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The Impact of Green Supply Chain Management on Circular Economy Performance: The Moderating Role of IT Capability

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Abstract

This study investigates the impact of Green Supply Chain Management (GSCM) on Circular Economy Performance (CEP) in Pakistan's manufacturing sector by examining the mediating roles of green product, green process, and green management innovation, alongside the moderating role of IT capability. A quantitative, deductive, and explanatory research design was adopted. Data were collected from 207 supply chain professionals using a structured five-point Likert-scale questionnaire through purposive sampling. Partial Least Squares Structural Equation Modeling (PLS-SEM) was employed to assess the measurement and structural models, including direct, mediating, and moderating relationships. The results indicate that GSCM significantly enhances green product, green process, and green management innovation. GSCM, green product innovation, and green process innovation positively influence CEP, whereas green management innovation has no significant direct effect. Green product and green process innovation significantly mediate the GSCM–CEP relationship, while green management innovation exhibits only a negligible mediating effect. IT capability significantly moderates the relationships between GSCM and CEP and between green process innovation and CEP but does not strengthen the effects of green product or green management innovation on CEP. This study extends the GSCM literature by integrating multiple dimensions of green innovation with IT capability in a single framework, providing practical insights for manufacturing firms seeking to accelerate circular economy adoption and sustainable competitive performance in emerging economies.

Keywords: Green Supply Chain Management, Circular Economy Performance, Manufacturing Sector, Pakistan, PLS-SEM.

Introduction

Background of the Study

The global environmental issues such as climate change, depletion of natural resources and loss of biodiversity have escalated and gained much attention in the last few decades. The rapid pace of industrialization and active use of natural resources has placed a major strain on ecological systems and accelerated environmental degradation (Lu & Wang, 2023). These issues are not purely environmental but also operational since SC are the significant sources of greenhouse gases emissions, energy use and the general environmental degradation (Nweje & Taiwo, 2025).

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Problem Statement

Although there is a rising trend towards the application of sustainability strategies, it is still noted that most organizations are **f**unctioning on a linear production and consumption basis, which causes chronic inefficiencies in the application and management of resources and waste. In practice, companies find it difficult to develop an effective recycling framework, reverse logistics, and material recovery procedures, preventing them from aligning their performance towards a significant CE (Ferreira et al., 2026). These threats show that mere implementation of sustainability policies is not good enough without supporting operational capabilities and integrated SC practices (SCP) (Hasan et al., 2026).

Research Objectives

- To examine the impact of GSCM on GPRD, GPRC, and GMGT.
- To analyze the impact of GSCM on CEP.
- To investigate the impact of GPRD, GPRC, and GMGT on CEP.
- To assess the mediating role of GPRD, GPRC, and GMGT between GSCM and CEP.
- To examine the moderating role of ITC on the impact of GSCM on CEP.
- To examine the moderating role of ITC on the relationship of GPRD, GPRC, and GMGT with CEP.

Research Questions

1. What is the impact of GSCM on GPRD, GPRC, and GMGT?
2. What is the impact of GSCM on CEP?
3. What is the impact of GPRD, GPRC, and GMGT on CEP?
4. What is the mediating role of GPRD, GPRC, and GMGT between GSCM and CEP?
5. What is the moderating role of ITC on the impact of GSCM on CE performance?
6. What is the moderating role of ITC on the relationship of GPRD, GPRC, and GMGT with CEP?

Gap Analysis

Recent research has extensively studied the use of GSCM to improve organizations' environmental and OP. Experimental research suggests that GSCM techniques contribute to emissions reduction, cost efficiency, regulatory compliance, and CA (Hasan et al., 2026; Ranta et al., 2018). Although these results confirm the significance of GSCM in sustainability, the majority of extant literature pays attention to the typical environmental or financial performance indicators as opposed to the CEP. Therefore, the nature of the contribution made by GSCM on core circular outcomes, like material recovery, waste reuse, closed-loop SCs, and resource circularity, is under-discovered (Ben Salem et al., 2025).

Literature Review

Theoretical Framework

Resource-Based View (RBV) Theory

Barney (1991) proposed the Resource-Based View (RBV) theory for strategic management. It is designed to explain the existence of some firms with sustained CA by considering the resources of the firm rather than its environment (Shaharudin et al., 2025). According to RBV, the performance in the long run is affected by the development and use of unique capabilities of the firm. In this research, GSCMP, GI and SC IT capabilities are considered as strategic resources for enhancing CEP. Pakistani manufacturing firms' SC management can consider these capabilities as the formula for future growth (Ibrahim et al., 2025).

Dynamic Capability View (DCV) Theory

Teece et al. (1997) established the Dynamic Capability View (DCV) theory to explain how firms can build and sustain competitive edge in rapidly changing and uncertain environments. The RBV considers the current resources of organizations, but the DCV is center on an organization's capacity to combine, develop and redeploy internal and external competence to respond to dynamic environmental challenges. Teece et al. (1997) suggested dynamic capabilities like strategic management, innovation, and re-innovation enable firms to adapt to their changing environments, technological and market opportunities, and competition (AlSheyadi et al., 2025).

Empirical Evidence

Green Supply Chain Management

GSCM may be defined as an inclusion of green environmental practices in SC operations and processes of the company, i.e., procurement, production, logistics, and distribution, i.e. waste minimization, energy efficiency, environmental regulations, and green sourcing (Ibrahim et al., 2025). In the DCV perspective, the term, GSCM, implies the ability of a firm to find and use opportunities and threats, restructure and integrate the upstream and downstream operations to initiate and execute environmental strategies and programs in the SC operation with suppliers and partners (Mahar et al., 2025).

Green Process Innovation

Green process innovation (GPRC) is the integration of green techniques into the manufacturing and operational processes of a firm. This involves the adoption of energy efficient practices, waste minimization and prevention, pollution control and prevention, water and material recycling, and other green technologies in production to minimize environmental impact (Gelmez et al., 2024).

Green Product Innovation

Green product innovation (GPRD) is the launching of the green products whose effects on the environmental circumstances are minimal during their life cycle. This will entail the creation of products that have low energy use, can be reused or biodegraded, low emissions, and optimum

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use of resources during manufacturing, use and disposal (Abdallah et al., 2024). One of the RBV resources is GPRD that gives firms CA. The RBV suggests that VRIN will help firms perform well. Real assets (including GPRD) are difficult to copy and add to the uniqueness of the firm in line with the sustainable product firms (Gelmez et al., 2024).

