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Digital Platform Capabilities and Circular Economy: Impact of Customer Green Pressure on Frugal Innovative Strategies

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ABSTRACT

Manufacturing entities in emerging economies face significant obstacles implementing circular economy principles due to resource-constrained environments. Arguably, manufacturers need customer green pressure to propel the circular economy, alongside frugal innovative strategies. There is a dearth of research on digital platform (DP) capabilities, customer green pressure, and frugal innovative strategies with circular economy. Drawing on dynamic capabilities theory, 889 manufacturers were surveyed in the emerging economy of India. Customer green pressure moderation was assessed on the links between frugal innovative strategies and circular economy, DP integration capabilities and frugal innovation, and DP reconfiguration capabilities and frugal innovative strategies. Structural equation modelling revealed that DP integration and reconfiguration capabilities positively influence frugal innovation strategies enabling circular economy performance. Customer green pressure positively moderated DP reconfiguration and frugal innovative strategies. Actionable insights are provided to prioritize DP capability development to satisfy customer green pressure and promote frugal innovative strategies, ultimately facilitating the circular economy.

1 | Introduction

Exponentially increasing concerns about overindulgence of resources, global warming, and social disparities have prompted demands for a change to more sustainable societies and businesses (Secomandi 2025). Manufacturers across the globe are under pressure to continually improve their circular economy performance (CEP) in response to growing trepidations amongst stakeholders, particularly consumers, and are reviewing their strategic approaches in addressing these issues (Fang, Yu, et al. 2024). In contrast to linear practices, rethinking circularity principles in business operations emphasizes the need to use regenerative and restorative practices including reusing, recycling, remanufacturing, and refurbishing to minimize environmental pollution and equitably reduce resource depletion (Awan et al. 2021; Kouhizadeh et al. 2023). Thus, circular economy

principles can facilitate an organization's potential to advance their corporate internal and external-oriented economic, environmental, and social sustainability outcomes, which governments, academics, and businesses are paying significant attention (Abbate et al. 2023; Secomandi 2025). Incorporating circular economy principles into routine operations mostly requires changes in existing manufacturing and supply chain designs and operational systems, which in turn calls for significant change in organizational social competencies (Ranjbari et al. 2024; Sahoo and Jakhar 2024). Despite growing interest in circular economy principles, manufacturing firms, especially in resource-constrained emerging economies like India, face significant challenges in operationalizing such principles due to limited resources, inadequate technological capabilities, and complex stakeholder dynamics (Frishammar et al. 2025). There remains a notable gap in understanding how firms can

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leverage digital technologies, especially digital platforms, as dynamic capabilities to facilitate sustainable innovation, such as frugal innovation (FRIN) that underpins CEP (K et al. 2023; Liu et al. 2022). Addressing this gap is critical given the rising urgency of environmental regulations and competitive pressures that compel firms toward sustainability transitions. Hence, earlier studies have called for new research to accumulate empirical evidence advancing the understanding of the socio-technical mechanisms directing advantageous circular economy progress in manufacturing organizations (Fang, Cai, et al. 2024; Lee et al. 2024; Zerbino et al. 2025).

Innovative strategies fundamentally underscore the importance of aligning novel approaches, resources, assets, or platforms with the organization's vision and mission while also propelling various associated business strategic objectives. However, among the various forms of innovation that businesses can pursue, frugal innovative strategies (also FRIN) are receiving more and more attention from academics and industry professionals within the rapidly evolving social fabric strongly advocating circular manufacturing (Al-kahtib et al. 2025; Perera and Badir 2025). Frugal innovative strategies emphasize fostering the creation of products, services, or alternatives that retain satisfactory deliverable standards while utilizing minimal resources (Adomako et al. 2024; Kun 2022; Shubin et al. 2018). Stated differently, frugal innovative strategies enable organizations to develop affordable solutions by streamlining design in such a way as to guarantee that only required features are included in solutions, so using available resources without compromising product functionality (Al-Omouh et al. 2024; Rossetto et al. 2023). Prior scholarship has advanced contentions exploring the role of FRIN in enhancing CEP, given its limited scholarly attention (Al-kahtib et al. 2025; AL-khatib and Ramayah 2025; Perera and Badir 2025). Fundamentally, FRIN aligns with circular economy principles, emphasizing resource optimization, waste reduction, and sustainability (Al-Omouh et al. 2025; Suchek et al. 2021). From a practical standpoint, manufacturers are becoming more eager than ever to nurture FRIN strategies because they understand the significance of them for circularity in operations (Al-kahtib et al. 2025; AL-khatib and Ramayah 2025). Developing FRIN, however, demands an organizational climate, mechanisms, and assets that stimulate exploration (Dabić et al. 2022; Hossain et al. 2024). Therefore, the foundation of cultivating an organization's FRIN strategic capabilities resides in its digital platform (DP) capabilities, as these facilitate access to valuable external resources through the utilization of cutting-edge information technology (Al-Omouh et al. 2024; Govindan 2024).

An organization's DPs' capabilities are the technical resources it uses to facilitate cloud-/web-based interaction, collaboration, and information sharing with its clients, users, and business associates (Jia et al. 2024). DPs' capabilities encompass both DPs' integration capability (DPIC) and DPs' reconfiguration capability (DPRC), representing two essential dimensions of a robust digital infrastructure (Wang et al. 2023). DPIC focuses on seamlessly connecting with external partners' information technology (IT) systems for real-time data exchange and integrated workflows, while DPRC emphasizes the agility to adapt and upgrade the platform with new technologies and functionalities (Cenamor et al. 2019; Y. Li, Chen, et al. 2025; D. Li, Gong, et al.

2025). Together, they enable organizations to build cohesive digital ecosystems and rapidly evolve to meet changing business needs (N. Wang et al. 2023; Y. Wang et al. 2022). Although DP capability is regarded as a higher-order adaptive capability, current scholarship largely addresses the effect of DP capabilities on the broader strategic or economic aspect of organizational performance (Ahmed et al. 2022; Bhatti et al. 2024; Jia et al. 2024). More recent research hints that by means of increased interaction, information exchange, and value co-creation, DPs may speed up environmentally conscious growth (Fang, Cai, et al. 2024; Kortus et al. 2025). Although prior research does suggest that leveraging DPs helps to achieve innovation performance (Liao et al. 2024; Wang et al. 2023), there is little evidence demonstrating how the adoption of these platforms equates to expanded capabilities of FRIN required to achieve CEP (Qin 2024). In addition, there has been a disturbing number of failed attempts at adopting DPs due to their complicated nature and the substantial sums of required financial resources (Yoffie et al. 2019). Moreover, the current understanding of how DPs affect the CEP of manufacturing organizations through FRIN strategies is still limited, so there has been scholarly advocacy to do more empirical research on this topic (Al-kahtib et al. 2025; AL-khatib and Ramayah 2025; Perera and Badir 2025). Building on the knowledge gap, the current investigation proposes and endeavors to investigate how the growing prominence of a democratic digital mindset and expertise within organizational social structures has led to chances of switching from conventional innovation strategies to sustainability-oriented frugal strategies targeted at achieving CEP. This transition is particularly critical in the context of the circular economy, where the efficient use of resources and minimization of waste are paramount. By leveraging DP capabilities to foster FRIN, manufacturers can not only reduce costs and enhance functionality but also significantly advance their CEP. Thus, this study situates DPs and FRIN within the broader framework of circular economy objectives, emphasizing their synergistic potential to drive sustainable manufacturing practices.

The dynamic capability view theory (DCVT) underpins this investigation by highlighting an organization's ability to combine, create, and reorganize internal and external competencies in response to rapidly evolving settings (Fang, Yu, et al. 2024; Lee et al. 2024). The current investigation, grounded on the foundations of DCVT, suggests that manufacturers could transition from linear to circular operations through leveraging dynamic capabilities (DPIC, DPRC, and FRIN), therefore meeting the requirements for environmental sustainability. Therefore, this study points out the following research questions (RQs) in order to add to the body of knowledge on the factors influencing CEP.

RQ1. How do frugal innovative strategies influence CEP?

RQ2. How do digital platforms' capabilities influence frugal innovative strategies to improve CEP?

