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Green supply chain management and sustainable performance: Sequential mediating role of technology adoption and circular economy

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ABSTRACT

In the digital era, academicians and professionals must integrate green concepts into supply chain management. This integration supports technology adoption, the circular economy, and organizational sustainability. The aim of this research is to explore the impact of green supply chain management (GSCM) on sustainable performance (SP), emphasizing the integration of the sequential mediation effect of technological capabilities (TAC) and circular economy practices (CEP). For analysis, this study has applied a structural equation modeling approach by using Smart PLS 4.0 based on the dynamic capabilities view and the Resource-Based view theory. The data was gathered using a survey method from 543 respondents from the garments industry of developing economies. The results proved that GSCM positively and significantly drive SP, also revealed that TAC and CEP partially mediated the relationship between GSCM and SP. Additionally, the study proved that TAC and CEP have a positive sequential mediating effect in the interlink between GSCM and SP. These insights can be useful for garment industry professionals, managers, practitioners, and policymakers who strategically want to integrate technology and green together to achieve sustainable competitive performance in the rapidly changing digital landscape.

1. Introduction

In the wake of growing environmental concerns and strategic environmental management issues, the textile industry is undergoing a substantial transformation toward sustainability, driven by increasing regulatory pressures and resource constraints (Seuring & Müller, 2008; Zhu & Sarkis, 2006). Particularly, the integration of Green Supply Chain Management (GSCM) practices and circular economy principles has emerged as a vital strategic initiative aimed at minimizing environmental impact while enhancing operational performance (Diabat &

Govindan, 2011; Yu et al., 2014). Moreover, due to the technological advancement, organizations are constantly facing challenges in adapting to evolving customer preferences for sustainable supply chain management (Genovese et al., 2017; Gunasekaran et al., 2017). Global warming has increased pressure to reduce energy consumption and emissions. Consequently, major economies like the USA, EU, and China face the challenge of balancing environmental protection with sustained economic growth (Khan et al., 2021a; Wangsa et al., 2023; Zhang et al., 2022).

Despite significant research attention, the pathways through which

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GSCM contributes to sustainable performance (SP) with technological adoption capabilities (TAC) and circular economy practices (CEP) as a sequential mediator remain under-investigated, especially in developing economies like Bangladesh, where the garment sector plays a dominant role in industrial output and export earnings. Moreover, in the garment industry, various technologies are commonly employed to ensure organizational sustainability, including Digital Human Modeling (DHM), Digital Twins, e-libraries and body-size databases, 3D body scanning and virtual avatars, closed-loop design, AI-driven personalization, the integration of robotics and automation, and mobile applications with cloud integration (Donmezer et al., 2023). Here GSCM is a strategic position integrating the "go-green" philosophy across the supply chain. In contrast, CEP specifically focuses on the 3R principles (reduce, reuse, recycle) and the recovery/regeneration of products to extend their lifecycle.

Recent literature suggests that the TAC and CEP are crucial enablers of sustainability within supply chains (Geissdoerfer et al., 2017; Imran, 2024; Iqbal & Su, 2025; Khan et al., 2020). The concept of GSCM began to gain recognition in the 1950s, to minimize manufacturing costs (Ahmad & Karadas, 2021; Chin et al., 2015). It has also emerged as a critical strategy for organizations striving to balance economic growth with environmental sustainability. Here, GSCM practices are not only involved in manufacturing products but also contribute to enhancing the long-term value of garment companies (Ananda et al., 2018) by improving service or product quality in efficient ways to ensure customer satisfaction. Technological Adoption Capabilities (TAC) refer to an organization's ability to integrate new technologies efficiently (Qing et al., 2023). Complementing this, Circular Economy Practices (CEP) focus on rejuvenating product lifecycles through resource recovery and alternative business models (Jabbour et al., 2019). These practices include minimizing the use of virgin materials, reusing resources, reducing energy losses, lowering carbon emissions, and preventing environmental pollution (Gaur et al., 2023).

Moreover, CEP emphasizes resource circularity, waste minimization, and closed-loop systems, all of which can significantly reduce the ecological footprint of manufacturing operations (Korhonen et al., 2018). However, the successful accomplishment of CEP largely depends on the technological readiness and innovation capabilities of organizations (Moktadir et al., 2018). The integration of digital and operational technologies, as reflected in TAC, enhances a firm's ability to process circular information, optimize resource utilization, and support environmentally responsible practices (Bag et al., 2021).

Drawing upon the dynamic capabilities view (Teece et al., 1997) and the Resource-Based View (RBV) (Barney, 1991), this study explores a serial mediation model. We propose that GSCM fosters TAC, which then enables CEP, leading to improved SP. The interlinkages of these constructs align with the argument that organizations must not only possess green strategies, but also the dynamic capability to reconfigure internal and external capabilities to address rapidly changing environmental contexts (Eisenhardt & Martin, 2000; Teece, 2007). Here the capabilities of GSCM, TAC, and CEP satisfy the VRIN criteria (Value, Rareness, Inimitability, and Non-substitutability). For example, the integration of digital readiness and environmental knowledge creates a path-dependent, socially complex resource that is difficult for competitors to replicate. Also, GSCM allows firms to sense environmental shifts, TAC allows them to seize these opportunities through technological innovation, and CEP enables the transformation of linear models into circular ones. Bangladeshi garments sectors are focusing on this high-pressure, export-oriented industry, so it can be demonstrated that firms are bound to navigate regulatory standards (e.g., ISO 14001) and international buyer demands through the proposed sequential capability framework. Although prior studies have examined the direct effects of GSCM on performance (Dubey et al., 2015; Green et al., 2012), GSCM practice have positive impact on sustainability (Ahmad et al., 2023; Chin et al., 2015; Fahimnia et al., 2015; Zhu & Sarkis, 2006). Moreover, GSCM and SP are linked to the go-green philosophy. Separately, some of

the researchers found that GSCM has a positive impact on improving technology innovation (Lee et al., 2014) and circular economy (Liu et al., 2018), none have empirically tested the sequential mediation of TAC and CEP in this relationship, particularly in the garments industry within the context of emerging economies like Bangladesh.

Furthermore, limited empirical research exists on how GSCM, TAC, CEP and SP interact in the garments sector of Bangladesh, which is often faces challenges such as outdated infrastructure, volatile global demands, and growing environmental dynamism (Hoque et al., 2022). Therefore, this study aims to fill this gap by analyzing responses from 543 supply chain and sustainability professionals working across leading Bangladeshi garment firms. Specifically, find the impact of GSCM practices on TAC and CEP, which ultimately leading to SP in the garments supply of Bangladesh. Through this lens, the study addresses a critical need to understand not only what but also the how of achieving sustainability performance through TAC and circularity-enhancing capabilities. Accordingly, this study seeks to address the following research questions.