Green Management Innovation

Green management innovation (GMGT) is a new management practice, strategy and organizational methods used to increase environmental responsibility in the company. They are eco-oriented leadership, environmental-based strategic planning, policies and practices that are eco-friendly, and the institutionalization of practices to incorporate green principles in the strategy and operations of the firm. These activities increase the efficiency of the firm in using its resources and promoting a culture of environmental responsibility (Abdallah et al., 2024).

One of the strategic resources that the RBV is viewed as possessing is GMGT, which is a valuable and difficult to replicate resource to add to the long-term CA. Managerial skills, leadership qualities, and an organizational culture with an environmental orientation is an intangible asset that is closely associated with GMGT, and it can be categorized as firm-specific resources, which are almost incapable of being copied by other organizations.

Circular Economy Performance

CEP is the capability of a company to develop a closed loop system in its business where resources are recycled or recovered and waste production is reduced. It represents the efficiency of the firms in inculcation of sustainability in production, distribution as well as product disposal at the life cycle and enhances the environmental and economic impacts. An elevated score on the CE performance means having an efficient utilization of resources, reduction of environmental footprint, and compliant to world sustainability requirements (Abdallah et al., 2024).

IT Capability

ITC is a firm's capability to successfully acquire and use IT resources to complete operations, make decisions, and innovate. It also includes IT infrastructure, technical competencies, data management, and the capability of the firm to utilize digital applications to enhance how efficiently it operates and how it performs strategically. ITC allows organizations to facilitate the operations, improve communication and reinforce knowledge based decision-making throughout the value chain (Qiao et al., 2023).

Hypothesis Development

GSCM and CE Performance

Prior studies displayed that GSCM has a positive impact on CEP because using green SCP may help organizations streamline their resources, decrease wastage, and recycle materials (Abdallah et al., 2024). Some of the practices that direct materials to be reused, recycled, and recovered include green procurements, eco-design, sustainable production methods, and reverse logistics, that can benefit the circular activities of a company. Empirical studies show that those organizations that implement a holistic GSCM strategy have had greater levels of CEP in terms of resource efficiency, decreased EP, and better sustainability performance (Khan et al., 2024).

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H1: GSCM has a significantly positive impact on CEP.

GSCM and Green Product Innovation

Many studies have found that GSCM has a positive impact on GPRD because firms can obtain and use green or environmental ideas, knowledge, resources, and capabilities to develop green products through environmentally friendly practices in SC operations (Gelmez et al., 2024; Levi-Bliech & Dahan, 2025; Triguero et al., 2023). GSCM methods such as green purchasing, tight collaboration with green suppliers, environmental design, and lifecycle environmental impact assessment assist firms in innovating products with green or decreased environmental effect, such as lower energy usage, recyclable materials, and less waste (Abdallah et al., 2024).

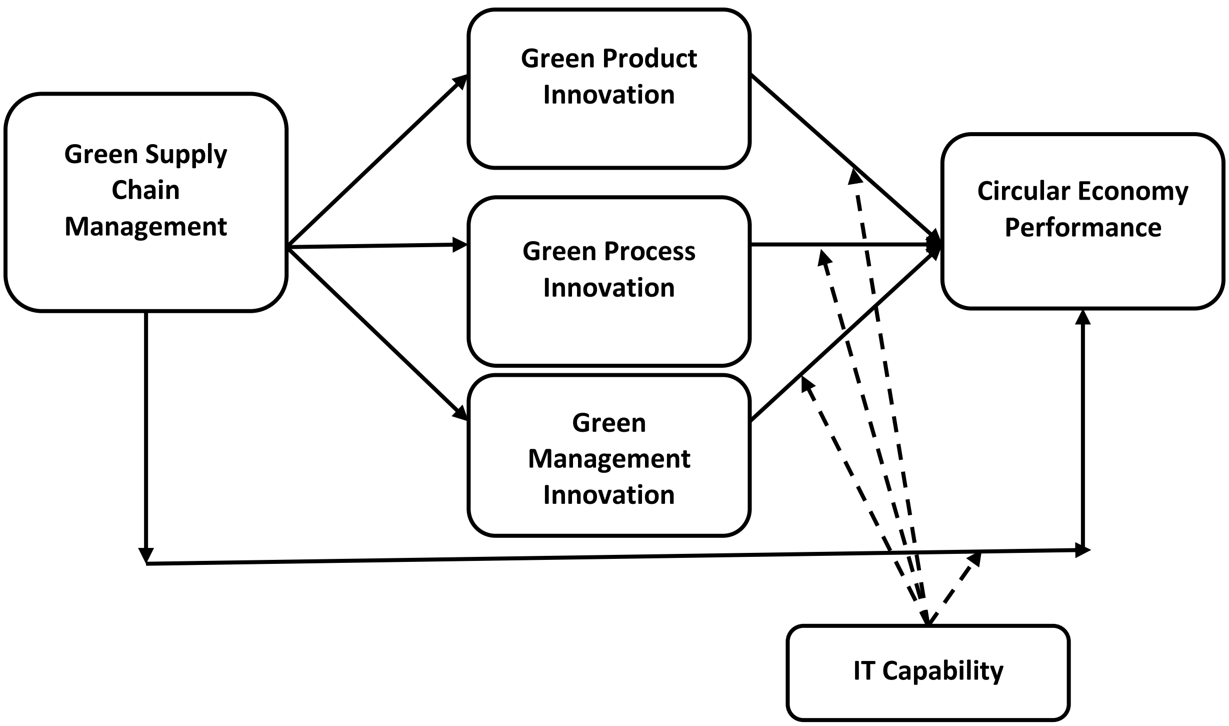

Figure 1 Conceptual Framework

H2: GSCM has a significantly positive impact on GPRD.

GSCM and Green Process Innovation

The GSCM effect on GPRC is vast and beneficial because the integration of the environment throughout the SC stimulates the development of internal production processes. Green purchasing, engagement of ecologically informative suppliers, and reverse logistics introduce pressure and incentives on enterprises to adjust the manufacturing processes and decrease the emissions, energy usage, and waste of the products (Gelmez et al., 2024). Research has shown that, firms engaged in high GSCM activities tend to be more inclined to adopt more recent clean technologies and engage in more environmental-friendly production processes and inclusive of waste-reduction measures (AlSheyadi et al., 2025).

H3: GSCM has a significantly positive impact on GPRC.