The behavioral theory of the firm posits that organizations are intricate structures whose decision-making is shaped by the intentions, interests, and actions of diverse internal and external stakeholders (Cyert and March 2006). This notion deviates from conventional economic models that presume businesses

are only profit-maximizing entities and instead emphasizes the role of bounded rationality, satisficing behavior, and the political dynamics in and out of organizations (Gavetti et al. 2012). As awareness surrounding environmental preservation increases, customers are exerting more pressure on organizations by demanding eco-friendly offerings and consistently scrutinizing company-wide pollution activities (Yang et al. 2025). Because of their larger influence and greater power in the competitive market, customers have, therefore, grown to be much more essential stakeholders (Nguyen et al. 2023). Organizations that desire to survive in the fiercely competitive marketplace by acquiring the requisite customer support have become more dedicated to investing in their DPs' capabilities (Rahman et al. 2024), therefore stimulating FRIN strategies and securing CEP. Stated differently, customer green pressure (CGP) might have a probable moderating influence on the relationship between DPs' capabilities and FRIN as well as between the DPs' capabilities and FRIN. Although the prior studies have mostly investigated the influence of CGP as an antecedent (Zameer et al. 2021), little is known about the context-dependent consequences of CGP (Yang et al. 2025). Therefore, how CGP induces this moderating effect is unexplored. In addition, when it comes to investigating the nature of the responses of the business to external stakeholder pressure, the most recent studies advocate the deduction of a single distinctive stakeholder for further drawing management implications for practice (Abbate et al. 2023; Shahzad et al. 2024). This is so because the majority of prior studies have handled stakeholder pressure as an integrated (single) variable and typically emphasized its moderating influence, therefore neglecting to explore certain stakeholder groups in depth based on their varied prominence, like that of customers (Nguyen et al. 2023; Zameer et al. 2021). As a result, it makes sense to reiterate that the understanding of the moderating effects of CGP remains ambiguous, necessitating more empirical research to deepen academic knowledge on the subject. In order to bridge this knowledge gap, the current investigation proposes to address the following RQ.

RQ3. How does CGP influence the interaction between digital platform capabilities, FRIN, and CEP?

Based upon these proposed RQs, this study aims to investigate, through the lens of the DCVT, the mechanisms by which DP capabilities enhance CEP in manufacturing within emerging economies. Specifically, it seeks to examine the direct influence of FRIN on CEP and its pivotal role as a mediating dynamic capability that translates DPIC and DPRC into circular outcomes. Furthermore, it endeavors to analyze how CGP serves as a contingent resource, moderating the capability configuration between DPIC/DPRC and FRIN, as well as between FRIN and CEP. By addressing these objectives, the study strives to provide a theoretically grounded framework that elucidates how manufacturers can deploy and reconfigure digital transformation and innovation routines to achieve sustainability goals, thereby offering actionable insights for both practitioners and policymakers. The DCVT is well-suited for the current investigation as it could explain how organizations in dynamic and resource-constrained environments, like manufacturing firms in emerging economies, adapt by integrating, reconfiguring, and optimizing resources to sustain competitive advantage.

The remainder of the paper is structured as follows. Section 2 delineates the theoretical foundation and formulates the hypotheses for the present investigation, culminating in the proposal of a theoretical framework. Section 3 covers the research approach and design. Section 4 delineates the data analysis and findings. Section 5 discusses the results in order to derive theoretical and managerial implications. Section 6 lastly sums up the conclusions, limitations of this investigation, and recommendations for future avenues of research.

2 | Review of Literature

2.1 | Theoretical Underpinning

The dynamic capability view theory (DCVT), fundamentally an extension of the resource-based view, serves as the core theory that elucidates the theoretical model shown in Figure 1. The Appendix contains articulations of the definitions of key constructs used in the theoretical model. DCVT elucidates how businesses adapt, integrate, and reconfigure their internal and external resources and capabilities to address dynamic situations (Rahman et al. 2024). This perspective highlights an organization's ability to identify opportunities and threats, capitalize on these opportunities, and strategically reorganize to sustain a competitive advantage (Al-Omouh et al. 2024). Organizations in highly competitive marketplaces can build a dynamic ecosystem using the capabilities of DPs, which becomes crucial for their existence (Ahmed et al. 2022). Building upon the theoretical underpinning of DCVT, it is proposed that the integration and reconfiguration aspects of DPs should be viewed as dynamic capabilities (Liao et al. 2024; N. Wang et al. 2023). DPIC, as a dynamic capability, emphasizes the integration of diverse partners within the value chain via DPs, while DPRC, as a dynamic capability, concentrates on reconfiguring DPs for adaptation throughout the value chain to accommodate evolving requirements (Y. Li et al., 2025). The emergence of DPs with hierarchical modular designs provides several opportunities for organizations to engage with various stakeholders, potentially leading to significant shifts in the rationale for creative thinking within these organizations (Awan et al. 2021). The crucial nature of an organization's dynamic abilities grows more pressing in a more unpredictable and uncertain environment resulting from environmental regulatory demands, digital transformation, and constant advances in technology (AL-khatib and Ramayah 2025; Liao et al. 2024). When an organization's dynamic capabilities are potent, it can adapt to its changing environment and compete with rivals (Y. Li et al., 2025). Organizations that have FRIN strategic capabilities will be able to capitalize on DPs to identify, examine, and seize opportunities to match resources for the best strategic fit, so staying ahead of the competition in the competitive corporate environment of today (Al-Omouh et al. 2024, 2025). As a result, FRIN strategies, characterized by resource efficiency and cost-effectiveness, serve as the conduit via which DP capabilities impact CEP, therefore aligning with the strategic objective of achieving circularity in business operations. Particularly when placing CGP in a moderating role, the behavioral theory of the firm (BTF) provides a complementary viewpoint on how companies make decisions compared to conventional economic models (Cyert and March 2006). BTF scrutinizes the internal processes, objectives, and power dynamics

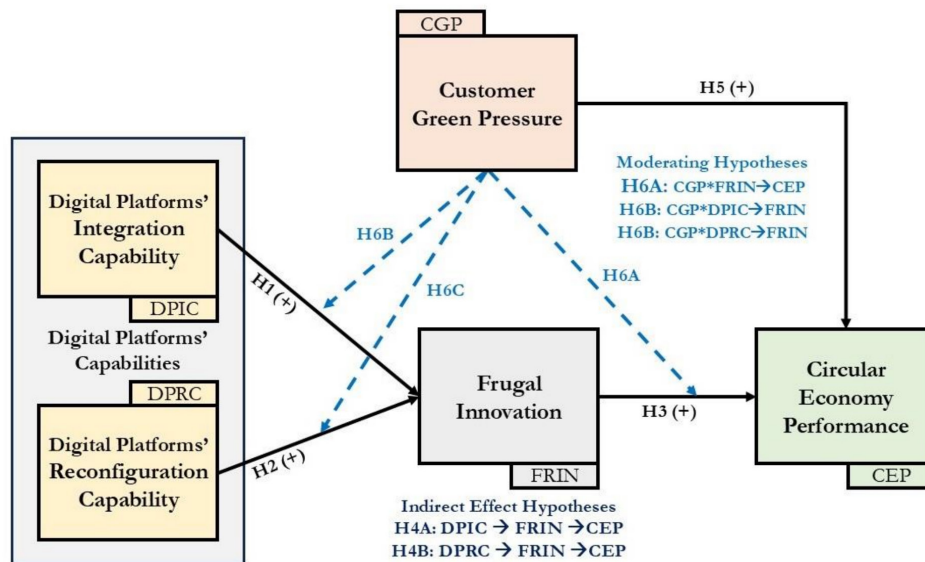


FIGURE 1 | Theoretical model.

influencing organizational behavior, contesting the notion that organizations operate only as rational profit maximizers (Lin and Ho 2011; Yang et al. 2025). Building on BTF, one might argue that, in times of high CGP, organizations would prioritize environmental goals and capitalize on their DPs and FRIN strategic capabilities to allocate resources and sharpen comprehension to satisfy customer demands. In contrast, when CGP is low, organizations may prioritize other strategic objectives, weakening the institutional mechanism required to accomplish CEP because there is less urgency to address environmental concerns. A detailed review of the proposed relationship among the various constructs illustrated in Figure 1 is being addressed subsequently.

