Corporate Social Responsibility and Environmental Management

WILEY

Corporate Social Responsibility and Environmental Management

RESEARCH ARTICLE

Sustainability Gets Smarter: Competitive Pressure and AI Leading the Way

João M. Lopes[1,2,3] | Cláudia Sofia Pinho[1,3] | Rui Centeno Martins[2,4] | Teresa Bandeira[5]

[1]Intrepid Lab, ECEO, Lusófona University, Porto, Portugal | [2]NECE-UBI – Research Unit in Business Sciences, University of Beira Interior, Covilhã, Portugal | [3]CETRAD, Centre for Transdisciplinary Studies for Development, UTAD, Vila Real, Portugal | [4]ISLA Santarém - Instituto Politécnico, Santarém, Portugal | [5]Miguel Torga Higher Institute, Coimbra, Portugal

Correspondence: João M. Lopes (joao.lopes.1987@hotmail.com)

Received: 12 January 2026 | **Revised:** 22 April 2026 | **Accepted:** 14 May 2026

Keywords: artificial intelligence | competitive pressure | digital transformation | green innovation | stimulus–organism–response (S–O–R)

ABSTRACT

Growing environmental concerns and the digital transformation of businesses have intensified the need to understand how sustainability and technology interact within organizational decision-making. This study examines how external market pressures, customer expectations, and competitive pressure shape internal innovation mechanisms (marketing, process, organizational) and artificial intelligence (AI) adoption, and how these factors influence decision-making toward green innovation in companies. A quantitative approach was applied using a structured questionnaire administered to 394 consumers and professionals with work experience in companies that integrate sustainability and innovation. The research model was tested through Partial Least Squares Structural Equation Modeling. Results indicate that customer expectations positively affect marketing, process, and organizational innovation but do not significantly influence AI adoption, whereas competitive pressure strongly drives all innovation dimensions, including AI. All internal mechanisms positively impact green innovation decisions, with AI emerging as a strategic enabler. This study applies the stimulus–organism–response (S–O–R) framework to sustainability contexts by integrating AI as an organizational mechanism. It highlights the distinct roles of external pressures, showing that competitive pressure, not customer expectations, is the main driver for technological integration, offering actionable insights for advancing green innovation strategies.

1 | Introduction

The climate crisis and its environmental impacts, such as climate change, biodiversity loss, and resource scarcity, have increased pressure on companies to adopt sustainable innovations (Mi et al. 2026; Sánchez-Sellero and Bataineh 2022). These innovations reduce environmental impact and promote social responsibility (Gomes et al. 2024).

In this scenario, green innovation emerges as a crucial element in promoting sustainable development, with technological and organizational solutions that minimize environmental impacts (Amin et al. 2025; El-Kassar and Singh 2019). Beyond its environmental role, green innovation can also provide firms with a competitive edge by supporting differentiation, improving resource efficiency, and strengthening legitimacy among stakeholders who increasingly value sustainable business conduct (El-Kassar and Singh 2019; Hojnik and Ruzzier 2016). Thus, green innovation should be considered a key element of the United Nations Sustainable Development Goals (SDGs). The 11th (creating sustainable cities and communities) and 12th (promoting responsible consumption and production) (Singh

et al. 2022; Song et al. 2020) are crucial for promoting an ecological organizational identity, environmental commitments, and legitimacy. Thus, the green transition requires the creation of new and valuable ideas for green products, processes, services, and behaviors. Only then can business models be strengthened, management attitudes changed, and finally, a green organizational identity established (Song and Yu 2018). Recent evidence from Spain reinforces this strategic view by showing that green innovation strategies increase the probability that firms enter and remain in export markets, suggesting that environmental innovation may generate advantages that go beyond regulatory compliance and extend to international competitive positioning (Martínez-Ros and Merino 2023). Evidence from Germany also indicates that green innovation-related knowledge spillovers can improve SMEs' productivity, profitability, and export intensity, which suggests that the competitive benefits of green innovation may diffuse through industrial networks rather than remain confined to focal innovators alone (Bryson et al. 2025). At the broader European level, cross-border green research networks have been shown to strengthen green innovation capabilities in European regions, underlining the importance of collaborative learning and interorganizational knowledge exchange in the green transition (Fabrizi et al. 2025).

Alongside green innovation, other approaches have emerged as drivers of sustainability, in particular artificial intelligence (AI), which is increasingly playing a significant role in advancing sustainability (Li and Li 2026). Its tools are used strategically to support decision-making by optimizing processes, reducing waste, and improving energy efficiency, thereby contributing to more sustainable business practices (Ferreira et al. 2023; Zhao and Fariñas 2023). They also offer solutions that improve environmental performance and streamline processes (Rashid et al. 2024), assist in identifying opportunities for ecological innovation, which can decrease energy use and reduce environmental pollution, and even increase financial gains (Qi et al. 2025). Thus, AI positively influences corporate sustainability performance (Jabbour et al. 2025), generates renewable energy gains (Dauvergne 2022), and improves waste and pollution management (Ferreira et al. 2023).

A practical example is Amazon, which used AI to identify and refine packaging solutions based on product shape, available resources, and customer feedback. Amazon scientists trained this AI tool to learn what best serves customers, and as a result, Amazon reduced its use of packaging material (Birch 2024). Examples such as this show that the fusion of AI and sustainability has gained prominence as the most viable path to contributing to better environmental governance. This fusion has contributed to long-term sustainable development in different economic sectors (Nishant et al. 2020). This contribution includes the Member States (MS) of the European Union (EU), other European countries, and regional neighbors that are developing innovation policies to stimulate a strategy of technological transformation combined with sustainability (EIS 2021).

In the Portuguese context, green innovation is also gaining prominence due to growing social pressure on companies to adopt sustainable practices, driven by consumers' environmental awareness (Lopes and Gomes 2022). Data from 2022 show that 73% of Portuguese companies recognize sustainability as a strategic area, 55% have their mission and vision aligned with sustainability commitments, and 52% claim to have implemented green innovation practices and monitor their sustainability strategy (BCSD 2023). However, data from 2024 show that only 17% of Portuguese companies have already adopted AI practices in their decision-making processes, thus highlighting that the integration of sustainability and digital skills represents a significant opportunity for Portugal (ACEPI 2024). At the same time, recent research suggests that the development of green innovation depends strongly on internal organizational conditions rather than on external pressures alone. Evidence from Spanish firms shows that organizational innovation is a significant driver of green innovation (Bataineh et al. 2024). Likewise, evidence from European SMEs indicates that changes in work responsibility and decision-making are among the organizational forms most conducive to eco-innovation (Rodríguez-Rebés et al. 2024). This argument is consistent with the organizational learning literature, which shows that stakeholder pressures are more effectively translated into green product and process innovation when firms develop learning mechanisms to absorb, interpret, and apply environmental knowledge (Zhang and Zhu 2019). Taken together, these studies suggest that learning-oriented organizations are better positioned to convert sustainability pressures into green innovation and, ultimately, into a competitive edge.

The existing literature (Nwachukwu and Vu 2022; YuSheng and Ibrahim 2019) indicates that external factors, such as competitive pressure and customer expectations, play a significant role in how companies innovate and adopt sustainable practices.

However, current knowledge remains fragmented in at least three ways. First, some studies examine external drivers or individual innovation dimensions separately, which makes it difficult to explain how customer expectations and competitive pressure are translated into green decisions through a combination of internal mechanisms (El-Kassar and Singh 2019; Hervas-Oliver et al. 2014; Nwachukwu and Vu 2022). Second, although AI is increasingly discussed as a sustainability enabler, it is rarely incorporated together with marketing, process, and organizational innovation in a single explanatory framework of green innovation-oriented decision-making (Ferreira et al. 2023; Jabbour et al. 2025). Third, the literature still provides limited evidence from contexts such as Portugal, where digital adoption remains comparatively modest and where the perceptions of workers and consumers with professional experience can illuminate how these mechanisms are interpreted in practice. Fourth, although prior studies suggest that organizational learning and organizational innovation help firms transform sustainability pressures into green innovation and stronger competitive positioning, these links are rarely examined together with AI adoption and external market pressures in one integrated explanatory framework, particularly in contexts such as Portugal and other European economies undergoing simultaneous green and digital transitions (Bataineh et al. 2024; Bryson et al. 2025; Rodríguez-Rebés et al. 2024). These gaps highlight the need for an integrated analysis that incorporates both external and internal

factors from the perspective of individuals with practical experience in the labor market, thereby clarifying the pathways through which sustainability-related stimuli shape green decisions in Portuguese companies.

