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**Research Article**

# Leveraging Green Supply Chain Management for Ambidextrous Innovation: The Mediating Role of Information Technology Absorptive Capacity

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**ABSTRACT**

Abstract: This research proposes the following narrative: How does green supply chain management (GSCM) influence Ambidextrous Sustainable Innovation, with attention to the moderating function of IT absorptive capacity? Specifically, manufacturing SMEs in Iraq were chosen for this study, and questionnaires were distributed among 39 companies through a convenient cluster sampling strategy aimed at top management. By applying PLS-SEM, this study provides empirical evidence that GSCM enhances the enactment of exploitative and exploratory innovation. Also, IT Absorptive Capacity fully mediates this relationship, thereby emphasizing the firm's competencies to acquire, transform, and exploit IT knowledge to maximize on GSCM. The results presented here provide important strategic insights for SMEs recommending that developing IT capabilities can improve the effectiveness of GSCM efforts to achieve a sustainable innovation perspective. From this research, the knowledge of implementing environmental sustainable strategies with robust IT networks to foster growth, focus innovation, and competitiveness in emerging markets is extended.

**Keywords:** Green Supply Chain Management; Information Technology Absorptive Capacity; Ambidextrous Sustainable Innovation; Smart PLS; Small and Medium-Sized Enterprises; Iraq; Mediation.

## 1 Introduction

Today it is more important than ever to be able to implement and maintain Sustainable Business practices. This paper has highlighted how firms are experiencing the pressure to integrate sustainability into economic objectives. Sustainability is especially problematic among SMEs due to resource constraints, high competition, and other constraints (Costa et al., 2024). Of all the available strategies, green supply chain management also known as the sustainable supply chain management has arguably been considered to be an important focus. It means incorporating environmental consideration in supply chain management of the product from its design, acquisition of raw material and accessories, the actual manufacture of the product, distribution of the actual product and disposal of the product when it is no longer useful. This balance is critical for SMEs looking for ways to sustainability, (Jihu, 2024).

This domain also has one of its key ideas in ambidextrous sustainable innovation. This term refers to the organisation's capacity to engage in both existing opportunity seeking or sustaining innovation or venture development, (exploratory) and existing capabilities enhancement or incremental innovation or venture development (exploitative), with a sustainability imperative. Consequently, ambidextrous innovation makes certain that companies both become accustomed to and thrive in uncertain environments for the ultimate value of sustainability and superior competitive advantage. The concurrent operation of the ambidextrous innovation is crucial for complementing the lecturing it provides to the multifaceted requirements for sustainable development (Srisathan et al., 2023).

As the analysis indicates, GSCM has a strong effect on ambidextrous sustainable innovation. Thus, GSCM

practices are capable of improving organizations environmental performance and creating value by finding creative solutions to minimize waste, maximize resource utilization, and minimize clientele's negative sustained impact on the environment. The use of GSCM practices makes the firms to challenge their way of doing things and what they produce hence enhances both operational improvement and breakthrough innovations towards sustainability. For the SMEs, the implementation of GSCM can result in better opportunities in the market, increased compliance with standards and better satisfaction of customers which could position them well within the market (Alsmairat and AL-Shboul, 2023).

Another important variable of this model is Information Technology (IT) Absorptive Capacity. A firm's IT absorptive capacity is defined by its capability to know what new information is relevant, to acquire it and to use it for business purposes via information technology. Consequently, this capability is essential for innovation as it allows firms to acquire and assimilate knowledge from the environment. When applied to the GSCM, the results indicate that IT absorptive capacity enables SMEs to effectively acquire, sort, and interpret large amounts of data, improve the functioning of supply chains, and improve decision-making. The study shows the possibility of using GSCM practices to support sustained innovation by SMEs. In this way they are able to incorporate environmental thinking into their supply chain management. (Feng and Chen, 2024).

But for SMEs, ambidextrous sustainable innovation, GSCM and IT absorptive capacity are related and complimentary corporate strategies. These practices are therefore easily adaptable by SMEs because of their dynamic structures and can thus be of immense benefit to them even though they may have limited resources. GSCM could offer SMEs the theoretical foundation it requires to attain innovative sustainable development; IT absorptive capacity could supply the knowledge and instruments SMEs require to leverage these innovations. These parts of change in organization together can go a long way in reducing the sustainability gap of SMEs, and enhancing their competitiveness and sustainability for the long future.

Although research on IT absorptive capacity and ambidextrous sustainable innovation is neglected, due to their significance, no prior studies provide insight into how IT absorptive capacity acts as the mediator between GSCM and ambidextrous sustainable innovation in SMEs. Although these variables have been discovered in different studies individually, little research has focused on the combined impacts, as well as the mediating role of technology adoption, of these variables in the context of SMEs located in developing countries, including Iraq. Hence, this study aims to fill the gap by offering that a closer look at how absorptive capacity of IT determines the capacity of SMEs to implement GSCM and achieve ambidextrous sustainable innovation.

The contribution and originality of this research highlights the importance and the extent of the research problem in developing a simultaneous GSCM-IT absorptive capacity-sustainable innovation ambidexterity framework to favorably address the research problem of the Iraqi SMEs context. Through furthering this understanding, this research also supports advances in the theory of sustainable innovation practice and provides valuable tips for SMEs wishing to improve their sustainability position. This research focuses on making recommendations for how SMEs can successfully realise sustainable innovation, by pointing to the potential role of IT capabilities in supporting sustainable supply chain management for these firms. Through the analysis of these variables simultaneously, the study provides a comprehensive view of how VR can enhance the application of IT absorptive capacity with GSCM to support innovation and SMEs' sustainable growth.