GSCM and Green Management Innovation

Organizations that adopt systematic environmental practices in their SCs are likely to improve their internal sustainability management systems as well (Bugri et al., 2025). Companies that adopt policies such as green purchasing, environmental assessment of suppliers, collaborative eco-design, and reverse logistics often develop new environmental planning systems, sustainability reporting processes, and cross-functional governance mechanisms. This is indicative of a trend toward more formalized environmental strategies and sustainability-oriented leadership (Mahar et al., 2025).

H4: GSCM has a significantly positive impact on GMGT.

Green Product Innovation and CE Performance

Previous research in sustainability have highlighted that creating greener products is one of the most significant ways of promoting the goal of a CE (Chen et al., 2024; Triguero et al., 2023). Companies that design their products with recyclable materials, energy-saving materials and modular design support the processes of reuse, remanufacturing and material recovery. GPRD fosters lifecycle thinking, where the environmental factors are considered during the manufacturing of the product up to its disposal. This method decreases the use of resources, lowers the rate of waste production, and makes production systems more sustainable (AlSheyadi et al., 2025).

H5: GPRD has a significantly positive impact on CEP.

Green Process Innovation and CE Performance

In order to realize a CE, companies must re-engineer their manufacturing to reduce waste, emissions and use of resources. GPRC, including clean technologies, energy-efficient devices, recycling and waste removal techniques in the manufacturing process, is crucial in this sense (Triguero et al., 2023). Through changes in production process, rather than the product alone, companies can improve material recovery, minimize environmental impacts, and promote closed-loop manufacturing (Abdallah et al., 2024).

H6: GPRC has a significantly positive impact on CEP.

Green Management Innovation and CE Performance

Abdallah et al. (2024) mentioned that CE strategies require both operational and strategic and organizational innovation. GMGT facilitates such innovation with sustainability-focused management, environmental policies, sustainability programs and sustainability performance indicators. By embracing environmental policies and eco-centric managerial procedures, companies align the focus of managers with the CE principles, including resource optimization, waste prevention, and thinking life-cycle (Khan et al., 2024).

H7: GMGT has a significantly positive impact on CEP.

Mediating Role of Green Product Innovation between GSCM and CE Performance

The effects of GSCM on the performance of CE are amplified when GPRD is applied as a mediating variable between these variables. GSCM promotes the implementation of environmental requirements and specifications in sourcing, production, and logistics, which creates knowledge, cooperation, and technical skills that are required to create products that are eco-friendly. Recyclable, durable, and material intensive, these eco-designed products provide a direct contribution to CE results like recovery of resources, minimization of waste, and extending the lifecycle (Abdallah et al., 2024).

H8: GPRD positively mediates the impact of GSCM on CEP.

Mediating Role of Green Process Innovation between GSCM and CE Performance

It has been showed that GPRC's mediating effect strengthens the influence of GSCM on CEP. GSCM integrates environmental practices throughout procurement, production, logistics, and reverse SC activities, providing organizations with the knowledge, technical expertise, and resources they need to redesign operational processes in an ecologically sustainable manner (Gelmez et al., 2024). GPRC is defined as the application of cleaner production, energy-efficient production, minimization of waste and sustainable processes of the workflow that enhance resources efficiency, environmental impact reduction, and utilize closed-loop production systems (Triguero et al., 2023).

H9: GPRC positively mediates the impact of GSCM on CEP.

Mediating Role of Green Management Innovation between GSCM and CE Performance

When GMGT acts as an intermediate, the connection between GSCM and CEP can be enhanced. GSCM is pivotal in incorporating environmental activities into procurement, production, logistics, and reverse SC activities, which can offer firms with knowledge, technological capabilities, and supplier collaboration prospects that should facilitate them to create eco-friendly products (Abdallah et al., 2024). GMGT refers to creating eco-friendly, sustainable, recyclable, and reusable products with energy-efficient lifecycle that directly reflects on the CEP by minimizing waste, increasing product lifecycle, and the closed-loop systems (Triguero et al., 2023).

H10: GMGT positively mediates the impact of GSCM on CEP.

Moderating Role of ITC between GSCM and CE Performance

ITC positively affects the connection between GSCM and CEP. The ability of the firm to purchase, combine, and use digital technologies, information systems, and data analytics to enhance the decision-making processes, operational performance, and/or strategic initiatives can be referred to as ITC (Duman Altan et al., 2024). In combination with GSCM, ITC improves the capacity of companies to monitor the EP, communicate with suppliers, trace the flow of materials, and optimize logistics, which amplify the impact of the green practices on cyclical outcomes (Qiao et al., 2023).

H11: ITC positively moderates the relationship between GSCM and CEP.

Moderating Role of ITC between GPRD and CE Performance

There is a positive correlation between GPRD and CEP that is moderated by ITC. Although GPRD results in increased resource efficiency, waste minimization, and more desirable cyclic economy results, resource efficiency performance as well as waste reduction largely depends on IT capabilities of a particular organization. With high IT capacity, these companies are better placed to acquire, combine, process, and utilize information and implement innovative green products using a smaller amount of resources, thereby balance performance in terms of a CE (Qiao et al., 2023). (Emere et al., 2025), found that digital and ITC improve GIP by enhancing data analytics, SC coordination, and knowledge sharing. Recent research suggests that developing technologies such as AI, big data, and digital may positively impact innovation and sustainability, leading to CE outcomes. (Ye & Zhang, 2025).

H12: ITC positively moderates the relationship between GPRD and CEP.

Moderating Role of ITC between GPRC and CE Performance

The association between GPRC and CEP is positively moderated by ITC. ITC increase the impact of GPRC on CEP by allowing businesses to better manage, monitor, and optimize eco-friendly processes. GPRC involves creating manufacturing processes to minimize waste, energy use and greenhouse gas emissions, thereby encouraging CEP such as recycling and resource efficiency (Emere et al., 2025). But it is more effective when supported by adequate IT skills. Recent studies suggest IT technologies, including BDA and IoT, enhance process visibility, control, and monitoring, which allows for better outcomes of GPRC (Bhattacharjee et al., 2024).

H13: ITC positively moderates the relationship between GPRC and CEP.