In view of this, this study aims to analyze how external factors (competitive pressure and customer expectations) drive Portuguese companies to implement sustainable practices by influencing internal factors (marketing innovation, process innovation, organizational innovation, and AI adoption), as perceived by consumers with labor-market experience. To this end, a questionnaire was administered, obtaining 394 valid responses from consumers and workers with professional experience in Portuguese companies that incorporate environmental sustainability and innovation practices.

This study has four main contributions. First, it addresses the fragmentation of prior literature by jointly examining customer expectations, competitive pressure, marketing innovation, process innovation, organizational innovation, and AI within one S–O–R model of green innovation-oriented decision-making. Second, it strengthens the theoretical explanation of the phenomenon by treating innovation dimensions and AI as internal mechanisms through which external market stimuli are interpreted and converted into sustainability-oriented responses, rather than as isolated correlates. Third, it extends the literature on green innovation by clarifying the enabling role of organizational innovation and AI in the formation of environmentally oriented decisions, while also engaging with the view that learning-oriented internal arrangements matter for firms' green adaptation. Finally, it provides evidence from Portugal based on the perceptions of individuals with professional experience, thereby adding contextual insight to a research stream still dominated by firm-level and non-Portuguese studies.

2 | Literature Review

2.1 | Theoretical Framework

The S–O–R framework explains behavior as a sequence where external stimuli (S) first act upon an entity, shaping its internal organism (O) state, which then leads to a specific response (R), either approaching or avoiding the situation (Lopes et al. 2026; Vieira 2013). In this model, the organism functions as the bridge between stimulus and response, translating environmental inputs into internal changes such as attitudes, perceptions, and motivations that ultimately drive behavior (Mehrabian and Russell 1974). This model is typically used to predict and explain an individual's behavior in a given situation. In the business context, S–O–R is used to examine how companies respond to external pressures, such as customer expectations and competitive pressures.

The Stimulus (S) refers to external or environmental factors that affect a user's individual psychological or perceptual state (Li et al. 2021), and is an omnipresent indicator in the physical environment (Talwar et al. 2021). In the S–O–R model, stimuli (S) serve as the basis for a series of individual perceptions or psychological and behavioral outputs, which can trigger the individual's cognitive and emotional organism (O) and, subsequently, their behavioral response (R) (Mehrabian and Russell 1974). In the business context, competitive pressure and customer expectations can drive changes in innovation and sustainability.

The organism (O) is understood as the internal process, individual perception or feeling, and the cognitive, psychological, and emotional state of the individual (Duong 2023). It covers a wide range of content, such as attitudes, beliefs, values, motives, and cognitions. Individuals analyze environmental stimuli and use their cognition and emotion to process relevant information before responding to external stimuli (Sun et al. 2021). In the business context, "organism" can involve actions such as AI integration, innovations in marketing, processes, and organizational structure, aiming to respond to the demand for sustainability.

Sultan et al. (2021) define response (R) as the behavioral intention manifested by an individual, based on cognitive and emotional responses, corresponding to the organism's outcome and including intentions of approach or avoidance. Actions or intentions, whether approach or avoidance, can be considered reactive content. When users respond, the influence of the external environment can lead to positive or negative behaviour.

Thus, green innovation-oriented decision-making is conceptualized in this study as the response that follows when firms interpret external sustainability-related pressures and activate internal mechanisms to address them. The S–O–R model has been widely applied in consumer behavior, organizational behavior, marketing, and innovation research to analyze the relationships between external influences, cognitive processes, and emotional behaviors following decision-making (Anić et al. 2023; Le et al. 2025). Yet, in sustainability research, its application often stops at identifying associations, offering less detail on the conversion process that links market pressures to organizational action. This is particularly evident in contexts of green innovation integrated with AI, especially in emerging economies such as Portugal, where cultural, regulatory, and digital-maturity conditions can alter behavioral and organizational dynamics.

This model was chosen for the present study because it explains how external factors (customer expectations and competitive pressure) are perceived by companies and translated into internal mechanisms, including the adoption of AI, process innovation, marketing innovation, and organizational structures. More specifically, customer expectations and competitive pressure are treated as stimuli because they raise the salience of environmental requirements in the market; marketing innovation, process innovation, organizational innovation, and AI are treated as organismic mechanisms because they represent the internal arrangements through which firms interpret, prioritize, and operationalize those requirements; and green innovation-oriented decision-making is treated as the response because it reflects the organization's enacted sustainability choice. This structure provides the theoretical basis for the hypotheses by addressing two linked questions: why should external pressures trigger internal innovation, and how do those internal mechanisms translate pressure into green decisions?

2.2 | Green Innovation and Artificial Intelligence in the Future of Companies

Based on the S–O–R model, this literature review explores how external stimuli (S) impact internal decision-making processes (O) in companies, leading to organizational responses (R) oriented toward sustainability. Sustainability is defined as development that meets the needs of the present without compromising the ability of future generations to meet their own needs (Silvestre and Ţîrcă 2019). In the business context, this sustainability orientation also becomes strategically relevant when green innovation allows firms to differentiate their offerings, improve operational efficiency, and respond more credibly to stakeholder demands, thereby strengthening competitive positioning (El-Kassar and Singh 2019; Hojnik and Ruzzier 2016). Evidence from Spain reinforces this argument by showing that green innovation strategies create incentives for firms to enter new markets and remain persistent in export activities, indicating that the benefits of green innovation extend beyond environmental compliance to firms' international competitive positioning (Martínez-Ros and Merino 2023). In the German context, green innovation also generates broader economic effects, as green knowledge spillovers have been shown to boost SMEs' green innovation, productivity, profitability, and exporting performance, suggesting that green innovation can create a competitive edge not only within focal firms but also along value chains and industrial ecosystems (Bryson et al. 2025). At the broader European level, cross-border green research networks have also been shown to strengthen green innovation capabilities in European regions, highlighting the strategic value of collaboration and knowledge diffusion for environmental innovation (Fabrizi et al. 2025).

In this sense, AI has played a key role in transforming companies' environmentally responsible practices by driving economic growth, improving social well-being, and advancing environmental sustainability (Gandía et al. 2025; Grewal et al. 2021). Additionally, AI is a powerful driver of innovation, transforming industries by optimizing processes, improving decision-making, and enabling entirely new business models (Magistretti et al. 2019). However, the literature reveals a gap in the analysis of how AI interacts with green innovations in specific regional contexts, such as Portugal, where the adoption of digital technologies is still low.

With regard to stimuli (S), the demands of consumers who are increasingly attentive to sustainable consumption stand out, driven by growing environmental concerns and competitive pressure to adopt green practices (ElHaffar et al. 2020). These external pressures reinforce green marketing as a strategic element aimed at satisfying customer needs and generating a competitive advantage (Chen et al. 2024; Zameer et al. 2020). Accordingly, green innovation should be understood not only as a response to environmental expectations, but also as a mechanism through which firms protect and renew their market position (Silvério et al. 2025; Van et al. 2025).

In the field of the organism (O), company employees serve as agents that process these stimuli. This process leads workers to feel the impact of external pressures and, consequently, to align their responsibilities with new organizational requirements, such as the adoption of AI in the organization (Ozen and Ozturk-Kose 2023). AI has been applied to optimize processes, balance environmental responsibility with profitability, reduce waste without increasing costs, and innovate quickly. Thus, companies have implemented transparent green manufacturing and logistics policies, committing to work only with partners who share the same sustainable practices (Kiba-Janiak et al. 2024). Despite these advances, research on how employees perceive and internalize these pressures in low-digital-maturity work environments remains limited. At the same time, recent evidence indicates that internal organizational conditions play a decisive role in the development of green innovation. In Spanish firms, organizational innovation has been shown to promote green innovation directly, confirming that changes in organizational practices are not merely supportive but constitutive of firms' environmental innovation capacity (Bataineh et al. 2024). Similarly, evidence from European SMEs shows that the relationship between eco-innovation and organizational innovation is especially strong when firms innovate in work responsibility and decision-making, suggesting that learning-oriented organizational arrangements are particularly conducive to the development of green innovation (Rodríguez-Rebés et al. 2024). These findings are important for the present study because they indicate that firms do not respond to sustainability pressures through technology alone; they also rely on internal organizational redesign and knowledge-related adaptation to convert such pressures into green innovation outcomes.

In response (R), companies have implemented AI-driven changes. For example, companies such as Adidas and Ikea are using AI algorithms in their production processes to adopt a more sustainable stance, with the replacement of raw materials, the reduction of their carbon footprint, the development of 3D-printed clothing, and the innovation of environmentally conscious products (Laurin and Fantazy 2017; Sheng 2022).

In addition, many companies have turned to social media platforms, particularly TikTok and Instagram, not only to promote products or services but also as part of their institutional communication strategy. Such platforms allow brands to communicate directly with consumers and encourage real-time engagement, thereby fostering an authentic, transparent corporate image (Grewal et al. 2017; Sapag et al. 2023).