## 2 Literature Review and Hypothesis Development

### *2.1. GSCM and Ambidextrous Sustainable Innovation*

Being comprehensively defined as the integration of environmental issues into supply chain management, GSCM covers a wide range of practices which include purchasing with environmental consideration, design for environment, green production, environmental returns and green transportation. GSCM therefore fruitful focuses on integrating sustainability into all the supply chain management activities with pulls of diminishing ecosystem harms, efficiency in utilization of resources and social responsibilities. Considering the relationship between ambidextrous sustainable innovation and GSCM, more attention should be paid to small and medium-sized enterprises (SMEs) because such enterprises may experience both opportunities and challenges in the process of implementing sustainable change (Carvalho et al., 2019). These key concepts have recently attracted considerable attention because sustainable innovation can improve not only environmental performance but also organizational competitiveness (Assumpção et al., 2022). This study reveals that there are potential benefits for SMEs when they

decide to implement GSCM practices. While SMEs generally could have fewer capital to invest than the large firms, the usually possess more elasticity and can respond faster to fresh practices and new requests. From the literature, GSCM can assist SMEs to conform to various legal and regulatory demand, lower costs depending on improved efficiency, better their image, and appeal to the environmental concern clients as noted by Sun 2024.

Ambidextrous sustainable innovation refers to the capability of an organisation to innovate both for exploitation and exploration while keeping sustainablity at the fore. This kind of dual capability is therefore crucial for longevity in the market. Ambidextrous innovation contributes to the conditions under which radical changes do not contradict the improvement of organizational activities. It allows the firms to adapt to environmental pressures and opportunities efficiently and helped to foster culture of perpetuated improvisation and adaptability (Xing et al., 2024). The relationship between GSCM and ambidextrous sustainable innovation is co-dependent. Thus, GSCM creates an environment for the development of sustainable principles that can promote explorative and exploitative types of innovation. From the following GSCM, it can be deduced that SMEs can experience cost reduction by minimizing wastes and enhancing resource utilization. Such cost savings can then be channeled towards investment in new business development and both exploration and exploitation. GSCM assists SMEs to control environmental legislations and ordinances that are becoming prominent in global markets. It helps to gain new market access and provide certain competitive advantage, which would stimulate firms innovation (Yu and Xiao, 2024).

The GSCM can be a way of improving company credibility and brand equity by using the promise of sustainability. This positive image can help draw in customers, investors, and partners improving the climate for finding innovative solutions. Finally, GSCM practices have been seen to assist SMEs in comprehending environmental risks to be able to reduce or eliminate them. This approach to risk management may help promote a culture of creativity since firms are always on the lookout for solutions to possible problems (Dzikriansyah, 2023).

Finally, It is proposed that, to achieve Implementing of GSCM, a firm needs to absorb new knowledge about sustainability and developed sustainability capabilities. By having this kind of knowledge it will be a source of generating exploratory and exploitative innovation as a basis for new ideas and farther improvements.

GSCM and ambidextrous sustainable innovation can have a profound value for SMEs. SMEs by their very nature and this size, often find themselves at a disadvantage in having to adapt and be creative when compared to their larger counterparts. Hence, with the help of GSCM, SMEs are able to build an innovation-supporting environment for organizations focusing on sustainable growth due to their flexibility and entrepreneurial orientation.

Different researches have brought out how GSCM impacts positively on innovation. For instance, Carvalho et al. (2019) found that GSCM practices enhance significantly the performance of organizations and innovation capabilities. This paper demonstrates the trend of research in the discussed area and indicates its focus on innovation promoted by the actions toward GSCM. Similarly, Assumpção et al. (2022) revealed that GSCM improves both operational and environmental performance, creating pressures for innovation in manufacture. The managerial implication for this paper is that specific GSCM practices should be implemented by executives to improve innovative process in organizations to increase performance. Furthermore, Yu and Xiao's (2024) study also establishes the fact that GSCM can promote innovation persistence. They discovered that while both MET and TET have positive moderating effects on this relationship. Mechanism tests also show that, by improving the efficiency of innovation innovation, guaranteeing the quality of innovations, and solving financing problems, GSCM can promote firm innovation persistence.

Analyzing the connection between GSCM and ambidextrous sustainable innovation, firms can manage these threats while also maximise sustainability opportunities. It is the strategy that not only improves their competition advantage, but also helps to change environment and achieve social objectives that corresponds to the global sustainability. Given the insights from the aforementioned literature, the following hypotheses can be formulated:

**Hypothesis 1 (H1).** *GSCM positively influences ambidextrous sustainable innovation.*

### *2.2. GSCM and IT Absorptive Capacity*

It adopts supply chain management approach wherein environmental management issues are incorporated into all stages, from purchasing to product design and development, manufacturing, distribution and disposal. Some of

the GSCM principles applicable to the organization include green procurement, eco-design, green manufacturing, reverse logistics and sustainable distribution whose purpose is to reduce environmental burden, waste and optimize resource utilization. This study suggests that GSCM is important for companies keen on integrating their activities to promote sustainability to help support enduring environmental and economic returns (Shahzad et al., 2020).

IT absorptive capacity refers to the ability of an organisation to evaluate the value of information technology, assimilate it and exploit it. This form of capacity is useful in managing innovative and efficient ways of operating in the organization. It comprises three main dimensions: These include: acquisition, which involves the classification and acquisition of external knowledge; assimilation which is the processes of understanding the acquired information; and application this is the utilization of the knowledge to improve business activities (Bi and Yu, 2008). Thus for SMEs, IT absorptive capacity is significantly important because it allows firms to value and utilise such knowledge externally sourced, assimilate it and create innovations (Rauniar et al., 2024).