Moderating Role of ITC between GMGT and CE Performance

ITC moderates positively the relationship between GMGT and CEP. GMGT involves application of sustainable managerial practices, strategies and organizational structures to enhance sustainability and resource optimization (Waqas et al., 2024). While such innovations provide a strategic framework for CEP, their efficacy heavily relies on the firm's capacity to harness digital technology and information systems. ITC enhances environmental management methods by enabling real-time information integration, performance analysis, and interdepartmental integration (Hossain et al., 2025). Moreover, online platforms and analytics can enhance decision-making and apply sustainable policies, leading to enhanced circular outcomes, including waste minimization and resource re-utilization (Makhloufi et al., 2024)

H13: ITC positively moderates the relationship between GMGT and CEP.

Methodology

Research Design

The research has employed a deductive approach to research. The use of this method of research is justified in the sense that it enables the researcher to make an assessment of the pre-defined relationships against the scholarly facts and find out whether or not they are supported by empirical facts. Moving from broad conceptual understandings to specific observations provides logical coherence and analytical rigor to the inquiry. The deductive process also improves objectivity because it does not seek to generate new assumptions but rather tests previously defined assumptions, increasing the dependability and validity of the findings (Creswell & Creswell, 2017).

Sampling Design

Target Population

This study targets SC professionals of manufacturing companies based in Pakistan. These professionals are directly associated with strategic and operational SCP, environmental initiatives, and organizational performance initiatives making them as informed respondents who can give precise information about firm-level sustainability and innovation practices. It would be appropriate to target manufacturing companies since they have a high environmental significance and are increasingly concerned with sustainable practices in developing economies (Mahar et al., 2025).

Data Collection Instrument

In this study, agreement among respondents was measured in a systematic and consistent manner by the use of a five-point Likert scale. It is appropriate to the scale because it allows the respondents to indicate their degree of concurrence or dissent regarding the propositions put across (Joshi et al., 2015). The five-point scales are straightforward, less exhausting to the respondent and increases accuracy of the answers by providing a set of balanced and comfortable to read options. Moreover, it enables comparison of the answers and valid measurement of abstract organizational traits, thus strengthening the validity and interpretability of the data collected (Nemoto & Beglar, 2014).

Data Analysis Technique

The PLS-SEM approach was employed to carry out the analysis of the data. This particular methodology was selected due to the presence of many relationships, which were direct, indirect and moderating in nature (Hair et al., 2019). In fact, it is highly effective for predicting multiple latent variable studies with moderators. PLS is also quite efficient for dealing with complicated models and does not have to assume high levels of normality. Thus, it is appropriate for use in management and social science surveys (Joe F Hair et al., 2011).

Results and Discussion

Demographic Profile of the Respondents

Table 1 shows the demographic characteristics of the 207 respondents. The study's demographic profile includes 207 participants in total. In terms of gender distribution, 146 (70.5%) participants were male and 61 (29.5%) were female. Regarding employment positions, 23 participants (11.1%) were in senior management/executive roles, 73 participants (35.3%) were managers, 53 participants (25.6%) were supervisors or team leaders, 43 participants (20.8%) were officers, and 15 participants (7.2%) were in other positions. Concerning company age, 13 participants (6.3%) were from firms less than 5 years old, 19 participants (9.2%) from 5–less than 10 years, 21 participants (10.1%) from 10–less than 15 years, and 154 participants (74.4%) were from firms aged 15 years and above. In terms of respondents' experience, 59 participants (28.5%) had less than 5

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years of experience, 73 participants (35.3%) had 5–less than 10 years, 49 participants (23.7%) had 10–less than 15 years, and 26 participants (12.6%) had 15 years and above. Regarding industry type, 30 participants (14.5%) were from textile, 20 participants (9.7%) from pharmaceutical, 38 participants (18.4%) from FMCG, 19 participants (9.2%) from service, 27 participants (13.0%) from healthcare, 29 participants (14.0%) from machinery and hardware, 26 participants (12.6%) from chemical, and 18 participants (8.7%) belonged to other industries.

Table 1: Demographic Profile (n = 207)

		Frequency	Percent
Gender	Male	146	70.5
	Female	61	29.5
Job Position	Senior management/ Executive	23	11.1
	Manager	73	35.3
	Supervisor/ Team Lead	53	25.6
	Officer	43	20.8
	Others	15	7.2
Company Age	Less than 5 years	13	6.3
	5–less than 10 years	19	9.2
	10–less than 15 years	21	10.1
	15 years and above	154	74.4
Respondent's Experience	Less than 5 years	59	28.5
	5–less than 10 years	73	35.3
	10–less than 15 years	49	23.7
	15 years and above	26	12.6
Industry Type	Textile	30	14.5
	Pharmaceutical	20	9.7
	FMCG	38	18.4
	Service	19	9.2
	Healthcare	27	13.0
	Machinery and hardware	29	14.0
	Chemical	26	12.6
	Others	18	8.7

Construct Validity

Construct validity assesses the degree to which the measuring instrument captures the theoretical construct it intended to measure (Hair et al., 2017). Indicator loadings must be > 0.60, p-values < 0.05, and VIF < 5 to establish construct validity (Hair, 2018). Table 4.2 presents the result of measurement model analysis using PLS algorithm technique.

Construct Validity using PLS Algorithm

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Table 2: Construct Validity using PLS Algorithm

Constructs	Indicators	Loadings	Prob.	VIF
Circular Economy Performance	CEP1	0.789	0.000	2.228
	CEP2	0.733	0.000	1.912
	CEP3	0.775	0.000	2.185
	CEP4	0.765	0.000	2.182
	CEP5	0.824	0.000	2.601
	CEP6	0.885	0.000	4.188
	CEP7	0.823	0.000	3.139
Green Management Innovation	GMGT1	0.781	0.000	1.671
	GMGT2	0.840	0.000	1.756
	GMGT3	0.750	0.000	1.549
	GMGT4	0.768	0.000	1.565
Green Process Innovation	GPRC1	0.774	0.000	1.665
	GPRC2	0.777	0.000	1.570
	GPRC3	0.779	0.000	1.575
	GPRC4	0.720	0.000	1.381
Green Product Innovation	GPRD1	0.844	0.000	2.343
	GPRD2	0.872	0.000	2.628
	GPRD3	0.847	0.000	2.373
	GPRD4	0.788	0.000	1.907
	GPRD5	0.776	0.000	1.778
Green Supply Chain Management	GSCM1	0.817	0.000	4.718
	GSCM10	0.750	0.000	2.080
	GSCM11	0.657	0.000	1.618
	GSCM2	0.827	0.000	6.635
	GSCM3	0.834	0.000	5.117
	GSCM4	0.805	0.000	3.577
	GSCM5	0.828	0.000	4.425
	GSCM6	0.792	0.000	3.363
	GSCM7	0.774	0.000	3.409
	GSCM8	0.688	0.000	2.016
	GSCM9	0.750	0.000	2.115
IT Capability	ITC1	0.825	0.000	1.890
	ITC2	0.786	0.000	1.557
	ITC3	0.857	0.000	2.266
	ITC4	0.805	0.000	1.962

Above table showed that all the indicators have factor loadings exceeding the threshold level of 0.60, probability values lower than 5%, and VIF values lower than 5. While some indicators barely exceed 5, most indicators still remain under the threshold, hence, there are no issues of multicollinearity (J F Hair et al., 2011; Hair et al., 2013).