RQ1: How does GSCM influence TAC and CEP in the garments sector?

RQ2: How do TAC and CEP mediate the relationship between GSCM and SP?

RQ3: Do TAC and CEP sequentially mediate the relationship between GSCM and SP in the garment sector of Bangladesh?

To address these questions, the study applies the PLS-SEM technique to validate a conceptual framework integrating GSCM, TAC, CEP, and SP, covers an empirical investigation of the garment sector supply chain in Bangladesh. By applying the DCV and RBV theoretical lenses, this paper contributes to a more nuanced understanding of how green strategies are operationalized through innovation and circularity to yield sustainable outcomes in emerging market contexts suggested by (Govindan et al., 2020). We have organized the documents as follows: Section one describes the contextual backgrounds of the research concepts. Section two presents the hypotheses used to develop the framework. Section three details the research methods, while section four demonstrates the findings and analysis. Section five elaborates on the research discussion, and section six provides the conclusion, including theoretical and managerial implications, limitations, and directions for future research.

2. Literature review and hypothesis development

2.1. Theoretical framework

The purpose of this study is to investigate the impact of GSCM practices on SP, with a focus on the sequential mediating roles of TAC and CE practices. In developing countries, GSCM practices, as an environmentally conscious approach to supply chain operations in manufacturing organizations, influence enhancing organizational performance (Srivastava, 2007; Zhu & Sarkis, 2004). Our model proposes that GSCM influences TAC, which facilitates CEP. Consequently, TAC and CEP function as serial mediators leading to enhanced SP. Thus, TAC and CEP are modeled as serial mediators between GSCM and SP. The proposed model of this study underpinned by two complementary theories one is dynamic capabilities view DCV) and Resource-Based View (RBV). Teece et al. (1997) developed DCV theory, which justifies that organizational green strategic capabilities and dynamic technological adoption capabilities support for CEP and ultimately leading to SP. The proposed model operationalizes the DCV framework in three stages: sensing (where GSCM allows firms to recognize the global demand for sustainable fashion), seizing (where TAC allows firms to adopt the digital tools needed to meet these demands), and transforming (where CEP enables the reconfiguration of linear processes into circular, renewable systems). This staged progression ensures that dynamic responses to

environmental shifts are technically grounded and strategically aligned.

The garment industry of Bangladesh, exposed to increasing environmental regulations, international buyer demands, and technological shifts, must enhance its dynamic capabilities to achieve SP in a volatile and complex market (Moktadir et al., 2018). It clarifies that Bangladesh are facing high-pressure to integrate regulatory standards e.g., ISO 14001 and international buyer demands in the garments industry. To comply these rules, it can be explained that GSCM, TAC, and CEP function as valuable, rare, inimitable, and non-substitutable (VRIN) resources that provide a competitive advantage for the garments industry. In that case GSCM allows a firm to "sense" environmental shifts, TAC "seizes" these through technological readiness, and CEP "transforms" operations into circular systems.

Also, Barney (1991) developed and emphasized the Resource-Based view (RBV) as a foundational theory supporting business literature. Through the lens of the Resource-Based View (RBV), we propose that the integration of GSCM and TAC constitutes a VRIN-compliant resource. In the resource-constrained context of Bangladesh, these capabilities are Valuable for meeting international buyer compliance (e.g., ISO 14001) and Rare because sophisticated digital-green integration is not yet widespread in emerging markets. Furthermore, they are Inimitable and Non-substitutable as they rely on socially complex organizational learning and path-dependent digital readiness that competitors cannot easily replicate. The major benefit of RBV theory is that organizations can gain competitive advantages by effectively utilizing their resources and capabilities (Conner, 1991). These theories combinedly justify the hypothesized direct impact and serial mediation model, where the implementation of GSCM supports TAC, which in turn enables the transition toward CE, culminating in enhanced SP. Therefore, the present study adopts an integrated RBV and DCV framework to explore how firms can translate their GSCM efforts into sustainable outcomes through dynamic adaptation and technological advancement.

2.2. Green supply chain management practices and sustainable performance

In recent years, the sustainable performance of firms has become increasingly crucial amid intensifying competition. Stakeholders from various perspectives have extensively examined and advocated for the incorporation of GSCM practices as essential elements of the social interaction between business and society. Actually, environmental innovation management systems such as GSCM practices aim to reduce or eliminate hazardous and solid waste throughout the supply chain, from product design and material selection through manufacturing and delivery to consumers (Chin et al., 2015; Wisner et al., 2012). Extensive research has established that GSCM practices enhance SP by optimizing resource distribution and reducing hazardous waste across the supply chain (Ahmad et al., 2023; Han & Huo, 2020; Martínez-Falcó et al., 2023; Maskuroh et al., 2023). However, in emerging markets like Bangladesh, the literature shifts from asking if these practices work to how they are operationalized through specific intermediaries like technology and circularity. According to Awan and Sroufe (2022) GSCM methods also boost operational efficiency in factories. The majority of the prior research has been on the retail business (Behl et al., 2024), the manufacturing industry (Nazir et al., 2024; Opoku & Li, 2025), and how GSCMP impacts these sectors to provide long-term success. Nevertheless, the garment sector in Bangladesh, an emerging economy that has not previously been thoroughly investigated, was the primary focus of the present research. Thus, the following hypothesis is put out by this study.

H1. GSCM Practices have a positive impact on SP.

2.3. Mediating role of technological adoption capabilities

Historically, supply chain management systems relied on centralized

approaches involving planning, resource management, and information tracking (Majeed & Rupasinghe, 2017), which introduced risks such as hacking and corruption (Winch, 2003). It is observed that rapid advances of technology have created a turbulent business environment associates with the adoption of circular economy practices and innovation. Theoretically, investment in GSCM supports both physical and non-physical infrastructure, enhance pollution control, and improves management systems (Vachon, 2007). Due to globalization, supply chain managers and stakeholders increasingly seek greater efficiency such as shorter lead times, high-quality production, and more responsive global supply chains (Paul et al., 2021), in this context TAC are essential for maintaining a smooth supply chain. Moreover, technology supports responsiveness to customer needs and demands (Effendi et al., 2020), and helps organizations remain competitive (Wang et al., 2015; West et al., 2014).

