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Digital Technology Ecosystems and Sustainable Firm Performance: The Mediating Role of GSCM and Circular Economy Under Institutional Pressure

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ABSTRACT

This study examines how integrated digital technology ecosystems (IDTE) improve sustainable firm performance (SFP). With the transformation of IDTE, firms should incorporate complementary dimensions to achieve long-term efficiency. The study employs the dynamic capabilities view (DCV) and institutional theory to examine the complex impact of IDTE on SFP, mediated by the effects of green supply chain management (GSCM) and circular economy practices (CEP). Additionally, the study investigates the moderation effect of institutional pressure (IP) on the impact of IDTE on GSCM and CEP. PLS-SEM was applied to analyze 260 valid responses collected from IT and logistics and supply chain managers of MNEs. Contrary to our hypothesis, IDTE does not directly improve SFP. However, the IDTE-SFP relationship is significantly mediated by GSCM and CEP. Institutional pressure (IP) significantly affects how legislative frameworks, market dynamics, and stakeholder expectations influence sustainable practices, thereby amplifying the impact of IDTE's GSCM and CEP. Thus, MNEs should purposefully link IDTE to sustainability-focused capabilities for long-term benefits. Our findings underscore the importance of Gulf Cooperation Council (GCC) governments and MNEs in supporting integrated digital technology ecosystems that promote GSCM and CEP to achieve SFP.

Keywords: ***circular economy practices, integrated digital technology ecosystems, GSCM practices, sustainable firm performance***

1. INTRODUCTION

Today's complex globalized businesses require Integrated digital technology ecosystems (IDTE) for supply chain sustainability (Ivanov, 2023; Liu *et al.,* 2023). IDTE comprises big data analytics, IoT, AI, and blockchain, enabling organizations to collect, process, and analyze vast amounts of data in real-time (Tiwari *et al.,* 2024). These technologies enhance supply chain visibility and traceability, improving decision-making and efficiency (Tiwari *et al.,* 2024). IDTE streamlines inventory management, operational costs, and disruption response (Van Dyck *et al.,* 2023) and optimizes resource utilization, waste reduction, and environmental performance by improving demand forecasting and production scheduling (Kamble *et al.,* 2020). IDTE enhances operational efficiency and helps organizations meet legal and commercial sustainability requirements as supply chains become more complex and environmental concerns grow (Ivanov, 2023; Van Dyck *et al.,* 2023; Rehman *et al.,* 2025). It also helps companies in a digital, eco-conscious global economy to be competitive, adaptive, and sustainable. In addition, modern supply chain management links, coordinates, and manages all value-added production phases (Ivanov, 2023). Over the past 40 years, technological innovations, global sourcing, market growth, trade liberalization, and increased regulation have transformed supply chains (Iftikhar *et al.,* 2024; Ivanov, 2023). The pandemic and other disasters have increased the need for supply security and resilience (Iftikhar *et al.,* 2024). Society and governments recognize the critical need for sustainable supply systems. IDTE has become a priority for corporations (Elalfy *et al.,* 2021; Rehman, Hamdan, & Sindhu, 2024). Advancements in technology continue to impact production, sourcing, and supply chains (Aisjah &

Prabandari, 2021). Our focus is on the rising digitalization of trade, which has dramatically impacted supply chains and their management (Afum *et al.,* 2023; Aisjah & Prabandari, 2021).

Over the years, research has emphasized the integration of technology and firms' internal capabilities to maximize the benefits (Enrique *et al.,* 2022; Ghobakhloo *et al.,* 2023; Iftikhar *et al.,* 2024; Ivanov, 2023). The relevance of sustainable methods, such as GSCM and CEP, and their integration with IDTE are essential parameters for firm success (Enrique *et al.,* 2022; Ghobakhloo *et al.,* 2023; Iftikhar *et al.,* 2024; Ivanov, 2023). Researchers are increasingly advocating for the integration of IDTE with sustainable methods, such as GSCM and CEP. Digital systems like GSCM and CEP integrate environmental sustainability into supply chains (Le *et al.,* 2024; Lerman *et al.,* 2022; Li *et al.,* 2023). This system also offers an internal capability to adapt to the changes required to streamline IDTE's impact on sustainable initiatives. GSCM boosts energy efficiency, waste reduction, and supply chain resource sustainability (Chatzoudes & Chatzoglou, 2022; Kara & Edinsel, 2023; Moktadir *et al.,* 2020; Susanty *et al.,* 2019). CEP promotes the reuse, recycling, and efficient use of raw materials to create a closed-loop system that decreases waste (Moktadir *et al.,* 2020). Both methods increase SFP and help companies reach sustainable goals. Sustainable supply chains involve technology and sustainable practices (Afum *et al.,* 2023; Aisjah & Prabandari, 2021; Rehman, Hamdan, & Sindhu, 2024).

This study also emphasizes institutional pressure (IP), particularly in emerging economies such as the Gulf Cooperation Council (GCC), where businesses face market-driven and regulatory challenges. Pressures like this push businesses to be greener (Ma *et al.,* 2022; Qi *et al.,* 2021; Saeed *et al.,* 2018; Villena & Dhanorkar, 2020). IP helps emerging economies adapt to changing regulations, thereby sustaining MNEs. To comply with regulations and compete globally, organizations utilize GSCM and CEP due to legal frameworks, stakeholder demands, sustainability, and market factors. As GCC states swiftly set ambitious sustainability targets like Saudi Arabia's Vision 2030 and the UAE's Green Agenda 2050, this is crucial (Villena & Dhanorkar, 2020).

The study makes several important contributions. First, it discusses GCC MNEs' green supply chain management. It illuminates how IDTE increases sustainable firm performance. The study finds no direct linkage between IDTE and SFP. The study suggests that GSCM and circular economy practices are needed to boost SFP once MNEs adopt IDTE. This paper improves supply chain and sustainability models by integrating technology with sustainable behaviors. The study demonstrates that GSCM and CEP mediate the relationship between IDTE and SFP. Second, the mediation effect highlights how digital technologies, GSCM, and circular practices contribute to increased sustainability. It highlights how multinational enterprises (MNEs) can utilize technology to enhance environmental and operational performance. Third, the study shows how institutional pressure moderates GCC. Given the region's evolving regulatory framework and increasing demand for sustainability, the research demonstrates how government regulations and market dynamics impact sustainable practices. GCC authorities and business leaders can utilize this information to enhance the sustainability efforts of MNEs. Finally, this study contributes to the literature on emerging economies, where sustainability concerns are emerging in the field of supply chain sustainability. Despite the increased focus on integrating digital technologies into company operations, earlier research has primarily explored their direct effects on firm performance, overlooking the mediating role of sustainability-oriented strategies, such as GSCM and CEP (Rehman *et al.,* 2025). Moreover, prior research has primarily focused on established countries, with limited insights into how institutional challenges in developing regions, notably the GCC, affect the effectiveness of IDTE for sustainable objectives. This study addresses these gaps by evaluating how IDTE affects sustainable business performance through GSCM and CEP, while also addressing the moderating role of institutional constraints in a GCC setting. The study helps MNEs manage IDTE, GSCM, and CEP deployment in a rapidly changing market by focusing on environmental implications.