Reliability and Convergent Validity

Reliability and convergent validity relate to accuracy and consistency measurements. Reliability entails internal consistency of conceptions that can be measured through either the Cronbach's Alpha or CR value. Values ≥ 0.70 are well accepted (Hair, 2018). Convergent validity is said to be achieved when factor loadings are higher than 0.70 and AVE is ≥ 0.50, hence, the convergent indicators accurately measure the same construct (Hair et al., 2013).

Internal Consistency and Degree of Convergence of Latent Constructs

Table 3: Internal Consistency and Degree of Convergence of Latent Constructs

Latent Constructs	Cronbach's Alpha	Composite Reliability	Average Variance Extracted
CEP	0.906	0.926	0.641
GMGT	0.794	0.866	0.617
GPRC	0.760	0.847	0.582
GPRD	0.884	0.915	0.683
GSCM	0.934	0.943	0.604
ITC	0.836	0.890	0.670

For all latent variables, Cronbach's alpha and composite reliability (CR) values are above 0.70 and mostly above 0.80 (Hair et al., 2019). All average variance extracted (AVE) is above the standard value of 0.50, thus confirming the acceptable convergence of the indicator of construct (J F Hair et al., 2011; Hair et al., 2013). This indicates that convergent validity has been confirmed.

Discriminant Validity

Heterotrait-Monotrait (HTMT) Ratio

Heterotrait-Monotrait (HTMT) Ratio for Discriminant Validity

Table 4: Heterotrait-Monotrait (HTMT) Ratio for Discriminant Validity

	CEP	GMGT	GPRC	GPRD	GSCM	ITC
CEP						
GMGT	0.787					
GPRC	0.858	0.962				
GPRD	0.808	0.764	0.867			
GSCM	0.658	0.884	0.765	0.612		
ITC	0.693	0.825	0.769	0.686	0.766	

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Henseler et al. (2016); Henseler et al. (2015) evaluated discriminant validity on the basis that the HTMT ratio of any two latent variables should be lower than the recommended value of 0.90. Tablet generated the highest HTMT ratio of GPRC and GMGT with an HTMT ratio of 0.862, as indicated in the table above. Since the HTMT ratio falls within the acceptable limits, the results indicate that discriminant validity can be used based on the HTMT ratio criterion.

Fornell-Larcker Criteria (FLC)

Fornell-Larcker Criteria (FLC) for Discriminant Validity

Table 5: Fornell-Larcker Criteria (FLC) for Discriminant Validity

	CEP	GMGT	GPRC	GPRD	GSCM	ITC
CEP	**0.800**					
GMGT	0.681	**0.786**				
GPRC	0.722	0.750	**0.763**			
GPRD	0.726	0.647	0.717	**0.826**		
GSCM	0.628	0.777	0.654	0.569	**0.777**	
ITC	0.615	0.679	0.620	0.593	0.687	**0.819**

As seen from the table above, the diagonal bold figures (square root of AVE) are higher than correlation coefficient provided that constructs have high level of variance as compared to the correlation among constructs (Ab Hamid et al., 2017; Fornell & Larcker, 1981). Hence, constructs had high degree of divergence and thus, discriminant validity through FLC was established.

Crossloadings Method

Crossloadings Method for Discriminant Validity

Table 6: Crossloadings Method for Discriminant Validity

	CEP	GMGT	GPRC	GPRD	GSCM	ITC
CEP1	**0.789**	0.617	0.642	0.599	0.622	0.575
CEP2	**0.733**	0.663	0.673	0.568	0.641	0.575
CEP3	**0.775**	0.445	0.492	0.561	0.415	0.436
CEP4	**0.765**	0.467	0.544	0.544	0.334	0.405
CEP5	**0.824**	0.517	0.496	0.595	0.464	0.473
CEP6	**0.885**	0.552	0.590	0.620	0.535	0.505
CEP7	**0.823**	0.508	0.568	0.563	0.439	0.434
GMGT1	0.466	**0.781**	0.592	0.496	0.567	0.504
GMGT2	0.615	**0.840**	0.615	0.589	0.748	0.614
GMGT3	0.468	**0.750**	0.587	0.476	0.569	0.466
GMGT4	0.574	**0.768**	0.566	0.458	0.530	0.533
GPRC1	0.559	0.450	**0.774**	0.619	0.393	0.367

GPRC2	0.678	0.579	**0.777**	0.621	0.451	0.493
GPRC3	0.483	0.676	**0.779**	0.503	0.549	0.513
GPRC4	0.473	0.572	**0.720**	0.442	0.595	0.508
GPRD1	0.606	0.615	0.691	**0.844**	0.539	0.507
GPRD2	0.651	0.548	0.660	**0.872**	0.529	0.564
GPRD3	0.585	0.506	0.597	**0.847**	0.422	0.436
GPRD4	0.557	0.460	0.423	**0.788**	0.396	0.445
GPRD5	0.593	0.533	0.564	**0.776**	0.449	0.485
GSCM1	0.388	0.583	0.474	0.371	**0.817**	0.491
GSCM10	0.504	0.621	0.548	0.541	**0.750**	0.579
GSCM11	0.488	0.596	0.613	0.388	**0.657**	0.434
GSCM2	0.401	0.573	0.433	0.371	**0.827**	0.484
GSCM3	0.390	0.555	0.469	0.360	**0.834**	0.532
GSCM4	0.452	0.571	0.479	0.434	**0.805**	0.537
GSCM5	0.410	0.570	0.482	0.382	**0.828**	0.519
GSCM6	0.519	0.645	0.526	0.436	**0.792**	0.557
GSCM7	0.596	0.679	0.562	0.509	**0.774**	0.604
GSCM8	0.613	0.573	0.476	0.548	**0.688**	0.522
GSCM9	0.497	0.605	0.450	0.435	**0.750**	0.547
ITC1	0.485	0.572	0.495	0.487	0.588	**0.825**
ITC2	0.564	0.551	0.547	0.474	0.602	**0.786**
ITC3	0.480	0.558	0.516	0.497	0.526	**0.857**
ITC4	0.470	0.538	0.462	0.480	0.520	**0.805**

The above table shows that the indicators have high loading on the construction of those indicators compared to cross-loading on other constructs. This indicated that the constructs have common variance compared to other constructs and hence there is significant divergence between structures and other constructs (Ab Hamid et al., 2017; Cheung & Wang, 2017).