Besides this, supply chain flexibility supports firms in adapting to market uncertainties, swiftly addressing customer requirements, ensuring rapid service delivery, and achieving efficient distribution (Rajesh, 2017). While technology can support the integration of suppliers, manufacturers, and customers by enabling coordination based on real-time information. From this perspective (Li, 2020), clearly stated that technological innovation supports organizations in lowering lead times from production to distribution for the purpose of achieving better supply and demand (Cachon & Swinney, 2011). Additionally, technology can be spontaneous and responsive for any system, which is very helpful for smooth operation and running business. On a separate note, supply chain literature has also acknowledged the need for TA capabilities to achieve the desired SP. Also technological capabilities of the organizational leads to organizational sustainability (Mollah et al., 2023, 2024, 2025). Previous studies have also mentioned that for the purpose of sustainable supply chain performance, some organizations use blockchain methods (Di Vaio & Varriale, 2020), some organizations use BDA (Cheng et al., 2022), some organizations embracing closed-loop design, e-libraries and digital twins system for cloth measurement and presentation (Donmezer et al., 2023). Some organizations are initiating the use of AI for various applications (Hassanein & Yousef, 2022), along with technologies such as computer-aided design (CAD), 3D modeling, blockchain, and digital platforms for inventory management to ensure real-time tracking and enhance sustainability in the garments industry (Imran, 2024). Therefore, considering the above discussion, we assumed the following hypothesis.

H2. TAC positively mediates the relationship between GSCMP and SP. That is:

H2a. GSCMP have a positive impact on TAC.

H2b. TAC has a positive impact on SP.

2.4. Mediating role of circular economy practices

In general, CE refers to the generic terms that focus on the 3R principles: reduce, reuse, and recycle during production, circulation, and consumption (Ying & Li-jun, 2012), which have match with GSCM perception (Ying & Li-jun, 2012). While GSCM and CEP both aim for waste reduction, they are theoretically distinct in scope. GSCM serves as the broad strategic philosophy that aligns the entire supply chain toward environmental goals (Ying & Li-jun, 2012). In contrast, CEP functions as the specific operational mechanism focused on closed-loop systems, specifically the recovery and rejuvenation of a product's lifecycle through 3R principles. Thus, GSCM provides the strategic mandate, while CEP provides the technical loop for resource longevity. GSCM practices and CE practices are interlinked with sustainable development concepts and depend on each other (Zhu et al., 2011). Previous literature showed that there is an interconnection between GSCM practice and CE practices (Brandenburg et al., 2014; Dubey et al., 2015). In support of this, the United Nations Environment Programme report

logically explained that GSCM and CE are positively aligned (Genovese et al., 2017), while they are increasingly interconnected, though the results may expose uncertain results (Liu et al., 2018).

Moreover, at present CE practice and sustainability are grabbing the attention of researchers, investors, governments, different organizations, and also civil society. To ensure the well-being of present and future generations, sustainability necessitates a harmonious coexistence of economic growth, social progress, and ecological preservation (Geissdoerfer et al., 2017). Minimizing waste, increasing reusability, and recycling are all ways that CE contributes to save the planet. From the perspective of the Earth as a closed and circular system with limited assimilative capacity, it is suggested that there should be a balance between environmental protection and economic growth (Boulding, 1966). Achieving triple bottom line concept of sustainability, the four components of CE i.e., 'reduce,' 'reuse,' 'recycle,' and 'remanufacture'—are required emphasizing the micro level of CE practices models (Bocken et al., 2018). It has been suggested by the European Commission that CE practices may be used to execute the full integration of sustainability. However, as previously said, CE practices is a key role for preventing waste, optimizing resources, dematerializing the industrial economy, and creating jobs (Geissdoerfer et al., 2017). These actions eventually contribute to the sustainability of both the organization and the environment. Therefore, this study assumes that.

H3. CEP positively mediates the relationship between GSCMP and SP. That is:

H3a. GSCMP has a positive impact on CEP.

H3b. CEP has a positive impact on SP.

2.5. Sequential mediating role of technology adoption capabilities and circular economy practice

In the field of supply chain technology adoption and use of circular economy have proliferated in the recent age. In fact, CEP changes the traditional methods of 'resource, product, and waste' into a new feedback-related economy, including 'resource, product, waste, and renewable resource' (Nikolaou & Tsarakakis, 2021). In the case of renewable processes, it is mostly supported by technology. Actually, due to technological dynamism, the transition toward CE is changing for adaptation, review, activities, and operations (Kjaer et al., 2019), re-designing processes, structures, and behaviors (Bertassini et al., 2021; Ritzén & Sandström, 2017) for the sake of suitability. The successful implementation of CEP in the garment industry is not merely a strategic choice but is largely dependent on the technological readiness and innovation capabilities of the organization. Technologies such as AI, blockchain, and Big Data are essential for processing the complex circular information required to optimize resource utilization and manage closed-loop systems (Cheng et al., 2022; Di Vaio & Varriale, 2020; Donmezer et al., 2023; Hassanein & Yousef, 2022). The successful implementation of CEP in the garment industry is not merely a strategic choice but is largely dependent on the technological readiness and innovation capabilities of the organization. Technologies such as AI, blockchain, and Big Data are essential for processing the complex circular information required to optimize resource utilization and manage closed-loop systems (Cheng et al., 2022; Di Vaio & Varriale, 2020; Donmezer et al., 2023; Hassanein & Yousef, 2022). Based on Dynamic Capabilities View, GSCM acts as the initial strategic trigger that allows a firm to "sense" environmental opportunities. However, to "seize" these opportunities and "transform" traditional linear models into circular ones, the firm must first possess the technological infrastructure (TAC) to re-design processes and behaviors. The logic follows that GSCM establishes the green strategic direction, which then necessitates the adoption of specific technologies (e.g., Digital Twins or 3D body scanning) to enable circular outcomes like product life-cycle extension and material recycling (Donmezer et al., 2023). As noted in the sources,

technology adoption has been empirically proven to positively support circular practices, serving as the bridge that closes the gap between environmental aspirations and practical implementation.

It is also found that lack of management prioritizing and to avoid disruption are main barrier for digital adoption which is the ultima barrier for CEP (Vimal et al., 2023). According to Ucar et al. (2020), Khan et al. (2021b), and Sanchez-García et al. (2024), digital technologies play a crucial role in the transition to a circular economy, which is essential for improving organizational success and sustainability. But no studies have shown how TAC and CEP work together to get SP in the clothing business. We argue that TAC must precede CEP because circularity requires high-level data transparency and resource tracking. For instance, without technologies like Digital Twins or AI-driven analytics, firms lack the infrastructure to 'seize' the opportunities of a closed-loop system, such as managing the complex logistics of remanufacturing and resource rejuvenation. Therefore, digital maturity TAC serves as the essential bridge between a green strategy GSCM and circular operational reality CEP. In addition to H2a and H3b, and considering the previous discussions, this study put up the following hypothesis.

H4. TAC has a positive impact on CEP.

H5. TAC and CEP sequentially mediate the relationship between GSCM and SP.

2.6. Research framework

In light of the above literature discussion, this study put up the following conceptual research framework shown in following Fig. 1 to demonstrate its hypotheses, research aims, and literature reviews.