In the case of GSCM and IT absorptive capacity, positive feedback exists as both components maintain synergistic relationship within the value chain. The IT absorptive capacity relates to the management and integration of information for implementing GSCM practices while the acquisition of new Environmental knowledge for organisational use. The clear structure and integration of IT systems in the supply chain are said to facilitate the proper flow of information; thereby improving the way that SMEs handle and use this information and consequently improving the implementation of GSCM strategies. For example, the use of the system in delivering IT services can assist in monitoring carbon emissions, resource utilization, and wastes generated in real-time, which support organizational sustainability objectives (Wang et al., 2019).

For every GSCM process to be effective, there is need to make right decisions at the right time and with the right information. IT absorptive capacity involves the capability of SMEs to collect, assess, and act upon information of the environment. Some of the elements that the firm needs to embrace are green supply chain management of suppliers, green supply chain management of logistics and green supply chain management of manufacturing. Sophisticated IT solutions and business analysis allow SMEs to understand patterns, future scenarios and improve outcomes that contribute to sustainability transformation. Therefore, while IT absorptive capacity can enhance the execution of GSCM, it also drives innovation by facilitating process and product enhancement (Trang et al., 2024).

IT has playing the important role in GSCM by consolidating collaborative and knowledge sharing with supply chain partners. This commonly involves supplier and customer interfaces as well as other stakeholders in order to achieve sustainability goals. It can improve this collaboration when IT absorptive capacity facilitates the exchange of information between these organisations. IT tools can be applied by SMEs to get connected and discuss the green concerns, ideas and strategies and coherent joint initiatives. To increase the standards of transparency thereof and to promote the overall supply chain environmental sustainability, noted technologies in the form of tools for virtual collaboration and online information sharing can help supply chain members develop a culture of environmentally responsible behaviors (Karmaker et al., 2023).

The above models show that there are opportunities for the integration of GSCM and IT absorptive capacity for SMEs despite the constraints that come with resource constraint. On the one hand, the introduction of GSCM can entail considerable capital commitments in terms of technology and processes, Cutting operational costs and optimising resource use may be possible for these SMEs if they have ITAC. For example an SME using cloud based inventory management system for his/her business can be in a position to reduce wastage and hence influence the best stock to order and hence be in a position to cut cost and also protect the environment. Additionally, through increased IT absorptive capacity, SMEs are well informed on changes to the regulation to enable them to meet environmental standards when seeking to penetrate markets with strict environmental requirements as noted by Rasool et al., (2023).

Implementing of GSCM and also showing a sincere effort in the area of sustainability are some of the few ways that SMEs can respond competitively. IT absorptive capacity improves their ability to create and position themselves in the market through offering sustainable products and services. SMES in Kenya could also use various digital marketing applications in a bid to market themselves on the aspects of being green and appeal to globally conscious clients and accumulate a loyal following. In addition, IT absorptive capacity sustains the scalability of GSCM practices to encourage SMEs to achieve larger levels of sustainability without a corresponding rise in resource consumption. Integrated supply management information systems for SMEs are suitable IT platforms as

they enable firms to handle voluminous information and transactions as businesses scale up (Winter et al., 2023).

In regard to this topic, we have noted in previous work that there is a strong positive relationship between GSCM and IT absorptive capacity. For instance, Asamoah et al., (2023) revealed that some structure capabilities improve supply chain IT infrastructure integration and critical for GSCM. As seen in figure 2 above, it is hypothesized that absorptive capacity positively mediates the relationship between green purchasing, customer cooperation and firm performance. Respectively to that, the present study found that absorptive capacity, triggered by GSCM practices and RS, fully mediates the proposed relationships; highlighting its importance as a firm capability in innovation of products based on the constantly developing market needs.

The results imply that management of all absorptive capacity elements in combination may improve performance outcomes. Wei (2023) also confirmed this idea stating that IT capabilities enhance the green practice in supply chain management. Study explores the benefits and drawbacks of using IT in IGSCM in terms of environmental and social impacts, costs, and performances during embracing IT, technological, organizational, and regulatory barriers to their application. As realized above, IT for SMEs provides a perfect solution since it can promote the improvement of GSCM practices. GSCM with the integration with IT absorptive capacity provide solution to resource constraint problem, and satisfy regulatory requirements for the SMEs to gain competitive advantage. Therefore, we can propose the following hypothesis:

**Hypothesis 2 (H2).** *GSCM positively influences IT Absorptive Capacity*

### *2.3. IT Absorptive Capacity and Ambidextrous Sustainable Innovation*

IT absorptive capacity is an important enabler of IT innovation and operational improvement. In the case of SMEs, IT absorptive capacity is highly relevant as it allows the firms to adequately utilise outside knowledge and translate and apply it within the organisation context. Exploratory sustainable ambidexterity is the organisation's capability to implement exploratory and exploitative innovation at the same time with a focus on sustainability (Shahzad et al., 2020). The positive relationship between absorptive capacity of IT and the notion of ambidextrous sustainable innovation is co-creative. IT absorptive capacity defines the ability of a firm to acquire and utilise knowledge external to that organisation hence it plays an important role in explorative and exploitative innovation. IT absorptive capacity improves the ability of a firm to acquire and utilize new environmental knowledge necessary for the creation of new sustainable goods and the optimization of current processes (Feng and Chen, 2024). SMEs having a high level of IT absorptive capacity are able to recognize environmental technologies and practices in the same environment, as well as integrate them into the innovation and enhancement of sustainability activities (Alshahrani and Salam, 2024).