2.2 | Dynamic Platforms' Capabilities and Frugal Innovative Strategies

Manufacturing organizations are looking more and more for innovative concepts highlighting technological adaptability and cost-effectiveness as the need for efficient utilization of resources gets more and more pressing (Kortus et al. 2025). To gain a competitive edge, DPs are essential, but they are not enough on their own (Y. Wang et al. 2022). To effectively reap the benefits of DPs, they must be integrated into organizational capabilities (N. Wang et al. 2023). When it comes to DPs, there are two different dimensions: one integration (i.e., DPIC) and the other reconfiguration (i.e., DPRC); the former concentrates on enhancing communication and coordination skills among strategic partners while the latter focuses on the ability of an organization to manage partners' onboarding, information interoperability, system modularity, and technology upgrade competence (Cenamora et al. 2019). One could argue that DPs enable the synthesis of different resources—essential for FRIN—because dynamic platforms function as critical enablers of collaboration and resource sharing (Ahmed et al. 2022; Bhatti et al. 2024). When DPIC is strong, organizations across the value chain may work together more effectively on these platforms by sharing knowledge and streamlining operations,

which leads to more long-term sustaining innovations (N. Wang et al. 2023; Y. Wang et al. 2022). Prior research has implicitly advocated that organizations that leverage network capabilities perform better in terms of innovation (Haffar et al. 2021), emphasizing the advantageous effects of digital integration in the development of frugal ideas that address market-specific needs (Al-Omouh et al. 2024). On the other hand, organizations with high DPRC would be able to capitalize on new technologies and establish new linkages to current devices, enabling them to reconfigure the inherent potential of their innovation process to develop novel functions (Bhatti et al. 2024; Wang et al. 2022). Furthermore, organizations with a potent DPRC have a distinct opportunity—and arguably a responsibility—to remodel their DPs across their value chain (Jia et al. 2024; Wang et al. 2023). This adjustment is crucial for enhancing collaboration and integration with significant (strategic) stakeholders, enabling smoother and more efficient workflows across the value chain, and ultimately increasing the level of innovation effectiveness (Liao et al. 2024). Hence, organizations with high DPs' capabilities are positioned to adapt their value chain infrastructure to meet the evolving needs of their partners, a flexibility that is especially valuable in emerging markets, where partners may face diverse constraints and require customized solutions (Ahmed et al. 2022; Y. Li et al., 2025). Conversely, there is an opposing perspective regarding the dependence on DP capability for FRIN strategies. Critics argue that overdependence on technology could lead to a homogenization of ideas, undermining the very essence of FRIN, which prospers in ingenuity and creativity (Sacanamboy-Trujillo and Escandón-Barbosa 2025). This point of view suggests that integrating DPs could limit the singularity and adaptability characteristic of frugal solutions because organizations can prioritize approaches driven by technology on basic innovations (Ahuja and Chan 2019). The advocacy discussed above leads one to formulate the following hypotheses.

H1. DPIC positively impacts FRIN strategies.

H2. DPRC positively impacts FRIN strategies.

2.3 | Frugal Innovative Strategies and CEP

The circular economy is a system that substitutes the “end-of-life” notion with the principles of reduction, reuse, recycling, and recovery of resources across manufacturing and distribution operations (Castro-Lopez et al. 2023; Perera and Badir 2025). Organizations that exhibit the traits of FRIN—lower pricing, satisfactory quality, and optimum functionality—often design their processes and products with an eye toward resource economics (McMurray et al. 2019; Qin 2024; Rossetto and Borini 2017). Given the similarities in these underlying concepts (i.e., FRIN and circular economy) (Albert 2019), FRIN strategies may serve as a catalyst for the implementation of CEP in this setting (De Marchi et al. 2022; Ezeudu et al. 2022). As a result, FRIN strategies, characterized by the ability to create more value with fewer resources and focus on affordability and functionality, are more and more recognized in the context of the circular economy (AL-khatib and Ramayah 2025; Govindan 2024). For example, Albert (2019) articulates that sustainable FRIN strategies link the principles of affordability and conviviality, causing manufacturers to rethink the use of resources. This connection is particularly obvious in scenarios where operational constraints cause innovative design and manufacturing solutions. De Marchi et al. (2022) underline this point by showing that by lowering resource consumption and waste generation, FRIN may provide favorable effects on sustainability, hence boosting the CEP. Prior studies have unambiguously demonstrated the advantages of FRIN for the ecological environment: better pollution prevention (Ebolor et al. 2022), the mainstreaming of sustainable methods of production (da Silva et al. 2024), sustainable disposal of waste (D. Li et al., 2025), and the utilization of locally sourced resources (Pedroso et al. 2023). Stated differently, frugal innovative strategies, in these studies, strive to encourage more industrial techniques aiming at recycling and reusing resources and eradicating wasteful actions endangering the natural environment. Notwithstanding these benefits, there are certain challenges in integrating FRIN strategies into circular economy initiatives. The “dark side” of FRIN, as articulated by McMurray et al. (2019), encompasses the potential for reinforcing substandard outputs, which may unwittingly lead to heightened waste if the products lack durability or recyclability. Such aspects raise concerns concerning long-term sustainability, suggesting that adopting frugal practices without a holistic vision of circularity can undermine the planned environmental advantages. The multidisciplinary perspective described by Dabić et al. (2022) adds depth to this conversation, positing that FRIN strategies require consideration between economic, social, and environmental dimensions. Such a multitude of perspectives suggests that although FRIN may enhance the CEP, a nuanced understanding of the context and implementation is crucial. The unique characteristics of each economy make a unique approach for inadequate FRIN to achieve complete circular potential. Therefore, the interaction between FRIN and CEP produces a multifaceted array of benefits and drawbacks for manufacturers, resulting in the following hypothesis.

H3. *FRIN strategies positively impact CEP.*

2.4 | Role of Frugal Innovative Strategies

The DCVT posits that the capabilities of DPs constitute key resources, including DPIC and DPRC; nevertheless, the theory

does not clearly specify the mechanism by which these capabilities contribute to CEP. Emerging literature indicates that DPs' capabilities indirectly improve the CEP by promoting FRIN strategies (Al-kahtib et al. 2025; Ebolor et al. 2022). For example, AL-khatib and Ramayah (2025) explore the dynamics of artificial intelligence and its ability to affect circular supply chains, noting that FRIN strategies are a crucial mediator in retail companies. In addition, Ahuja (2021) emphasizes the transformation capacity of platform ecosystems to boost frugal digital innovation. Their research suggested that the platforms provide the scalability and capabilities required to integrate several stakeholders, hence enhancing collaboration. This collaboration advantage can be crucial to achieving sustainable practices in manufacturing, where resource optimization is essential (Ahuja 2021; Ahuja and Chan 2016). Ezeudu et al. (2022) delve even deeper into the conceptual relationship between the circular economy and FRIN strategies, stressing that synergy between both realms might provide greater environmental benefits when enabled digitally. Ahuja and Chan (2016) further prove this argument, presenting a frugal ecosystem perspective on digital innovation. They articulate that the interconnectivity of DPs with FRIN leads to greater resource productivity and reductions in environmental footprints—important principles of the circular economy. This integration leads to a paradigm transformation wherein environmental responsibility and economic viability are perceived as complementing outcomes enabled by digital technologies rather than as opposing objectives. This interaction between technological advancement (i.e., DPIC and DPRC) and sustainable innovation strategies (i.e., FRIN) underlines a unique trajectory for manufacturers in emerging markets to achieve operational circularity (i.e., CEP), proposing the following hypotheses for empirical validation.

H4A. *DPIC influences CEP indirectly via FRIN strategies.*

H4B. *DPRC influences CEP indirectly via FRIN strategies.*

2.5 | Role of Customer Green Pressure

The BTF specifies an organization as a coalition of an economic entity with its many stakeholders, where it is primarily believed that important stakeholders would influence the decision-making process of the organization in some way (Gavetti et al. 2012). Customers are considered among the most significant stakeholders, and organizations that neglect their expectations and needs would incur losses and face potential risks in the fiercely competitive marketplace (Chiambaretto et al. 2024; Zameer et al. 2021). Prior studies have contended that, especially in the context of the circular economy, CGP could be a major determinant of the organizational strategies striving toward FRIN (Nguyen et al. 2023; Yang et al. 2025). For example, Castro-Lopez et al. (2023) explore the impact of institutional pressures on organizational skills, underlining that a strong alignment with the CGP can improve the adoption of the principles of the circular economy. The interaction between FRIN strategies and these pressures suggests that organizations may need to reconcile the cost-effectiveness relationship with ecological responsibility (Levänen et al. 2022). In this light, Ezeudu et al. (2022) proposed a conceptual link

between FRIN and circular economic practices, underlining the need for innovative solutions in contexts limited to resources. Al-Omouh et al. (2025) found in their study that the impetus to include sustainability goals into operations may catalyze substantial innovation within the manufacturing value chain. They affirm that institutional pressures combined with the analysis of the supply chain can encourage an environment in favor of FRIN, thus potentially improving performance metrics. Shibin et al. (2018) further substantiate these observations by demonstrating that, notably under the CGP, organizations augmented by FRIN could improve their supply chain sustainability. These discussions demonstrate the direct and moderating impact of CGP, leading to the following hypotheses.