3. Methodology

3.1. Sampling and unit of analysis

An opinion survey was conducted using a structured questionnaire targeting mid- and upper-level employees with relevant knowledge of TA and CE practices in supply chain management within garments manufacturing organizations in Bangladesh. The sample firms are selected from Bangladesh Garments Manufacturers and Exporters Association (BGMEA) registered organizations. The researchers in this study used purposive sampling, as it was essential to be meticulous in selecting participants by carefully considering specific inclusion criteria. The inclusion criteria for the unit of analysis required that participants be employees or managers currently working in the garment industry, with sufficient educational background and expertise relevant to the study's focus.

A pre-test was conducted with 16 respondents to ensure that the survey questions were understandable to the participants, and the questionnaire was prepared in both English and naive language, Bengali. Based on the following suggestions of Connelly (2008), a sample of 40 employees, approximately 10% of the total expected respondents was selected to participate in the preliminary test. The Cronbach's Alpha value is over 0.60, indicating that this study fulfilled the required level threshold for internal consistency and reliability in empirical research. A total of about 1000 questionnaires were disseminated using a combination of online and traditional approaches, of which 561 were successfully received. During the questionnaire screening process, several responses were excluded due to non-responses, missing data, or overlapping answers. As a result, 543 responses were retained for the final analysis, surpassing the minimal sample size requirement of 386 suggested by Faul et al. (2009). Moreover, the overall response rate in this study was 54.3%. In comparison, response rates reported in previous studies conducted in Asian nations, include 52.25 percent by Amin et al. (2024) and 41.8 percent by Amin and Oláh (2024) for Bangladesh; 41.8 percent by Qing et al. (2023) for China; and 35.7 percent by Karim et al.

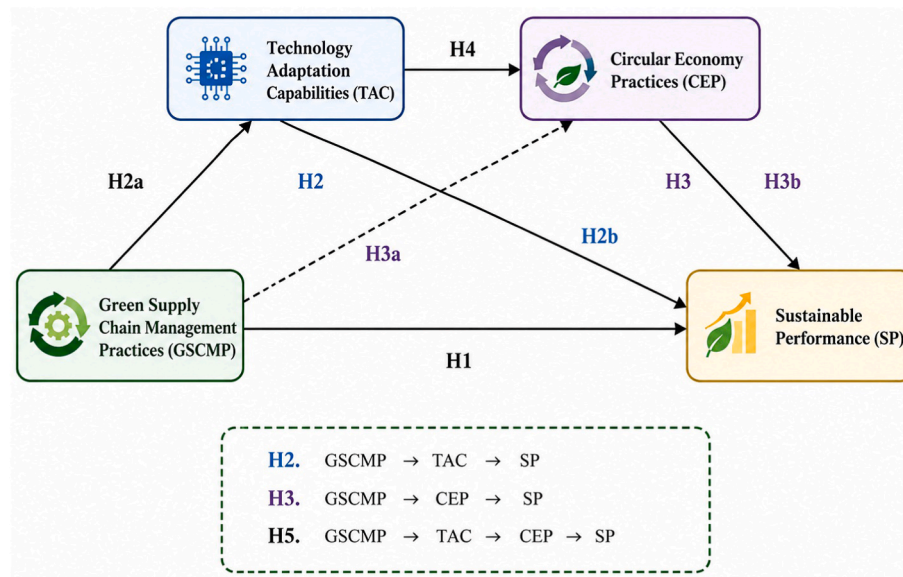


Fig. 1. Proposed conceptual model.

(2023) for Malaysia.

3.2. Measurement scales

Based on the recommendations of Cooper and Schindler (2014), the present study collected and analyzed a sufficient of data ($n = 543$) to investigate the potential relationships among all the proposed variables. This research applied a structured, self-generated questionnaire to gather cross-sectional data; however, while the questionnaire items were adapted from exiting literature. Measurement scales were used to assess each latent construct and their relationships. For each construct, respondents were asked to indicate their level of agreement using a 5-point Likert scale, ranging from 1 = strongly disagree to 5 = strongly agree. To collect data, this study first adopted five items adapted from Yildiz Çankaya and Sezen (2019) to measure the independent construct of GSCM practices. Then, the first mediator TA, was measured using five items derived from Qing et al., (2023). The second mediator, CE practices, was assessed using five items collected from Kristoffersen et al. (2021). Finally, the outcome construct, SP, was measured with six indicators adapted from Cheng et al. (2022) (see Appendix A). Here sustainable performance (SP) is modeled as a reflective first-order construct is now justified in accordance with contemporary PLS-SEM standards (e. g., Hair, Hult, et al., 2021), supported by our high internal consistency (Cronbach's Alpha = 0.927) and convergent validity (AVE = 0.774) results.

3.3. Tools and techniques for research

This study uses Microsoft 365 tools to input and organize data in electronic format and for analytical purposes SPSS 26 and PLS-SEM was used for assessing the structural relationship of independent and dependent variables. PLS-SEM is a variance-based structural equation modelling (SEM) techniques commonly used in business and social science research due to its convenient process of handling complex models with multiple constructs and indicators (Hair et al., 2019). The forecasts are based on an in-depth investigation of multiple variables, focusing on the wellbeing of employees and managers involved in the garments sector.

3.4. Common Method Biases (CMB) test

To address CMB, the authors applied the previous research

suggestions to shorten the recorded scale (Podsakoff et al., 2003). This research used Harman's single factor inquiry (Harman, 1976) to statistically quantify CMB difficulties, and the input was guaranteed to be secret. The research by Podsakoff et al. (2003) suggested that if one component does not explain for more than 50% of the common variance across the constructs, then CMB would not be a significant issue in the measuring procedure. According to the results, only one un-rotated component accounts for 31.66% of the total variance. As a result, CMB is not related to any significant concerns in our studies. During data collection process we have ensured respondent anonymity and shortening scales to provide a more transparent account of our efforts to mitigate common method variance.

Additionally, VIF scores obtained from a thorough collinearity test are seen as signs of pathological collinearity and perhaps the introduction of common method bias into a model (Kock, 2015). An inner model is free of common method bias if and only if every VIF value is less than or equal to 3.3 (Kock, 2015). According to Table 4, there is no issue with common technique bias in this research since the VIF values are less than 3.3.

4. Findings and analysis

4.1. Demographic information

Appendix B. represents the participants' demographic profile of employees from Bangladeshi garments sector. This information includes male and female employees; typically, the maximum percentage of the employees are male (62.80%), and the rest are female (37.20%). Moreover, their age categories were designed as <20, 21–30, 31–40, 41–50 and 51 and above; here shows that the highest number of employees were within the ages of 20 (28.55%) followed by the age between 21 and 30 (24.68%) and the lowest number is aged group who are 51 years and above (49). Additionally, it also demonstrates that most of the employees hold lower-level positions (55.8%), the second highest is mid-level (33.7%), and the lowest numbers hold the highest position (10.5%). The distribution of education level shows that a maximum number of employees have a Bachelor degree (217), followed by up to Higher Secondary certificate (HSC) is about 27.62% (150) and 12.34% have professional or other degrees. Finally, about 45.86% (249) followed by 11 to 20 years (34.62%), employees have work experience within ten years. But the minimum number of them (15) have 31 or years of job experience.

