AI (Belhadi, Mani, et al., 2024). It increases transparency, supports ethical practices, and uses resources more efficiently to reduce waste and improve sustainability (Pal, 2023).

AI integration in supply chains increases efficiency, demand forecasting accuracy, and energy-efficient transportation routing, which eventually leads to lower operational costs and a reduced environmental impact (Gupta et al., 2023). Its application ranges from data analysis and demand forecasting to logistics optimization, hence supporting sustainable development (Ghanbari, 2023).

The challenges in AI adoption include high costs and concerns regarding data privacy (Dwivedi et al., 2021), but it can significantly enhance supply chains by making them more cost-effective and environmentally friendly (Esmaeilian et al., 2020; Joel et al., 2024). In general, AI is one of the significant tools for developing smart and sustainable supply chains in the digital era.

AIDIP functions as a transforming capability that supports supply chain innovation and adaptation, key components in achieving long-term sustainable performance. Hence, the hypothesis is developed as follows:

H4: AIDIP significantly and positively impacts SSCP.

3.1 The Mediating Role of IoT-Oriented Supply Chain Management Practices and AI-Driven Innovative Practices

Integration of the Internet of Things (IoT) and artificial intelligence (AI) is considerably revolutionizing practices in the field of supply chain management. These technologies enable wider visibility, efficiency, and effectiveness within a supply chain (Singh et al., 2021).

The IoT, on the other hand, enables real-time data gathering and tracking of assets, inventory, and logistics; AI brings advanced analytics and predictive capabilities (Vijaykumar et al., 2024). Integration of IoT, AI, and SSCM is represented by the IoT-AI-SCM approach to improve supply chain operations, data collection, intelligent planning, and improvement (Alheadary, 2023).

The main problems identified with this integration include those of data security, interoperability, and non-conformity to regulatory measures. Even so, the benefits that it has to offer include better efficiency in many different processes, a more enhanced customer experience as well as the availability and authenticity of products in a supply chain (Vazquez Melendez et al., 2024).

Additionally, new methodologies such as incessant data processing (IDP) and federated learning are also being developed that will aptly deal with the streams of data both in a continuous or discontinuous way. This development brings more accuracy to the predictions while taking less time to manage supply chains (Zeng & Yi, 2023).

This way, through the fusion of data, the integration between IoT and AI has revolutionized supply chain management, improving visibility, efficiency, and predictive decision-making capabilities. This synergistic approach would, therefore, address all the critical challenges while optimizing its operations, hence mediating the relationship between advanced technological practices and SSCP. The following hypothesis is consequently proposed:

H5a: IoTP mediates the relationship between DR and SSCP.

H5b: AIDIP mediates the relationship between DR and SSCP.

3.2 The Moderating Role of Supply Chain Dynamism

SCD refers to the degree to which supply chains can respond and change with rapid changes in the business environment influenced by rapid technological advancement and volatile markets (Yu et al., 2019). The research conducted by Roh and Xiao (2024), shows that dynamic capabilities (DCs) are necessary to enable a firm to sail through disruptions with greater strength and hence sustain superior performance under uncertain circumstances.

Besides, SCD also plays a moderating role between supply chain resilience (SCR) and digital supply chain (DSC) initiatives for achieving positive impacts on sustainability performance, and building up efficient and environmentally controlled practices (Ali et al., 2024). Furthermore, the interaction of SCD with risk management strategies shows that firms need to match their operational approaches with the complexities of their supply base to reduce disruptions and improve performance (Deshpande & Hudnurkar, 2024).

From a theoretical standpoint, SCD acts as a contextual amplifier of firm-level dynamic capabilities. In turbulent environments, the ability to rapidly sense change (through DR) becomes more valuable, leading firms to more aggressively seize real-time digital tools like IoT to respond. This builds on dynamic capability theory and is supported by findings in volatile markets where turbulence strengthens the effect of internal resilience on external action (Belhadi et al., 2022; Younis et al., 2024).

In highly dynamic supply chain environments, firms face continuous uncertainty, disruptions, and the need to respond swiftly to market changes. This turbulence enhances the importance of converting internal resilience capabilities into operational technologies. SCD thus strengthens the link between DR and IoTP, as firms seek technologies that offer real-time data and adaptive control.

Prior research (Belhadi et al., 2022; Jum'a et al., 2025; Younis et al., 2024) supports that dynamic environments intensify the role of strategic capabilities in driving digital technology adoption. Based on this, we propose the following moderation hypotheses:

H6a: SCD significantly moderates the relationship between DR and IoTP.

H6b: SCD significantly moderates the relationship between DR and AIDIP.