H5. *CGP positively impacts CEP.*

H6A. *CGP moderates the association between FRIN strategies and CEP.*

DPs act as facilitators that allow organizations to respond more effectively to environmental concerns and consumer preferences (Ahuja and Chan 2016; Tiwari 2021). In light of the growing customer expectations for sustainable practices, organizations are forced to integrate these pressures into their innovation strategies (Yang et al. 2025), which leads to greater FRIN. This relationship is particularly relevant in emerging economies where resource restrictions are pronounced (Khattak et al. 2022). Tiwari (2021) underlines that digital transformation facilitates green excellence at affordable prices, which is crucial to achieving FRIN strategies in sectors such as renewable energy. Therefore, the interaction between DPs and customer expectations models the trajectories of innovation, strengthening the need for companies to adapt their frugal strategies. Al-Omouh et al. (2025) further clarified this evidence by examining the way in which institutional pressures, including the CGP, interact with the analysis of the supply chain to promote FRIN. This interaction suggests that companies must advance their digital skills to improve the reconfiguration processes that respond to these pressures. De Marchi et al. (2022) provide empirical evidence linking the mechanisms of FRIN to sustainability outcomes, asserting that customer-driven environmental pressure catalyzes the DP's successful integration and reconfiguration. Heightened CGP will incite fierce competition as organizations compete for customers by addressing what they want (Buhaya and Metwally 2024). Thus, in keeping with the BTF, an organization's existence in a competitive marketplace is contingent upon functional routines that provide a competitive advantage, grounded on its knowledge integration and procedural reconfiguration capabilities (Cyert and March 2006). That is why prior studies have backed the moderating role of CGP in the interaction between organization capabilities and strategic outcomes (Buhaya and Metwally 2024; Yang et al. 2025), thereby leading to the proposal of the following hypotheses.

H6B. *CGP moderates the association between DPIC and FRIN strategies.*

H6C. *CGP moderates the association between DPRC and FRIN strategies.*

3 | Research Methods and Settings

3.1 | Development of Survey Instrument

A review of prior studies helped to identify suitable indicators to capture the constructs proposed in the current investigation. This option was chosen in accordance with the fundamental tenets outlined in the methodology literature on psychometric measurement, which indicates that using measurement items that were tested in multiple empirical evaluations across diverse contexts enhances measurement robustness and reliability, thereby augmenting the validity of the results concerning the hypothesized relationship (Hair et al. 2011). The appendix section addresses sources of adaptation and the items used in the current research for the DPs' capabilities (Cenamor et al. 2019), FRIN (Rossetto and Borini 2017), CEP (Kouhizadeh et al. 2023), and CGP (Lin and Ho 2011). The selected measurement items from prior studies were aligned with the current conceptualization and subsequently adapted to the context of this investigation. They were then evaluated for face validity by academics specializing in technology, innovation, environmental, and operations management. In response to their feedback, some measuring questions were modified to improve clarity and suitability for the intended industry and respondents. The questionnaire is structured in parts labeled Part A, B, and C to reduce common method bias. Part A documented the demographic profiles of the respondents, Part B recorded responses to the constructs CGP and CEP, and Part C recorded responses to the constructs DPIC, DPRC, and FRIN. Responses to questions in Part A were open-ended; responses to questions in Part B and Part C were rated on a 7-point Likert Scale based on Degree of Agreements (1—*Strongly disagree* and 7—*Strongly agree*).

3.2 | Data Collection Procedure

Referring to the Confederation of Indian Industries (CII) Directory, the researcher identified technology-intensive industrial companies dispersed all across many states in India. Three main considerations guided the selection of these Indian manufacturing companies as the research sample. India is currently undergoing a "Circular Economy" and a "Make in India" revolution in alignment with sustainable development goals and national interests. The government has implemented stringent regulations and statutes compelling manufacturers to adopt both initiatives for the greater national interest and global prominence. This offers a perfect setting for investigating circular economy and FRIN strategies in the manufacturing sector as organizations are forced to quickly adapt to acquire the appropriate expertise. In addition, Indian industries have shown an overwhelming propensity for embracing Industry 4.0 technologies in their operations, aligning themselves with the "Digital India" revolution. These three conditions provide an ideal setting, along with Indian manufacturers constituting suitable participants for this current investigation. A consultant associated with CII, working closely with the Indian Ministry of Commerce and Industry, assisted the researcher in identifying those companies enrolled in or participating in these three national initiatives. The consultant supported the current investigation by providing a list of potential 2194 manufacturers, which included the respondents' names, designations, and contact information.

The researcher contacted these respondents over the telephone, explaining to them the context of the current investigation and requesting them to participate in the survey. During this telephone conversation, the researcher assessed their eligibility for the current investigation based on the three criteria covered above. Once their eligibility and the manufacturing organization were associated with had been determined to be in line with the scope of the current inquiry, the researcher shared the link to the web-based survey instrument. The respondents were also reassured that their responses would be kept confidential, ensuring that neither the affiliated business nor their personal reputation would be harmed. Following repeated follow-ups with these potential respondents between August 2023 and November 2024, the researcher was able to collect information from 889 respondents, with a response rate of 40.51% for the current investigation. The respondents who participated in the survey submitted self-reported answers to the survey questions, and their demographic summary is shown in Table 1.

3.3 | Assessment of Nonresponse Bias and Common Method Bias

Nonresponse bias has been examined by considering two examination criteria to further confirm the representativeness of the identified sample (Armstrong and Overton 1977). The first examination assessed whether a substantial difference existed between responding and nonresponding organizations. The *T* test did not reveal any statistically significant difference between the sample and the nonresponding organizations. This was determined by examining demographic variables, including the age and size of the organizations. The second examination considers comparing the responses from the early and late waves of respondents. The first 35% of respondents (i.e., early wave) and the last 35% of respondents (i.e., late wave) from the total sample were compared, and the *T* test revealed no significant differences between the two groups. Therefore, it can be concluded that nonresponse bias is not a concern in the current investigation. Common method bias has been assessed using the Harman single-factor test to conduct factor analysis on all items (Podsakoff et al. 2003). The first unrotated principal component represented 31.7%, did not surpass the critical threshold of 40%, and remained within an acceptable range. Therefore, common method bias is not a concern for the current investigation.

4 | Data Analysis and Results

Particularly for complicated models including numerous constructs, the modeling software for structural equations of the smallest partial squares (PLS-SEM) has become a potent instrument in statistical analysis (Hair et al. 2011). Its fundamental advantage is in its capacity to handle small to medium sample sizes and nonnormal data distributions, making it a more favorable option than conventional approaches like covariance-based structural equation modeling (CB-SEM), which often need bigger samples and assumptions of multivariate normality (Hair et al. 2017). This characteristic improves its applicability in difficult data collection contexts, as in studies involving niche markets or emerging technologies (Hair et al. 2019). In addition, PLS-SEM allows the modeling of complex relationships

between latent variables without the need for strict hypotheses on measurement scales, thus offering more flexibility compared to traditional approaches (Hair et al. 2017). Another significant advantage of PLS-SEM is its ability to assess both exploratory and confirmatory models, to accommodate a range of research conceptions (Hair et al. 2011). PLS-SEM was therefore viewed as appropriate for the current investigation and shall be further assessed as per guidelines for tests of measurement and structural models (Hair et al. 2019).

4.1 | Testing the Measurement Model

The results of the measurement model assessment are encapsulated in Tables 2–3, which presents findings for the evaluation of construct reliability, convergent validity, and discriminant validity (Hair et al. 2011; Hair et al. 2017). Referring to Table 2, it was determined that every item and construct satisfied the necessary cutoff criteria needed for reliable and valid measurements (Hair et al. 2019). The factor loadings for all items within each construct and the Cronbach alpha and composite reliability values of each construct exceeded the threshold criteria of 0.70 (in Table 2). Furthermore, clearly apparent in Table 2 were average variance extracted (AVE) values above the 0.5 cutoff criteria. As a result, it can be concluded that the measurement model has shown sufficient construct reliability and convergent validity (i.e., how closely items in a construct relate to other items measuring the same construct?) required for evaluating the structural model. The next step in testing the measurement model is the analysis of discriminant validity (i.e., measures the extent to which the constructs differ from each other), the results of which are encapsulated in Table 3. The discriminant validity analysis consists of two parts: (1) the Fornell–Larcker criterion and (2) the Heterotrait–Monotrait (HTMT) criterion. The Fornell–Larcker criterion indicates that if the square root of the AVE exceeds the correlation coefficients, then discriminant validity is deemed acceptable, as seen in the results of Table 3. The HTMT criterion for discriminant validity, as shown in Table 3, is met with the ratio of between-trait correlations to within-trait correlations of two constructs being less than 0.85. Thus, the measurement model exhibits adequate discriminant validity required for the test of the structural model.

4.2 | Testing the Structural Model

The test of the structural model evaluates the direct, indirect, and moderating hypotheses posited in the theoretical framework (i.e., Figure 1). The results are summarized in Table 4 and Figures 2–5. At the outset, while evaluating the path coefficient across several constructs in the structural model, the R^2 and Q^2 are essential metrics used to measure the model's predictive power (the former) and validity (the latter). R^2 , the model's predictive power, indicates how much of the variation in the dependent (endogenous) construct is explained by the independent (exogenous) constructs. Figure 2 illustrates that the R^2 values for FRIN and CEP are 0.300 and 0.277, respectively, indicating an adequate explanatory power of the structural model. Q^2 , on the other hand, is a measure of the model's predictive relevance, indicating how well the model can predict the observed data. Higher than zero, the Q^2 values for FRIN and CEP are

TABLE 1 | Demographic profile of the respondents.