4.2. Measurement model

This research initially evaluated the measurement model to measure the reliability and validity of the causal components. The degree of reliability was determined using the Cronbach's alpha evaluations and Composite reliability (CR) test. The output shown in Table 1 validates that all of the results (the values of Cronbach's alpha and CR) exceeded the criterion of 0.70 which constructs possess sufficient reliability for the study endeavor. In addition, for the conformation of the convergent validity, researchers measured average variance extracted (AVE) and rho_A from the factors loading of each item of the constructs. If factor loading values are greater than 0.70 and AVE scores are greater than 0.60 infers the establishment of convergent validity of the model (Hair, Hult, et al., 2021). The acceptable criterion of 0.70 was exceeded by all factor-loading scores in this study and AVE demonstrated the amount of variation in the items that latent constructs values over marginal value of 0.60 were obtained indicates study have sufficient convergent validity. The following Table 1 shows the convergent validity results.

In this study, the Fornell-Larcker criterion and the Heterotrait-monotrait ratio (HTMT) of correlations were used to evaluate the constructs' discriminant validity (Fornell & Larcker, 1981). Table 2 displays the results of the Fornell-Larcker criteria, which states that discriminant validity has been reached when the square root of the AVE for all constructs i.e., the bolded diagonal values are greater than their correlation coefficient values. In addition, according to (Henseler et al., 2015), all of the HTMT values needed to be below 0.85 in order to verify discriminant validity. The findings showed that all constructs had HTMT values below the marginal value of 0.85. Table 2 shows the results of the HTMT analysis and the Fornell-Larcker criterion.

4.3. Structural model

Using the PLS-SEM data analysis approach, the researchers in the present study tested the structural model and evaluated the proposed associations between the constructs. At first, the R^2 values were used to evaluate the explanatory competence of the current model. The analysis revealed that GSCMP explains 12.8% of the variation in the CEP, and that the R^2 value for the CEP was 0.128. With a TAC score of 0.107, GSCMP also explains 10.7 percent of the total TAC variability. Similarly, the SP's R^2 value of 0.127 shows that GSCMP accounts for 12.7% of the SP's variability.

To further evaluate the route model's predictive significance, the blindfolding approach was used with an omission distance of 7. According to Table 3, the endogenous components had Stone-Geisser Q^2

values that were more than zero: $Q^2_{CEP} = 0.095$, $Q^2_{TAC} = 0.065$ and $Q^2_{SP} = 0.090$ (Geisser, 1975; Stone, 1974). This result suggests that the route model has a suitable level of cross-validated predictive relevance, based on the recommendation of Hair, Astrachan, et al. (2021). The following Table 3 shows the R^2 , Adjusted R^2 , and Q^2 values of this study.

4.4. Results of structural model and hypotheses testing

Afterward, a bootstrapping procedure (one-tailed) was used, using 5000 subsamples, to determine the weights and significance of the path coefficients. The results in Table 4 show that the hypothesis H1 relationships between GSCMP and SP ($\beta = 0.186$; $p < .05$). Therefore, H1 is supported. Then, this study has tested the hypothesis H2a, the direct relations of GSCMP and TAC ($\beta = 0.328$; $p < .05$), and H2b the relationship of TAC and SP ($\beta = 0.129$; $p < .05$). Therefore, results depicted that H2a and H2b are supported. After that, tested hypothesis H3a, the interlink between GSCMP and CEP ($\beta = 0.158$; $p < .05$), and H3b the link between CEP and SP ($\beta = 0.172$; $p < .05$) are statistically substantial. Therefore, H3a, and H3b exhibited statistical significance. Lastly, this study has tested hypothesis H4 the impact of TAC on CEP ($\beta = 0.274$; $p < .05$), also demonstrated significant direct positive relationship. The following Table 4 shows the results of the hypotheses test for direct and indirect relationships.

Additionally, the following Fig. 2 demonstrates the path co-efficient of the model generated from Smart-PLS software (version 4) and the results of the hypotheses test for direct and indirect relationships.

Moreover, the current study examined the indirect impact of CEP and TAC on the associations between GSCMP and SP. However, we have tested the sequential mediation of CEP and TAC in the proposed relationship. The results of hypothesis H2 the mediation effect of TAC between GSCMP and SP results ($\beta = 0.042$; $p < .05$) proved that TAC have significant mediation effect between GSCMP and SP. Similarly, the results of hypothesis H3 also proved that CEP has significant mediation effect ($\beta = 0.027$; $p < .05$) between GSCMP and SP. Finally, the sequential mediation effect of TAC and CEP in the relationship between GSCMP and SP is also significant ($\beta = 0.015$; $p < .05$). Thereafter H5 also supported. The above Table 4 also shows the mediation and the sequential mediation effect of TAC and CEP in between GSCMP and SP.

Hence, it can be concluded that GSCMP indirectly correlates with SP through positive perceptions about TAC and CEP. On the other hand, GSCMP has an indirect relationship with SP. Notably, TAC and CEP sequentially mediates in the relationship between GSCMP and SP in garments sector in Bangladesh. This infers that the sustainability of the supply chain performance depends on the environmentally friendly technology adoption and thereafter adopting CEP based on the strategic requirements.

5. Discussion

The present study empirically explored the how GSCM affects SP in the garment sector of Bangladesh, specifically through the serial mediating roles of TAC and CEP. Drawing upon the DCV and the RBV theory, this study provides significant insights into how environmentally conscious supply chain strategies can lead to sustainable outcomes when supported by technological competencies and CEP.

Firstly, the outcome of the study proved that the interconnection between GSCM and SP is positive and significant, confirming that the adoption of environmentally focused supply chain strategies for instance, green procurement, eco-design, and reverse logistics, can enhance a firm's environmental, economic, and even social performance. These findings align with previous studies that underscore GSCM's role in reducing environmental footprints while product design, material selection, manufacturing processes enhancing customer satisfaction (Wisner et al., 2012), also engaging in propelling organizational efficiency (Green et al., 2012; Zhu & Sarkis, 2004). The garments sector of Bangladesh is the largest exporter of ready-made garments to foreign

Table 1
Convergent validity.