The abilities of interpreting new information depend upon the higher level of analytic skills. IT absorptive capacity gives the SMEs the means and the know-how to process environmental information, and to emerge with trends, and create new strategic options and solutions. This capacity helps both fragmental and reducer innovative activities because it allows firms to make right decisions and apply correct sustainability strategies. For example, such tools as advanced analytics and big data tools can help the SMEs to anticipate the environmental impact of the processes and to build the strategies that will reduce the detrimental consequences, achieve the constant enhancement and the culture of sustainable innovation (Tufan and Mert, 2023).

In addition to what it has been explained already, the ambidextrous sustainable innovation with the help of integration of IT helps to stimulate collaboration and information sharing both within and outside the organization. IT absorptive capacity on the other hand supports sustained communication and transfer of information and knowledge by helping SMEs undertake sustainability projects collectively and in unison with their partners while sharing the very best practices and co-developing with partners. Virtual tools for collaboration and information exchange can facilitate transparency between the stakeholders, and create an umbrella for collaborative sustainable innovation. It becomes evident that this collaborative environment is invaluable for exploring new ideas – exploratory innovation and for exploiting existing ideas with an aim of improving them – exploitative innovation(Lee et al., 2023).

Larger organizations may benefit more from ambidextrous sustainable innovation than SMEs since the latter particularly struggle with absorptive capacity for IT, although ambidextrous sustainable innovation offers rich opportunities for development in this area due to limited resources. IT absorptive capacity enables SMEs to

maximise optimisation of its resource utilization, cut down wastage as well as enhance on the reduction of costs. These cost savings may be redirected to innovation investments, including both search and implementation initiatives. For instance, IT solutions to inventory controls can assist SMEs avoid excessive stock and its connected wastes, both financial and environmental, and; IT solutions for regulatory compliance assists SMEs to penetrate markets that have highly sensitive environment standards (Fulgence et al., 2023).

Improving effects of sustainable innovation and showing concern towards sustainability can be beneficial for SMEs as they can offer competitive edge to the organizations. IT absorptive capacity improves their capacity to create and position themselves in a market by offering unique, sustainable solutions. SMEs may employ, the digital marketing tools to advertise themselves to environmentally conscious customers, to target niche customer base and increase their popularity. In addition, the expertise absorption capacity of IT increases the capability of SMEs to grow sustainable innovation practices without a corresponding relative rise in cost outlay. Integrated IT platforms for supply chain management because they allow the SME keep up with the increasing volume of data and transactions in the supply chain as the business scales (Müller et al., 2021).

Researchers confirmed the relationship between IT absorptive capacity and innovation in different research papers. For instance, Müller et al. (2021) make an argument that the knowledge acquisition, conversion, transformation, and use are the processes that help the firms pursue both exploration and exploitation innovation strategies.

Fulgence et al. (2023) discovered on the effects of cluster environment that knowledge absorptive capacity has a significant positive relation and boosts innovation performance. Moreover, the reaction of the cluster environment adds value as a contingency which moderates the link between knowledge absorptive capacity and innovation performance.

Carrasco-Carvajal et al. (2023) further developed such notion, arguing that other aspects, especially absorptive capacity, become important in environments that change constantly and requires firm innovation. It was shown that absorptive capacity matters a lot for strategic decisions and outbound innovation processes of firms. Firm strategies are a full mediator between absorptive capacity and inbound open innovation practices and a part mediator between absorptive capacity and outbound open innovation practices the quantity of explained variance. How IT absorptive capacity can facilitate ambidextrous sustainable innovation to SME is the transformative model for them. Through the application of the absorptive IT capacity and innovation practices, the SMEs can go round resource scarcities, meet the requirements of the laws, gain competitive edge and expand effectively. Based on the information provided, we formulated the following hypothesis:

**Hypothesis 3 (H3).** *IT Absorptive Capacity positively influences Ambidextrous Sustainable Innovation.*

### *2.4. The Mediating Role of IT Absorptive Capacity*

This study finds that IT absorptive capacity also plays the role of a mediator between GSCM and ambidextrous sustainable innovation. This mediation suggests that the relationship between GSCM and ambidextrous sustainable innovation is amplified by the creation and application of IT absorptive capacity. This mediating role presents an opportunity, for SMEs to harness towards sustainable invention to protect competitive advantage. Concerning GSCM and ambidextrous sustainable innovation, IT absorptive capacity is a mediator that enables the transformation of GSCM best practices into sustainable innovation performance.

IT absorptive capacity improves knowledge acquisition and consequently the integration processes (Haryanti and Subriadi). Applying GSCM practices forces firms to gather a vast amount of information about the environment, such as regulation compliance, sustainable materials, and the like. IT absorptive capacity allows SMEs to effectively acquire, develop and utilise this information (Aboelmaged & Hashem, 2019). For instance, an SME that pursues green procurement can leverage on IT applications to monitor supplier's performance and environmental compliance, and the insights gathered can be incorporated in supply chain management in that organization.

IT absorptive capacity enhances the ability to analyse. Knowledge processing, which is the ability to manage and assimilate the quantity of information produced by GSCM practices is important for generating exploratory and exploitative innovations (Cooper & Molla, 2017). To the extent that gaps in the supply flow may actually contribute to inefficient and environmentally unsound practices, such tools may be adopted by SMEs to rectify these

problems, and refine the process even further to achieve better sustainability. The mentioned improved understanding helps to make decisions backed by quality data, and the practical application of successful sustainability measures (Mohezar et al., 2023).