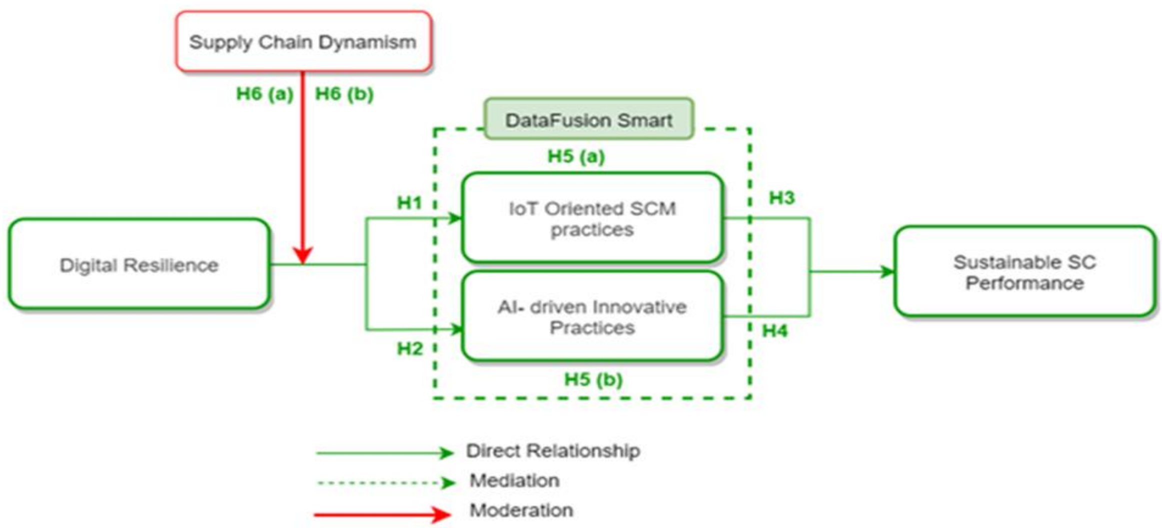

Figure 1. Conceptual Framework (Source: Authors' own work)

4 Methodology

4.1 Data Collection and Procedure

Small and medium-sized enterprises (SMEs) in China, defined as businesses with fewer than 300 employees or annual revenues below 10 million yuan (State Council of the PRC, 2011), are critical contributors to economic growth. High-tech SMEs (HTSMEs) foster innovation and job creation by converting intellectual property into high-tech products through research and development (R&D) (Fan & Liang, 2023). As of 2019, HTSMEs represented 5.56% of companies, 2.53% of employment, and contributed 3.55% of GDP in China (Zhang & Merchant, 2020).

However, they face significant challenges, such as limited financial and technological resources, further aggravated by the COVID-19 pandemic (Katalla & Masele, 2024; Palombi et al., 2024). Hence, the current study explores the strategies and capabilities that enable enterprises to enhance their supply chain performance amidst evolving external challenges.

To ensure the relevance and consistency of the study, only high-tech SMEs that had implemented IoT and AI-driven practices in their operations were selected. During the initial outreach and screening process, respondents were asked a preliminary question confirming the presence of IoT and AI applications in their supply chain processes. Only firms affirming such adoption were included in the final sample. While the degree of technological sophistication varied, all firms had operational IoT-based systems in areas such as logistics tracking, inventory management, or production processes. This pre-screening ensured that the analysis reflects actual application and experience, thereby enhancing the validity of the relationships explored in the model.

Questionnaires were distributed, and then a purposive sampling method was employed to ensure participants were representative of HTSMEs across diverse industries and regions. Initial respondents were identified using publicly available industry directories and government databases of registered HTSMEs, which provided a credible and reliable starting point. Further respondents were reached by referral and professional networks within Beijing, Jiangsu, and Zhejiang provinces.

The survey was sent online through both email and WeChat platforms. A total of 330 responses were received from 400 distributed questionnaires, resulting in a high response rate of 82.5%. After eliminating 37 invalid responses by using a logic validation criterion, 293 valid responses were included in the analysis, representing 73.25% of the overall distributed questionnaires to evaluate the proposed relationships.

The high response rate was achieved without any incentivization or third-party intervention, relying solely on direct outreach through industry directories, official databases, and professional networks. This high response rate is attributable to the use of trusted industry directories, government databases, and direct professional contacts, particularly in innovation-driven regions such as Beijing, Jiangsu, and Zhejiang. Many respondents were already engaged in digital transformation efforts, which increased interest and willingness to participate.

Additionally, to ensure organizational-level insights, the survey targeted individuals in decision-making or management roles (operations managers, IT heads, and general managers). These roles were specifically chosen as they hold strategic and operational responsibility for implementing digital technologies, ensuring responses reflected firm-level practices and not personal opinions.