2. THEORETICAL BACKGROUND

The Gulf Cooperation Council (GCC) governments have initiated numerous programs to promote sustainability. Recent research has progressively explored how integrated digital technology ecosystems (IDTEs) enhance sustainability through green supply chain management (GSCM) and circular economy practices (CEPs) (Enrique *et al.,* 2022; Ghobakhloo *et al.,* 2023; Iftikhar *et al.,* 2024). Institutional theory and the dynamic capabilities view are employed to analyze Gulf Cooperation Council initiatives, including IDTE, GSCM, CEP, and SFP (Chari *et al.,* 2022; Chen *et al.,* 2024). The DCV model and institutional theory provide a solid foundation for understanding how environmental issues impact organizational practices, particularly sustainable ones such as green supply chain management (GSCM) and circular economy methods (Chari *et al.,* 2022; Chen *et al.,* 2024; Rehman *et al.,* 2025). The DCV model highlights how regulatory, competitive, and societal factors influence the adoption of organizational green practices. These influence innovation and sustainability, especially when integrating digital technologies. Green, energy-efficient solutions, process optimization, and real-time supply chain monitoring are possible with digital ecosystems. IoT, cloud computing, and data analytics enhance transparency, resource tracking, and waste reduction, facilitating the adoption of GSCM and circular economy models (Chen *et al.,* 2024).

The dynamic capabilities view (DCV) offers a rigorous theoretical perspective on how organisations integrate, create, and reconfigure internal and external skills in dynamically evolving environments (Teece, 2007). In the context of integrated digital technology ecosystems (IDTE), dynamic capabilities enable firms to sense new opportunities through big data analytics, IoT, AI, and blockchain, seize these opportunities by embedding them into supply chain processes, and reconfigure resources to align with sustainability goals (Darbanian, Brandtner, Falatouri, & Nasseri, 2024; Rehman, Hamdan, & Sindhu, 2024). Prior

research implies that technical investments alone are insufficient to improve business performance unless organizations establish dynamic capacities that translate technological inputs into sustainability-oriented outputs (Ivanov, 2023; Ghobakhloo *et al.,* 2023). Accordingly, this study draws on DCV to claim that the association between IDTE and sustainable firm performance (SFP) is mediated by practices such as green supply chain management (GSCM) and circular economy practices (CEP) (Darbanian *et al.,* 2024). These techniques demonstrate reconfigurable capabilities that translate digital infrastructure into verifiable sustainability results.

Institutional theory emphasizes how external pressures—such as legal frameworks, stakeholder requirements, and marketplace competition—influence organizational behavior (DiMaggio & Powell, 1983). Firms do not function in isolation; instead, they adapt to institutional contexts that dictate appropriate activities for legitimacy and long-term survival (Darbanian *et al.,* 2024). In growing economies, notably within the Gulf Cooperation Council (GCC), institutional constraints are particularly prominent due to ambitious national sustainability objectives, such as Saudi Arabia's Vision 2030 and the UAE's Green Agenda 2050. These external forces encourage multinational businesses (MNEs) to embrace digital ecosystems that are aligned with sustainability principles, hence deepening the convergence of GSCM and CEP. Institutional theory, therefore, provides a platform for investigating the moderating function of institutional pressure in amplifying the influence of IDTE on sustainable practices, ensuring that enterprises not only comply with legislation but also enhance competitiveness in global marketplaces. Institutional theory helps the DCV model explain how organizations meet external expectations. Institutional factors, norms, and mimetic pressures coerce organizations to adopt sustainable practices (Chari *et al.,* 2022). Industry and professional standards force organizations to follow sustainability criteria, including carbon emissions and waste disposal (Hartley *et al.,* 2022; Sharma *et al.,* 2023). Mimetic pressure occurs when corporations emulate the successful practices of their competitors, particularly in uncertain markets where adopting environmentally friendly practices is beneficial. GSCM and circular economy adoption are explained by the DCV model and institutional theory (Hartley *et al.,* 2022). Due to laws and society, firms implement sustainability (Dwivedi & Paul, 2022; Hartley *et al.,* 2022). Digital ecosystems aid these approaches in daily operations, enhancing business performance and sustainability.

3. HYPOTHESES DEVELOPMENT

3.1 IDTE and SFP

Integrated digital technology ecosystems (IDTE) monitor, manage, and report activities to support supply chains (Dwivedi & Paul, 2022). These ecosystems increase MNE sustainability by increasing transparency and accuracy in sustainability reporting. IDTE collects data throughout a product's life to reduce organizations' environmental loads across products and industries (Gunasekaran *et al.,* 2023; Rehman Khan *et al.,* 2022). This data enables organizations to manage their environmental impact and meet regulatory and customer expectations through effective sustainability reporting.

The use of IoT and Big Data has expanded beyond manufacturing to other sectors with a focus on sustainability (Dwivedi & Paul, 2022). IDTE enhances supply networks, achieving economic, environmental, and social goals. IoT and Big Data-equipped supply networks are enhancing sustainability in traditional supply chain operations, innovation management, and social development (Agrawal & Narain, 2018; Alnaser *et al.,* 2024). IDTE enhances efficiency, transparency, and responsiveness, transforming supply chains into comprehensive sustainability initiatives. Sustainable and robust supply chains are essential for meeting customer needs (Chen *et al.,* 2024). IDTE focuses on optimizing industrial output and sustainably managing the supply chain. IDTE and sustainable performance necessitate that manufacturers optimize their smart and resilient supply chains using IoT and Big Data (Dwivedi & Paul, 2022; Liu *et al.,* 2023). It will enable the creation of digital, eco-friendly supply chains. Several supply chain concerns necessitate adjustments to supply chain management. A supply chain incorporating IoT and big data can mitigate environmental risk through an optimization model, according to Hampton *et al.,* (2013). According to Vatankhah Barenji *et al.,* (2020), IoT is a network of physical devices with remote sensors and software that communicate data online. IDTEs help MNEs meet GCC sustainability targets by promoting transparency, lowering costs, and aligning operations with global goals, creating a more sustainable supply chain (Zhu *et al.,* 2013). Therefore, we hypothesized that:

H1: *Integrated digital technology ecosystems (IDTEs) enhance the sustainable firm performance (SFP) of multinational enterprises (MNEs) in the emerging GCC context.*

3.2 IDTE impact on GSCM and CEP

Integrated digital technology ecosystems (IDTE) improve green supply chain management (GSCM) (Calzolari *et al.,* 2023; Hartley *et al.,* 2022). Empirical studies have shown a positive impact of these technologies' sustainability initiatives (Calzolari *et al.,* 2023; Hartley *et al.,* 2022; Hassan *et al.,* 2023; Hussain *et al.,* 2023). With the help of IoT data, companies can track resources, energy, and waste in real-time. Furthermore, IoT sensors enable firms to identify process inefficiencies and adjust their operations to conserve energy, reduce waste, and optimize resource utilization, resulting in CEP (Chatzoudes & Chatzoglou, 2022; Kara & Edinsel, 2023; Susanty *et al.,* 2019). Likewise, through the use of Blockchain, firms can achieve transparency and traceability in their GSCM practices (Dorfleitner & Braun, 2019). Firms can track their products' environmental impact through Blockchain, ensuring green supply chain partners (Cao *et al.,* 2023; Cole *et al.,* 2019; Dorfleitner & Braun, 2019). Cloud computing empowers firms to exchange and collaborate on supply chain data in real-time, thereby boosting GSCM. Better decision-making and teamwork enable partners to achieve their sustainability goals. Firms can scale sustainability and supply chain performance by optimizing cloud environmental data processing (Bag *et al.,* 2024). IDTE utilizes these technologies to enhance GSCM, eliminate inefficiencies,

and maintain sustainable supply chains. It promotes green design, innovation, and sustainable product development, aligning company operations with environmental goals. IDTE promotes operational efficiency, competitiveness, and global sustainability (Bai *et al.,* 2020; Rehman Khan *et al.,* 2022; Riaz *et al.,* 2024; Umar *et al.,* 2022). IDTE helps GSCM companies reduce their environmental impact and improve supply chain performance (Sarkis *et al.,* 2019). Hence, the following hypothesis is proposed.