Partnerships with social media influencers and the active participation of employees in content creation have become commonplace, sharing the company's day-to-day activities, behind-the-scenes insights, sustainable initiatives, and actions that reflect its values. As a result, companies engage and attract future employees who identify with their values (Sinemus et al. 2025). Additionally, research (Herrmann et al. 2022; Olawade et al. 2024) shows that companies with sustainable practices have gained a larger market share, as consumers are willing to pay a higher price for sustainable products. These outcomes indicate that green innovation can create a competitive edge when firms translate environmental efforts into value that customers recognize and reward. Therefore, AI can transform consumption patterns by promoting more ethical, environmentally responsible, and efficient practices (Borre et al. 2024).

The integration of AI into sustainability is a revolutionary solution to address critical challenges and achieve the United Nations Sustainable Development Goals (SDGs), offering innovative approaches to mitigate environmental impact, create sustainable products, and increase overall efficiency (Alqaralleh 2023). These digital AI technologies play a key and strategic role in facilitating circular economy ambitions, as they accelerate sustainable circular processes. As a result, several companies worldwide are turning to AI technologies to promote circularity, such as using sensors to monitor and maintain products more effectively (Khulbe 2025).

Therefore, AI not only makes processes faster or cheaper, but also helps companies think differently, enabling teams to see connections, test ideas, and solve problems in ways previously unthinkable (Füller et al. 2022). Combined with sustainability, AI has become a catalyst for change, enabling companies to innovate faster and with less waste, anticipate environmental regulations, and meet growing consumer demand for sustainable products (Gandía et al. 2025). In this sense, AI can reinforce the competitive benefits of green innovation by helping firms innovate faster, reduce waste, anticipate regulatory change, and respond more effectively to demand for sustainable products (Füller et al. 2022; Gandía et al. 2025). AI is not just a tool for technology companies, but an opportunity for all sectors. However, the literature lacks studies that examine barriers to AI adoption, limiting understanding of its impact on green innovation. AI can transform sustainability into a competitive advantage. Thus, sustainability should not be seen only as a goal, but rather as a continuous process in which AI serves as a strategic vector for green innovation, aligning technology, sustainability, and competitive advantage within companies.

2.3 | Hypothesis Development

Guided by this logic, the hypotheses are developed as a sequential deduction rather than as independent bivariate expectations. In the first stage, the study argues that external stimuli increase the need for adaptation, legitimacy, and competitive positioning, thereby activating internal innovation mechanisms. In the second stage, it argues that once these mechanisms are activated, they shape the firm's capacity to recognize opportunities, reconfigure routines, and make sustainability-oriented decisions. The following subsections therefore explain both why each relationship is expected and how it operates within the S–O–R sequence.

2.3.1 | Customer Expectations

Customer expectations are preconceived ideas about a product or service that serve as criteria or benchmarks for measuring its efficiency. These perceptions influence how consumers evaluate companies' performance and the services they actually receive (Bebko et al. 2006; Xu et al. 2017). In sustainability contexts, these expectations increase the salience of environmental attributes in market evaluation, meaning that firms are judged not only on functional performance but also on whether their offerings, processes, and conduct are aligned with responsible consumption values (ElHaffar et al. 2020; Reppmann et al. 2025). From an S–O–R perspective, customer expectations operate as a stimulus because they signal what customers consider acceptable, desirable, and legitimate. Firms that perceive these signals are pressured to adapt internally so that sustainability claims are reflected in market-facing actions and operational practices rather than remaining symbolic.

To exceed customer expectations, marketing innovation emerges as a strategic response because sustainability-sensitive customers require visible and credible signals of environmental commitment. Marketing innovation involves the implementation of new promotion methods, products, or services to improve the customer experience and reinforce the company's image (Nwachukwu and Vu 2022; Tran et al. 2025). When firms respond to these expectations through eco-labeling, communication redesign, or sustainability-oriented positioning, they are not simply promoting products; they are adjusting internal market-facing practices to align with what customers value. In this way, customer expectations function as a driver of perceived marketing innovation.

H1. *Customer expectations positively impact perceived marketing innovation.*

Customer expectations can also stimulate process innovation because sustainability-oriented demand is difficult to satisfy through communication alone; it often requires changes in how products are produced, delivered, and recovered. As firms seek to meet expectations for lower waste, safer materials, and responsible production, they are pushed to redesign routines, adopt cleaner technologies, and improve resource efficiency (Garza-Reyes 2015; Hojnik and Ruzzier 2016). Process innovation becomes the operational mechanism that makes sustainability promises feasible, while also helping firms control costs through recycling, reuse, and more efficient resource use (Martínez-Jurado and Moyano-Fuentes 2014).

H2. *Customer expectations positively impact perceived process innovation.*

Consumers have set expectations for companies' socio-environmental behavior, demanding a wide range of sustainable products; this pressure has led companies to adopt sustainable, purposeful decision-making to drive changes in sustainable consumption behavior (Lopes et al. 2024; Reppmann et al. 2025). Thus, green organizational innovation encompasses the creation of new and valuable ideas for green products, processes, services, and behaviors that can strengthen business models and change management attitudes to establish a green organizational identity (Song and Yu 2018).

According to Borsatto and Amui (2019), green organizational innovation reflects compliance with management standards and environmental regulations. Thus, investing in green innovations can boost an ecological organizational identity, environmental commitments, and legitimacy. As a result, the adoption of organizational innovation leads to successful green strategies that optimize the use of organizational resources and coordinate tasks to increase compliance and reduce waste (Sánchez-Sellero and Bataineh 2022).

H3. *Customer expectations positively impact perceived organizational innovation.*

AI has become an important enabler of personalized customer experiences by helping firms manage interactions, interpret data, and tailor services to individual needs (Peruchini et al. 2024). In principle, rising customer expectations may encourage firms to adopt AI because digital tools can improve speed, accuracy, and responsiveness in customer relationship management, including sustainability-related information and service support (Gomes et al. 2025; Nogueira, Lopes, and Gomes 2025).

One practical application is the use of AI-driven chatbots in customer relationship management (Mohamed et al. 2025; Vebrianti et al. 2025). These systems automate communication through text or voice, streamline routine interactions, and support faster responses to customer requests (Miraz et al. 2024). Because customer expectations increasingly include convenience, transparency, and timely support, AI becomes a plausible internal mechanism through which firms attempt to satisfy those expectations more effectively.

From the S–O–R perspective, the mechanism is that customer expectations raise the value of information-rich and responsive systems, thereby making AI adoption more attractive to firms seeking to improve service quality and support more informed, environmentally conscious choices. However, the literature still offers limited evidence on how customer expectations shape perceived AI adoption in green business contexts.

H4. *Customer expectations positively impact perceived AI.*

2.3.2 | Competitive Pressure

Instead of reacting passively, companies often reshape their strategies to remain competitive. When rivals introduce greener products, processes, or technologies, firms face a risk of relative disadvantage in cost, reputation, and legitimacy, which turns competition into a powerful stimulus for change (Hsu et al. 2013; Tran 2025). Competitive pressure is therefore more than general market rivalry; it is a signal that existing routines may no longer be sufficient to protect market position. In sustainability settings, this pressure can trigger multiple forms of internal adaptation because firms seek not only compliance but also differentiation and strategic parity with competitors. This interpretation is reinforced by recent evidence showing that competitive pressure can redirect firms' sustainability efforts toward innovation-oriented responses. In particular, Cenci et al. (2025) show that stronger competitive pressure induces firms to diversify environmental initiatives and increase the relative emphasis placed on innovation capabilities, with positive abatement potential. This is strategically relevant because green innovation is increasingly associated with competitive outcomes. In Germany, Bryson et al. (2025) show that green knowledge spillovers improve SMEs' green innovation, productivity, profitability, and exporting performance, suggesting that firms operating under competitive pressure may pursue environmental innovation not only to respond to rivals but also to protect and strengthen their competitive position.

Marketing innovation is one likely response because competition pushes firms to communicate environmental value more effectively and to reposition brands around sustainability (Pant et al. 2020; Vuong et al. 2024). Green marketing innovation allows firms to make their environmental efforts visible, differentiate their offerings, and defend their reputation in markets where sustainability claims influence customer choice (Borsatto and Amui 2019; Jung et al. 2020). The mechanism is that competitive pressure raises the strategic payoff of being seen as innovative and responsible, thereby encouraging firms to revise marketing practices.