4.2 Non-Response Bias Assessment

To check for non-response bias, several t-tests were performed comparing the characteristics of respondents and non-respondents. No significant differences were found, thus indicating no considerable risk of bias. Again, following Armstrong and Overton (1977), the sample was divided into early and late respondents based on the timing of their responses. Initial respondents were defined as those who completed the questionnaire within two weeks, while late respondents were defined as those who returned their responses after this period. Comparisons between these two groups revealed no significant differences, thereby supporting the absence of non-response bias. The sample was, therefore, assumed to be representative of the broader population of firms surveyed. Demographic details of the sample are presented in Table 1.

Table 1. Socio-demographic Profiles (n=293) (Source: Authors' own work)

Demographic Variable	**Category**	**Sample Size**	**Percentage (%)**
Age (years)			
	20-27	50	17.06%
	28-37	70	23.89%
	38-47	60	20.48%
	48-57	55	18.77%
	57 above	58	19.80%
Gender			
	Male	160	54.61%
	Female	133	45.39%
	Others	0	0%
Years in Operation			
	1-5 years	80	27.30%
	6-10 years	90	30.72%
	11-15 years	70	23.89%
	16 above	53	18.09%
Annual Revenue (CNY)			

	<100K	50	17.06%
	100K-500K	100	34.13%
	500K-1M	90	30.72%
	>1M	53	18.09%

4.3 Measures and Validation

The measurement scales used in this study are rigorously validated from the established literature to ensure theoretical robustness and empirical accuracy. The first variable, DR, is operationalized through three items adapted from Mehedintu and Soava (2022). To capture SCD and AIDIP, measurement scales were adopted from Belhadi et al. (2024). SCD is evaluated through four specific criteria, including the statement. In contrast, the measurement of AIDIP comprises five distinct items, exemplified by the assertion. Likewise, the assessment of IoTP is conducted using five items derived from Imran et al. (2018), this is illustrated by the statement. Ultimately, the dependent variable, which is SSCP, is assessed through eight items that were validated by Bag et al. (2020), one of which states.

The process of data collection employed a structured questionnaire featuring Likert-scale questions that ranged from 1 (strongly disagree) to 5 (strongly agree), thereby ensuring clarity and consistency in the responses obtained. The authors made a careful, independent review of the possible observations to determine the content validity of the developed questionnaire. After much discussion and coming to a consensus, the final version of the questionnaire was approved and then distributed.

There is a high level of concern regarding common method bias (CMB) in studies using questionnaires (Schwarz et al., 2017). Therefore, it becomes imperative to make detailed analyses of CMB before empirical analysis can be carried out. Two separate tests are used to perform a statistical analysis of the common method bias (CMB). The tests used were a one-dimensional test made by Harman (1976) and a full collinearity test made by Kock (2015). Also, a detailed analysis of collinearity was done using Smart PLS since it is a new and strong method often used in social sciences. The variance inflation factor (VIF) values found in our model were below the important limit of 3.3 (see Table 3). This means that common method bias (CMB) was not a problem in this model (Kock, 2015).

4.4 Data Analysis

This study has applied the smart-PLS version 4.0, partial least squares structural equation modeling (PLS-SEM). In general, PLS-SEM is regarded as a very useful approach in testing complex models. The purpose of this research was to identify those endogenous variables that have the minimum variance contribution toward the model. The strength of PLS-SEM lies in analyzing structural as well as measurement models together (Sarstedt et al., 2022). In light of this fact, the proposed model has been tested by PLS-SEM. Explicit approximations were made for the measurement and structural models through Hair et al. (2021) to get reliable results.

5 Results

5.1 Measurement Model

Data analysis results are presented in two steps. First, for the validity and reliability of the theoretical framework, the constructs have been checked using internal consistency, indicator reliability, convergent validity, and discriminant validity criteria.

Concerning internal consistency, the values of composite reliability in addition to Cronbach's α values, are above 0.8 (see Table 2). The reliability of the indicators was confirmed since all indicator loadings exceeded 0.7, of which the majority were above 0.8. For convergent validity, most of the AVE scores were greater than 0.6 except for some variables (see Table 2).

Discriminant validity was established since each indicator's outer loading was higher on its respective construct than its cross-loadings on other constructs. Moreover, the square root of each construct's AVE was greater than its highest correlation with any other construct in the model, further establishing discriminant validity (Fornell & Larcker, 1981).