H2: *Integrated digital technology ecosystems (IDTE) enhance MNEs' green supply chain management (GSCM) in the emerging GCC context.*

Integrated digital technology ecosystems (IDTE) promote a circular economy. RFID, cloud computing, blockchain, and IoT enable firms to create circular systems and reduce resource consumption. These innovations enhance resource utilization, improve energy efficiency, and streamline logistics for CEP. (Liu *et al.,* 2023). In a circular economy, IDTE can enable firms to reduce material waste and extend the life cycles of their products. Thus, firms can track resource use and enhance product life cycles through supply chain transparency. Similarly, IoT and RFID provide real-time data on material life cycles. This helps firms manage resources effectively and facilitate product returns within supply chains (Parviziomran & Elliot, 2024). These technologies optimize material flows for recycling and remanufacturing. Through the use of Blockchain and cloud computing, firms can improve material traceability by securely exchanging supply chain data. This helps organizations reduce waste, recover resources, and increase output (Bai *et al.,* 2020; Rehman Khan *et al.,* 2022; Riaz *et al.,* 2024; Umar *et al.,* 2022). Waste-to-resource automation by IDTE cuts costs and optimizes supply chains (Gupta *et al.,* 2022; Jabbour, Fiorini, Ndubisi *et al.,* 2020; Jabbour, Fiorini, Wong, *et al.,* 2020). Circular procurement and design enhance industrial efficiency and reduce resource consumption, thereby increasing competitiveness (Jabbour, Fiorini, Ndubisi, *et al.,* 2020; Jabbour, Fiorini, Wong, *et al.,* 2020). IDTE boosts circular economy value. In conclusion, IDTE promotes a circular economy and sustainable supply chains by enhancing resource efficiency, which in turn results in extended product life cycles and optimized waste management. Thus, we proposed as:

H3: *Integrated digital technology ecosystems (IDTE) enhance MNEs' circular economy practices (CEP) in the emerging GCC context.*

3.3 Moderation Effect of Institutional Pressure

The integration of green supply chain management (GSCM) methods is increasingly influenced by IDTE, particularly under institutional pressure, as firms must comply with these norms. According to institutional theory, coercive, mimetic, and normative restrictions affect a firm's environmental practices (Hartley *et al.,* 2022). Government restrictions and environmental measures drive GSCM use in underdeveloped nations (Hartley *et al.,* 2022; Saini *et al.,* 2023). IoT, blockchain, cloud computing, and Big Data Analytics improve GSCM transparency, resource management, and supply chain collaboration (Es-satty, Naimi, Lemghari, & Okar, 2025). Institutions encourage firms to adopt digital technology to enhance their environmental performance, thereby linking GSCM drivers and practices. When institutions put pressure on businesses, IDTE fosters regulatory compliance and sustainability innovation (Ahmed *et al.,* 2020; Bag *et al.,* 2024; Calzolari *et al.,* 2023; Dubey *et al.,* 2023; El-Garaihy *et al.,* 2022; Geng *et al.,* 2024; Jazairy & von Haartman, 2020). IDTE functions as a catalyst, ensuring that GSCM techniques are implemented successfully and matched with environmental goals, specifically under high institutional pressures. GSCM procedures are widely adopted due to institutional forces, yet market isomorphism may reduce their positive effects on economic performance (Ma *et al.,* 2022; Qi *et al.,* 2021; Singh, 2024; Villena & Dhanorkar, 2020; Rehman, S. U. *et al.,* 2025). Therefore, we hypothesized:

H4a: *High institutional pressure (IP) positively moderates the relationship between MNEs' IDTE and GSCM, thereby strengthening the impact of IDTE in the GCC.*

Institutional pressure may influence the adoption of IDTE practices and the circular economy (CE) in GCC countries. Institutional theory states that regulatory frameworks, societal expectations, and industry conventions affect organizations. Pressures may aid or inhibit IDTE-CEP integration. IoT, AI, and big data-enabled supply chains enhance efficiency, reduce waste, and improve resource management (Ahmed *et al.,* 2020; El-Garaihy *et al.,* 2022; Geng *et al.,* 2024). These technologies support the conservation of resources in the circular economy and achieve product lifecycle goals. Institutions influence the acceptance of these principles among GCC companies. Environmental, corporate social responsibility, and sustainability standards in the GCC apply enormous institutional pressure (Awan *et al.,* 2022; Edwin Cheng *et al.,* 2022; Gao *et al.,* 2024). Firms utilize these policies to reduce waste and resource consumption, promoting circular economy corporate practices. Once firms are under high institutional pressure to optimize resource use, Companies are more likely to utilize IDTE to meet environmental goals under strict laws, thereby improving circular economy outcomes. Therefore, firms must comply with the sustainability needs and social expectations of stakeholders, which have a direct and indirect impact on business dynamics. (Bag *et al.,* 2024; Edwin Cheng *et al.,* 2022;J. L. Hartley *et al.,* 2022; Jabbour, Fiorini, Wong, *et al.,* 2020). In the GCC, firms are under pressure, and a significant portion of their stakeholders require them to adopt sustainable policies. With the rise in public expectations, technology-driven IDTE can provide a solution for sustainability initiatives (Bag *et al.,* 2024; Liu *et al.,* 2023). Thus, institutional pressures moderate the relationships between IDTE and the circular economy. The IDTE and circular economy want to align with the GCC due to legal and social constraints. Because firms prioritize short-term efficiency over long-term sustainability, softer institutional forces may hinder their adoption (Bag *et al.,* 2024). Thus, institutional restrictions significantly limit the integration of the GCC IDTE and circular economy.

H4b: *High institutional pressure (IP) positively moderates the link between MNEs' IDTE and CEP.*

3.4 GSCM, CEP, and SFP

The DCV states that firms' capacity to create a green supply chain is unique and valuable (Huang *et al.,* 2023). GSCM construct improves environmental and sustainable operational performance (Helfat & Peteraf, 2003). From the DCV perspective, green supplier collaboration, strategic green purchasing, and green purchasing personnel enable a firm's human resources to execute environmental practices efficiently. GSCM-based strategic human resource development is complex for competitors to copy (Kara & Edinsel, 2023). In accordance with RBV, our research views GSCM as a key enabler of sustained performance. GSCM strategies mitigate ecological degradation, helping organizations reduce the adverse effects of unsustainable production and achieve TBL sustainability (Kara & Edinsel, 2023). Previous operations management research has extensively explored and quantitatively proven the impact of GSCM methods in improving SSC performance. Several studies have demonstrated that GSCM techniques reduce waste output and treatment costs, thereby enhancing economic performance (Kara & Edinsel, 2023; Susanty *et al.,* 2019). Eco-design and investment recovery boost the economy. Previous studies (Chatzoudes & Chatzoglou, 2022; Kara & Edinsel, 2023; Susanty *et al.,* 2019) show that GSCM exercises can reduce hazardous emissions, input material and energy consumption, and waste formation. These methods ensure worker safety through sustainable production, a crucial aspect for both manufacturing and human health. Social sustainability in manufacturing enterprises has increased due to public awareness of workplace safety, health, and equity (Chatzoudes & Chatzoglou, 2022; Kara & Edinsel, 2023; Moktadir *et al.,* 2020; Susanty *et al.,* 2019; Rehman, S. U. *et al.,* 2025). Social sustainability performance boosts an organization's competitiveness and reputation in domestic and international marketplaces (Chatzoudes & Chatzoglou, 2022). Based on the Resource-Based View (RBV), this study suggests that selecting green suppliers is crucial for long-term cooperation between the firm and its suppliers, thereby achieving environmental and sustainable goals. We hypothesize as follows:

H5a: *MNEs' green supply chain management (GSCM) enhances SFP in the emerging GCC context.*

According to the DCV, non-imitable resources can provide a firm with a competitive edge and enhance its performance (Enrique *et al.,* 2022; Ghobakhloo *et al.,* 2023; Iftikhar *et al.,* 2024; Ivanov, 2023). CE practices enhance sustainable environmental and financial performance by incorporating eco-friendly components into production. CEP practices help sustain performance inspired by RBV. According to (Ghobakhloo *et al.,* 2023), CEs reduce waste and utilize resources efficiently, thereby boosting the economy. The circular economy has reduced pollution and improved air quality. Therefore, stakeholders believe CEP has enhanced social performance. According to the RBV, CE procedures can promote sustainability and market competitiveness. CE practices support SSC's goal of developing regenerative and restorative systems with minimal environmental impact (Genovese *et al.,* 2023). Thus, CE practices such as recycling, remanufacturing, and circular design can offer significant benefits to organizations, including reduced toxic gas emissions and waste generation, resource optimization, enhanced brand reputation, increased market share, and competitive advantages (Lahane *et al.,* 2020). These practices also help organizations achieve sustainable performance by recovering and replenishing vital resources to enhance their use and effectively obtain necessary inputs (Iftikhar *et al.,* 2024; Ivanov, 2023). CE practices improve sustainability performance, as shown by numerous studies (Zhu *et al.,* 2011; Khan *et al.,* 2022). Recycling, re-manufacturing, and circular design techniques increase economic benefits by recycling production waste, reusing and selling by-products, removing residuals from all processes, ensuring resource availability, and lowering product cost. Obtaining CE practices will yield long-term benefits for organizations. Several studies have demonstrated that CE practices can enhance an organization's financial performance (Tang *et al.,* 2022; Yu, 2022; Harun, Wahab, Daud, Yanamandra, & Marrouchi, 2025). CE techniques in SC can reduce the environmental and social impact of standard business activities. Razzaq *et al.,* (2021) investigated the role of recycling and remanufacturing in promoting economic growth and environmental benefits. Recycling and remanufacturing can offer numerous job opportunities in waste management and help conserve energy resources. This approach also minimizes industrial waste disposal and land use, while removing hazardous gases, thereby promoting environmental and social sustainability. Changing product and process design, as well as adopting circular manufacturing, can reduce energy consumption and hazardous petrochemical emissions, which cause environmental contamination and health problems (Khan *et al.,* 2022). The circular design and production methods of CE affect SC's environmental and social performance. Thus, echoing the DCV and considering the foregoing, the following relationship can be formed:

H5b: *MNEs' circular economy practices (CEP) enhance SFP in the emerging GCC context*

3.5 Mediation Effect

Adopting IDTE technologies can boost an organization's performance in several ways. GSCM and CE are also crucial sustainable strategies that increase SFP. IDTE is needed to adopt these practices in SCs for sustainable performance (Afraz *et al.,* 2021). Researchers and SC specialists have conducted many empirical studies on the roles of IDTE, CEP, and GSCM practices in improving SSC performance over the past two decades. IDTE can improve firm performance solely by using GSCM (Afraz *et al.,* 2021). Joshi and Gupta (2019) demonstrated how the Internet of Things (IoT) can monitor production lines, reducing energy and CO2 emissions to make an organization more sustainable (Agarwal *et al.,* 2018; Khan *et al.,* 2022; Mahmah, Oulfarsi, & Hammou, 2025). IDTE has been directly linked to sustainable behaviors and company performance; however, the combined benefits of these two factors have not been statistically examined (Lerman *et al.,* 2022; Martín-Gómez *et al.,* 2019; Mathivathanan & Kirubanandan, 2024). Kamble *et al.,* (2020) employed partial least squares structural equation modeling (PLS-SEM) to investigate the impact of Industry 4.0 and lean manufacturing on Indian manufacturing firms. We believe this is one of the few studies to examine how IDTE, GSCM, and CEP in GCC MNEs can affect SSC performance. The

preceding debate prompts us to analyze the direct effects of such technologies on sustainable practices and sustainability performance, as well as the combined effects of both practices on I4.0 technology and SSC performance. Thus, DCV propositions can establish the following relationships:

H6a: *GSCM mediates the MNEs' IDTE and SFP relationship in the GCC context*.

H6b: *CEP mediates the MNEs' IDTE and SFP relationship in the GCC context.*

3.6 Research Framework

This study draws its conceptual foundation on the combination of the Dynamic Capabilities View (DCV) and Institutional Theory. The framework highlights how integrated digital technology ecosystems (IDTE) affect sustainable firm performance (SFP), both directly and indirectly, through green supply chain management (GSCM) and circular economy practices (CEP). IDTE equips organisations with technology tools to boost supply chain visibility, traceability, and efficiency. However, similar to DCV, their influence on performance is not automatic; it involves reconfiguration into sustainability-oriented behaviours. GSCM and CEP are such mediating processes, enabling enterprises to translate digital capabilities into long-term environmental and operational advantages.

Additionally, the framework incorporates the function of institutional pressure (IP) as a moderating component. Institutional theory claims that organisations are impacted by regulatory, normative, and market-driven constraints that require them to embrace sustainable practices. In the Gulf Cooperation Council (GCC) setting, institutional pressures—exemplified by efforts such as Saudi Arabia's Vision 2030 and the UAE's Green Agenda 2050—are especially salient. Thus, IP is projected to magnify the impact of IDTE in encouraging GSCM and CEP adoption. Figure 1 provides the research framework. We have mentioned the hypotheses in the figure. Appendix A provides several items and details measuring each variable.