Variables	Items	Loadings	Cronbach's Alpha	CR	AVE
Green Supply Chain Management Practices (GSCMP)	GSCMP1	0.867	0.907	0.931	0.730
	GSCMP2	0.899			
	GSCMP3	0.896			
	GSCMP4	0.823			
	GSCMP5	0.781			
Technology Adaptation Capabilities (TAC)	TAC1	0.759	0.809	0.874	0.634
	TAC2	0.800			
	TAC3	0.844			
	TAC4	0.779			
Circular Economy Practices (CEP)	CEP1	0.775	0.924	0.943	0.771
	CEP2	0.904			
	CEP3	0.947			
	CEP4	0.806			
	CEP5	0.943			
Sustainable Performance (SP)	SP1	0.909	0.927	0.944	0.774
	SP2	0.928			
	SP3	0.913			
	SP4	0.891			
	SP6	0.744			

Table 2
Discriminant validity.

Fornell-Larcker Criterion					Heterotrait-Monotrait Ratio (HTMT)			
Variable	CEP	GSCMP	SP	TAC	CEP	GSCMP	SP	TAC
CEP	0.878							
GSCMP	0.248	0.854			0.262			
SP	0.260	0.271	0.880		0.267	0.278		
TAC	0.325	0.328	0.246	0.796	0.365	0.373	0.271	

Table 3
Predictive relevance.

Predictors	R ²	Adjusted R ²	Q ² Values
CEP	0.128	0.125	0.095
SP	0.127	0.122	0.090
TAC	0.107	0.106	0.065

markets such as Europe and the USA, where increasing international scrutiny for sustainability compliance presents a strategic opportunity to meet regulatory standards like ISO 14001 while responding to market-driven demands.

Secondly, results proved that TAC also plays a mediating role suggesting that advanced technologies help maximize production, reduce

waste, enhance traceability, and lower the environmental footprint—ultimately contributing to a firm's SP. This findings is also supported by theory that investment in GSCM contributes to the development of better technological systems(Vachon, 2007) and TAC enhances organizational performance through shortening lead time, high quality production and quickly responsive worldwide supply chain (Paul et al., 2021). This result highlight that the garments sector of Bangladesh focusing on the centrality of technology in facilitating eco-efficient practices and long-term competitiveness and sustainability. Additionally, the results confirm that GSCM has a significant positive influence on CEP, supporting the notion that adopting practices such as green procurement, eco-design, and waste reduction naturally fosters circularity within operations (Kazancoglu et al., 2020; Zhu et al., 2011). Supported by previous studies results proved that GSCM practices are

Table 4
Direct and indirect effect.

Hypothesis		Standardize β	5% LLCI	95% ULCI	P Values	Results	VIF
H1	GSCMP -> SP	0.186	0.119	0.250	0.000	S	1.149
H2a	GSCMP -> TAC	0.328	0.256	0.388	0.000	S	1.000
H2b	TAC -> SP	0.129	0.060	0.196	0.001	S	1.206
H3a	GSCMP -> CEP	0.158	0.084	0.226	0.000	S	1.120
H3b	CEP -> SP	0.172	0.104	0.243	0.001	S	1.147
H4	TAC -> CEP	0.274	0.201	0.340	0.000	S	1.120
H2	GSCMP -> TAC -> SP	0.042	0.018	0.071	0.005	S	
H3	GSCMP -> CEP -> SP	0.027	0.013	0.047	0.004	S	
H5	GSCMP -> TAC -> CEP -> SP	0.015	0.009	0.025	0.001	S	

Note(s): GSCMP = Green Supply Chain Management Practices; CEP = Circular Economy Practices; TAC = Technology Adaptation Capabilities; SP = Sustainable Performance; VIF = Variance Inflation Factors; S = Supported.

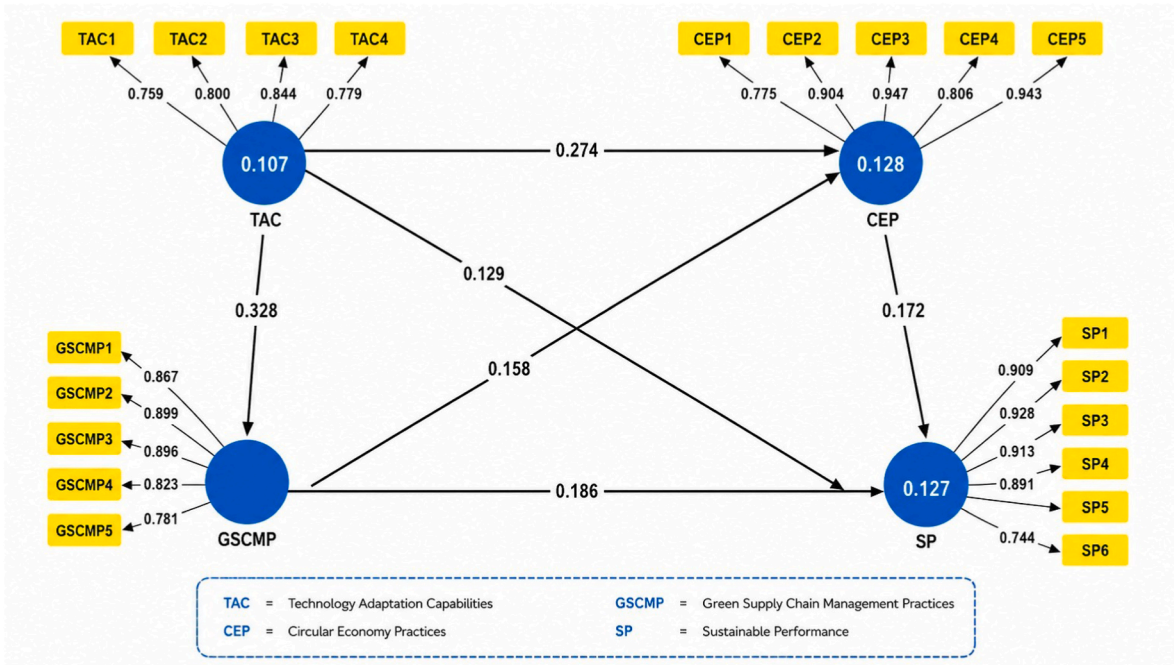


Fig. 2. Path co-efficient of the model.

the key propeller for incorporating CEP (Brandenburg et al., 2014; Dubey et al., 2016) and support for facing uncertain results due to the technological transformation (Mollah et al., 2024) environmental change (Liu et al., 2018). This supports the growing understanding that green policies not only promote compliance but also encourage internal process innovations aimed at resource efficiency and sustainability (Geissdoerfer et al., 2017).