Predictive Power

Predictive Power of the Endogenous Constructs

Table 7: Predictive Power of the Endogenous Constructs

Endogenous Latent Constructs	R-Square	Adjusted R-Square
CEP	0.657	0.641
GMGT	0.604	0.602
GPRC	0.427	0.424
GPRD	0.324	0.321

R^2 indicates the percentage of variance in the endogenous variables which is explained by the structural model. As per Hair et al. (2011), R^2 values greater than 0.75 represent strong predictive

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ability, R^2 values between 0.50 and 0.75 represent moderate predictive ability, and R^2 values less than 0.25 represent weak predictive ability. As seen from Table 4.7, the R^2 value for CEP is 0.657 and its adjusted R^2 value is 0.641, representing moderate predictive ability. In the same way, the R^2 value for GMGT is 0.604 and its adjusted R^2 value is 0.602, representing moderate predictive ability. In addition, the R^2 value for GPRC is 0.427 and its adjusted R^2 value is 0.424, representing weak to moderate predictive ability. Moreover, the R^2 value for GPRD is 0.324 and its adjusted R^2 value is 0.321, also representing weak to moderate predictive ability.

Structural Model

The structural model tests the hypothesized relationships between latent constructs by estimating path coefficients to determine the strength and significance of direct, indirect effects between variables. All effects are considered significant at $p < 0.05$, allowing for a clear and meaningful interpretation (Hair, 2009; Hair, 2018).

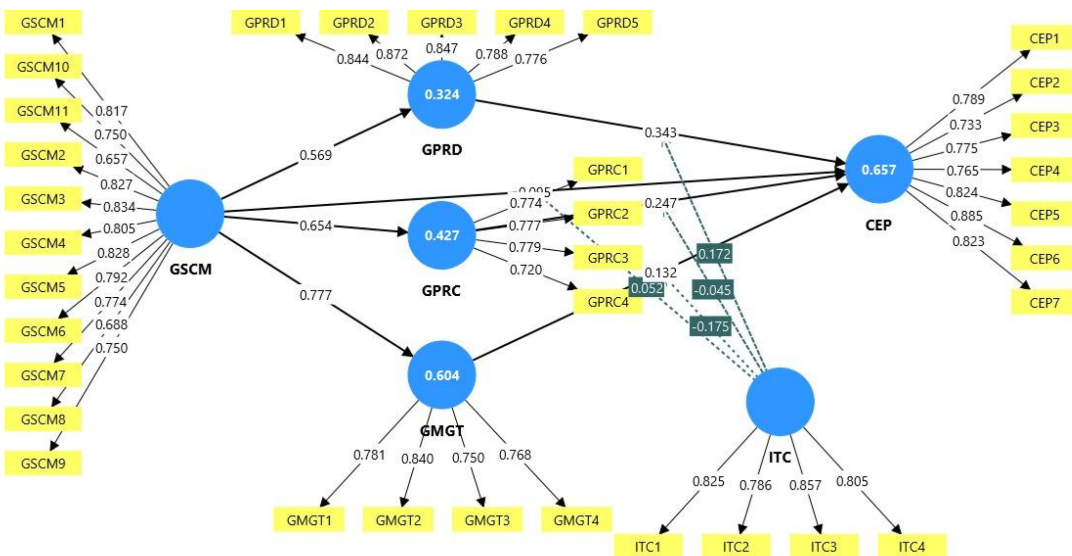

Figure 2: PLS Bootstrapping

Direct-Effect Analysis

Direct-Effect Analysis using PLS Path Modeling

Table 8: Direct-Effect Analysis using PLS Path Modeling

Path Relationships	Estimate	Std. Dev.	t-Statistics	Prob.	Prob.
GMGT -> CEP	0.132	0.081	1.631	0.103	Not Supported
GPRC -> CEP	0.247	0.080	3.081	0.002	Supported
GPRD -> CEP	0.343	0.075	4.594	0.000	Supported
GSCM -> CEP	0.095	0.033	2.849	0.036	Supported
GSCM -> GMGT	0.777	0.028	27.995	0.000	Supported
GSCM -> GPRC	0.654	0.043	15.060	0.000	Supported
GSCM -> GPRD	0.569	0.061	9.260	0.000	Supported

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The above table showed that GMGT ($\beta = 0.132$; $p > 0.05$) has positive insignificant effects on CEP. GPRC ($\beta = 0.247$; $p < 0.05$) has positive significant effects on CEP. GPRD ($\beta = 0.343$; $p < 0.05$) has positive significant effects on CEP. Additionally, GSCM ($\beta = 0.095$; $p < 0.05$) has positive significant effects on CEP. GSCM ($\beta = 0.777$; $p < 0.05$) has positive significant effects on GMGT. GSCM ($\beta = 0.654$; $p < 0.05$) has positive significant effects on GPRC. Also, GSCM ($\beta = 0.095$; $p < 0.05$) has positive significant effects on GPRD.

Specific Indirect-Effect Analysis

Specific Indirect-Effect Analysis using PLS Path Modeling

Table 9: Specific Indirect-Effect Analysis using PLS Path Modeling

Path Relationships	Estimate	Std. Dev.	t-Statistics	Prob.	Prob.
GSCM -> GPRD -> CEP	0.195	0.046	4.207	0.000	Supported
GSCM -> GPRC -> CEP	0.161	0.053	3.015	0.003	Supported
GSCM -> GMGT -> CEP	0.103	0.064	1.611	0.107	Not Supported

As indicated in the table above, GPRD ($\beta = 0.195$; $p < 0.05$) positively mediates between GSCM and CEP. GPRC ($\beta = 0.161$; $p < 0.05$) positively mediates between GSCM and CEP. Finally, GMGT ($\beta = 0.103$; $p > 0.05$) positively but insignificantly mediates between GSCM and CEP.