Moreover, IT absorptive capacity enables the utilisation of acquired/assimilated knowledge to translate green supply chain bestpractice into new and improved services and goods. In this application, IT absorptive capacity gives the necessary technological standpoint to support the concept (Liu et al., 2018).

Furthermore, IT absorptive capacity cause encourage structural transformation and learning that enhances innovation in SMEs. In this context IT absorptive capacity enables the continuous assessment and improvement of GSCM practices to enable SMEs overcome new challenges or leverage new opportunities. SMEs that possess superior IT absorptive capacity are capable of constantly scanning and upgrading the sustainability profile in order to depict the most advanced sustainable improvement.

Moreover, IT absorptive capacity enables the internal communication and external integration which are the vital activities integrated in GSCM and ambidextrous sustainable innovation. IT absorptive capacity offers a way to create and facilitate communication channels and information sharing to foster collaboration among SMEs both in addressing sustainability issues and in sharing ideas and best practices with their partners (Khraishi et al., 2023).

Another factor of special interest to SMEs is the mediating role of IT absorptive capacity in the connection between GSCM and ambidextrous sustainable innovation. SMEs lack adequate resources to afford a comprehensive GSCM system and practices in realizing sustainable innovation on their own. But this is an important gap where SMEs can close by building up their IT absorptive capacity and optimise benefits derived from their GSCM programme. IT absorptive capacity gives SMEs the benefit of 'getting the right information for the right use at the right time' by efficiently utilising the available resources. This optimization is paramount in the provision of efficient GSCM practices hence the sustainable innovation (Aliasghar et al., 2023).

In addition, IT absorptive capacity enhances the scale and scope of GSCM practices and sustainable innovation activities. Self learning one: The core message of the chapter 5 is that while SMEs are growing they can take more measures to work to sustainability framework than proportionately increase resource costs. New technologies of IT services help SMEs to process a growing amount of data and turnover; they promote sustainable development. Also, IT absorptive capacity assists SMEs in learning about regulatory changes and necessary compliances to meet environmental standards required to access international markets as well as penalty for noncompliance (Abourokbah et al., 2023). The following hypothesis can be postulated:

**Hypothesis 4 (H4).** IT absorptive capacity is found to moderate the effects of green supply chain management on ambidextrous sustainable innovation.

**Table 1** summarizes the preceding literature contributions and shows the research gaps filled by the current research, and Figure 1 presents the theoretical framework of the current research.

**Table 1** Comparison of Contributions of Previous Studies.

| *Author(s)* | *Green Supply Chain Management* | *IT Absorptive Capacity* | *Ambidextrous Sustainable Innovation* |
|---|---|---|---|
| Jihu (2024) | ☐ | | |
| Dzikriansyah (2023) Shahzad et al. (2020) | ☐ ☐ | ☐ | |
| Ibrahim et al. (2024) | ☐ | ☐ | |
| Alsmairat and AL-Shboul (2023) | ☐ | | ☐ |
| Feng and Chen (2024) | | ☐ | ☐ |
| Srisathan et al. (2023) Lu et al. (2024) Carvalho et al. (2019) | | | ☐ ☐ |
| | ☐ | | ☐ |
| Assumpção et al. (2022) | ☐ | | ☐ |
| Yu and Xiao (2024) | ☐ | | ☐ |

| | | | |
|---|---|---|---|
| Asamoah et al. (2023) | ☐ | ☐ | |
| Shafique and Hyder (2019) | ☐ | ☐ | |
| Wei (2023) | ☐ | ☐ | |
| Fulgence et al. (2023) Carrasco- | | ☐ | ☐ |
| Carvajal et al. (2023) Müller et | | ☐ | ☐ |
| al. (2021) | ☐ | ☐ | ☐ |
| **Present Study** | | ☐ | ☐ |

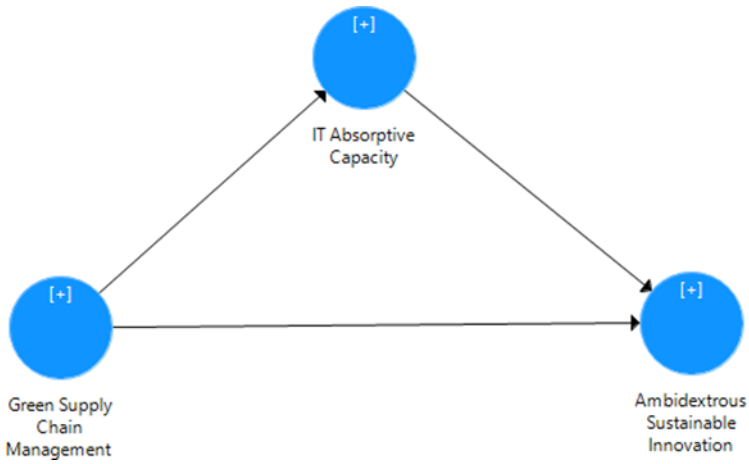


**Figure 1** Research framework.

## 3 Methodology

### *3.1. Sample and Procedure*

The data for this study were collected from manufacturing firms in Iraq, focusing on top-level managers from various businesses across the country. A total of 39 manufacturing firms were selected using a convenience cluster sampling method based on their proximity within chosen clusters. Cluster sampling is advantageous when the population is widely distributed and selecting a representative sample is impractical (Acharya et al., 2013). Clusters often represent natural groups, such as schools, hospitals, and businesses. In this study, industries were considered as clusters.