One popular method of assessing discriminant validity is the Fornell and Larcker criterion. Discriminant validity for this study was examined based on the widely applied Fornell and Larcker approach. As per the method developed by (Fornell & Larcker, 1981), discriminant validity can be assessed by comparing the square root of each construct's AVE (represented in bold diagonals) against the correlation coefficients between constructs (off-diagonal values). Discriminant validity is established when the square root of the AVE for each construct is greater than its correlation coefficients.

Besides, for discriminant validity, no constructs in the measurement model should show strong correlations as per the Fornell and Larcker (1981) method. Hair et al. (2019) suggested that the HTMT value should not exceed 0.85. In this study, the HTMT values remained below this threshold, as indicated in Table 2, thereby confirming that the discriminant validity criteria have been met.

Table 2. Reliability and Validity (Source: Authors' own work)

Constructs	**Reliability**			**HTMT Ratio**				
	α	CR	AVE	1	2	3	4	5
AI-Driven Innovative Practices	0.792	0.852	0.536					
Digital Resilience	0.855	0.912	0.776	0.603				
IoT Oriented SCM Practices	0.931	0.948	0.784	0.673	0.432			
Supply Chain Dynamism	0.879	0.917	0.734	0.567	0.385	0.398		
Sustainable SC Performance	0.875	0.896	0.519	0.699	0.844	0.552	0.470	
Note: α=Cronbach's alpha; CR=Composite reliability; AVE=Average variance extracted								

Table 3. Factor Loadings & Variance Inflation Factor (VIF) (Source: Authors' own work)

I- Code	**Item Description**	**FL**	**VIF**
Digital Resilience			
DRSL1	Our organization has developed a robust strategy to enhance its digital business model, ensuring adaptability and resilience in a dynamic environment.	0.847	2.074
DRSL2	Our organization has enhanced customer experiences by optimizing digital customer journeys, interaction channels, and touchpoints	0.923	2.962
DRSL3	Our organization leverages advanced digital platforms and infrastructure for efficient data and information processing, enabling resilience in supply chain operations.	0.871	2.074
AI-Driven Innovative Practices			
AIDIP1	We are equipped with the infrastructure and talent required to deploy AI-based information processing systems effectively.	0.698	1.357
AIDIP2	AI techniques are employed to forecast and predict patterns in environmental dynamics.	0.759	2.560
AIDIP3	Our organization leverages AI technologies to develop advanced statistical, self-learning, and predictive capabilities.	0.705	2.605
AIDIP4	The application of AI techniques spans all levels of the supply chain, ensuring comprehensive integration.	0.792	3.290
AIDIP5	Insights generated from AI are utilized collaboratively across the supply chain to drive strategic decisions.	0.702	1.386
IoT Oriented SCM Practices			

IoTP1	Our supply chain practices ensure reduced lead times for customers and lower overall operational costs through IoT-oriented solutions.	0.870	2.643
IoTP2	These practices enhance production capacity by leveraging IoT-based technologies.	0.878	2.968
IoTP3	The integration of devices into the internet facilitates seamless production processes within our supply chain.	0.909	3.701
IoTP4	Supply chain operations foster improved communication and collaboration among employees through IoT-driven connectivity.	0.910	3.900
IoTP5	These practices strengthen the link between customers and the company, increasing customer satisfaction and engagement	0.860	2.594
Supply Chain Dynamism			
SCDM1	Our organization's operating processes require frequent updates to keep pace with changing industry demands.	0.840	1.900
SCDM2	The requirements and preferences of our customers evolve rapidly, necessitating continuous adaptation.	0.864	2.460
SCDM3	Our supply chain frequently faces unexpected disruptions, such as market shocks, global outbreaks, or emerging technologies.	0.895	2.913
SCDM4	Competitors regularly enhance their capabilities, prompting the need for strategic adjustments in our operations.	0.825	2.042
Sustainable SC Performance			
SSCP1	Our organization ensures comprehensive visibility of supply chain activities and dynamics across the network.	0.720	2.178
SSCP2	Risks within the supply network are identified and managed proactively to maintain stability and sustainability.	0.770	2.959
SSCP3	Our organization effectively controls supply chain costs to ensure economic sustainability.	0.741	2.601
SSCP4	Significant efforts have been made to reduce waste throughout the supply chain network, promoting environmental responsibility.	0.663	1.870
SSCP5	Our primary supply chain reliably delivers complete and timely orders to final customers.	0.700	3.643
SSCP6	The supply chain operations are designed to adhere to environmental standards and meet customer sustainability requirements.	0.650	2.946
SSCP7	Buffer stocks have been minimized across all levels of the supply chain, enhancing efficiency and reducing waste.	0.744	2.812
SSCP8	Our supply chain demonstrates superior responsiveness compared to competitors in volatile and dynamic business environments.	0.765	2.893

5.2 Structural Model's Analysis

The respective correlations are described in Tables 4 & 5. To evaluate the structural model of our conceptual framework, we have subsequently examined construct collinearity, the coefficient of determination R^2, path coefficients, and both direct and mediation effects' significance (Hair et al., 2013; Hair Jr. et al., 2014). The R^2, value for AIDIP is (0.429), IoTP (0.285), and SSCP (0.486) (see table 4). These values demonstrate the model's ability to explain the variance in the respective constructs.