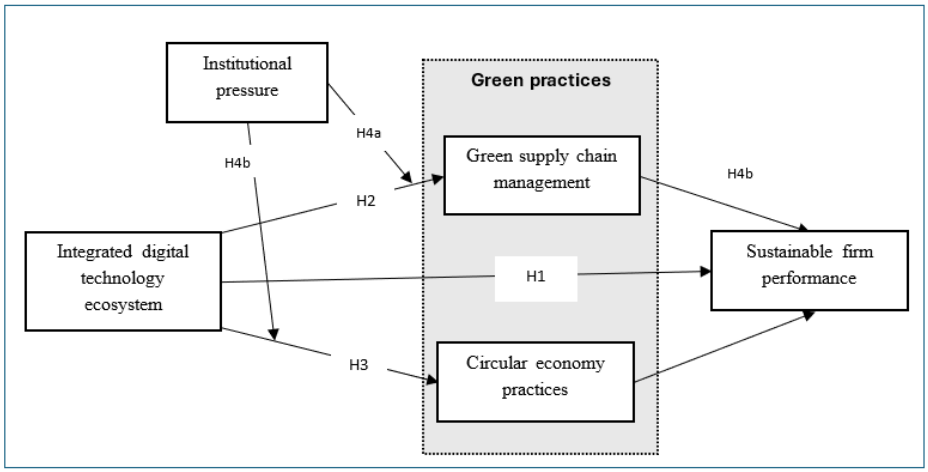

Figure 1 Theoretical Framework

4. METHODS

4.1 Measurement and Descriptives

To ensure validity, reliability, and contextual relevance, the questionnaire was developed sequentially. Before distribution, a selection was constructed through a combination of literature review, expert evaluation, pilot testing, and iterative revisions. The constructs and measurement items were drawn from the literature on supply chain digitalization and sustainability to ensure content validity. Rehman Khan *et al.,* (2022), Dubey *et al.,* (2023), Kamble *et al.,* (2023), and Lerman *et al.,* (2022b) measured integrated digital technology ecosystems (IDTEs) using real-time analytics, automation, and AI-driven decision-making, as well as digitization. Based on past studies (El-Garaihy *et al.,* 2022; Geng *et al.,* 2024), green procurement, sustainable logistics, eco-friendly practices, and regulatory compliance were examined in the context of green supply chain management (GSCM). Circular economy practices (CEP) include waste minimization, resource reuse, and closed-loop supply chains (Bai *et al.,* 2024). Based on Dubey *et al.,* (2023), Zhu *et al.,* (2013), and Rehman Khan *et al.,* (2022) measured sustainable firm performance (SFP) in terms of economic, environmental, and operational sustainability. Institutional Pressure (IP) was quantified by regulatory, normative, and competitive forces driving sustainability adoption, utilizing models from past studies (Ahmed *et al.,* 2020; El-Garaihy *et al.,* 2022; Geng *et al.,* 2024; Jazairy & von Haartman, 2020; Ma *et al.,* 2022). A supply chain professor, four IT managers, four operational managers, and a business communication expert, all with a focus on theoretical alignment, digital supply chain transformations, sustainability, and green supply chains, reviewed the questionnaire to refine it. Their suggestions for question clarity, item relevance, and duplication resulted in moderate improvements in contextual accuracy.

Multi-respondent survey methodology is applied. The data were obtained from two respondents inside each firm: one IT professional and one logistics and supply chain management (LSCM). This dual-response strategy ensured that both technological and operational perspectives were represented. In all, 1,252 questionnaires were delivered to 626 organisations (two per organisation). We got 603 replies, of which 521 were complete and legitimate. Since the company is the unit of analysis, results from IT and LSCM were matched and aggregated by averaging concept scores, providing 260 firm-level examples. This strategy reduces common method variance and enhances construct validity. Table 1 displays the distribution of replies acquired over

many rounds of data collection. A total of 1,252 surveys were given to 626 multinational corporations (MNEs), addressing both IT experts and logistics and supply chain managers (LSCM) inside each organisation. This dual-respondent design was utilised to ensure that both technological and operational perspectives were represented. Of the 603 replies received, 82 were incomplete and hence eliminated. The remaining 521 valid replies relate to 260 businesses (with two responses per firm). After aggregation, the final dataset consisted of 260 firm-level instances, producing an effective response rate of 41.53%.

Table 1 Data Collection

Methods	IT professionals		Logistics and supply chain managers		Total	
	N	%age	N	%age	N	%age
Emailed	626		626		1252	
First Response	112	17.89	112	17.89	224	17.89
First follow-up	96	15.34	93	14.86	189	15.10
Second follow-up	76	12.14	68	10.86	144	11.50
Personally collected	23	3.67	23	3.67	46	3.67
Total	307	49.04	296	47.28	603	48.16
Incomplete	39	6.23	43	6.87	82	6.55
Complete	268	42.81	253	40.42	521	41.61
Number of firms (521/2)					260	
Response rate (260/626)						41.53

Source: Authors' Compilation

5. FINDINGS

5.1 Common Method Bias

Numerous precautions were taken throughout the study design, data collection, and analysis to ensure the reliability and validity of the results. These measurements address biases, measurement errors, and methodological inconsistencies, following the methods of previous studies (Baumgartner *et al.,* 2021). For construct validity and reliability, constructs were derived from validated scales in previous research to reduce measurement bias (Min *et al.,* 2016). Eight industry professionals (four IT managers and four operations managers) and two university professors of supply chain management and language refinement were reviewed, and the pilot tested the questionnaire. To improve clarity and precision, their criticism led to changes in phrasing, the removal of unnecessary items, and the rearrangement of ambiguous questions. In pilot research (n = 40), to examine internal consistency using Cronbach's Alpha and Exploratory Factor Analysis (EFA), four items (one from IDTE, one from GSCM, and two from SFP) were removed due to weak loadings or redundancy. These efforts improved instrument content validity. Survey administration was procedurally corrected for common method bias (CMB). To prevent respondents from aligning their replies, independent and dependent variables were administered at different times (Podsakoff *et al.,* 2012). To avoid social desirability and response consistency bias, the survey included reverse-coded items and unambiguous wording (Tehseen *et al.,* 2017). Harman's single-factor test and full collinearity VIF analysis were used to test the CMB. VIF values were geven in Table 4, indicating that CMB was not a problem (Baumgartner *et al.,* 2021).

A three-wave follow-up method improved response rates by preventing non-response bias. The first email yielded a response rate of 19%, the second 12%, and the third 3%, resulting in a survey-based study response rate within an acceptable range (see Table 1). Paired t-tests showed no significant differences between early and late responders, demonstrating no non-response bias. To ensure external validity and generalizability, 260 GCC MNE IT and supply chain managers contributed data. The variety of samples across different industries and company sizes enhances the applicability of the data. A comprehensive data screening method was employed to exclude missing replies and outliers, thereby maintaining data integrity. According to Hair *et al.* (2021) instrumental variable and Gaussian copula methods reduced endogeneity. Endogeneity was not a problem since all copula constructions were insignificant ($p > 0.05$). We employed PLS-SEM, a structural equation modeling method that can accommodate non-normal data and mitigate the effects of small sample sizes. The structural model was assessed for reliability, validity, and goodness of fit using R^2, Q^2, and bootstrapping techniques to ensure statistical validity. Strong explanations are provided by R^2 values of > 0.50 for GSCM, CEP, and SFP. Our thorough mitigation mechanisms guarantee that the study's conclusions accurately represent IDTE, GSCM, CEP, institutional pressure, and sustainable firm performance.

5.2 Outer Loadings

Items' factor loadings must be large and statistically significant to accurately evaluate variables. The item requires a 0.50 factor loading (Hair *et al.,* 2021). We proposed excluding items with factor loadings below 0.50. Moreover, items with factor loadings over 0.50 will

contribute to a more robust theoretical framework, as articulated by Hayduk and Littvay (2012).

5.3 Construct Reliability and Validity

Determining the degree of connection among several variables within a common framework is essential to the concept of convergent validity. A confirmatory factor analysis (CFA) was conducted using the Smart-PLS tool to verify the validity and reliability of all items. The following table delineates the reliability and convergent validity assessments of this research. All constructs had Cronbach's alpha values beyond the threshold, ranging from 0.721 to 0.923 (Chang, 2019) (see Table 2).