To ensure an efficient cluster sampling technique, a sampling frame is essential. However, randomly selecting clusters from a sampling frame can be time-consuming and inefficient. Therefore, clusters were selected based on their geographic location to address these issues (Sedgwick, 2014). For this research, clusters were chosen from industries located in Baghdad and Diyala, selected based on their industry type and geographical proximity. Data were collected from various manufacturing businesses to ensure diversity among industries. These provinces represent distinct environments of manufacturing development and market economy, making them suitable for this study. Diyala, an eastern province of Iraq, represented an average level of economic development, while Baghdad, the capital, represented an advanced level.

The sample included manufacturing SMEs operating in various industries such as shoes and textiles. A close-ended self-administered questionnaire was distributed to the top management of these businesses, achieving a high response rate of 95.17%, which is considered optimal (Comrey and Lee, 1992). Instead of simply asking respondents to agree or disagree with a statement, Likert scale items measured the degree of agreement on a 7-point scale ranging from 1 (strongly disagree) to 7 (strongly agree), with 4 indicating a neutral stance. Research indicates that using scales with 5 to 7 points improves the validity and reliability of responses compared to scales with fewer points. However, using scales with more points, such as a 10-point Likert scale, does not necessarily enhance reliability and may lead to slightly lower scores at the upper end of the scale.

GSCM was assessed using items proposed by Jihu (2024), while items to measure IT absorptive capacity were adopted from Abou-Foul et al. (2023). The measure for ambidextrous sustainable innovation was adopted from Khan et al. (2023). Before the formal survey, a pilot test was conducted on seven randomly selected companies to

validate the survey items.

## 4 Data Analysis

### 4.1. *Data Analysis*

The partial least squares (PLS) method was used in two forms in the present study. First, I ran a reliability analysis with a view of checking the reliability and validity of the measurement items. In the next stage, paths analysis procedure was performed to test the causal linkages of research variables. These steps supported the reliability and validity tests of the variables as well as the determination of inter-variable relationship (Hulland, 1999). PLS is well known for its efficiency in handling measurement items and delivering powerful analysis of research models. For this reason, it is regarded as one of the most stable research data analysis tools there is (Petter, et al., 2007). Possibly the greatest strength of PLS is the ability to manage uncertainty, which means PLS is superb when the variables are asymmetric. Furthermore, the usage of PLS also effective in evaluating the dynamic assessment outlines (Chin et al., 2003). Based on these characteristics, PLS was especially suitable for this study, outcomping with other SEM methods traditionally used. PLS was chosen to test hypotheses on relationships between constructs, minimize measurement error, and avoid multicollinearity problem. This approach provided more reliable and consistent information regarding the research hypotheses and interaction of the variables of interest.

### 4.2. *Convergent and Discriminant Validity*

Structural equation modeling (SEM) was used as the method of analysis for the current study, with Smart PLS 3.2.8 used in the analysis process to test the hypotheses formulated in the current study above. The appropriateness of the proposed research model leads to choosing the partial least squares structural equation modeling (PLS-SEM) method for its application to both simple and complex models. Scholars have noted that PLS-SEM outperforms the measurement aspect compared to CB- SEM, for several reasons a preferred technique. First and foremost, PLS- SEM is excellent for handling and assessing estimations compared to traditional regression approaches, and especially relevant in evaluating mediating effects. Moreover, it has been pointed out by various scholars that PLS-SEM does not have the provisions of normal assumption in the analysis of different data distributions. Because of these characteristics and flexibility, PLS-SEM is the appropriate approach to analyze the relationship between the constructs in this investigation (Hair et al., 2014). Fix and signature2 models that are used by PLS-SEM requires estimating the outer and the inner model. For the reflective constructs of the outer model, three types of assessments were conducted: Cronbach's alpha coefficient for individual items, composite reliability (CR) and convergent validity coefficients. For readability, the factor loadings of the items are presented in Table 2, of which all the loading factors are greater than 0.50 which is the recommended cut-off value. These outcomes confirm that the study retains satisfactory level of individual item

reliability as long as the Hair et al. (2014) standards have been met.

To assess the internal consistency reliability of the constructs, CR was calculated where each construct should obtain a minimum value of 0.60. As demonstrated in Table 2, all the constructs were above this criteria, indicating the homogeneity, internal consistency and reliability of the measures (Hair et al., 2014). Convergent validity was established by Average Variance Extracted (AVE), which measures the extent of the relationship of the items to their own construct (Bergkvist and Rossiter, 2007, pp. 352). As labelled in Table 2, the AVE values for all the studied variables lay between 0.635 and 0.761. These values are greater than 0.50, which signifies that the research fulfils the condition of convergent validity.

**Table 2** Measurement Model Assessment

| *Item Code* | *Factor Loading* | *Composite Reliability (CR)* | *Average Variance Extracted (AVE)* |
|---|---|---|---|
| GSCM1 | 0.716 | | |
| GSCM2 | 0.824 | | |

| | | | |
|---|---|---|---|
| Green Supply Chain Management | GSCM3 0.884<br>GSCM4 0.749<br>GSCM5 0.874<br>GSCM6 0.754<br>GSCM7 0.814<br>GSCM8 0.868 | 0.939 | 0.660 |
| IT Absorptive Capacity | ITAC1 0.730<br>ITAC2 0.710<br>ITAC3 0.575<br>ITAC4 0.657<br>ITAC5 0.465<br>ITAC6 0.765<br>ITAC7 0.696<br>ITAC8 0.736 | 0.867 | 0.635 |
| Ambidextrous Sustainable Innovation | ASI1 0.671<br>ASI2 0.520<br>ASI3 0.787<br>ASI4 0.682<br>ASI5 0.558<br>ASI6 0.643<br>ASI7 0.621<br>ASI8 0.729 | 0.856 | 0.761 |

As Equation (1) suggests, formulated by Tenenhaus et al. (2005), the measure of the adequacy of fit (GOF) for this research was calculated and examined. This method was utilized to evaluate the efficacy of the proposed research model, as demonstrated below:

(1)

$$\text{GOF} = \sqrt{\text{Average } R^2 \times \text{ Average AVE}} = \sqrt{0.822 \times 0.827} = 0.824$$

According to the above calculation, the GOF attained a value of 0.824 and highly exceeded the minimum acceptable cutoff of 0.305 to conclude substantial impact size (Wetzels et al., 2009).