Further, Table 5 presents the effect size (f^2) values for the constructs, reflecting their relative impact on the dependent variables in the model. According to Cohen's (1988) guidelines, effect sizes are categorized as small (0.02), medium (0.15), and large (0.35). The analysis reveals that AIDIP exhibits a large effect size (f^2= 0.310) on SSCP, highlighting its substantial contribution to explaining variance. DR demonstrates medium effect sizes on both AIDIP (f^2= 0.248) and IoTP (f^2 = 0.141), indicating its moderate influence. IoTP, on the other hand, shows a small effect size (f^2 = 0.095) on SSCP, suggesting a relatively lower impact. SCD has medium effect sizes on AIDIP (f^2 = 0.258) and IoTP (f^2 = 0.153), signifying its moderate role in driving these outcomes. Finally, the interaction between SCD and DR exhibits negligible to small effects on AIDIP (f^2 = 0.014) and IoTP (f^2 = 0.102), indicating limited synergistic impact. These results emphasize the varying levels of influence across constructs, with AIDIP and SCD emerging as key contributors to performance outcomes.

Moreover, the model was extended to assess construct collinearity, and the results were very good (VIF values were far below 5) and thus indicated no issues of multicollinearity as suggested by (Ringle et al., 2013). The significance of the path coefficients was assessed using a bootstrapping algorithm with 5,000 subsamples for a two-tailed test.

We also assessed the model fit by formula (*GoF* = √ (AVE × R^2) (Wetzels et al., 2009). Our *GoF* is 0.518, signifying that the model fit meets the large criterion.

Note. R^2= Coefficient of determination; f^2 = Effect Size; *GoF* = Goodness of fit.

Table 4. Coefficient of Determination (R^2) (Source: Authors' own work)

Constructs	R^2	R^2 adjusted
AI-Driven Innovative Practices	0.429	0.423
IoT Oriented SCM Practices	0.285	0.277
Sustainable SC Performance	0.486	0.483

Table 5. Effect Size (f^2) (Source: Authors' own work)

Constructs	AIDIP	IoTP	SSCP
AI-Driven Innovative Practices			0.310
Digital Resilience	0.248	0.141	
IoT Oriented SCM Practices			0.095
Supply Chain Dynamism	0.258	0.153	
Sustainable SC Performance			
Supply Chain Dynamism x Digital Resilience	0.014	0.102	

5.3 Mediation and Moderation Analysis

Using a bootstrapping approach, this study investigated the mediating role through hypotheses H5a and H5b, following the guidelines outlined by Hussain et al. (2021). Gaskin et al. (2018) emphasized that a significant indirect effect is necessary to confirm mediation. The mediation analysis revealed a positive and significant association between DR → IoTP → SSCP (β = 0.094, *p*-value= 0.004), providing support for H5a. Additionally, a similar analysis confirmed a positive mediation effect between DR → AIDIP → SSCP (β = 0.201, *p*-value= 0.000), further supporting our H5b (see Table 6). This study provides critical insights into the mediating roles of IoTP and AIDIP in enhancing SSCP. By leveraging a robust bootstrapping methodology, the findings confirm the significance of these mediating variables in fostering sustainability within supply chain frameworks. Specifically, the analysis underscores that IoTP and AIDIP play pivotal roles in driving adaptability, operational efficiency, and resilience, which are essential for achieving long-term sustainability goals.

The current study also explores the role of SCD as a moderator in the relationship between DR, IOSP, and DR, AIDIP. The results, as shown in Table 6, indicate that SCD x DR → IoTP has a significant moderating effect (β = 0.254; *p*-value = 0.000), and SCD x DR → AIDIP has witnessed no substantial moderating effect (β = 0.083; *p*-value = 0.112), indicating H6b influence does not have a significant impact on AIDIP. Accordingly, hypothesis H6a is supported, which indicates that SCD plays a significant role in moderating the impact of this targeted variable on IoTP. However, H6b is not supported, indicating that although SCD may be influential on operational dynamics, it is not able to moderate effectively the relationship of this targeted variable with AIDIP, suggesting a complex interplay that needs further exploration. 5