H5. *Competitive pressure has a positive impact on perceived marketing innovation.*

Competitive pressure can also encourage process innovation because firms confronted with rivals' sustainability initiatives must improve efficiency and environmental performance simultaneously (Cenci et al. 2025; Nguyen et al. 2023). Cleaner technologies, redesigned production systems, and resource-saving practices help firms reduce pollution, lower waste, and respond to more stringent market expectations without sacrificing competitiveness (Tian et al. 2023; Xu et al. 2023). In this case, process innovation works as an internal adaptation mechanism that allows firms to answer competitive threats through better operational performance and greener production.

H6. *Competitive pressure positively impacts perceived process innovation.*

Organizational innovation also represents a strategic response to competitive pressure, as it significantly impacts business performance in terms of productivity, delivery times, quality, and flexibility (Atkinson et al. 2022). The pursuit of sustainability within organizations has driven innovation to gain a competitive advantage, developing specific solutions for resource-constrained environments that create a value proposition that can lead to opportunities in such markets (Tian et al. 2023). Evidence indicates that companies with sustainable practices have a positive impact on green innovation (Gomes et al. 2024). Organizational innovation also allows companies to invest in capabilities and resources that enhance their competitive positioning and achieve superior performance, enabling them to reinvest profits in the development of unique capabilities and resources, sustain their competitive advantage, and support decision-making (Lopes et al. 2022; Nogueira et al. 2023). Therefore, companies tend to adopt innovative organizational practices in response to the competitive pressure environment (Fernandes et al. 2021). Recent evidence provides more direct support for this mechanism. In Spanish firms, Bataineh et al. (2024) show that organizational innovation significantly promotes green innovation, indicating that changes in organizational practices are not merely supportive, but part of the mechanism through which firms build environmental innovation capacity. Complementing this finding, evidence from European SMEs shows that innovation in work responsibility and decision-making is the organizational form most conducive to eco-innovation (Rodríguez-Rebés et al. 2024). Taken together, these findings suggest that, under competitive pressure, firms are likely to rely on learning-oriented changes in structures, responsibilities, and decision processes in order to generate green innovations that can sustain competitive edge.

H7. *Competitive pressure positively impacts perceived organizational innovation.*

Most organizations have implemented AI-based technology to sustain competitive advantage (Krakowski et al. 2023). In competitive environments, AI can become attractive because it expands information-processing capacity, improves forecasting, and supports faster and more consistent decisions than conventional routines alone (Mahajan et al. 2025).

In sustainability contexts, this means that firms under competitive pressure may adopt AI to enhance environmental analysis, partner coordination, and decision support, thereby improving both sustainable performance and market responsiveness (Gandía et al. 2025; Jabbour et al. 2025; Zhao and Fariñas 2023). The expected mechanism is that competitive intensity increases the value of AI as a capability that helps firms respond more quickly and intelligently to environmental and market demands.

H8. *Competitive pressure positively impacts perceived AI.*

2.3.3 | Marketing Innovation

Marketing innovation refers to the implementation of new marketing methods that involve significant changes in packaging design, product placement, product promotion, or pricing (Chen et al. 2024). Its relevance for green decision-making lies in the fact that it does not merely publicize existing sustainability efforts; it helps define how environmental value is framed, prioritized, and communicated within the firm. When companies invest in eco-labeling, sustainability-oriented branding, and new forms of stakeholder engagement, they strengthen the internal legitimacy of green initiatives and generate clearer signals about which environmentally responsible actions should be pursued (Alhamad et al. 2023; Borsatto and Amui 2019; Chen et al. 2024). In other words, marketing innovation can convert sustainability from a peripheral message into a concrete strategic criterion in organizational decision-making.

H9. *Perceived marketing innovation positively impacts decision-making on green and sustainable innovation.*

2.3.4 | Process Innovation

Process innovation involves significant changes in production and delivery methods, aiming to maximize production process flexibility, minimize production costs, and improve product quality (Ramadani et al. 2019). It is expected to influence green decision-making because it directly affects the feasibility of environmental action inside the firm. When organizations adopt cleaner technologies, redesign production flows, or improve material and energy efficiency, green choices become easier to implement and less dependent on symbolic commitment alone (Garza-Reyes 2015; Khurshid et al. 2023). Process innovation therefore operates as the practical mechanism through which sustainability objectives are translated into operational routines, which should favor decisions oriented toward green innovation (Liu et al. 2025).

H10. *Perceived process innovation has a positive impact on decision-making regarding green and sustainable innovation.*

2.3.5 | Organizational Innovation

Organizational innovation refers to the transformation of internal structures and workflows, aiming to improve how resources are managed and utilized. It encompasses adjustments in administrative systems, the application of managerial knowledge, and the development of skills that support effective decision-making. These changes enable organizations to operate efficiently and achieve sustainable success (Damanpour et al. 2009). In sustainability contexts, its importance goes beyond administrative efficiency, because changes in structures, managerial systems, and knowledge deployment create the internal conditions through which green innovation can be developed and implemented. By improving coordination, reallocating resources, and embedding environmental objectives in daily routines, organizational innovation helps firms transform sustainability pressures into concrete green products, processes, services, and behaviors (Sánchez-Sellero and Bataineh 2022; Song and Yu 2018). With growing concerns about environmental sustainability and climate change, and increasing regulatory and social pressures, organizations must adopt green practices across their internal structures and processes (Ali et al. 2024). Recent empirical evidence strengthens this argument by showing that organizational innovation is not only complementary to green innovation, but one of its direct drivers. In Spanish firms, Bataineh et al. (2024) show that organizational innovation significantly promotes green innovation, indicating that changes in internal structures and managerial arrangements are part of the mechanism through which firms build environmental innovation capacity. At the European level, Rodríguez-Rebés et al. (2024) also find that the relationship between eco-innovation and organizational innovation is particularly strong when firms innovate in work responsibility and decision-making, suggesting that internal redesign in how people coordinate, decide, and assume responsibilities is especially conducive to the development of green innovation in SMEs.

In this context, green transformational leadership is a key factor, as it motivates employees to adopt sustainable practices (Abourokbah et al. 2024) and increases employees' green creativity (Begum et al. 2022). This suggests that organizational innovation also has a learning-oriented role: when firms encourage employee participation, develop green skills, and create conditions for shared problem-solving, they become better able to generate and absorb green ideas across the organization. By creating an environment that values employee participation, the process of sustainability-oriented decision-making is facilitated, and the importance of involving the team in environmentally responsible actions to achieve long-term sustainability and improve organizational performance and overall competitiveness is emphasized (Ahmed et al. 2023; Nogueira, Gomes, and Lopes 2025; Tian et al. 2023). This learning-oriented perspective is consistent with the organizational learning literature. Zhang and Zhu (2019) show that stakeholder pressures are more effectively translated into green product and green process innovation when firms develop organizational learning capabilities. Their findings suggest that firms do not convert environmental pressures into green

innovation automatically; rather, they do so through internal learning processes that help absorb, interpret, and apply environmental knowledge. In this sense, organizational innovation can be understood as a structural and managerial expression of a learning organization, because it creates the routines, coordination mechanisms, and decision environments through which green ideas can be generated, shared, and implemented.

Therefore, organizational innovation does not merely accompany green innovation; it supports its development by aligning leadership, participation, and internal coordination around environmental goals, while also strengthening long-term organizational performance and competitiveness (Ahmed et al. 2023; Gomes et al. 2023; Tian et al. 2023). Accordingly, organizational innovation should be seen not only as an internal adjustment to sustainability demands, but also as a mechanism through which firms build learning capacity, strengthen green innovation, and improve their competitive position. This is particularly relevant in the present study, because it supports the expectation that firms perceiving stronger organizational innovation will also show stronger green and sustainable innovation-oriented decision-making.

H11. *Perceived organizational innovation positively impacts decision-making for green and sustainable innovation.*

2.3.6 | Artificial Intelligence

Companies have used AI as a strategic tool to drive sustainability (Schwaeke et al. 2025). AI is used to promote a strong green culture, improve supply chain management, support process control, and help firms obtain more value from green innovation (Ferreira et al. 2023; Wamba et al. 2024). Its theoretical relevance in this study is that AI increases the firm's capacity to collect, process, and interpret information that would otherwise be too complex or too dispersed for timely sustainability decisions.

As AI systems are implemented in environmental decision-making, they can improve transparency, forecasting, accountability, and the identification of opportunities for more sustainable action (Aljohani 2025; Jabbour et al. 2025; Vinuesa et al. 2020). The mechanism is therefore analytical and coordinative: AI helps organizations evaluate environmental alternatives, anticipate impacts, and support greener choices with better information. In contexts of low technological adoption, this relationship still requires more evidence, but the literature suggests that perceived AI should positively influence green and sustainable decision-making.

H12. *Perceived artificial intelligence positively impacts decision-making for green and sustainable innovation.*

Figure 1 shows the research model used in this study.