### *4.3. Empirical Results*

Smart PLS 3.2.8 was utilized to perform the path analysis of the research framework. This section is dedicated to evaluating the inner model. To test the proposed hypotheses within the inner model, p-values and t-values are assessed. A hypothesis is considered supported if the p- value is less than 0.05 or if the t-value exceeds 1.96.

As per the consequences of this study, as shown in Table 3 and Figure 2, GSCM was exposed to have a positive influence on ambidextrous sustainable innovation, hence supporting H1 ($\beta$ = 0.382, t-value = 8.678). Furthermore, GSCM also had a significant influence on IT absorptive capacity; therefore, H2 ($\beta$= 0.780, t-value = 34.213) was supported. Moreover, IT absorptive capacity significantly influenced ambidextrous sustainable innovation; therefore, H3 ($\beta$= 0.531, t-value = 12.396) was supported.

**Table 3** Hypothesis results

| *Hypothesis* | *Path Coefficient* | *t-Statistics* | *p-Values* | *Results* |
|---|---|---|---|---|
| H1 | 0.382 | 8.678 | 0.000 | Supported |
| H2 | 0.780 | 34.213 | 0.000 | Supported |
| H3 | 0.531 | 12.396 | 0.000 | Supported |

This study employed activity theory as developed by Kofod-Petersen and Cassens (2005) along with the indirect effects generated by Smart PLS, as shown in Table 4, to test the mediation results. The findings in Table 4 demonstrate that IT absorptive capacity fully mediates the relationship between GSCM and ambidextrous sustainable innovation.

**Table 4** Hypothesis and Mediation Analysis

| *Hypothesis* | *Path Coefficient* | *t-Statistics* | *p-Values* | *Results* |
|---|---|---|---|---|
| H4 | 0.330 | 7.254 | 0.001 | Full mediation |

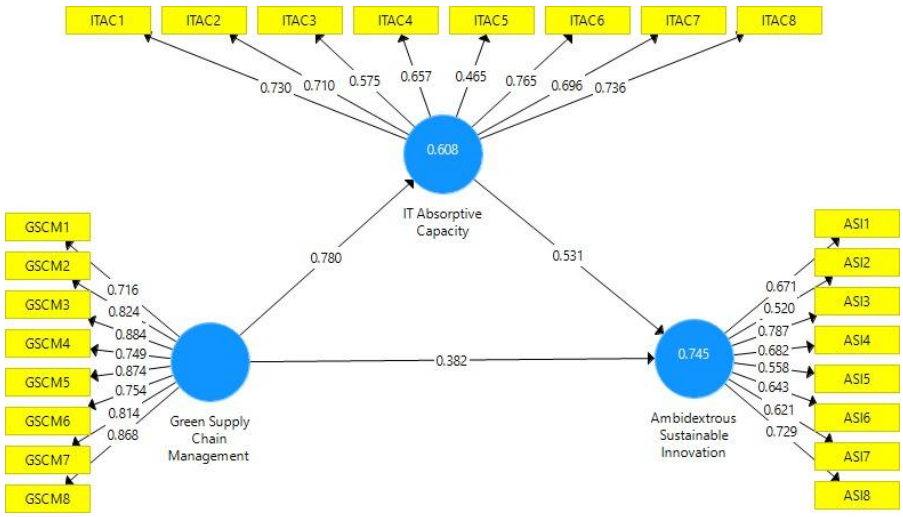


**Figure 2** Hypothesis Testing and Mediation Effects

## 5 Discussions

Within the context of this research, the relationship between GSCM, IT absorptive capacity, and ambidextrous sustainable innovation in Iraq's manufacturing SMEs is discussed. The study proposes GSCM to have a positive relationship with ASI specifying that implementing sustainable supply chain management strategy would be useful to positively affect exploitative and exploratory innovation. It emphasizes information on the fact that green practices do not only conform to the set guidelines but also extend best practices improvements, innovation, and

value addition.

This research also identifies IT absorptive capacity as a moderator that positively impacts the utilisation of GSCM for sustainable innovation by firms. This paper finds that green initiatives produce substantial innovation outcomes for firms with higher IT absorptive capacity, given the ability to process and utilize the obtained knowledge. To sum up, the study demonstrates that IT enhance and the upgrade of skills can enhance the effects of GSCM for SMEs in the developing country Iraq despite the resource limitation.

The research addresses an important void in the literature by targeting SMEs located in emerging economies — a subject that is underresearched due to extensive attention to large firms operating in developed countries. This study contributes to the literature on GSCM and IT capability, in terms of their impact on innovation, in smaller firms in resource constrained environments.

Therefore, the study has established for itself the necessity of GSCM and strong information technologies to harmoniously work in tandem. For manufacturing SMEs in Iraq, it is identified that such investments can be strategically made to address growth oriented goals since such needs can be sustainable and dovetail the short-term requirements with the strategic direction of the company.