Table 6. Hypotheses Testing Bootstrapping @5000 (Source: Authors' own work)

Sr.#	Relationships	β	SD	t-values	P values
H1	Digital Resilience → IoT-Oriented SCM Practices	0.342	0.057	6.015	0.000^{S}
H2	Digital Resilience → AI-Driven Innovative Practices	0.405	0.053	7.616	0.000^{S}
H3	IoT Oriented SCM Practices → Sustainable SC Performance	0.275	0.070	3.911	0.000^{S}
H4	AI-Driven Innovative Practices → Sustainable SC Performance	0.497	0.058	8.533	0.000^{S}
H5a	Digital Resilience → IoT-Oriented SCM Practices → Sustainable SC Performance	0.094	0.033	2.883	0.004^{S}
H5b	Digital Resilience → AI-Driven Innovative Practices → Sustainable SC Performance	0.201	0.037	5.443	0.000^{S}
H6a	Supply Chain Dynamism x Digital Resilience → IoT-Oriented SCM Practices	0.254	0.058	4.383	0.000^{S}
H6b	Supply Chain Dynamism x Digital Resilience → AI-Driven Innovative Practices	0.083	0.052	1.591	0.112^{NS}

Note: β=Path Coefficients; SD= Standard Deviation; S=Supported; NS=Not Supported

6 Discussion

The present study, therefore, builds on the DCV theory to provide a nuanced understanding of how organizations harness DR, IoTP, AIDIP, and SCD to achieve SSCP. In doing so, this research puts much emphasis on the construct of dynamic capabilities that facilitate the firm's adaptation to rapidly changing technological landscapes and market uncertainties. The empirical evidence substantiates the claim that firms possessing robust dynamic capabilities are more effectively positioned to optimize resource utilization, enhance SCD, and achieve long-term sustainability objectives.

Based on the empirical analysis of the questionnaire data, several findings have emerged. First, our hypothesis (H1) indicates that DR exerts a positive effect on IoTP (β=0.342). This finding adds to the growing body of research on digital resilience in IoT-oriented supply chain management practices, which is increasingly recognized as essential for disruption navigation in today's globalized economy (Kurniawan et al., 2022). Therefore, the careful implementation of digital technologies, including the Internet of Things (IoT) and connected technologies, can help in building resistant supply chains that can adapt to changing market demands.

Moreover, DR significantly impacted AIDIP (β=0.405); so, our proposed hypothesis (H2), was accepted. According to Boh et al. (2023), DR enabled through information systems might help the organizations absorb the shock from exogenous disruptions effectively and recover quickly. Therefore, these findings underline the critical role of DR in driving AIDIP, which contributes to improvement in SSCP.

According to hypothesis (H3), our findings confirm the correlation between IoTP and SSCP (β=0.282). This may be an indication that IoT supports organizations in their effort to develop financially, socially, and environmentally sustainable supply chains (De Vass et al., 2021). Furthermore, the findings support the link between AIDIP and SSCP as posited in hypothesis (H4) (β=0.497). Based on recent research, the integration of AI into supply chain management increases its efficiency, reduces its environmental impact, and leads toward sustainability by way of accurate demand forecasting, resource optimization, and reducing energy in transportation (Eyo-Udo, 2024; Gupta et al., 2023).

In the present study, IoTP and AIDIP were used as mediators as hypothesized in (H5a) and (H5b). The results demonstrate a full mediation effect (β=0.094 and β=0.201). The integration of IoT and AI in supply chain management brings about many benefits, such as cost reduction, increased profitability, and competitive advantages (Kediya et al., 2021; Zeng & Yi, 2023).

Finally, our hypothesis (H6a) results indicate a significant moderating effect (β = 0.254), which shows that the interaction between SCD and DR amplifies the adoption and effectiveness of IoTP. Organizations with dynamic supply chains and high DR have more chances of assimilating IoMT technologies, being responsive to changes in the market, and gaining higher operational efficiency (Belhadi, Kamble, et al., 2024). On the other hand, hypothesis (H6b) did not support the moderation of SCD on DR concerning AIDIP (β = 0.083). It therefore suggests that while both SCD and DR are individually important, their interaction does not have a significant effect on the implementation of AIDIP (Han, 2024).

Through the application of advanced methodologies like Partial Least Squares Structural Equation Modeling (PLS-SEM), this study increases the accuracy, reliability, and robustness of its results. This methodological rigor aims not only at strengthening the theoretical foundations of the research but also at offering practical insights for practitioners, hence narrowing the gap between academic frameworks and real-world applications.