Moderation Analysis

Moderating-Effect Analysis using PLS Path Modeling

Table 10: Moderating-Effect Analysis using PLS Path Modeling

Path Relationships	Estimate	Std. Dev.	t-Statistics	Prob.	Prob.
ITC x GMGT -> CEP	-0.175	0.087	2.006	0.045	Supported
ITC x GPRC -> CEP	-0.045	0.084	0.542	0.588	Not Supported
ITC x GPRD -> CEP	0.172	0.086	1.999	0.046	Supported
ITC x GSCM -> CEP	0.052	0.078	0.666	0.506	Not Supported

From the table above, it is clear that ITC ($\beta = -0.175$; $p < 0.05$) has a negative moderating effect on the relationship between GMGT and CEP. Nevertheless, ITC ($\beta = -0.045$; $p > 0.05$) fails to have a moderating effect on the relationship between GPRC and CEP. ITC ($\beta = 0.172$; $p < 0.05$) has a positive moderating effect on the relationship between GPRD and CEP.

Discussion

The result showed that GSCM has positively significant effects on CEP. The outcome aligns with the previous results, which demonstrated that GSCMP may have significant positive impact on the CE outcome, by improving the efficiency of resources, waste management and sustainable circulation and flow of materials throughout the SC. GSCM allows companies to consider the environment in their purchasing, production and distribution activities, which allows them to pursue closed-loop processes and decrease environmental damage (Bag et al., 2022; Botezat et al., 2018; Zhu et al., 2010). The NRBV holds that competitiveness is achieved when firms develop capabilities that increase their environmental practices and resource use. GSCM processes, in turn, still have an impact on organizational culture, and this culture eventually promotes CEP, recycling, reusing, and responsibilities eco-efficient (Bai et al., 2020).

Conclusion

The research explores how GSCM is affecting CEP in the manufacturing industry in Pakistan where GI is the intermediary variable, and IT capabilities are the moderators. RBV and DCV theory were the theoretical backgrounds of the study. The research employed a quantitative research method and explanatory research to examine a particular topic problem, but with considerable modifications in place to take into consideration unknown elements. SC professionals with Pakistani manufacturing firms are also the target demographic of the study. The respondents used in the study were selected through non-probability, purposeful selection approach and PLS-SEM was used to test a complex modeling process.

Limitations of the Study

The study has a number of limitations that need to be put in consideration of the interpretation of the results. First, the research is confined to the manufacturing industry in Pakistan and thus cannot be applied to other industries or countries that have dissimilar economic and regulatory factors. In addition, a non-probability purposive sampling method will result into selection bias and this will limit the sample representativeness. In addition, these data were gathered using a self-report five-point Likert Scale questionnaire which is prone to both common method bias and bias in responding.

Future Research Directions

Future studies should expand the current study by examining other non-manufacturing aspects of industry in Pakistan, to generalize results of the research to other sectors. The comparative analysis between developing and developed economies might also serve to shed more light on the impact of the situation-specific factors on the correlation between GSCP and CEP. Furthermore, longitudinal research designs can be adopted in future studies in order to be able to comprehend the causal relationships overtime.

References

1. Ab Hamid, M., Sami, W., & Sidek, M. (2017). Discriminant validity assessment: Use of Fornell & Larcker criterion versus HTMT criterion. *Journal of Physics: Conference Series*.
2. Abdallah, A. B., Al-Ghwayeen, W. S., Al-Amayreh, E. A. M., & Sweis, R. J. (2024). The impact of green supply chain management on circular economy performance: The mediating roles of green innovations. *Logistics, 8*(1), 20.
3. AlSheyadi, A., Abbas, H., Baawain, A., & Saeed, A. (2025). Linking zero-waste management and green innovative supply chains to sustainable performance: The mediating role of green dynamic capabilities in manufacturing firms. *Sustainability, 17*(22), 10348.

4. Bag, S., Dhamija, P., Bryde, D. J., & Singh, R. K. (2022). Effect of eco-innovation on green supply chain management, circular economy capability, and performance of small and medium enterprises. *Journal of Business Research*, *141*, 60–72.
5. Bai, C., Sarkis, J., Yin, F., & Dou, Y. (2020). Sustainable supply chain flexibility and its relationship to circular economy-target performance. *International Journal of Production Research*, *58*(19), 5893–5910.
6. Barney, J. (1991). Firm resources and sustained competitive advantage. *Journal of Management*, *17*(1), 99–120.
7. Ben Salem, A., Iyiola, K., & Alzubi, A. (2025). Do supply chain management, ESG sustainability practices, and ICT have an impact on environmental sustainability? *Systems*, *13*(9), 725.
8. Bhattacharjee, P., Sharma, K., & Bhattacharya, J. (2024). Unlocking the green potential: Assessing the role of green hydrogen in revolutionizing electricity generation and fueling automotive vehicles (FCEVS). *Sachetas*, *2*(2), 29–38.
9. Botezat, E. A., Dodescu, A. O., Văduva, S., & Fotea, S. L. (2018). An exploration of circular economy practices and performance among Romanian producers. *Sustainability*, *10*(9), 3191.
10. Bugri, B. A., Muntaka, A. S., & Mensah, J. (2025). Green innovation and sustainability performance: Exploring the impact of green supply chain management, absorptive capacity, and institutional pressures. *Thunderbird International Business Review*, *67*(6), 797–814.
11. Chen, G., Sabir, A., Rasheed, M. F., Belascu, L., & Su, C.-W. (2024). Green marketing horizon: Industry sustainability through marketing and innovation. *Journal of Innovation & Knowledge*, *9*(4), 100606.
12. Cheung, G. W., & Wang, C. (2017). Current approaches for assessing convergent and discriminant validity with SEM: Issues and solutions. *Academy of Management Annual Meeting Proceedings*.
13. Creswell, J. W., & Creswell, J. D. (2017). *Research design: Qualitative, quantitative, and mixed methods approaches* (5th ed.). SAGE Publications.
14. Duman Altan, A., Beyca, Ö. F., & Zaim, S. (2024). Link between digital technologies adoption and sustainability performance: Supply chain traceability/resilience or circular economy practices. *Sustainability*, *16*(19), 8694.
15. Emere, C. E., Aigbavboa, C. O., & Oguntona, O. A. (2025). Critical project delivery strategies for sustainable building construction in South Africa. *Frontiers in Built Environment*, *11*, 1566468.
16. Ferreira, J. J., Candeias Fernandes, A. J., Nguyen, T. H. D., Rammal, H. G., & Pereira, V. (2026). Green logistics and supply chain knowledge management: An extended framework-based systematic literature review. *Journal of Knowledge Management*, 1–21.
17. Fornell, C., & Larcker, D. F. (1981). Structural equation models with unobservable variables and measurement error: Algebra and statistics. *Journal of Marketing Research*, *18*(3), 382–388.
18. Gelmez, E., Özceylan, E., & Mrugalska, B. (2024). The impact of green supply chain management on green innovation, environmental performance, and competitive advantage. *Sustainability*, *16*(22), 9757.
19. Hair, J. F. (2009). *Multivariate data analysis*.
20. Hair, J. F. (2018). *Multivariate data analysis* (8th ed.). Cengage Learning.