Industry	n (%)	Subsector	n (%)
Automotive manufacturing	193 (21.71%)	Automotive parts & components	62 (6.97%)
		Commercial vehicles	44 (4.95%)
		Electric and hybrid vehicles	35 (3.94%)
		Passenger vehicles	29 (3.26%)
		Heavy vehicles	23 (2.59%)
Chemical manufacturing	182 (20.47%)	Adhesive, paints, & coatings	51 (5.74%)
		Fertilizers & agricultural chemicals	93 (10.46%)
		Pharmaceutical & biotechnology	38 (4.27%)
Electronics and electrical equipment manufacturing	175 (19.69%)	Consumer electronics	47 (5.29%)
		Electrical equipment	35 (3.94%)
		Semiconductors & electronic components	49 (5.51%)
		Solar panels and wind turbines	23 (2.59%)
		Energy storage systems	21 (2.36%)
Food and beverage manufacturing	178 (20.02%)	Food processing	46 (5.17%)
		Beverage manufacturing	42 (4.72%)
		Dairy products	46 (5.17%)
		Bakery & confectionery	44 (4.95%)
Medical equipment and supplies manufacturing	161 (18.11%)	Diagnostic equipment	43 (4.84%)
		Dental equipment & supplies	39 (4.39%)
		Medical devices	42 (4.72%)
		Orthopedic & prosthetic devices	36 (4.05%)
Respondent's roles	n (%)	Designation	n (%)
Cross-functional and support roles	74 (8.32%)	Data scientist (manufacturing)	22 (2.47%)
		Project manager (innovation projects)	18 (2.02%)
		Supply chain analyst	28 (3.15%)
		Others	6 (0.67%)
Design and engineering roles	93 (10.46%)	Design engineer	21 (2.36%)
		Industrial designer	15 (1.69%)
		Sustainable design engineer	33 (3.71%)
		Value engineering specialist	20 (2.25%)
		Others	4 (0.45%)
Manufacturing and production roles	98 (11.02%)	Additive manufacturing engineer	19 (2.14%)
		Lean manufacturing specialist	27 (3.04%)
		Production manager	28 (3.15%)
		Quality assurance engineer	22 (2.47%)
		Others	2 (0.22%)

(Continues)

TABLE 1 | (Continued)

Respondent's roles	n (%)	Designation	n (%)
R&D roles	189 (21.26%)	Innovation manager	65 (7.31%)
		Materials scientist	21 (2.36%)
		Product development engineer	34 (3.82%)
		Process development engineer	22 (2.47%)
		R&D engineer	47 (5.29%)
Strategic and leadership roles	246 (27.67%)	Chief innovation officer	87 (9.79%)
		Chief technological officer	64 (7.20%)
		R&D director	78 (8.77%)
		Others	17 (1.91%)
Sustainability and resource optimization roles	189 (21.26%)	Circular economy specialist	66 (7.42%)
		Energy efficiency specialist	59 (6.64%)
		Sustainability engineer	42 (4.72%)
		Waste reduction analyst	22 (2.47%)
Organization's age	n (%)	Organization's size	n (%)
10–15 years	314 (35.32%)	250–500 Employees	231 (25.98%)
16–30 years	294 (33.07%)	501–1000 Employees	209 (23.51%)
> 30 years	281 (31.61%)	1001–2500 Employees	217 (24.41%)
		> 2500 Employees	232 (26.10%)

Abbreviation: R&D, research and development.

0.296 and 0.222, respectively, as shown in Figure 2, suggesting adequate predictive relevance of the structural model. Table 4 summarizes the findings of direct and indirect hypotheses, and Figure 2 graphically shows it. The direct impact of DPs' capabilities is statistically significant on FRIN (i.e., hypothesis H1: $D.\beta=0.417$ and hypothesis H2: $D.\beta=0.205$), while the effect of FRIN on CEP is also statistically significant (i.e., hypothesis H3: $D.\beta=0.341$). Table 4 unequivocally illustrates that the integration (hypothesis H4a: $ID.\beta=0.142$) and reconfiguration (hypothesis H4b: $ID.\beta=0.070$) aspects of DPs' capabilities have a statistically significant indirect effect on CEP via FRIN. Lastly, the direct effect of CGP on CEP is statistically significant, hence validating hypothesis H5 with $D.\beta=0.306$.

The subsequent results regarding the moderating influence of CGP on the interactions between FRIN–CEP (Hypothesis H6a), DPIC–FRIN (Hypothesis 6b), and DPRC–FRIN (Hypothesis 6c) are presented in Table 4 and Figure 2, with the simple slope analysis of each of these interactions depicted in Figures 3–5. Among the three sets of moderating hypotheses, the results indicate that the moderating effect of CGP is statistically significant solely in relation to the impact of DPRC on FRIN (i.e., hypothesis H6c: $Mo.\beta=0.117$). Figure 5 shows the simple slope analysis associated with hypothesis H6c, which shows that the slope increases at a higher level of CGP while it reduces at a lower level of CGP, with slopes crossing each other. It is apparent that a high CGP strengthens the statistical relationship between DPRC and FRIN, whereas a low CGP weakens it. For hypotheses H6a (CGP*FRIN→CEP) and H6b (CGP*DPIC→FRIN), the results

were statistically insignificant (refer to Figures 3 and 4). The control variables—sector, age, and size of the organization—were binary coded using dummy variables and subsequently analyzed, revealing that these control variables do not significantly impact FRIN and CEP (as seen in Table 4). Therefore, it can be concluded that control variables are not relevant in the structural model analysis.

5 | Discussion

5.1 | Theoretical Implications

The findings of this study offer profound theoretical implications by extending and enriching the DCVT and BTF, while also providing nuanced insights into the relationships between DP capabilities, FRIN, CEP, and CGP. The results align with the DCVT, which asserts that organizations have to dynamically integrate, reconfigure, and optimize the use of internal and outside resources to maintain their competitive advantage and fit with their new environments. To be more precise, the fact that DPIC and DPRC have a positive and significant effect on FRIN (i.e., hypotheses H1 and H2) highlights the crucial nature of DPs as dynamic capabilities that enable organizations to optimize their resources, foster collaboration, and drive innovation. These findings resonate with prior studies that highlight the importance of digital capabilities in enhancing innovation performance (Al-Omouh et al. 2024; N. Wang et al. 2023) and align with the growing body of literature that emphasizes the

TABLE 2 | Results of measurement model—construct's reliability and convergent validity.

Constructs	Particular	Descriptive statistics & factor loadings				α	CR (rho_a)	CR (rho_c)	AVE
		I1	I2	I3	I4				
DPIC	Factor loading	0.722	0.889	0.890	0.913	0.877	0.894	0.917	0.735
	Mean	6.208	6.063	6.331	6.153				
	SD	0.979	0.987	0.815	0.925				
DPRC	Factor loading	0.933	0.909	0.939	0.917	0.943	0.944	0.959	0.855
	Mean	5.687	5.612	5.633	5.787				
	SD	1.051	1.157	1.099	1.065				
FRIN	Factor loading	0.880	0.861	0.833	0.729	0.847	0.852	0.896	0.685
	Mean	5.530	5.200	5.103	5.880				
	SD	1.250	1.341	1.441	1.155				
CEP	Factor loading	0.890	0.932	0.913	0.932	0.937	0.939	0.955	0.841
	Mean	6.105	6.228	5.123	5.229				
	SD	0.928	0.874	0.902	0.875				
CGP	Factor loading	0.928	0.942	0.921		0.922	0.923	0.951	0.865
	Mean	6.124	6.179	6.103					
	SD	1.013	0.965	1.041					

Abbreviations: CEP, circular economy performance; CGP, customer green pressure; DPIC, digital platforms' integration capability; DPRC, digital platforms' reconfiguration capability; FRIN, frugal innovation; SD, standard deviation. The factor loadings of items associated with each construct are listed in the same sequence as in the Appendix. α , Cronbach's alpha (threshold criterion: > 0.70); AVE, average variance extracted (threshold criterion: > 0.50); CR, composite reliability (threshold criterion: > 0.70); I1—Item 1 (threshold criterion: > 0.70); I2—Item 2 (threshold criterion: > 0.70); I3—Item 3 (threshold criterion: > 0.70); I4—Item 4 (threshold criterion: > 0.70).

TABLE 3 | Results of measurement model—discriminant validity.