7 Conclusion, Managerial Implications, Limitations, and Future Research Directions

7.1 Conclusion

This study explores SSCP by using DRV theory and integrating recent technologies such as DR, IoTP, and AIDIP. Results indicate their imperative roles in promoting adaptability, effectiveness, and resilience in uncertain global business environments. This study confirms how the practices of IoT and AI interlink digital resilience with SSCP. These mediators no longer only enable organizations to optimize their operations but also nurture their ability to respond proactively to disruptions in ways that ensure environmental, economic, and social sustainability.

Secondly, the moderating role of SCD indicates that agile supply chains must harness digital capabilities to be competitive in today's turbulent markets. This study uses Partial Least Squares Structural Equation Modeling (PLS-SEM) to validate its findings. These results contribute to the development of DCV theory and offer insights with practical value.

The results show that for policymakers, there is a need to create an ecosystem that not only fosters technological innovation but also resilient supply chains in the face of challenges. This study links academic theory with real-world application, providing a strategic framework for SSCP. This will reduce risks and generate growth, efficiency, and sustainability opportunities for firms deploying advanced digital technologies and dynamic capabilities, hence setting a benchmark for future research and practice in supply chain management.

7.2 Theoretical Implications

This study makes a substantial contribution to the Information Systems (IS) discipline by extending and contextualizing the DCV theory within digital transformation and sustainable supply chain management. It highlights the pivotal role of DR, IoTP, and AIDIP as core IS-enabled capabilities that shape organizational adaptability and performance in the digital economy. For the IS field, this research deepens the understanding of how technologies like IoT platforms and AI analytics engines function not merely as tools but as enablers of dynamic capabilities.

DR serves as a sensing capability to identify risks and opportunities; IoTP as a seizing capability to harness real-time data for decision-making; and AIDIP as a transforming capability to drive process innovation through predictive analytics and intelligent automation. By incorporating SCD as a contextual factor, the study adds nuance to DCV theory by demonstrating how environmental volatility impacts digital capability effectiveness. This underscores the need for adaptive, scalable, and responsive information system architectures to enhance resilience and sustainability.

Addressing a gap in IS literature, this work empirically integrates DCV with the use of emerging IS technologies like IoT and AI in practice, moving beyond static adoption models to emphasize IS as a driver of dynamic, sustainable performance in volatile settings. The context of Chinese high-tech SMEs further validates the global applicability of these insights, extending DCV theory to emerging digital economies. By linking DCV theory with IS practice, this study guides managers in shaping resilient, data-centric organizations prepared for continual transformation.

7.3 Managerial Implications

In practice, this study encourages IS managers to redefine the role of information systems as proactive enablers of supply chain resilience, adaptability, and sustainability. Digital resilience is not simply about system stability but about equipping the organization to anticipate, respond to, and recover from disruptions using data-driven insights and intelligent technologies. The results show that IoT-oriented practices provide IS managers with tools to achieve real-time visibility, improve operational responsiveness, and enhance coordination across supply chains. At the same time, AIDIP supports predictive decision-making, efficient resource allocation, and the automation of complex processes, contributing directly to operational excellence.

Additionally, the importance of SCD underlines the need for information systems that are flexible, scalable, and adaptable to changing market and environmental conditions. Rigid or outdated systems risk becoming barriers to agility in volatile business contexts. In essence, this study offers IS managers a strategic perspective on using digital technologies not as supporting tools but as core components for driving competitiveness, resilience, and sustainable organizational performance.

7.4 Limitations and Future Research Directions

While this study does offer some valuable insights into dynamic capabilities with digital technologies for sustainable supply chains, it has its limitations. Firstly, the current study focus on high-tech SMEs in China constrains generalizability. Therefore, given the focus on high-tech SMEs in China, which typically have less complex supply chains and resource constraints, the findings are contextual and not intended to be generalized to larger or multinational firms. Future research should take a diverse range of industries, regions, and organization sizes to enhance the broader applicability of the findings.

Secondly, although able to reveal relationships, the cross-sectional design falls short with temporal changes; longitudinal research will be able to elucidate precisely how DR and the SCD interact over time regarding IoT and AI adoption. Thirdly, self-reporting on surveys may incorporate common-method bias, no matter the quality of the statistical control employed. Future research should combine findings with performance metrics, case studies, or real-time data to increase reliability.

Fourthly, the impact of SCD was meaningful for IoT practices but not for AI innovations, indicating that further exploration is needed concerning elements like agility, technology, and leadership. Finally, emerging technologies offer further opportunities for study. Future research ought to examine how blockchain, predictive analytics, and advanced AI can further enhance sustainable supply chains. Such integration of these innovations will enable an understanding of how dynamic capabilities enhance operational excellence, resilience, and sustainability for the researcher.