3 | Methodology

3.1 | Data Collection

The data collection instrument employed in this quantitative research was a structured questionnaire designed based on validated scales from the literature and carefully adapted to the Portuguese business context, with an emphasis on green innovation and artificial intelligence. The content and format of the questionnaire items were directly adapted from the measures presented in Mahboub and Ghanem (2024) and Tran et al. (2025), ensuring that the operationalization of each construct aligned with both recognized international standards and previous empirical research. The use of a structured questionnaire as the primary data collection instrument is consistent with established practice in green innovation and AI adoption research, where survey-based measures have been widely employed to capture managers' and professionals' perceptions of external pressures and internal organizational responses (Mahboub and

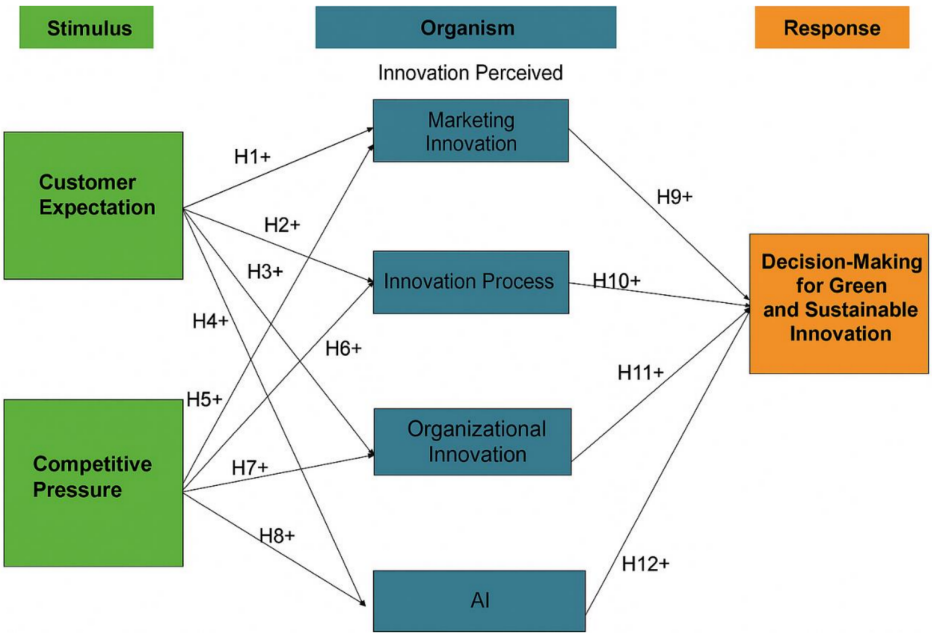

FIGURE 1 | Research model.

Ghanem 2024; Nwachukwu and Vu 2022; Tran 2025). This approach is also aligned with the operationalization of S–O–R models in organizational contexts, where individual and professional perceptions serve as the unit of analysis (Lopes et al. 2026; Talwar et al. 2021).

The questionnaire comprised two central sections. The initial section collected information on the sociodemographic background of respondents, which included gender, age, education, region, and monthly net income. The second section addressed the main dimensions of the theoretical model and consisted of seven latent constructs. These constructs were Customer Expectations (CE) composed of five items, Competitive Pressure (CP) comprising eight items, Perceived Marketing Innovation (PMI) described by seven items, Perceived Process Innovation (PPI) consisting of five items, Perceived Organizational Innovation (POI) measured through six items, Artificial Intelligence (AI) comprising six items, and Firm Innovation Decision-Making (FID) measured by seven items.

A pretest was conducted with a group of twenty participants, including employees and students from multiple professional backgrounds, aiming to evaluate the clarity, coherence, and average completion time of the instrument. Based on their feedback, minor revisions were introduced into the wording and the sequence of specific questions, which resulted in a final version that was both concise and readily comprehensible.

The data collection phase took place between June and September of 2025 and was predominantly carried out through digital platforms, including Facebook, LinkedIn, Reddit, and professional WhatsApp groups. Participation was voluntary and anonymous. The mean completion time for the full questionnaire was approximately 7 minutes.

In total, 394 valid responses were collected from consumers and workers with professional experience in Portuguese companies that incorporate environmental sustainability and innovation practices.

The adequacy of the sample size ($N = 394$) was evaluated against multiple criteria. Following the minimum sample size guidelines proposed by Hair et al. (2019) for PLS-SEM, the recommended threshold corresponds to 10 times the largest number of structural paths directed at any single endogenous construct. In this model, the construct with the greatest number of predictors is Firm Innovation Decision-Making (FID), which receives four direct antecedents, yielding a minimum requirement of 40 observations, a threshold substantially exceeded by the present sample. Additionally, a statistical power analysis was conducted using the General Linear Model power analysis procedure in Jamovi (v2.7.12.0), assuming a medium effect size ($p\eta^2 = 0.130$, equivalent to $f^2 = 0.149$), a significance level of $\alpha = 0.05$, and four predictors. With $N = 394$, the achieved statistical power reached 1.000, confirming that the sample provides more than adequate power for reliable parameter estimation and hypothesis testing within the proposed structural model. As a result, the final sample included respondents from a diverse range of organizations and sectors distributed throughout Portugal. This diversity contributed to the representativeness of the sample and facilitated comparative analyses between companies of various sizes and different regional contexts.

3.2 | Data Analysis

Statistical analysis began with an examination of the constructs included in the research model and the specific items associated with each construct. The software SPSS version 29 was used to conduct initial data exploration and descriptive statistics. Hypotheses formulated within the research framework were subsequently tested using the partial least squares method, which was executed with software SmartPLS version 4.1.1.5. This approach represents an advanced multivariate technique that combines statistical analysis with regression modeling.

The choice of PLS-SEM as the primary analytical method is theoretically grounded in the nature of the S–O–R framework adopted in this study. PLS-SEM is particularly suited to models with composite causal chains between latent constructs, an exploratory-predictive orientation, and non-normally distributed data (Hair et al. 2019; Sarstedt et al. 2024). Unlike covariance-based SEM, which requires strict distributional assumptions and is more appropriate for confirmatory purposes, PLS-SEM optimizes the relationships between latent variables and their indicators while remaining robust under violations of normality, a condition consistent with survey-based Likert-scale data. Moreover, PLS-SEM has been widely employed in green innovation and sustainability research as well as in studies examining AI adoption in organizational contexts (Mahboub and Ghanem 2024; Nwachukwu and Vu 2022; Tran 2025), which further supports its appropriateness for the present investigation. The model structure tested here, with two exogenous constructs predicting four mediating mechanisms, which in turn predict a single outcome, is well within the analytical scope of PLS-SEM, particularly given the exploratory nature of integrating AI as an organismic mechanism within the S–O–R framework in a sustainability context where established theoretical benchmarks are still developing.

First, the statistical characteristics of both the model constructs and their respective items were explored. Next, the reliability and validity of the measurement instruments were assessed. The third phase involved testing the structural model and the hypotheses through a bootstrapping procedure combined with multiple linear regression estimation. Bootstrapping is a non-parametric method for evaluating the significance of the path coefficients estimated in PLS structural equation modeling. This approach creates subsamples by randomly drawing observations, with replacement, from the original dataset, and each subsample is then used to estimate the structural path model. In this study, 10,000 distinct bootstrap samples were created, and the resulting parameter estimations were used to generate 95% confidence intervals, which supported rigorous significance testing of the research hypotheses.

4 | Results and Discussion

4.1 | Statistical Description of the Sample

With regard to gender, female respondents constitute 50.8% of the sample, while males represent 48.7%. Only 0.5% of participants identify with an alternative gender. This balanced distribution

TABLE 1 | Sociodemographic profile of the sample.

Category	Frequency	Percentage
Gender		
Female	200	50.8%
Male	192	48.7%
Other	2	0.5%
Age range		
< 25	210	53.6%
25–34	120	30.6%
35–44	36	9.2%
45–54	16	4.1%
≥ 55	10	2.6%
Education		
Secondary or lower	47	11.9%
Bachelor's degree	164	41.6%
Master's degree	142	36.0%
Doctorate	41	10.4%
Region		
Centro	156	39.6%
Norte	130	33.0%
Lisbon Metropolitan Area	74	18.8%
Alentejo	16	4.1%
Algarve	10	2.5%
Açores	6	1.5%
Madeira	2	0.5%

of gender provides a robust basis for interpreting findings across demographic groups.

The sample is composed predominantly of respondents below 25 years old, who represent 53.6% of participants. Additionally, 30.6% are aged between 25 and 34 years, 9.2% are in the 35–44 age group, and 4.1% are between 45 and 54 years old. Only 2.6% of the total sample is aged 55 or above. This age distribution underscores a strong representation of younger and early-career adults in the research. The sociodemographic profile of the study is summarized in Table 1.