This study addresses **RQ1** by showing that GSCM affects SP directly and indirectly, with the indirect way operating through TAC and CEP. The application of GSCM techniques lays groundwork for fostering the company's ability to integrate pertinent technology, which in turn accelerates a circular mindset in the garments supply chain practices. Regarding **RQ2**, the study demonstrates that TAC has a significant role in facilitating circular initiatives and translating them into measurable performance outcomes. The results demonstrate that the garment industry utilizes blockchain methods, Big data analytics, closed-loop design, digital twin systems and AI applications to enhance organizational sustainability (Cheng et al., 2022; Di Vaio & Varriale, 2020; Donmez et al., 2023; Hassanein & Yousef, 2022). While CEP is a key mediating factor that improves the firm's readiness to promote better sustainability performance. Recent research highlighting the connection between digitalization and circularity in supply chain transformation lends further credence to these findings (Centobelli et al., 2020; Kristoffersen et al., 2021).

Regarding **RQ3**, the study identifies a serial mediation effect, whereby GSCM first influences TAC, which subsequently impacts CEP, ultimately leading to enhanced SP. The sequential mediation from GSCM → TAC → CEP → SP is statistically significant, demonstrating a coherent pathway through which green practices, combined with circularity and technological readiness, generate synergistic effects on sustainability performance. This sequence exposes a critical pathway for sustainability transformation. This finding aligns with the DCV and RBV theories, which suggest that by effectively coping with environmental changes (Teece, 2014), garment organizations can gain a competitive advantage through strategic capabilities such as technological integration and sustainability-focused innovation (Barney, 1991). Thus, the current study contributes to the literature by integrating GSCM, TAC, and CEP within a single empirical model, validated with a substantial sample of 543 individual employees from the garment industry in emerging economies. The findings highlight a strategic pathway operationalizing environmental sustainability in resource-constrained developing economies. In the context of the Bangladeshi garment sector, which often faces resource constraints and outdated infrastructure, this staged capability development is critical. Firms must first build their technological maturity to effectively operationalize circularity and achieve long-term SP.

5.1. Theoretical contribution

This study makes a theoretical contribution by integrating GSCM practices with SP by examining sequential mediating effects of TA and CE practices in enhancing SP within the garment supply chain system. Drawing upon the Dynamic Capability View (DCV) theory (Teece et al., 1997), this study contributes by analyzing TAC and CEP as dynamic capabilities that allow organizations to address the capability development logic, it have mapped sequential mediation model directly to the core tenets of DCV. It has also explicitly state that GSCM allows firms to "sense" environmental shifts (e.g., demand for sustainable fashion), TAC enables them to "seize" these opportunities through technological innovation, and CEP allows them to "transform" internal resources into a closed-loop system. Specifically, based on the integration of VRIN criteria of RBV, the digital readiness of TAC and circular knowledge CEP creates a socially complex and path-dependent resource that is valuable for market compliance, Rare in emerging economies, and Inimitable due to the organizational learning required to operationalize it. This adds depth to the RBV by showing how intangible assets like environmental

knowledge and digital readiness combine to achieve sustainability objectives.

By demonstrating the serial mediation pathways from GSCM to TAC, then to CEP, and ultimately to SP, our study broadens the scope of the DCV theory by showing that dynamic responses to environmental challenges must progress through a sequence of interrelated capabilities (Jurksiene & Pundziene, 2016; Teece, 2014). Additionally, this research contributes to the RBV theory (Barney, 1991) by identifying green practices, technology adoption, and circular process practices as valuable, rare and inimitable and non-substitutable resources that drive competitive advantage. In particular, the integration of TAC and CEP reflects the organization's capabilities and commitment to embedding sustainability in the garments supply chain. When appropriately configured, these resources directly and indirectly influence SP. This adds depth to the RBV framework by highlighting how intangible assets such as environmental knowledge, digital readiness, and organizational learning can combine to achieve sustainability objectives (Hart, 1995; Wernerfelt, 1984). Furthermore, the research emphasizes how industry-specific practices function as expressions of both dynamic and Resource-Based capacities, by situating the study within Bangladesh's labor-intensive garment sector. This contextual approach enhances sector-specific knowledge on sustainable operations while simultaneously improving the proposed model's theoretical generalizability. Finally, this is the most critical area for integration of TVB and DCV. It reflects the move beyond repeating statistical results to interpret what the findings imply for capability development. It clearly, explain that technology is a prerequisite for circularity broadens the scope of DCV by showing that dynamic responses are not immediate but progress through interrelated capabilities. Therefore, the study refines the RBV and DCV by identifying this specific, staged pathway as essential for competitive advantage in emerging economies.

5.2. Practical implications

The results of the study have useful insights industry leaders, operating managers and practitioners within the garment sector of Bangladesh. For managers in the Bangladeshi garment sector an industry characterized by outdated infrastructure and volatile global demands sustainability is no longer optional but a requirement for maintaining access to export markets like the EU and USA. The discoveries underscore the importance of strategically embedding GSCM practices within garment industry's operations to enhance long-term SP, through the sequential mediation effects of TAC and CEP. In that case managers must first invest in TAC such as ERP systems, IoT-based monitoring, and AI-driven analytics before they can effectively operationalize complex CEP (Tseng et al., 2018).

As the global garment industry faces increasing pressure to comply with international environmental and social standards, managers must consider this study to improve their operational resilience, and sustainability credentials. One of the primary implications of the findings is that managers must prioritize the adoption of GSCM practices such as eco-friendly sourcing, energy-efficient production, waste minimization, and reverse logistics. Our findings suggest that green initiatives must be transformed into circular actions. This requires operationalizing procedures such as resource dematerialization and narrowing resource loops while fostering a circular mindset across the supply chain (Geissdoerfer et al., 2018). Thus, managers should focus on aligning internal policies, performance metrics, supplier relationships, to foster circularity through technology adoption in the supply chain network. For industry leader, instead of merely reacting to international buyer scrutiny for ISO 14001 compliance, we encourage leaders to use green strategic orientations GSCM to build internal environmental knowledge and digital readiness. This transitions the firm from a compliance-only mindset to strategic sustainability leadership.

Moreover, in the garments industry there are different kinds of technology commonly seen including Digital Human Modeling (DHM)

and Digital Twins, E-libraries and body-size database, 3D body scanning and virtual avatars, close-loop design, AI-driven personalization, integration of robotics and automation, mobile application and cloud integration for ensuring organizational sustainability (Donmezer et al., 2023). Another practical implication highlights the adoption of CEP models supported by a technology adoption mindset, not only at the strategic level, but also among mid-level and operational managers. This requires the development of forums for cross-functional cooperation and training in life cycle thinking, material tracking, and closed-loop logistics, among other capacity-building initiatives. According to our research, management should fund supplier- and internal-focused training initiatives to develop the technical know-how and knowledge base required to apply CEP at all operational levels to reconcile ecological systems and economic growth (Franco, 2017).