## 6 Conclusions

The positive link between GSCM and ambidextrous sustainable innovation supports the use of environmentally sustainable practices in SCP practices. This study underscores the notion that, apart from the compliance and environmentalism angle of GSCM, there is also emphasis and advancement of an innovative culture which would help support exploitative as well as explorative innovation endeavours. Thus, to manufacturing SMEs, this study tries to equally underscore the indispensability of implementing the green practice in the supply chain together with recognizing that embracing digital technologies, IT management systems would help improve the positive effects of these innovations.

The paper also emphasizes the mediating function of IT absorptive capacity in the relationship between GSCM and ambidextrous sustainable innovation. This result suggests that the extent to which a firm acquires, captures, and exploits external IT knowledge enhances the relationship between GSCM and innovation. Improving on the IT strength becomes a prerequisite for firms intending to derive maximal value from environmentally sustainable supply chain management schemes, including ERP systems, massive data processing, and technologies. This is particularly important for SMEs given that they are characteristically challenged by lack of capital to invest in the required IT facilities and train their staff adequately.

This research will fill this gap by addressing the experiences of manufacturing SMEs from developing nations. In particular, by focusing on the use of digital technologies and smart management systems, the study shows that these firms can use GSCM and IT capabilities to a sustainable innovation. Building on the available knowledge about the factors affecting M&As and the prospects of emerging market firms, the results from Iraq enhance and expand the generality of current theories for both academic and real business contexts.

## 7 Theoretical Implications

On the theoretical side, this research has relevant implications for advancing the extant knowledge of GSCM, the role of IT absorptive capacity, and the concept of sustainable innovation as both one's and two's. In showing the implication of GSCM on ambidextrous sustainable innovation, this study points to the strategic roles of green affairs in exploitative and exploratory innovation. The inclusion of IT absorptive capacity as a moderator enhances the theory, then clarify the flow of GSCM to innovative results. This indicates that GSCM is enhanced by certain IT capabilities and that future research should account for IT absorptive capacity by the business when studying the impacts of green measures.

Consequently, the findings derived from manufacturing SMEs in Iraq enrich theory with definite context-specific perspectives usually underrepresented in prior emic research in emerging markets. This study affirms the its generalisation of GSCM and innovation concepts for businesses of various economic classifications in diverse economic structures and therefore calls for research inclusiveness from a wider cross-section. From a methodological point of view, the application of PLS-SEM to analyze relationships and mediations seems to suggest an efficient research approach for future works. Therefore, this book contribution as a whole and individually

improves the theoretical body of GSCM, IT absorptive capacity, and ambidextrous sustainable innovation, to provide a more comprehensive approach to the sustainability of business activities by considering environmental management, capability in IT, and strategic ambidexterity.

## 8 Managerial Implications

The implication of the conclusion of this study for managers of SMEs in transition economies including Iraq cannot be underscored this is because. Firstly, the study established a significant positive relationship between GSCM and ambidextrous sustainable innovation, therefore urging managers to incorporate green supply chain management into their operations. So, in addition to following environmental requirements and fulfilling the legal requirements by adopting environmentally friendly practices, firms can increase innovation and, therefore, the long-term competitiveness of SMEs in the marketplace, which would be their unique selling proposition.

Second, the study focuses on the mediating effect of IT absorptive capacity in the relationship between GSCM and innovation. From this, managers can appreciate the need to enhance expenditure on IT infrastructure and skills. Improving IT competence allows firms to capture, acquire and transfer useful external context information for the green supply chain, thereby maximizing the returns on the strategy. Organization managers should try to adopt formal mechanisms like training programs to enhance their firm's absorptive capacity together with the improvement of its IT systems. This rational investment in IT is twofold; owing to the it helping sustain innovation as well as improving organizational operational performance and market flexibility.

Last but not least, this research has implications for managers of firms operating in emerging markets to adapt their strategies to their economic and operational contexts. The results further suggest that for Iraqi manufacturing SMEs, filtering clusters on industry and geography can be valuable in terms of GSCM practice and IT adoption. Managers must take information related to the regional bias into consideration; it is also possible for them to take advantage of the strengths of different provinces. This approach guarantees that GSCM and IT improvement efforts are appropriate and valuable towards the various contexts. Altogether, the research offers a clear structure of green supply chain practices and IT capabilities for managers to improve organizational sustainable innovation and competitive advantages.

## 9 Limitations and Future Research

There are some restrictions for this research thst have been identified and bears potential for further investigation. Firstly, the study used a single dimension to capture the construct of IT absorptive capacity. Nevertheless, previous research suggests that IT absorptive capacity is a construct that should be defined multi-dimensionally. In future research, however, the present study's multidimensional model of IT absorptive capacity should be employed, which includes several attitudinal and cognitive precursors. This will enable us to not only understand which factors affect IT absorptive capacity but also how they affect other organisational results.

Secondly, the research design of this study was cross-sectional, and no data was collected at more than one point in time. Yet this approach lacks time-series analysis, although does yield good results. It is suggested that future studies should use a longitudinal research design that can produce time-orientated views or document the dynamics of the GSCM IT absorptive capacity and ambidextrous sustainable innovation relationships.

In turn, longitudinal studies should offer more proof to the effect that these parameters are causal and shed more light on the long term effects.

Also, this research mainly targeted manufacturing SMEs in Iraq. However, further research should try to involve other subjects from different geographical areas to increase the generality of the results. Cross- sectional research can also be carried out with developed nations in analyzing the dissimilarities and affinities in GSCM practices and innovation results between emerging fraternity and developed counterparts. However, bearing in mind the existing global environment, the future researchers could add the COVID-19 effect and utilize AI to further develop the GSCM and ambidextrous sustainable innovation lever. This will offer a modern perspective and real-life application to organisations in operation post-pandemic.

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