Although this study positions DR, IoTP, and AIDIP as dynamic capabilities within the DCV framework, future research could empirically test the evolution of these capabilities over time. Longitudinal studies may reveal whether continuous engagement with IoT and AI technologies contributes back to the strengthening of digital resilience, suggesting a feedback loop not captured in this cross-sectional design. In addition, future research could explore reverse or reciprocal causality between digital resilience and technology adoption. Longitudinal or experimental designs would help determine whether sustained IoTP or AIDIP implementation reinforces or develops digital resilience over time.

Addressing these limitations and pursuing suggested directions will advance sustainable supply chain management theory and offer actionable insights for navigating modern supply chains. This agenda highlights the importance of interdisciplinary research in shaping future sustainable supply chains.

Declaration of AI

During the preparation of this work, the authors used ChatGPT (OpenAI) to assist in refining the clarity and grammar of the manuscript text. No AI tools were used for data analysis or interpretation. The final manuscript reflects our own work and intellectual input.

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Appendix A: Comparison of Our Proposed Research with Recent Published Studies

Author(s) & Year	Title	Focus Area	Key Findings	Gaps Identified	How Current Study Addresses the Gap
(Tim & Leidner, 2023)	Digital resilience: a conceptual framework for information systems research.	Conceptual foundation of digital resilience in IS.	Develops a framework on digital resilience for IS research.	Purely conceptual, lacks empirical testing and connection to supply chains.	Current study empirically validates DR in high-tech supply chains and extends it to performance outcomes under dynamic conditions.
(Hu et al., 2023)	How does AI use drive individual digital resilience?	AI use and DR development.	Demonstrates how AI use fosters individual digital resilience.	Focuses on individual users; lacks organizational or SCM focus.	In this study, authors elevate the context from individual behavior to organizational level and link AIDIP to SSCP.
(Boh et al., 2023)	Building Digital Resilience Against Major Shocks.	Organizationa l digital resilience.	Proposes DR framework to mitigate systemic shocks.	No quantitative analysis or supply chain application.	Authors quantify DR and test its effects in a structural model, integrating IS theory with OM context.
(Tim et al., 2021)	Digital resilience: How rural communities leapfrogged into sustainable development.	Community-level digital resilience.	Showcases digital leapfrogging in rural IS contexts.	Lacks firm-level insights and theoretical grounding in DCV.	Authors study embeds DR within DCV and provides an enterprise-level application with empirical testing.
(Wright, 2016)	Toward a digital resilience.	Systems view of digital resilience.	Introduces DR from systems theory perspective.	Theoretical discussion without linkage to IS/OM or business outcomes.	Current study operationalizes system-level DR into measurable constructs and links to SSCP.
(Atif & Qureshi, 2024)	Enhancing Digital Resilience through AI in Industry 5.0.	DR through AI in Industry 5.0.	Examines how AI contributes to digital resilience.	Focuses on manufacturing without mediation/mod eration analysis.	The proposed model introduces mediation through AIDIP and empirically tests their impact on performance, thereby enhancing its practical applicability.
(Garrido-Moreno et al., 2024)	Innovation and resilience in improving business performance.	Organizationa l resilience and innovation.	Mixed-methods approach to resilience and innovation.	Doesn't examine digital-specific or SCM-related constructs.	The study conceptualizes digital resilience and integrates it within a strategic IS–OM interface to enhance

					SSCP.
(Zhou et al., 2023)	Supply chain digitalization and performance.	Digital tools and SC resilience.	Shows digitalization boosts resilience and performance.	Lacks integration of DR and does not model AI or IoT explicitly.	The current study addresses this gap by explicitly linking digital resilience with AIDIP and IoTP, and by empirically testing their mediating and moderating effects on SSCP.
(Aghazadeh et al., 2023)	Digital transformation and SME internationalization.	SME capabilities and resilience.	DR moderates SME digitalization and internationalization.	No supply chain or performance focus.	Current study applies DR in SCM of SMEs and links it to sustainability via empirical modeling.
(Rai, 2020)	The COVID-19 pandemic: Building resilience with IS research.	IS role in pandemic resilience.	Commentary on role of IS in resilience.	Lacks empirical validation or performance modeling.	This study tests a robust framework showing how IS-enabled resilience drives supply chain outcomes.
(Belhadi et al., 2024)	AI-driven innovation for enhancing SC resilience.	AI and SC resilience under dynamism.	Shows AI enhances resilience under volatile conditions.	Does not explore DR explicitly or mediation/moderation.	Authors integrate DR with AIDIP and test them under SCD to explain SSCP

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