Furthermore, this study empirically establishes a staged sustainability capability model within the high-pressure Bangladeshi garment sector, demonstrating that GSCM is positively associated with SP through a distinct sequential pathway involving TAC and CEP. Underpinned by the RBV and DCV, the study identifies that GSCM serves as a "sensing" strategic trigger, while TAC acts as the essential "seizing" infrastructure—specifically as a prerequisite for the "transforming" phase of circularity, which requires high-level data transparency. This integration of digital readiness and environmental knowledge creates a VRIN-compliant resource that is difficult for competitors to replicate in resource-constrained emerging markets. Consequently, the research offers a strategic roadmap for managers and policymakers, emphasizing that technological maturity must precede complex circular initiatives to successfully bridge the gap between green aspirations and sustainable outcomes.

In the context of Bangladesh's garments industry, where resource constraints and compliance pressures from government and foreign suppliers are common, these practical implications are particularly critical. In summary, the study suggests that, to realize SP, garment organizations should not only adopt GSCM practices but also operationalize these practices through technological innovations and circular economy strategies. In the rapidly changing global garment market, leadership needs to foster an atmosphere of organizational learning, technological maturity, and green commitment, all of which are critical elements that facilitate long-term sustainability success. These real-world applications provide managers with a path forward from mere compliance to strategic sustainability leadership.

5.3. Policy implications

For policymakers and industry leaders, this study suggests that targeted investments in technological infrastructures and circular capabilities rooted in GSCM principles are essential for achieving sustainable development goals in export-oriented industries such as the garment sector. Given that a significant portion of the industry consists of Small and Medium Enterprises (SMEs), we suggest that policy frameworks should prioritize the adoption of scalable and modular digital tools. Large firms should seek technical and financial partnerships with international buyers and NGOs. This allows smaller firms to participate in circularity without the burden of prohibitive upfront capital costs. We propose that the government and industry bodies (such as the BGMEA) facilitate cooperative opportunities with international buyers, NGOs, and financial institutions. These partnerships should focus on providing financial incentives, technical training, and subsidies for green technological investments to ensure the sector's long-term resilience.

5.4. Limitations, and future work scopes

The current study has some inherent limits that warrant acknowledgement. First, the data used for this research were collected through a survey at a single point in time, rendering the study cross-sectional in nature. This introduces the potential for endogeneity issues and confines

the ability to establish a causal link between the constructs, as changes over time are not accounted for. While the model's explanatory power R^2 is modest and the cross-sectional data limits causal inferences, the study provides a foundational staged sustainability capability model. It indicates that the complexity and volatility of the Bangladeshi garment sector, where external pressures from global buyers and infrastructure challenges significantly influence performance beyond the internal capabilities measured in our model. To overcome this limitation, future research could employ longitudinal data collection methods, which would allow for a more robust analysis of causal relationships and offer deeper insights into the dynamic processes among GSCM, TAC, CEP, and SP. Second, to assess the we have used Herman's single factor Common Method Bias (CMB) test and VIF scores. In future research we will employ more rigorous statistical techniques, such as the marker variable approach or the correlation matrix procedure, to provide a higher level of confidence in the findings.

Third, the research theoretical framework and variables are chosen based on the DCV and RBV theory, which is widely applied and are not free from criticism. Relying solely on theoretical assumptions may not fully capture the complexities of real-world GSCM practices. For example, the DCV does not always specify the conditions under which dynamic capabilities lead to superior organizational performance (Ling-yee, 2007). Therefore, given the unique context of the garment sector in Bangladesh, future research could benefit from integrating insights from diverse industrial and geographical contexts to provide more context-specific and actionable guidance for practitioners.

Fourth, the current study did not compare its proposed model against or rival models. A more comprehensive approach could involve testing competing models to validate the robustness and superiority of the proposed framework. Future research could incorporate such comparisons to determine whether alternative theoretical frameworks provide a better fit or yield more precise understanding of the relationships among the variables. Such analyses could reveal additional mediating or moderating factors that might play a significant role in driving SP within the garment industry. Additionally, as this study covers only two mediations, future studies could consider additional variables such as supply chain agility, AI-powered leadership capabilities, customer roles, and the influence of social media. Last but not least GSCM covers a broad range of activities, but our measurement focused on five specific items adapted from Yildiz Çankaya and Sezen (2019), covering environmentally friendly products, waste reduction in production, and recyclable packaging within the garment sector. Finally, the selected sample represents the garment industry supply chain in Bangladesh. Future studies could extend this research to other sectors such as manufacturing, transportation, and healthcare, as well as explore cross-cultural contexts for broader generalizability.

6. Conclusion

This study confirms that GSCM is positively related to the SP of firms in the Bangladeshi garment sector through a specific, staged capability progression. By integrating TAC and CEP as sequential mediators, the research offers a robust theoretical explanation of how green strategic orientations are operationalized into tangible outcomes. The findings extend the DCV by illustrating a "sensing-seizing-transforming" logic, where technological maturity acts as a critical, sequential prerequisite for circularity. Furthermore, it refines the RBV by identifying the integration of digital readiness and circular knowledge as a VRIN-compliant resource essential for competitive advantage in emerging economies. Ultimately, for industries in developing nations, achieving superior performance requires a coherent pathway that bridges the gap between green aspirations and operational circularity through targeted technological investment.

CRediT authorship contribution statement

Mohammad Bin Amin: Conceptualization, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Writing – original draft. **Md. Alamgir Mollah:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Validation, Visualization, Writing – original draft. **Gouranga Chandra Debnath:** Data curation, Methodology, Project administration, Resources, Software, Supervision, Writing – review & editing. **Nitai Chandra Debnath:** Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Software, Writing – review & editing. **K.M. Anwarul Islam:** Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – review & editing. **Md Atikur Rahaman:** Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – review & editing. **Judit Oláh:** Investigation, Methodology, Project administration, Resources, Software, Supervision, Writing – review & editing.

Data availability statement

Data will be available to the correspondence author upon reasonable request.

Ethical statement

In this research, ethical standards were maintained following Helsinki declarations. Before starting the data collection, the researchers of this study applied attaching the questionnaire, sampling details, and all other ethical requirements to the “Research Cell of the University of Barishal, Bangladesh” which is an academic authority for the ethical clearance. After assessing all ethical concerns and guidelines, the committee approved and provided the certificate (ref no: FSB-EC-50/2024), for further survey process. Additionally, the researchers of this study informed and collected both oral and written “consent letter” from each of the study respondents. Thus, all participants provided written informed consent.

Declaration of generative AI and AI-assisted technologies in the writing process

While preparing this manuscript, the author(s) used *Grammarly* to improve the Academic English since the Authors are not native speakers. After using this tool/service, the author(s) reviewed and edited the content as needed, taking full responsibility for the publication's content.

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Declaration of competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

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