Table 2 Construct Reliability and Validity

Variables	Cronbach's alpha	CR (rho_a)	CR (rho_c)	AVE
IDTE	0.778	0.783	0.797	0.631
GSCM	0.816	0.834	0.891	0.715
CEP	0.721	0.762	0.771	0.684
IP	0.853	0.884	0.894	0.641
SFP	0.923	0.943	0.951	0.568

CR = Composite reliability, rho_c = Composite reliability, AVE=Average variance extracted, IDTE= Integrated digital technology ecosystem, GSCM= green supply chain management, CEP= circular economy practices, IP= Institutional pressure, SFP= sustainable firm performance

5.4 Discriminant Validity

Discriminant validity requires real-world differentiation between variables. This assessment is crucial when evaluating various components. Three approaches were used to evaluate the study's discriminant validity. First, the Fornell-Larcker criterion was employed, comparing the square root of the Average Variance Extracted (AVE) with the correlations between constructs as outlined by Ali, Javed, and Danish (2021) (see Table 3). Second, the survey item loadings were reviewed. Finally, the Heterotrait-Monotrait Ratio (HTMT) was analyzed to ensure all values remained below the conservative threshold of 0.85, further confirming that each construct is empirically distinct.

Table 3 Fornell-Larcker Criterion

	IDTE	GSCM	CEP	IP	SFP
IDTE	**0.754**				
GSCM	0.410	**0.775**			
CEP	0.328	0.198	**0.821**		
IP	0.699	0.397	0.424	**0.856**	
SFP	0.092	0.020	-0.002	0.122	**0.794**

IDTE= Integrated digital technology ecosystem, GSCM= green supply chain management, CEP= circular economy practices, IP=Institutional pressure, SFP= sustainable firm performance

HTMT ratio criteria were developed to highlight the limitations of the Fornell-Larcker and cross-loading approaches. HTMT ratios around one signal study raise discriminant validity issues. HTMT focuses on calculating component correlations and finding the most significant value (see Table 3).

5.5 Collinearity Test

Our study is susceptible to common method bias (CMB). There is a possibility that its validity will become questionable. In addition to assuring the respondents that their comments would be handled with the strictest secrecy and anonymity, we notified those who participated in the survey that there were no right or wrong answers. To determine whether the survey items exhibited multicollinearity, we employed the outer VIF approach in our analysis, which was conducted using the SmartPLS program. If the VIF values in the study are lower than 4.00, there is no need to be concerned about multicollinearity appearing. Because the results of this research ranged from 1.531 to 3.322, it can be concluded that CMB did not have a significant influence on the conclusions of this investigation (see Inner Model VIF in Table 4).

Table 4 Inner Model - VIF

Constructs	VIF
IDTE -> SFP	2.134
IDTE -> GSCM	3.322
IDTE -> CEP	1.531
GSCM -> SFP	1.842
CEP -> SFP	2.642

VIF= variance inflation factors, IDTE= Integrated digital technology ecosystem, GSCM= green supply chain management, CEP= circular economy practices, IP=Institutional pressure, SFP= sustainable firm performance

5.6 Direct Effect

The direct impact of integrated digital technology ecosystems (IDTE) on sustainable firm performance (SFP)

was statistically insignificant (β = 0.035, p = 0.536), demonstrating that technology adoption alone does not increase sustainability. IDTE, such as AI, IoT, and blockchain, enhance operational efficiency; however, their impact on sustainability performance depends on complementary management approaches (Gunasekaran *et al.,* 2023). Digital transformation enhances supply chain visibility, automation, and cost reduction; however, sustainability depends on firms' ability to incorporate environmental and circular economy principles (Rehman Khan *et al.,* 2022; Bai *et al.,* 2020; Bag *et al.,* 2024; Lerman *et al.,* 2022a). IDTE's role as a facilitator rather than a driver of sustainability performance may explain this direct influence. According to the dynamic capability view (DCV), digital capabilities alone do not provide a competitive advantage unless enterprises establish dynamic, sustainability-oriented capacities to complement their technology investments (Agrawal & Narain, 2018; Alnaser *et al.,* 2024). Without sustainability policies, enterprises may not reap the environmental and social benefits of integrated digital technology ecosystems, resulting in no performance gain (Lerman *et al.,* 2022a, b; Zhu *et al.,* 2013; Papadopoulos *et al.,* 2017). The results in the following figure also indicate that the path analysis reveals no significant association (Figure 2: Bootstrapping Path Coefficient Analysis).

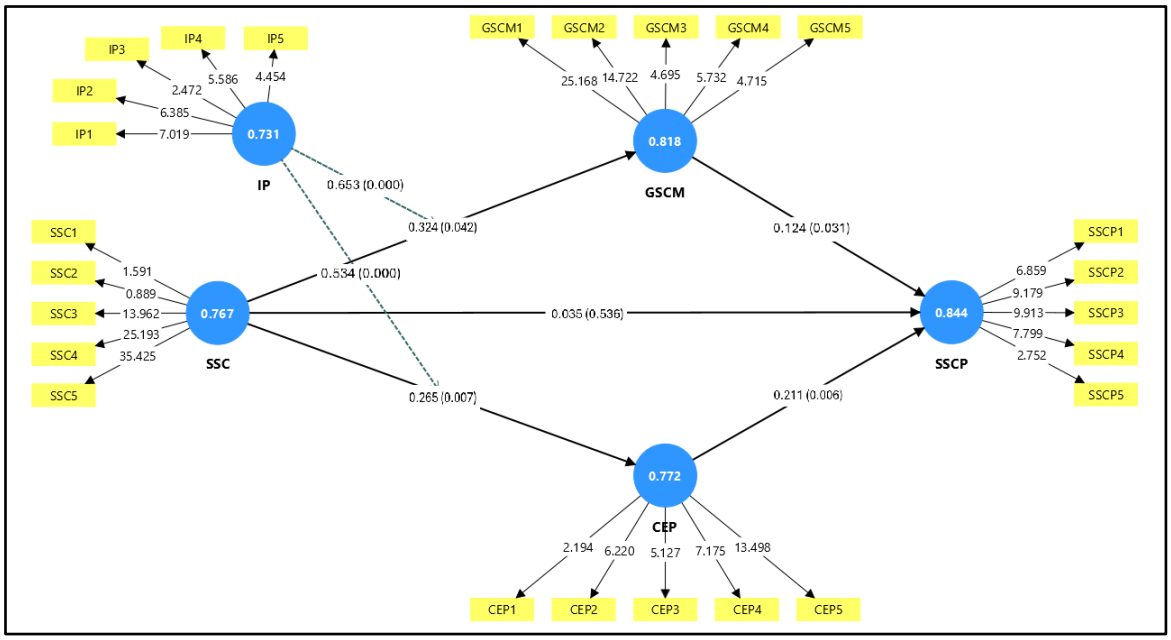

Figure 2 Bootstrapping Path Coefficient Analysis

Integrated digital technology ecosystems (IDTE) significantly impact green supply chain management (GSCM) at $p < 0.05$ ($\beta = 0.324$, $p < 0.05$) and circular economy practices (CEP) at $p < 0.05$ ($\beta = 0.265$, $p < 0.05$), highlighting the importance of smart technologies in sustainability-driven supply chain strategies. Digital transformation enhances supply chain visibility, automation, and data-driven decision-making, which supports green practices (Rehman Khan *et al.,* 2022; Lerman *et al.,* 2022a; Dubey *et al.,* 2023). The positive effect of IDTE on GSCM suggests that enterprises utilizing AI, IoT, and blockchain technologies enhance green procurement, optimize logistics for reduced carbon footprint, and comply with regulations. Empirical studies demonstrate that integrated digital technology ecosystems enable enterprises to monitor emissions, supplier sustainability, and eco-friendly practices (Calzolari *et al.,* 2023; J. L. Hartley *et al.,* 2022; Hassan *et al.,* 2023; Hussain *et al.,* 2023). The significant impact of IDTE on CEP demonstrates how digital platforms can enhance remanufacturing, waste reduction, and the circularity of product lifecycles (Dwivedi & Paul, 2022; Liu *et al.,* 2023). Predictive analytics, blockchain, and automated reverse logistics improve circular supply chain management (Gupta *et al.,* 2022; Jabbour, Fiorini, Ndubisi *et al.,* 2020; Jabbour, Fiorini, Wong, *et al.,* 2020). According to Dubey *et al.,* (2023), technology-driven sustainability strategies can help firms adapt to the circular economy and preserve operational efficiency.