Constructs	DPIC	DPRC	FRIN	CEP	CGP
DPIC		0.531	0.505	0.460	0.723
DPRC	<i>0.582</i>	(0.925)	0.416	0.359	0.436
FRIN	<i>0.574</i>	<i>0.461</i>		0.449	0.368
CEP	<i>0.512</i>	<i>0.380</i>	<i>0.470</i>	(0.917)	0.419
CGP	<i>0.828</i>	<i>0.467</i>	<i>0.408</i>	<i>0.451</i>	(0.930)

Notes: Values in parentheses (0.XXX) are the square root of the average value extracted for the specific construct; values in bold are the results of Fornell–Larcker criterion (threshold values: \leq values in parentheses); values in italics are the result of the Heterotrait–Monotrait ratio of correlations (threshold value: <0.85). Abbreviations: CEP, circular economy performance; CGP, customer green pressure; DPIC, digital platforms' integration capability; DPRC, digital platforms' reconfiguration capability; FRIN, frugal innovation.

transformative potential of DPs in enabling sustainable practices (Ahuja and Chan 2019; Govindan 2024). In addition, the evidence that DPIC and DPRC have substantial indirect effects on CEP via FRIN (i.e., hypotheses H4A and H4B) suggests that FRIN is an important intermediary in the translation of digital capabilities into circular economy outcomes. This is consistent with the DCVT's assertion that dynamic capabilities enable the alignment of resources with strategic objectives, especially in resource-constrained environments, and supports prior studies that find FRIN strategies as the primary engine of sustainability and resource efficiency (Albert 2019; De Marchi et al. 2022). The supportive relationship between FRIN and CEP—that is, hypothesis H3—helps underline even more how naturally aligned

FRIN is with the tenets of the circular economy, marked by its focus on affordability, functionality, and resource optimization. This confirms what previous studies have shown: that FRIN has positive effects on the environment and the economy at large, including reduced waste, more efficient use of resources, and better sustainability results (Al-kahtib et al. 2025; Ezeudu et al. 2022).

The significant positive effect of CGP on CEP resonates with the BTF (i.e., hypothesis H5), which holds that key stakeholders—especially customers—have a major influence on the strategic choices of organizations. This finding corroborates prior studies that emphasize the role of external stakeholder

TABLE 4 | Results of structural model—test of control variable, direct, mediating, and moderating hypotheses.

Direct hypothesis	D.β	t	p	CI (2.5% to 97.5%)	Decision
H1: DPIC → FRIN	0.417	8.618	0.000	0.323 to 0.516	Supported
H2: DPRC → FRIN	0.205	5.070	0.000	0.127 to 0.283	Supported
H3: FRIN → CEP	0.341	10.520	0.000	0.276 to 0.405	Supported
H5: CGP → CEP	0.306	8.005	0.000	0.233 to 0.385	Supported
Indirect effect hypothesis	ID.β	t	p	CI (2.5% to 97.5%)	Decision
H4A: DPIC → FRIN → CEP	0.142	6.627	0.000	0.103 to 0.188	Supported
H4B: DPRC → FRIN → CEP	0.070	4.299	0.000	0.039 to 0.103	Supported
Moderating hypothesis	Mo.β	t	p	CI (2.5% to 97.5%)	Decision
H6A: CGP*FRIN → CEP	0.024	0.854	0.393	−0.038 to 0.074	Not Supported
H6B: CGP*DPIC → FRIN	−0.006	0.176	0.861	−0.074 to 0.056	Not Supported
H6C: CGP*DPRC → FRIN	0.117	2.713	0.007	0.030 to 0.202	Supported
Control variables	C.β	t	p	CI (2.5% to 97.5%)	Decision
Organization's sector → FRIN	0.037	0.435	0.664	−0.145 to 0.188	Not Supported
Organization's age → FRIN	−0.037	0.456	0.648	−0.128 to 0.194	Not Supported
Organization's size → FRIN	−0.009	0.095	0.924	−0.183 to 0.157	Not Supported
Organization's sector → CEP	0.075	0.703	0.482	−0.187 to 0.229	Not Supported
Organization's age → CEP	−0.010	0.151	0.880	−0.135 to 0.129	Not Supported
Organization's size → CEP	−0.093	0.783	0.434	−0.237 to 0.193	Not Supported

Abbreviations: C.β, control variable path coefficient; CI, confidence intervals from 2.5% to 97.5%; CEP, circular economy performance; CGP, customer green pressure; DPIC, digital platforms' integration capability; DPRC, digital platforms' reconfiguration capability; FRIN, frugal innovation; D.β, direct path coefficient; ID.β, indirect path coefficient; Mo.β, moderating path coefficient.

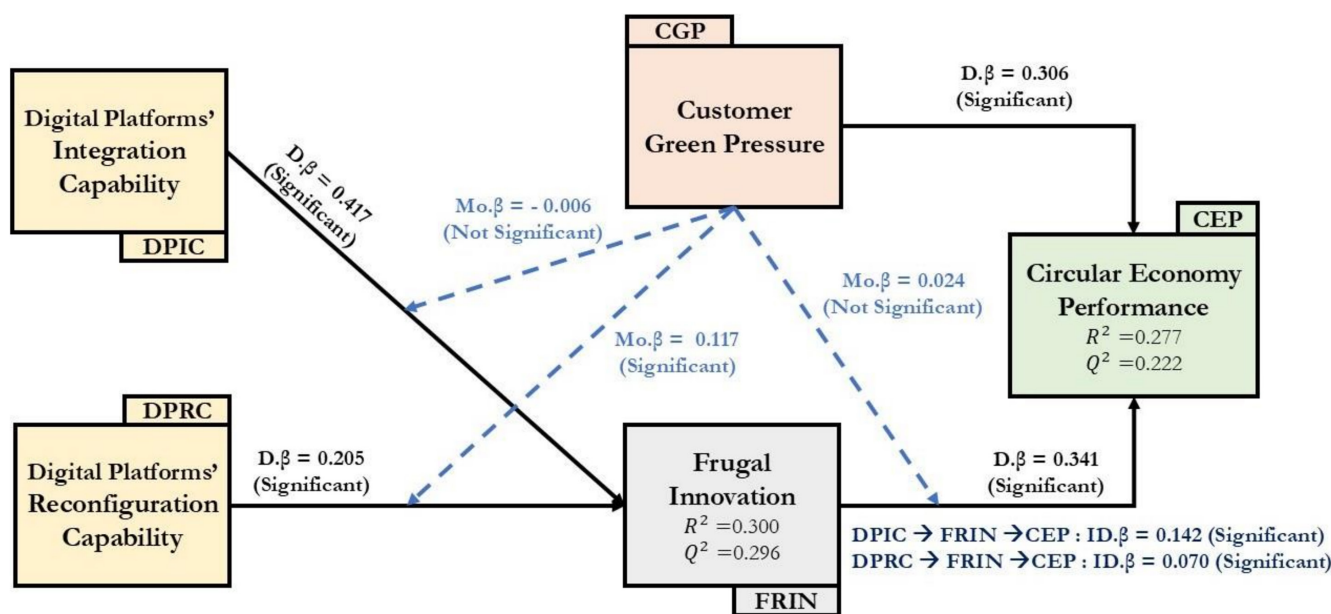


FIGURE 2 | Results of structural model.

pressures, such as customer demands for environmental sustainability, in driving organizations to adopt sustainable practices and improve their environmental performance (Nguyen et al. 2023; Yang et al. 2025). Thus, the study reinforces the

importance of customer-driven environmental pressures as a critical factor in advancing circular economy initiatives. As per the reasoning of the BTF, the moderating effect of CGP on the causal relationship between DPRC and FRIN (i.e., hypothesis

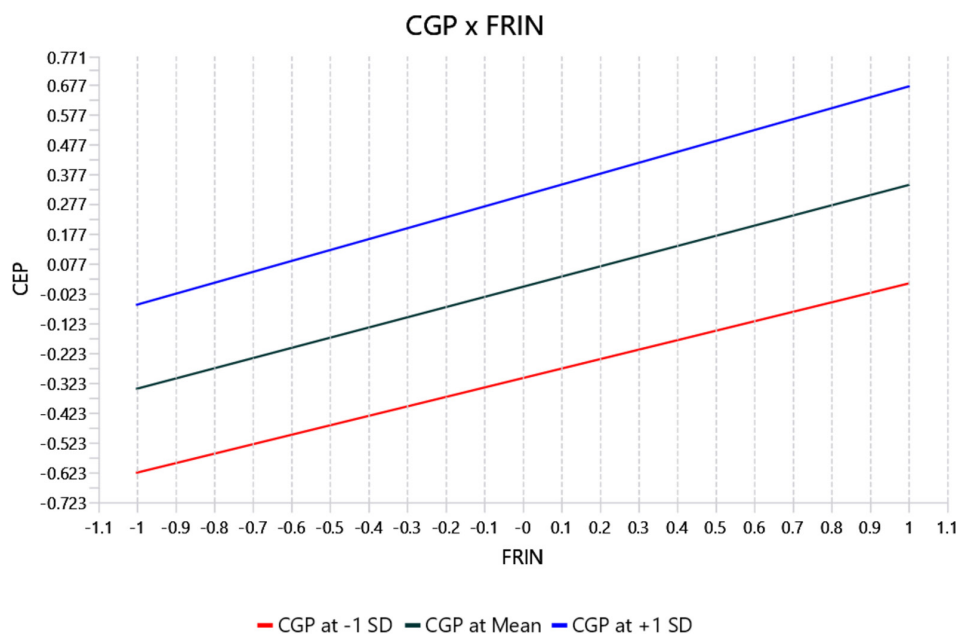


FIGURE 3 | Results of simple slope analysis—interaction effect of CGP*FRIN on CEP. CEP, circular economic performance; CGP, customer green pressure; FRIN, frugal innovation; SD, standard deviation.