In terms of education, a substantial majority holds higher education qualifications. Specifically, 41.6% possess a bachelor's degree, and 36.0% completed a master's degree, whereas 11.9% report secondary or lower education and 10.4% have obtained a doctorate (see Table 1). This high educational level aligns with the study's focus on business innovation and sustainability.

Geographically, respondents are distributed across all major regions of Portugal. The Centro region comprises 39.6% of the sample, followed by the Norte with 33.0%, the Lisbon Metropolitan Area accounts for 18.8%, while Alentejo and Algarve make up 4.1% and 2.5% respectively. A minority of participants are based in the Azores (1.5%) or Madeira (0.5%). Together, these proportions confirm strong national coverage and reinforce the external validity of the sample.

4.2 | Measures of Reliability and Validity of the Model

A confirmatory factor analysis (CFA) was conducted to confirm the reflective nature of the measurement model, in which each construct is assumed to be the common cause of its observed indicators (Hair 2014). Latent variables, such as Customer Expectations (CE), Competitive Pressure (CP), Perceived Marketing Innovation (PMI), Perceived Process Innovation (PPI), Perceived Organizational Innovation (POI), Artificial Intelligence (AI), and Firm Innovation Decision-Making (FID), were all measured using their dedicated observed variables, ensuring that the indicators do not exert direct causal effects over the constructs.

All retained indicators exhibited satisfactory factor loadings, with the exception of four items that were excluded from the model due to low loadings: CP1, with a loading of 0.569; FID1, with a loading of 0.600; POI1, with a loading of 0.592; and POI7, with a loading of 0.590. This process ensured that each construct was measured exclusively by robust indicators, in line with best practices and the guidelines set forth by Hair (2014).

The model fit to the data was excellent and met the reference values suggested by Hair (2014). The model demonstrated a very good fit to the data, as indicated by GFI = 0.964, CFI = 0.953, and IFI = 0.978, all of which are above the recommended threshold of 0.90. Additionally, the RMSEA was 0.063, remaining well below the accepted cut-off value of 0.08.

Reliability was confirmed by Cronbach's alpha (Ca > 0.70), composite reliability (CR > 0.70), and average variance extracted (AVE > 0.50) for each construct. The values observed in this study (e.g., CR and AVE above the reference values for all constructs) support the internal consistency and convergent validity of the scales.

Discriminant validity was examined using the Fornell-Larcker criterion, with results showing that for all constructs the square root of the AVE (diagonal) exceeded the correlations with other latent variables (off-diagonal), confirming discriminant validity. Table 2 summarizes all reliability, convergent, and discriminant validity indices for each construct and item of the measurement model.

Regarding predictive relevance, the PLSpredict procedure yielded Q^2 values above zero for all endogenous constructs, indicating meaningful predictive capability of the model (Q^2: AI = 0.211, PMI = 0.589, POI = 0.448, PPI = 0.403, FID = 0.473). In terms of explanation, the model showed substantial explanatory power, with the following R^2 values for the main endogenous constructs: AI = 0.241, FID = 0.707, PMI = 0.600, POI = 0.526, and PPI = 0.418.

4.3 | Research Model Testing

We tested the relationships presented in our model through bootstrapping. Figure 2 presents the results.

Except for H4, according to which customer expectations would increase perceived artificial intelligence, all other hypotheses

TABLE 2 | Evaluation of the model reliability and validity.

Variables	Factor loads	Ca	CR	AVE	CE	CP	PMI	PPI	POI	AI	FID
Customer expectations (CE)		0.795	0.858	0.549	0.741						
CE1	0.671										
CE2	0.774										
CE3	0.767										
CE4	0.743										
CE5	0.744										
Competitive pressure (CP)		0.852	0.884	0.491		0.701					
CP2	0.731										
CP3	0.799										
CP4	0.762										
CP5	0.653										
CP6	0.731										
CP7	0.672										
CP8	0.660										
Perceived marketing innovation (PMI)		0.827	0.868	0.485			0.697				
PMI1	0.606										
PMI2	0.734										
PMI3	0.710										
PMI4	0.760										
PMI5	0.754										
PMI6	0.649										
PMI7	0.646										
Perceived process innovation (PPI)		0.741	0.827	0.490				0.700			
PPI1	0.660										
PPI2	0.757										
PPI3	0.663										
PPI4	0.699										
PPI5	0.716										
Perceived organizational innovation (POI)		0.769	0.844	0.520					0.721		
POI2	0.645										
POI3	0.693										
POI4	0.671										
POI5	0.748										
POI6	0.702										
Artificial intelligence (AI)		0.906	0.922	0.599						0.774	
A1	0.620										
A2	0.736										
A3	0.803										
A4	0.785										
A5	0.815										
A6	0.779										
Firm innovation decision-making (FID)		0.801	0.856	0.498							0.706
FID2	0.711										
FID3	0.702										
FID4	0.657										
FID5	0.675										
FID6	0.698										
FID7	0.728										

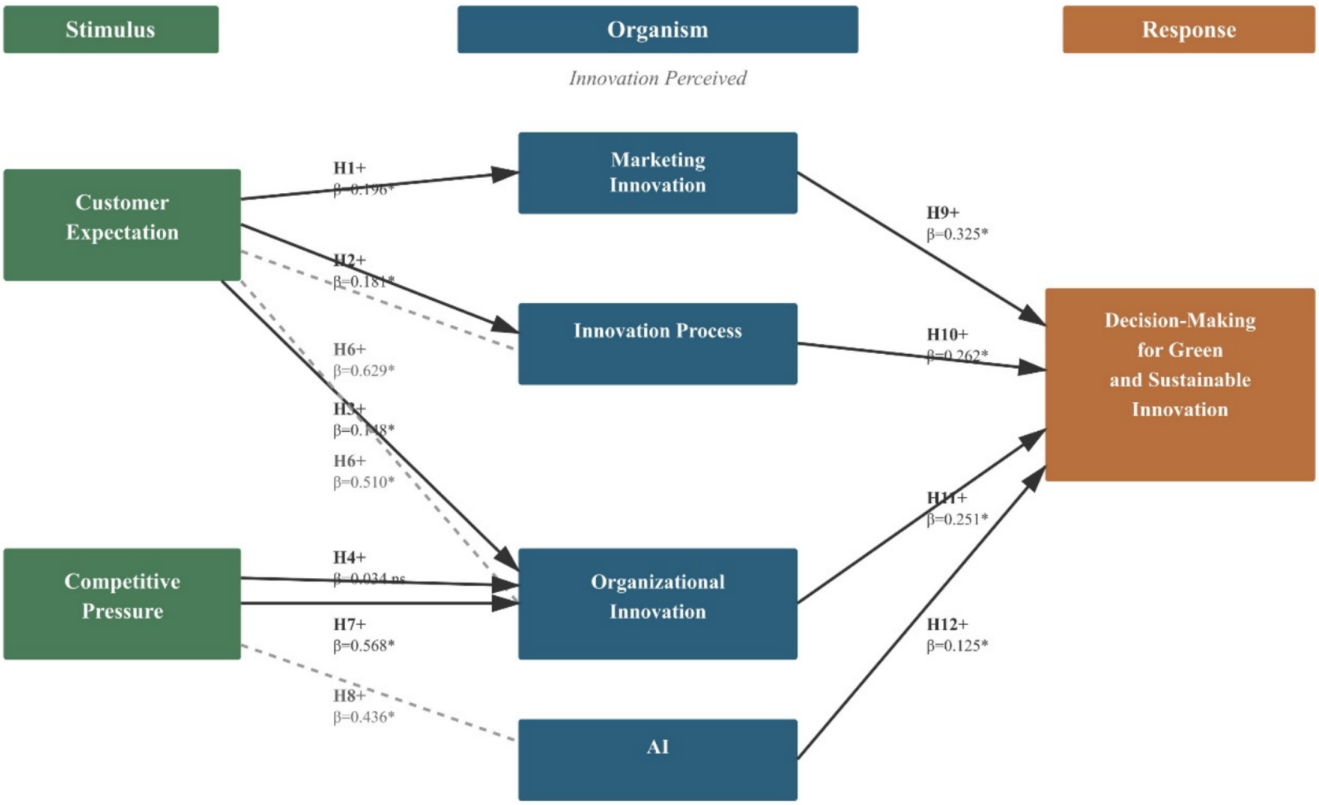

FIGURE 2 | Results of the research model and hypothesis testing via bootstrapping. *$p < 0.001$. $N = 394$. Coefficient estimates generated with 10,000 bootstrap iterations.

in the model were supported. Customer expectations raised perceived marketing innovation ($\beta = 0.196$), perceived process innovation ($\beta = 0.181$), and perceived organizational innovation ($\beta = 0.148$), but had no significant effect on perceived artificial intelligence ($\beta = 0.034$ and $p = 0.603$). Competitive pressure strengthened perceived artificial intelligence ($\beta = 0.448$) and increased perceived marketing innovation ($\beta = 0.629$), perceived process innovation ($\beta = 0.510$), and perceived organizational innovation ($\beta = 0.568$). Regarding decision-making for green and sustainable innovation, the effects were positive and significant for perceived marketing innovation ($\beta = 0.325$), perceived process innovation ($\beta = 0.266$), and perceived organizational innovation ($\beta = 0.251$).