5.7 Moderation Effect

The results of the moderation effect are also reported in Table 6. The interaction term is our variable of concern. The results show a positive and statistically significant coefficient estimate for the interaction term IDTE*IP ($\beta = 0.653$, $p < 0.001$), supporting Hypothesis 4a. The introduction of the interaction enhances the coefficient estimate and the level of significance for the direct impact of IDTE on GSCM. Similarly, the result of the second interaction term is also statistically significant ($\beta = 0.534$, $p < 0.001$), implying that institutional pressure moderates the impact of IDTE on circular economy practices. According to institutional theory, firms adopt sustainable practices to enhance internal efficiency, comply with legal requirements, and meet the needs of stakeholders (Ahmed *et al.,* 2020; Calzolari *et al.,* 2023; Dubey *et al.,* 2023; El-Garaihy *et al.,* 2022; Geng *et al.,* 2024); Jazairy & von Haartman, 2020). . Thus, firms tend to allocate more resources to IDTE with a focus on GSCM and CEP. Since MNEs possess dynamic capabilities to comply with environmental laws, implement carbon reduction measures, and adhere to ESG reporting systems, they are able to align IDTE with a more significant

impact on GSCM and CEP (Rehman Khan *et al.,* 2022; Dubey *et al.,* 2023; El-Garaihy *et al.,* 2022; Geng *et al.,* 2024). Strong legislative frameworks encourage green procurement, circular product design, and low-carbon logistics. Institutional factors enhance organizational sustainability and mitigate the environmental impact of digital transformation (Sarkis *et al.,* 2019).

Table 5 Bootstrap Direct Effects Results

Constructs	Original sample	Sample mean	STDEV	T-statistics	P values	Results
H1 = IDTE -> SFP	0.035	0.034	0.050	0.699	0.536	Rejected
H2 = IDTE -> GSCM	0.324*	0.344	0.154	2.103	0.042	Accepted
H3 = IDTE -> CEP	0.265**	0.276	0.091	2.912	0.007	Accepted

STDEV= Standard deviation, IDTE= Integrated digital technology ecosystems, GSCM= green supply chain management, CEP= circular economy practices, IP=Institutional pressure, SFP= sustainable firm performance

Table 6 Bootstrap Moderation Effects Results

Constructs	Original sample	Sample mean	STDEV	T statistics	P values	Results
H2 = IDTE -> GSCM	0.324*	0.344	0.154	2.103	0.042	Accepted
H4a = IDTE*IP -> GSCM	0.653***	0.687	0.087	7.511	0.000	Accepted
H3 = IDTE -> CEP	0.265**	0.276	0.091	2.912	0.007	Accepted
H4b = IDTE*IP -> CEP	0.534***	0.521	0.062	8.613	0.000	Accepted

The abbreviations are as follows: Standard Deviation, IDTE = Integrated Digital Technology Ecosystems, GSCM = Green Supply Chain Management, CEP = Circular Economy Practices, IP = Institutional Pressure, SFP = Sustainable firm performance, Note: Significance levels: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

5.8 Mediation Effect

Lastly, we examined the mediation effect of GSCM and CEP for the association between IDTE and SFP. As reported in Table 5, IDTE has no direct effect on SFP, rejecting hypothesis 1. Therefore, the significant mediation effect will demonstrate full mediation (Baron & Kenny, 1986). Before testing the mediation effect, we tested the direct impact of GSCM and CEP on SFP. In Table 6, results indicate that GSCM ($\beta = 0.174$, $p < 0.01$) and CEP ($\beta = 0.211$, $p < 0.001$) have a positive effect on SFP, supporting Hypotheses 5a and 5b. The findings suggest that GSCM and circular economy initiatives enhance MNEs' SFP by improving environmental and operational efficiency. GSCM enables firms to improve their supply chain efficiency through sustainable sourcing, waste reduction, and energy efficiency (Lerman *et al.,* 2022; Martín-Gómez *et al.,* 2019; Mathivathanan & Kirubanandan, 2024). This enables MNEs to save money and conserve the environment by reducing resource use and waste. Thus, MNEs promote sustainable supply chain Performance (SFP) (Mathivathanan & Kirubanandan, 2024). Likewise, CEP initiatives mitigate the environmental impact of MNEs by promoting reuse, recycling, and extending product lifespans. Therefore, MNEs that switch from linear to circular models and minimize waste can reduce their expenses and environmental impact (Agarwal *et al.,* 2018; Khan *et al.,* 2022). Firms can enhance operational efficiency and connect multinational enterprises (MNEs) to consumer demand for sustainable products, thereby boosting brand reputation and customer loyalty.

Mediation results indicate that IDTE enhances SFP by facilitating the implementation of GSCM ($\beta = 0.498$, $p < 0.001$) and CEP ($\beta = 0.476$, $p < 0.001$), demonstrating that technology serves as a catalyst for these sustainable initiatives. First, IDTE has a positive impact on GSCM, improving supply chain efficiency through sustainable sourcing, waste reduction, and energy efficiency (Khan *et al.,* 2022). Resultantly, GSCM leads to SFP in MNEs. This enables MNEs to save money and conserve the environment by reducing resource use and waste, thereby promoting Sustainable Supply Chain Performance (SFP).

Likewise, we also found a mediation effect of CEP on the association between IDTE and SFP ($\beta = 0.476$, $p < 0.001$- see Table 7). The study found that Circular Economy Practices (CEP) mediate the link between IDTE and SFP, with a path coefficient of $\beta = 0.476$ ($p < 0.001$). This significant finding supports the mediation effect, demonstrating that IDTE promotes circular economy activities that improve SFP. IDTE integration enables firms to leverage data analytics and automation, optimizing resource consumption, eliminating waste, and extending product lifecycles (Martín-Gómez *et al.,* 2019; Mathivathanan & Kirubanandan, 2024). Recycling, reusing, and planning for lifespan increase supply chain sustainability and efficiency. By adopting a cyclical approach, CEP enhances IDTE's impact on SFP, thereby improving

environmental and operational performance (Lerman *et al.,* 2022; Martín-Gómez *et al.,* 2019; Mathivathanan & Kirubanandan, 2024). Thus, circular economy methods facilitate the integration of technical advances into sustainable improvements.

Table 7 Bootstrap Mediation Effects Results

Constructs	Original sample	Sample mean	STDEV	T statistics	P values	Results
H5a = GSCM--> SFP	0.174*	0.170	0.063	2.756	0.031	Accepted
H6a = IDTE --> GSCM-> SFP	0.498***	0.484	0.075	6.673	0.000	Accepted
H5b = CEP -> SFP	0.211***	0.224	0.038	3.493	0.006	Accepted
H6b = IDTE -> CEP -> SFP	0.476***	0.481	0.045	10.527	0.000	Accepted

STDEV= Standard deviation, IDTE= Integrated digital technology ecosystems, GSCM= green supply chain management, CEP= circular economy practices, IP=Institutional pressure, SFP= sustainable firm performance, Note: Significance levels: *** p < 0.001, ** p < 0.01, * p < 0.05.