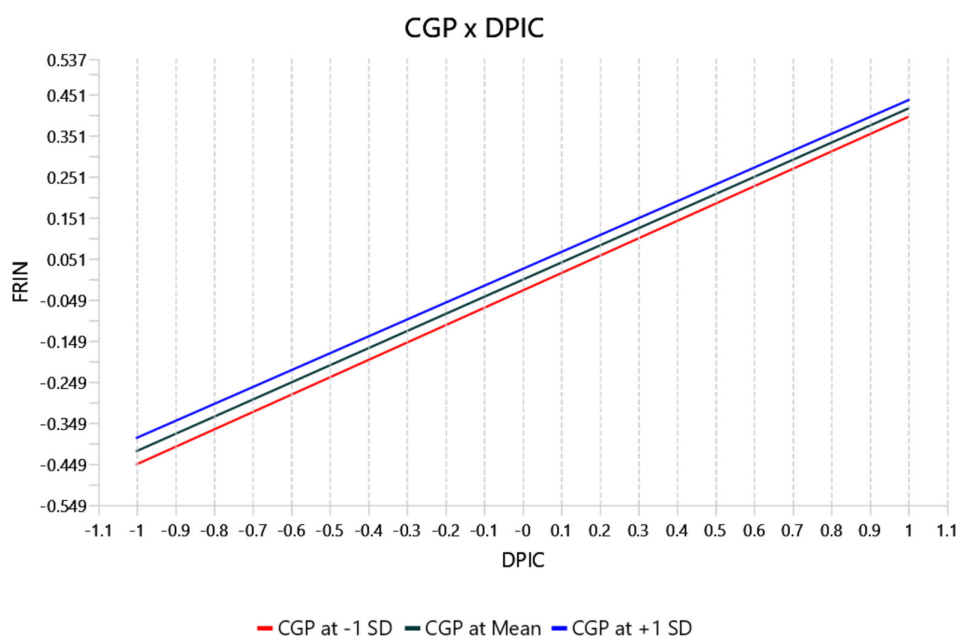


FIGURE 4 | Results of simple slope analysis—interaction effect of CGP*DPIC on CEP. CGP, customer green pressure; DPIC, digital platforms' integration capability; FRIN, frugal innovation; SD, standard deviation.

H6c) underscores the impact of external stakeholder pressures on organizational decision-making and innovation strategies. This finding corroborates the BTF's fundamental assertion that organizations are not only profit-maximizing entities but are shaped by the expectations and needs of key stakeholders, particularly customers (Cyert and March 2006). Organizations are inclined to reorganize their DPs and innovate sparingly in response to perceived strong environmental demands from customers, as shown by the significant moderating impact of CGP on the DPRC-FRIN relationship. This is in line with numerous studies highlighting the role

institutional pressures—including customer expectations—play in promoting circular economy solutions and sustainable innovation (Castro-Lopez et al. 2023; Yang et al. 2025). The absence of substantial moderating effects of CGP on the causal relationships between FRIN and CEP (i.e., hypothesis H6a) and DPIC and FRIN (i.e., hypothesis H6b) presents a notable contrast to previous studies that highlight the direct influence of stakeholder pressure on sustainability outcomes (Nguyen et al. 2023; Zameer et al. 2021). This implies that although CGP can lead to better reconfiguration of DPs, it may not directly affect the more general link between FRIN and CEP,

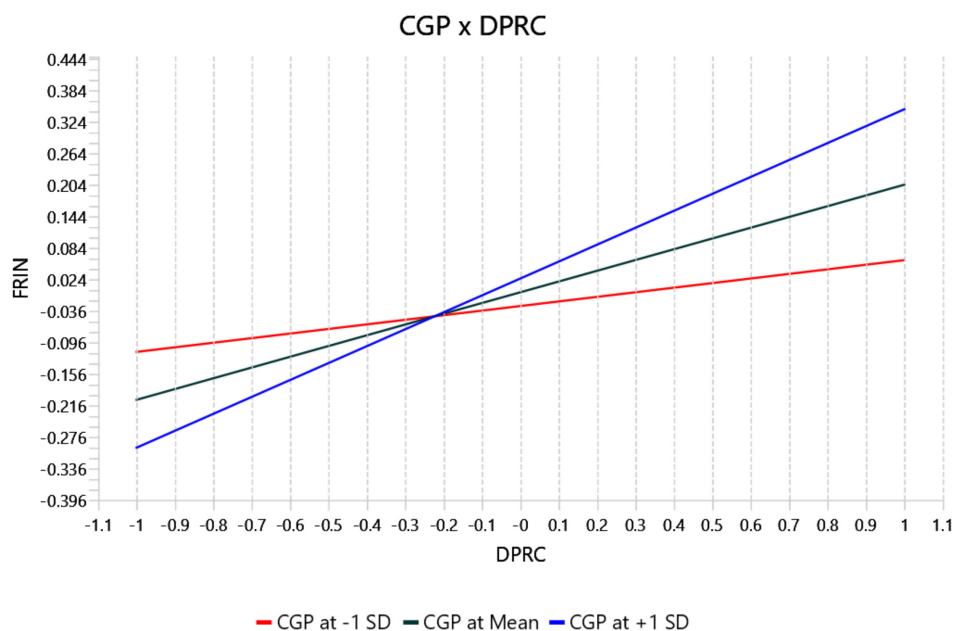


FIGURE 5 | Results of simple slope analysis—interaction effect of CGP*DPRC on CEP. CGP, customer green pressure; DPCR, digital platforms' reconfiguration capability; FRIN, frugal innovation; SD, standard deviation.

implying that other factors, such as organizational culture, regulatory frameworks, or technological readiness, may be of greater significance in shaping these interactions.

Overall, these findings contribute to the literature by providing a deeper understanding of the mechanisms through which DP capabilities and FRIN drive CEP, while also highlighting the contingent role of CGP in shaping these dynamics. This study addresses deficiencies in the prevailing literature by empirically confirming the intermediary role of FRIN and the moderating role of CGP, providing an expanded framework for comprehending how organizations may leverage digital capabilities and react to external pressures to attain their goals for sustainability. These results build on and complement existing theoretical frameworks and create the groundwork for future studies aiming to investigate the relationship between digital transformation, innovation, and sustainability in diverse contexts. This study contributes to DCVT in three novel ways. First, digital-frugal platform alignment theory underpins and demonstrates that DPIC and DPCR not only support general innovation but also specifically enable FRIN within resource-constrained contexts. This theory explicates how platform modularity and partner interoperability act as boundary-spanning dynamic capabilities that directly drive resource-efficient design and production processes. Second, this study argues and examines the FRIN Mediation Model, where FRIN functions as a core dynamic capability mediating the influence of DP capabilities on CEP. This study contributes to evidencing the mediation process by clearly identifying FRIN as the key mechanism through which DPIC and DPCR translate into measurable circular outcomes. Third, the CGP contingency proposition and evaluation contribute to the behavioral theory of the firm by specifying that CGP selectively moderates the pathway from DPCR to FRIN, intensifying the responsiveness of organizations to environmental demands via digital reconfiguration. This reveals an asymmetric moderating effect of external stakeholder pressures across different components of DP capabilities.

Collectively, these contributions form an integrated digital-frugal circularity framework that specifies (1) the distinct digital capabilities required for FRIN, (2) the mediating role of FRIN in achieving circular outcomes, and (3) the conditional influence of stakeholder pressure on capability effectiveness. This framework advances extant theories by elucidating the dynamic interplay between digital transformation, FRIN, and circular economy objectives in emerging market contexts, thus providing a structured basis for future theoretical development.

5.2 | Practical Implications

Particularly with respect to emerging economies like India, the results of this study have key pragmatic ramifications for both the management of manufacturing businesses and legislators. For manufacturers, the results underscore the importance of investing in DP capabilities, specifically DPIC and DPCR, to foster FRIN and enhance CEP. This implies that manufacturers should give foremost consideration to investments in accelerating the development of DPs that allow seamless integration with external collaborators and the capacity to reorganize these platforms to fit new technologies in response to market requirements. By doing so, manufacturers can optimize resource utilization, reduce waste, and develop affordable, sustainable products that align with circular economy principles (Cenamor et al. 2019; N. Wang et al. 2023).