5 | Discussion and Implications

5.1 | Discussion of Results

This section discusses the main findings of the study in relation to the research questions and the existing literature. Specifically, the analysis addresses how external market pressures, particularly customer expectations and competitive pressure, shape internal innovation mechanisms and the adoption of artificial intelligence, and how these elements influence firms' decision-making toward green innovation. By examining the interplay between marketing, process, and organizational innovation together with AI adoption, this study clarifies the mechanisms through which companies translate external sustainability pressures into concrete innovation strategies. In doing so, the findings contribute to understanding how firms can transform market demands for sustainability into competitive advantages through green innovation practices.

The results confirm the strong relevance of external factors, customer expectations, and competitive pressure as stimuli (S) that significantly shape companies' internal mechanisms (O), namely marketing, process, and organizational innovation, as well as the adoption of artificial intelligence (AI). In line with the S–O–R theory, these stimuli triggered internal reactions that materialize into responses (R) oriented toward green and sustainable innovation. Organizational innovation also emerges as a critical enabling mechanism for the successful implementation of green innovation initiatives. Changes in organizational structures, managerial practices, and knowledge-sharing processes can facilitate the integration of sustainability objectives into business strategies. Prior research indicates that organizations with flexible structures and strong learning capabilities are better able to adapt to environmental challenges and develop innovative solutions that support sustainability goals. Therefore, organizational innovation can function as a foundational element that supports the development and diffusion of green innovation within firms (Hervas-Oliver et al. 2014; Ansari et al. 2026).

This finding reinforces the perspective of the organizational learning literature, which argues that firms characterized as

"learning organizations" are more capable of sensing, assimilating, and applying environmental knowledge, thereby strengthening their green innovation performance (Singh et al. 2020). In this sense, organizational innovation should not be interpreted only as structural change, but as a manifestation of dynamic capabilities that enable firms to continuously reconfigure resources and sustain competitive advantage in turbulent and sustainability-oriented markets (Bulo et al. 2026).

First, customer expectations emerged as a decisive driver of internal organizational changes. This finding corroborates prior literature highlighting consumers' central role in shaping sustainable practices (Reppmann et al. 2025; Roxas 2022). However, contrary to expectations, customer expectations did not have a significant effect on AI adoption, indicating that client pressure alone is not sufficient to drive technological integration in green practices. On the other hand, expectations positively influenced marketing, process, and organizational innovations, suggesting that companies respond to environmental demands from customers through adjustments in these areas.

This result is consistent with evidence from European contexts, where customer-driven sustainability pressures tend to first influence visible and market-facing innovations (Haqqani et al. 2026), while more complex technological investments, such as AI adoption, are often contingent on strategic considerations and competitive dynamics rather than direct customer demand (Fatima et al. 2026). This helps explain why customer expectations alone may be insufficient to trigger deeper digital transformation processes (Gomes et al. 2025).

Second, competitive pressure was also found to activate internal innovation mechanisms significantly. Its positive effect on the three types of innovation: marketing, process, and organizational confirms that companies strategically adjust their practices to maintain or improve their position in competitive markets (Hafeez et al. 2025; Tian et al. 2023). Moreover, competitive pressure had a significant impact on AI adoption, indicating that organizations increasingly view AI as a strategic resource for boosting efficiency, supporting environmental forecasting, and responding to new market demands.

This finding strongly supports the argument that green innovation is closely linked to competitive advantage (Chen et al. 2024; Krakowski et al. 2023). Empirical evidence from countries such as Spain shows that firms engaging in green innovation are more likely to sustain export performance and international competitiveness (Martínez-Ros and Merino 2023), while studies in Germany highlight that green knowledge spillovers enhance productivity and profitability among SMEs (Bryson et al. 2025). At the European Union level, collaborative green innovation networks further reinforce firms' capacity to innovate and compete globally (Bulo et al. 2026). Together, these findings confirm that competitive pressure not only triggers innovation but also directs firms toward environmentally sustainable strategies as a means of differentiation and market positioning. Third, the findings show that all internal mechanisms, marketing innovation, process innovation, organizational innovation, and AI adoption, positively influence decision-making oriented toward green innovation. This pattern aligns with studies associating structured internal practices with improved environmental performance (Chen et al. 2024; Ferreira et al. 2023). Mainly, AI emerged as a strong antecedent of green decisions, highlighting that companies recognize its value not merely as a digital tool but as a key enabler of sustainability, capable of optimizing resources, supporting strategic decision-making, and enabling eco-innovative business models.

From a strategic perspective, these results suggest that the combination of technological capabilities, such as AI and organizational capabilities, such as learning, coordination, and innovation practices, creates complementarities that enhance firms' ability to generate green innovation (Bulo et al. 2026). This reinforces the idea that competitive advantage in sustainability contexts is not derived from isolated investments, but from the integration of multiple innovation dimensions within the firm (Fatima et al. 2026).

Overall, the results reveal a transparent chain of influence, external stimuli, internal innovative mechanisms, and sustainable decision-making, validating the robustness of the S–O–R model in explaining green innovation dynamics in Portugal. Furthermore, by analyzing the perceptions of workers and consumers with professional experience, this study provides contextual depth and captures the practical realities of sustainable innovation in Portuguese companies. Overall, the findings reinforce the idea that green innovation can serve as a source of competitive advantage for firms operating in increasingly sustainability-oriented markets. Companies that effectively respond to external pressures by adopting innovative practices and leveraging digital technologies such as artificial intelligence are better positioned to improve their environmental performance while maintaining market competitiveness. This perspective aligns with the growing body of literature emphasizing that sustainability-driven innovation can simultaneously generate environmental and economic value (Martín-Rojas et al. 2026).

5.2 | Theoretical Implications

This study contributes to the literature by clarifying how external market pressures are translated into internal innovation mechanisms that support green innovation decisions. By integrating customer expectations, competitive pressure, internal innovation practices, and artificial intelligence adoption into a single analytical framework, the research advances the understanding of how firms respond strategically to sustainability-related demands. In particular, the findings extend previous studies of Hojnik and Ruzzier (2016) and Martín-Rojas et al. (2026) on eco-innovation by demonstrating that the interaction between different types of innovation, marketing, process, and organization plays a relevant role in shaping firms' capacity to pursue environmentally oriented innovation strategies.

Moreover, this study responds directly to recent calls in JCR-indexed literature for more integrative frameworks that connect external pressures, internal capabilities, and sustainability outcomes. By combining these elements within the S–O–R model, the research contributes to bridging fragmented streams of literature that have traditionally examined these relationships in isolation.

Furthermore, this study contributes to the literature on learning organizations and sustainable innovation by suggesting that firms capable of adapting their internal processes and knowledge structures are more likely to transform external pressures into opportunities for green innovation. This reinforces the argument that organizational learning and innovation capabilities are essential for firms seeking to achieve long-term competitive advantages through sustainability-oriented strategies.

In particular, the findings strengthen the theoretical link between organizational learning, green innovation, and competitive advantage (Fatima et al. 2026). Firms that develop learning-oriented structures characterized by knowledge sharing, cross-functional collaboration, and adaptive decision-making are better equipped to absorb environmental knowledge and translate it into green innovation outcomes (Ansari et al. 2026). This process, in turn, enhances their ability to achieve sustained competitive advantage, supporting the view that learning capabilities are a central mechanism connecting sustainability and firm performance (Lopes et al. 2022; Nogueira et al. 2023).

This study advances theoretical understanding in three main ways. First, it reinforces the applicability of the S–O–R model to corporate sustainability contexts, demonstrating that external market factors (S) significantly influence internal mechanisms (O) that guide sustainable innovation responses (R). Although the model is well established in consumer behavior and marketing research, its integrated application to explain green innovation combined with AI remains limited. This study extends that boundary by empirically demonstrating how environmental stimuli are internally interpreted and transformed into sustainable decisions.

Additionally, by embedding green innovation within the S–O–R framework, the study contributes to sustainability research by showing that environmental strategies are not only reactive responses to external pressures but are mediated by internal cognitive, organizational, and technological processes. This perspective aligns with recent theoretical developments emphasizing the role of micro-foundations and internal capabilities in sustainability transitions.