6. CONCLUSION & IMPLICATIONS

6.1 Conclusion

In this study, we first studied how integrated digital technology ecosystems (IDTE) affect sustainable firm performance. IDTE is important in MNEs, but its direct effect on SFP was insignificant. This suggests a more refined approach to linking IDTE to SFP, highlighting other potential elements or mechanisms. We examined the mediation effect of GSCM and CEP on the IDTE-SFP relationship. Our investigation initially revealed that IDTE has a positive and significant impact on both GSCM and CEP, demonstrating that IDTE provides the technological foundation for green and circular economy practices. We explored Institutional pressure (IP) as a moderator, especially in the GCC, where regulatory frameworks and market demand impact sustainability. We observed that IP moderates the relationships between IDTE-GSCM and IDTE-CEP. Government regulations and customer demand for sustainability can improve IDTE's supply chain sustainability benefits. Our next step was to evaluate GSCM and CEP on SFP. Both GSCM and CEP significantly increased SFP, indicating that sustainable supply chain strategies, particularly in terms of resource efficiency, waste reduction, and environmental responsibility, enhance performance. Ultimately, our findings elucidate the impact of IDTE on SFP. The study shows that IDTE does not directly improve SFP, but it helps execute GSCM and CEP, which are crucial to sustainability. Institutional pressures moderate the effectiveness of IDTE in the GCC, highlighting the importance of external influences. These findings indicate that MNEs in the region must strategically integrate technical advances with sustainable practices to achieve optimal supply chain performance.

6.2 Research Implications

6.2.1 Research Implications

Our study has important theoretical implications, especially from the dynamic capabilities view (DCV). DCV emphasizes a firm's ability to adapt, incorporate new technology, and reorganize resources to stay competitive (Chari *et al.,* 2022). IDTE helps MNEs implement and integrate GSCM and CEP, enhancing Sustainable firm performance (SFP). The DCV's weak IDTE-SFP link indicates that new technologies alone do not increase performance. MNEs must leverage their dynamic skills to integrate these technologies into supply chain practices. The report recommends pairing IDTE with GSCM and CEP for a competitive edge. These capabilities enable MNEs to respond to environmental issues, legislative changes, and market expectations for sustainability, underscoring the need for dynamic and adaptable capabilities.

In line with the Dynamic Capability VIEW, GSCM and CEP's mediation effect supports the DCV's view that capabilities drive organizational success. Green and circular practices enhance IDTE's SFP, demonstrating that a firm's ability to reconfigure and integrate new capabilities, such as GSCM and CEP, is crucial to sustainability. External forces influence the development and deployment of these dynamic talents, as Institutional Pressure moderates internal capabilities and external market conditions. According to this DCV study, GCC MNEs can enhance supply chain sustainability by leveraging technology and complementing their existing skills. It showcases complementary and dynamic talents for long-term competitive advantage and sustainability.

6.2.2 Practical Implications

Our study offers practical implications for MNEs operating in the GCC region regarding their sustainable firm performance (SFP). It provides an advanced approach to enhancing the SFP relationship. MNEs should strategically use IDTE, GSCM, and CEP to improve SFP. Technical advances and sustainable practices must be combined to optimize resource utilization, minimize waste, and enhance environmental performance. GSCM and CEP mediation promote green and circular supply chains, leading to SFP. Gulf MNEs should implement Vision 2030 and the UAE's Green Agenda 2050. It boosts operational efficiency and sustainability. Government laws and market expectations are balanced by institutional pressure. Regional rules and market demand for sustainable products should inform MNEs' sustainability strategies. This alignment will enhance compliance, reduce risks, and give you a competitive edge in an eco-friendly market. Ultimately, GCC MNEs should

enhance SFP by integrating technology, sustainability, and external constraints.

6.2.3 Policy Implications

This study has significant policy implications, particularly for GCC countries, as governments increasingly promote business sustainability. IDTE alone does not improve Sustainable firm performance, the study finds. Through rules and incentives, policymakers should push MNEs to integrate IDTE with GSCM and CEP. Businesses that implement green technologies and practises may receive cash incentives, tax breaks, or subsidies. Study: Institutional pressure influences the sustainability behaviors of MNEs. Policymakers should raise sustainability standards to compel MNEs to reduce waste and optimize resource use. Governments should develop sustainability and performance standards to enable firms to adopt GSCM and CEP and promote openness and accountability. Finally, authorities should support the development of sustainable supply chain knowledge-sharing and technology through public-private partnerships. Government agencies, businesses, and research institutes can collaborate to help MNEs integrate technology and sustainability. This promotes regional supply chain sustainability.

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APPENDIX – A Questionnaire

	Integrated digital technology ecosystems
IDTE-1	We enhance Integrated Digital Technology Ecosystems process by integrating real-time data analytics, including AI, IoT, and Big Data.
IDTE-2	Our inventory management and demand forecasting are both enhanced through the use of automation and predictive analytics.
IDTE-3	To enhance the transparency and traceability of our supply chain activities, our business has adopted blockchain technology.
IDTE-4	To improve the sustainability of the Integrated Digital Technology Ecosystems, we use AI-driven decision-making.
IDTE-5	Thanks to smart logistics (e.g., digital twins, route optimization), the efficiency of the Integrated Digital Technology Ecosystems have increased.
	Green supply chain management
GSCM-1	It is essential to our business to purchase goods from vendors that prioritize environmental sustainability; therefore, we practice green procurement.
GSCM-2	To minimize our environmental impact, we have employed eco-friendly manufacturing methods.
GSCM-3	The goal of our logistics operations is to minimize our environmental impact by using energy and transportation efficiently.
GSCM-4	To improve product recycling and reusing, we have used reverse logistics.
GSCM-5	Sustainable supply chain initiatives are a shared goal among our company, suppliers, and partners.
	Circular economy practices
CEP-1	Our company integrates circular economy principles into our supply chain operations, including reuse and refurbishment.
CEP-2	We implement closed-loop supply chain models to minimize material waste and maximize resource efficiency.
CEP-3	Our organization adopts remanufacturing and recycling strategies to extend product life cycles.
CEP-4	We regularly assess and redesign our supply chain processes to improve material efficiency and reduce waste.
CEP-5	Our firm actively supports product take-back schemes and end-of-life recycling programs.
	Institutional pressure
IP-1	Government regulations have a significant influence on our company's adoption of the Integrated Digital Technology Ecosystems and GSCM.
IP-2	Our organization meets global standards for environmental sustainability, including ISO 14001 and ESG reporting.
IP-3	Consumer demands for sustainability influence our supply chain decisions.
IP-4	Competitive market factors drive our adoption of green and circular supply chain methods.
IP-5	Sustainable supply chain activities are incentivized by external sources, such as subsidies and tax credits, which we get.
	Sustainable firm performance
SFP-1	Our firm has achieved cost savings through the Integration of Digital Technology and sustainable supply chain Performance.
SFP-2	We have significantly reduced carbon emissions and environmental impact in supply chain operations.
SFP-3	Our supply chain maintains high transparency and ethical compliance in sourcing and supplier management.
SFP-4	Implementing Integrated Digital Technology Ecosystems and sustainable supply chain strategies has led to higher profitability and efficiency.
SFP-5	Our sustainability efforts have improved our brand reputation and customer trust.

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