21. Hair, J. F., Hollingsworth, C. L., Randolph, A. B., & Chong, A. Y. L. (2017). An updated and expanded assessment of PLS-SEM in information systems research. *Industrial Management & Data Systems*, *117*(3), 442–458.
22. Hair, J. F., Ringle, C. M., & Sarstedt, M. (2011). PLS-SEM: Indeed a silver bullet. *Journal of Marketing Theory and Practice*, *19*(2), 139–152.
23. Hair, J. F., Ringle, C. M., & Sarstedt, M. (2013). Partial least squares structural equation modeling: Rigorous applications, better results and higher acceptance. *Long Range Planning*, *46*(1–2), 1–12.
24. Hair, J. F., Risher, J. J., Sarstedt, M., & Ringle, C. M. (2019). When to use and how to report the results of PLS-SEM. *European Business Review*, *31*(1), 2–24.
25. Hasan, S. M., Ahmed, W., Waris, I., & Najmi, A. (2026). Understanding the influence of organizational compatibility on green supply chain management efforts to boost environmental performance. *Corporate Social Responsibility and Environmental Management*, *33*(1), 1511–1527.
26. Henseler, J., Hubona, G., & Ray, P. A. (2016). Using PLS path modeling in new technology research: Updated guidelines. *Industrial Management & Data Systems*, *116*(1), 2–20.
27. Henseler, J., Ringle, C. M., & Sarstedt, M. (2015). A new criterion for assessing discriminant validity in variance-based structural equation modeling. *Journal of the Academy of Marketing Science*, *43*(1), 115–135.
28. Hossain, M. I., Ong, T. S., Jamadar, Y., Teh, B. H., & Islam, A. (2025). Nexus among green entrepreneurship orientation, green ambidexterity innovation, green technological turbulence and green performance: Moderated-mediation evidence from Malaysian manufacturing SMEs. *European Journal of Innovation Management*, *28*(7), 2761–2783.
29. Ibrahim, M., Mahmood, R., & Som, H. M. (2025). Green absorptive capacity and environmental performance: A perspective of SMEs' relational capability and green supply chain management practices. *Environment, Development and Sustainability*, *27*(6), 13947–13971.
30. Joshi, A., Kale, S., Chandel, S., & Pal, D. K. (2015). Likert scale: Explored and explained. *British Journal of Applied Science & Technology*, *7*(4), 396–403.
31. Khan, S. A. R., Ahmad, Z., Sheikh, A. A., & Yu, Z. (2024). Green technology adoption paving the way toward sustainable performance in circular economy: A case of Pakistani small and medium enterprises. *International Journal of Innovation Science*, *16*(5), 801–822.
32. Levi-Bliech, M., & Dahan, G. (2025). The impact of green innovation products on an organization's social performance via green supply chain management. *Green Technologies and Sustainability*, 100273.
33. Lu, C., & Wang, K. (2023). Natural resource conservation outpaces and climate change: Roles of reforestation, mineral extraction, and natural resources depletion. *Resources Policy*, *86*, 104159.
34. Mahar, A. S., Zhang, Y., Sadiq, B., & Gul, R. F. (2025). Sustainability transformation through green supply chain management practices and green innovations in Pakistan's manufacturing and service industries. *Sustainability*, *17*(5), 2204.
35. Makhloufi, L., Djermani, F., & Meirun, T. (2024). Mediation-moderation model of green absorptive capacity and green entrepreneurship orientation for corporate environmental performance. *Management of Environmental Quality: An International Journal*, *35*(1), 139–157.

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36. Nemoto, T., & Beglar, D. (2014). Likert-scale questionnaires. *JALT 2013 Conference Proceedings*.
37. Nweje, U., & Taiwo, M. (2025). Supply chain management: Balancing efficiency and environmental responsibility. *World Journal of Advanced Research and Reviews, 25*(1), 1547–1564.
38. Qiao, J., Li, S., Xiong, S., & Li, N. (2023). How does the digital capability advantage affect green supply chain innovation? An inter-organizational learning perspective. *Sustainability*, *15*(15), 11583.
39. Ranta, V., Aarikka-Stenroos, L., & Mäkinen, S. J. (2018). Creating value in the circular economy: A structured multiple-case analysis of business models. *Journal of Cleaner Production*, *201*, 988–1000.
40. Shaharudin, M. R., Zailani, S., Tan, K.-C., Cross, J., & Hotrawaisaya, C. (2025). Fostering closed-loop supply chain orientation by leveraging strategic green capabilities for circular economy performance: Empirical evidence from Malaysian electrical and electronics manufacturing firms. *Environment, Development and Sustainability*, *27*(10), 24397–24434.
41. Triguero, A., Moreno-Mondéjar, L., & Sáez-Martínez, F. J. (2023). Circular economy and firm performance: The influence of product life cycle analysis, upcycling, and redesign. *Sustainable Development, 31*(4), 2318–2331.
42. Waqas, M., Meng, Q., Khan, S. A. R., & Hussain, K. (2024). Technological management capabilities as a pathway toward green production and green competitive advantage. *Journal of Manufacturing Technology Management, 35*(8), 1528–1553.
43. Ye, S., & Zhang, W. (2025). AI-driven circular economy performance in Chinese electronics manufacturing: The moderating role of green innovation capability. *Technology Analysis & Strategic Management*, 1–15.
44. Zhu, Q., Geng, Y., & Lai, K.-H. (2010). Circular economy practices among Chinese manufacturers varying in environmental-oriented supply chain cooperation and the performance implications. *Journal of Environmental Management*, *91*(6), 1324–1331.