Furthermore, this study emphasizes the moderating role of CGP in enhancing the causal relationship between DPCR and FRIN strategies. This implies that manufacturers in regions where eco-friendly products are in high demand shall have to capitalize upon the reconfigurability of their DPs to innovate frugally and fulfill the market's demands. In this regard, manufacturers should include a provision allowing them to reconfigure their DPs using customer feedback and environmental demands as driving factors, therefore enabling them to create sustainable

solutions suitable for their customer base (Yang et al. 2025). This is particularly pertinent in emerging economies because of an elevated degree of concern for the environment and the scarcity of resources. Businesses in the manufacturing sector could benefit wisely by incorporating CGP into their innovation plans, as it can encourage the implementation of circular economy strategies for improving their environmental performance (Nguyen et al. 2023).

For policymakers, the study provides a roadmap for promoting sustainable manufacturing practices through digital transformation and FRIN strategies. Policymakers should encourage the adoption of DPs by providing incentives for manufacturers to invest in digital infrastructure and capabilities. This could include subsidies for digital transformation projects, tax breaks for firms that adopt circular economy practices, or grants for research and development in FRIN strategies. Additionally, policymakers should focus on creating a regulatory environment that encourages organizations to respond to CGP by setting stringent environmental standards and promoting green certifications. This would not only drive firms to adopt sustainable practices but also align their operations with global sustainability goals (AL-khatib and Ramayah 2025; Kouhizadeh et al. 2023).

A practical roadmap for implementation could begin with firms conducting an audit of their current digital capabilities and identifying gaps in DPIC and DPRC. Manufacturers should then invest in technologies that enable seamless integration with their value chain partners and the ability to reconfigure platforms for new functionalities. Simultaneously, manufacturing organizations should engage with customers to understand their environmental expectations and incorporate these insights into their innovation strategies. On the other hand, policymakers should develop frameworks that support digital transformation and circular economy initiatives, such as public-private partnerships, industry-wide standards for DPs, and awareness campaigns on the benefits of FRIN. By aligning firm-level strategies with policy-level interventions, both manufacturing firms and policymakers can collectively drive the transition toward a more sustainable and circular economy.

6 | Conclusions

The study addresses the three RQs posed in the introduction section, providing valuable insights into how DPs' capabilities, FRIN, and CGP influence CEP in manufacturing organizations. First, the study confirms that FRIN strategies positively impact CEP (RQ1), highlighting the role of FRIN strategies in promoting resource efficiency, waste reduction, and sustainability, which are central to circular economy principles. Second, the findings reveal that DPs' capabilities, specifically integration (DPIC) and reconfiguration (DPRC) capabilities, significantly enhance FRIN strategies, which in turn improve CEP (RQ2). This underscores the importance of DPs as dynamic capabilities that enable organizations to adapt to changing environments and foster innovation. Third, the study demonstrates that CGP moderates the relationship between DPRC and frugal innovative strategies, indicating that customer demands for environmental sustainability can drive organizations to reconfigure their DPs and innovate frugally (RQ3). However, CGP does not

significantly moderate the relationships between FRIN strategies and CEP or between DPIC and FRIN, suggesting that other factors, such as organizational culture or regulatory frameworks, may play a more critical role in these interactions. The study provides actionable insights for manufacturing firms to leverage DPs' capabilities and FRIN strategies to achieve CEP. It also offers policymakers a clear direction for fostering sustainable manufacturing practices through digital transformation and customer-driven environmental pressures. By implementing these strategies, manufacturing organizations can enhance their competitive advantage and contribute to broader environmental and social sustainability goals.

Despite its contributions, the study has several limitations. First, the research is confined to Indian manufacturing organizations, which may limit the generalizability of the findings to other regions or industries. Future research could expand the scope to include other emerging economies or different sectors to validate the findings. Second, the study relies on cross-sectional data, which restricts the ability to infer causal relationships. Longitudinal studies could provide deeper insights into how DPs' capabilities and FRIN strategies evolve over time and their long-term impact on CEP. Third, the study focuses primarily on CGP as a moderating factor, but other external pressures, such as regulatory or competitive pressures, could also influence the relationships explored. Future research could investigate the role of these additional factors. Finally, the study does not explore the potential negative aspects of FRIN, such as the risk of reinforcing substandard outputs or unintended environmental consequences. Future research could delve into the "dark side" of FRIN strategies and its implications for long-term sustainability.

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Digital Platforms Integration Capability (DPIC)

Definition: The extent to which an organization's digital platforms can seamlessly connect and interact with the information technology systems of its partners to facilitate real-time information exchange, data aggregation, and integrated workflows. DPIC reflects the ability of an organization to create a cohesive digital ecosystem with its partners, enabling enhanced collaboration, improved decision-making, and optimized processes across the value chain.

Adapted from: (Cenamor et al. 2019)

Items:

DPIC-I1: The digital platform within our organization seamlessly retrieves data from our partners' information technology systems.

DPIC-I2: The digital platform within our organization facilitates seamless integration between our partners' information technology systems and our own (e.g., forecasting, production, manufacturing, shipment, etc.).

DPIC-I3: The digital platforms in our organization are capable of exchanging real-time information with our strategic partners.

DPIC-I4: The digital platforms within our organization are capable of aggregating pertinent information from our partners' databases (e.g., operating data, business customer performance, cost information, etc.).

Digital Platforms Reconfiguration Capability (DPRC)

Definition: The extent to which an organization's digital platforms can be readily adapted and upgraded to accommodate new partners, technologies, and functionalities while adhering to industry standards and leveraging reusable software components. DPRC reflects the agility and flexibility of an organization's digital infrastructure, enabling it to rapidly evolve and meet changing business needs and partner requirements.

Adapted from: (Cenamor et al. 2019)

Items:

• **DPRC-I1:** The digital platforms within our organization can be conveniently customized to include new strategic partners.

• **DPRC-I2:** The digital platforms in our organization can be effortlessly upgraded to integrate new information technology applications or functionalities.

• **DPRC-I3:** The digital platforms within our organization follow technical prerequisites that are accepted by a majority of our current and prospective partners.

• **DPRC-I4:** The digital platforms within our organization feature modular software components, the majority of which are reusable in other business applications.

Frugal Innovation (FRIN)

Definition: An organizational approach to innovation that focuses on developing products and services of satisfactory quality at affordable and competitive prices, achieved through resourcefulness in research & development, waste minimization in production, and a systematic reduction of operational expenses. FRIN emphasizes maximizing value for customers while minimizing costs and resource consumption.

Adapted from: (Kun 2022; Rossetto and Borini 2017)

Items:

• **FRIN-I1:** Our organization focuses on crafting an innovation strategy that prioritizes producing products of satisfactory quality which are affordably (and competitively) priced.

• **FRIN-I2:** The research and development department in our organization continuously explores technologies and methods to enhance the durability of manufactured products.

• **FRIN-I3:** Our organization prioritizes contemporary techniques that facilitate effective monitoring and control to minimize production waste.

• **FRIN-I4:** Our organization focusses upon developing groundbreaking approaches that systematically facilitate the reduction of operational expenses.

Circular Economy Performance (CEP)

Definition: The degree to which an organization demonstrates commitment to circular economy principles through effective management of remanufacturing processes, utilization of recyclable materials, reduction of resource consumption, and improvement of waste recycling rates. CEP reflects an organization's success in closing the loop and minimizing environmental impact across its operations.

Adapted from: (Kouhizadeh et al. 2023)

Items:

CEP-I1: Our organization adeptly manages a substantial volume of bills of materials for remanufacturing operations, which is increasing every single year.

CEP-I2: Our organization efficiently manages a substantial volume of bill-of-materials that demonstrates the use of recyclable waste and recycled components from end-of-life products, which is increasing every single year.

CEP-I3: Over the past three years, the energy and water consumption per unit of our organization's core product has been substantially reduced.

CEP-I4: Over the past three years, our organization has substantially improved the recycling rate of industrial wastewater and solid waste.

Customer Green Pressure (CGP)

Definition: The degree to which an organization perceives demands from its customers to prioritize environmental considerations, improve environmental performance, and adopt green certifications for manufacturing operations and products. CGP reflects the influence of customer expectations and preferences on a company's sustainability efforts.

Adapted from: (Lin and Ho 2011)

Items:

• **CGP-I1:** Caring for the environment is an important consideration for our customers.

• **CGP-I2:** Our customers require us to improve environmental performance.

• **CGP-I3:** Our customers expect and demand a green certification program linked to manufacturing operations and the products produced.

Note(s): All items are measured on a 7-point scale of agreement with 1—Strongly disagree, 2—Disagree; 3—More or less disagree; 4—Neutral or Cannot Say, 5—More or less agree; 6—Agree, and 7—Strongly Agree; I1 – Item 1 of construct; I2 – Item 2 of construct; I3 – Item 3 of construct; I4 – Item 4 of construct.