Second, the study integrates internal innovation dimensions (marketing, process, and organizational) and AI as mediators within the S–O–R framework. This is theoretically innovative because it positions AI simultaneously as a technological practice and an organizational mechanism that strengthens companies' capacity to respond to external pressures. However, contrary to expectations, customer expectations did not significantly influence AI adoption, which represents an important nuance and suggests that competitive pressure is the primary external driver for technological integration. This finding adds depth to theoretical discussions on the digital–sustainability interface. This result also contributes to the literature by differentiating the roles of distinct external drivers. While customer expectations appear to influence more incremental and market-oriented innovations, competitive pressure emerges as the key driver of more complex and resource-intensive transformations, such as AI adoption. This distinction refines existing theories by highlighting that not all external pressures exert the same influence on technological and organizational change. Third, the study adds empirical evidence to current discussions about the role of individual perceptions in sustainable innovation research. While traditional literature focuses mainly on organizational-level analyses, our findings highlight that workers' perceptions, which represent the lived cognitive and emotional states that constitute the "organism," are essential for understanding the internal dynamics preceding sustainable decision-making. This provides a micro-foundational contribution to corporate sustainability studies. Finally, by incorporating evidence from the European context, including insights consistent with findings from Spain, Germany, and broader EU innovation systems, the study contributes to the geographical diversification of the literature. This is particularly relevant given that much of the existing research is concentrated in non-European contexts, thereby reinforcing the importance of regional institutional and competitive environments in shaping green innovation dynamics.

5.3 | Practical Implications

The results also provide relevant insights for managers and practitioners seeking to promote sustainability-oriented innovation within their organizations. The findings suggest that firms should pay close attention to evolving customer expectations and competitive dynamics, as these external pressures can serve as important signals guiding the development of internal innovation capabilities. Managers can leverage these signals to redesign organizational processes, invest in digital technologies such as artificial intelligence, and foster a culture that supports experimentation and sustainability-oriented innovation.

Moreover, the results indicate that strengthening organizational innovation practices may facilitate the integration of sustainability objectives into corporate strategies. By encouraging cross-functional collaboration, knowledge sharing, and continuous learning, firms can enhance their ability to develop and implement green innovation initiatives that improve both environmental performance and market competitiveness.

The findings offer important practical implications for managers, policymakers, and organizations seeking to strengthen their sustainability strategies. For companies, the results show that investing in internal innovation mechanisms is an effective and strategic response to external market stimuli. Marketing innovation helps communicate environmental values, attract new segments, and reinforce a sustainable brand image. Process innovation reduces waste, increases efficiency, and lowers resource and energy costs. Organizational innovation enables team alignment, structural adjustments, and the creation of a sustainability-oriented culture. AI adoption proves particularly critical, but the results indicate that competitive pressure, not customer expectations, is the main driver for its integration. This suggests that companies should anticipate market competition and invest in AI as a strategic resource for sustainability. AI-based tools support environmental impact assessments, identify opportunities for energy reduction, optimize supply chains, and forecast environmental risks. Thus, AI becomes a cross-cutting driver of sustainability. Organizations should not only acquire technology but also invest in training and capacity building to maximize its benefits.

For policymakers, the findings highlight that public policies promoting AI adoption, business innovation, and sustainable practices can empower companies to respond more effectively to consumer and competitive pressures. Tax incentives, digital upskilling programs, and investment in technological infrastructure can accelerate Portugal's ecological and digital transition.

5.4 | Limitations and Future Lines of Research

Despite the contributions of this study, several limitations should be acknowledged. First, the empirical analysis relies on a specific sample, which may limit the generalizability of the findings to other contexts or industries. Although the sample size is consistent with similar studies in the innovation and sustainability literature, future research could expand the dataset to include firms from different sectors or countries in order to validate and extend the results. Additionally, future studies could explore the role of other organizational capabilities, such as knowledge management practices or learning mechanisms, in strengthening the relationship between external pressures and green innovation outcomes.

This study presents several limitations that open avenues for future research. This questionnaire was administered, obtaining 394 valid responses from consumers and workers with professional experience in Portuguese companies that incorporate environmental sustainability and innovation practices. Second, the cross-sectional design limits the ability to establish temporal causality. Future studies could adopt longitudinal approaches to capture how external stimuli and internal innovation mechanisms evolve over time. Third, although the sample is robust, it is restricted to the Portuguese context, characterized by moderate levels of digital maturity. Comparative studies across countries with different technological and regulatory environments could examine the generalizability of the S–O–R model.

Fourth, despite integrating workers' perceptions, the study does not differentiate between organizational hierarchy levels. Future research could investigate differences between managers, technical staff, and frontline employees to understand how organizational structure shapes the interpretation of external stimuli.

Finally, AI was treated as a unidimensional construct. Further studies could decompose it into more specific categories, such as predictive AI, automation, data analytics, and energy-efficiency AI, to deepen the understanding of how different forms of AI influence green innovation.

6 | Conclusion

This study provides an integrated analysis of how external stimuli, namely customer expectations and competitive pressure, are associated with internal innovation mechanisms and, in turn, with decision-making oriented toward green and sustainable innovation in Portuguese companies. Grounded in the S–O–R framework, the findings show that external market pressures matter because they increase the need for organizational adaptation, legitimacy, and competitive positioning, thereby encouraging firms to adjust their internal practices rather than remain passive in the face of sustainability demands.

More specifically, the results indicate that customer expectations positively influence perceived marketing, process, and organizational innovation, whereas competitive pressure positively influences marketing, process, organizational innovation, and AI adoption. In contrast, customer expectations do not significantly affect AI adoption. This pattern suggests that external pressures do not activate all internal mechanisms in the same way. While customer expectations appear to stimulate organizational and innovation-related adjustments that are more directly visible to the market and embedded in routines, AI adoption seems to depend more strongly on competitive dynamics and the strategic need to enhance efficiency, forecasting, and responsiveness.

The findings also clarify how internal mechanisms translate external pressures into green decisions. Marketing innovation, process innovation, organizational innovation, and AI all positively influence decision-making for green and sustainable innovation. This means that external pressures are not converted into green decisions automatically; rather, they are translated through internal mechanisms that shape how firms communicate environmental value, redesign operations, coordinate resources and people, and process complex information. In this sense, the study shows that green decision-making is enabled by the firm's ability to transform market signals into concrete organizational capabilities and practices.

Among these mechanisms, AI plays a particularly relevant role, as it emerged as a strong antecedent of green-oriented decision-making. At the same time, the results underline the importance of organizational innovation, since sustainable decisions depend not only on technology or market communication, but also on internal coordination, structures, and routines that support the development and implementation of green practices. Therefore, the findings suggest that green innovation should be understood not merely as an environmental response, but as the outcome of a structured internal transformation through which firms interpret and act upon external sustainability-related demands.

Overall, this study contributes to the literature by showing that the relationship between external pressures and green innovation-oriented decision-making is neither simple nor direct. Instead, it is explained by a chain of influence in which market stimuli activate distinct internal innovation mechanisms, and these mechanisms, in turn, support environmentally oriented decisions. By providing evidence from Portugal, the study also adds contextual insight to current debates on sustainability, innovation, and AI in business. In practical terms, the results suggest that firms seeking more effective green decisions should not focus exclusively on external pressures themselves, but on building the internal innovation capabilities through which those pressures can be translated into meaningful and sustained action.

Funding

This work is supported by national funds, through the FCT – Portuguese Foundation for Science and Technology under the project UIDB/04011/2025 (https://doi.org/10.54499/UID/04011/2025).

Consent

Consent was obtained from all the participants involved in the study. We attest to the fact that all authors have contributed significantly to the work, have read the manuscript, attest to the validity and legitimacy of the data and their interpretation.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

References

Abourokbah, S., S. Bajaba, and M. Z. Yaqub. 2024. "Leading the Green Wave: How and When Green Transformational Leadership Cultivates Employee Green Creativity." *Acta Psychologica* 250: 104503. https://doi.org/10.1016/j.actpsy.2024.104503.

ACEPI. 2024. "17% das Empresas Portuguesas Já Utilizam Inteligência Artificial." Revista Do Empreendedor. https://www.empreendedor.com/17-das-empresas-portuguesas-ja-utilizam-inteligencia-artificial/.

Ahmed, Z., M. Khosa, S. U. Rehman, and A. F. Omar Faqera. 2023. "Towards Sustainable Development in the Manufacturing Industry: Does Green Human Resource Management Facilitate Green Creative Behaviour? A Serial Mediation Model." *Journal of Manufacturing Technology Management* 34, no. 8: 1425–1447. https://doi.org/10.1108/jmtm-03-2023-0106.

Alhamad, A. M., M. Akyürek, S. A. Mohamed, and A. M. S. Baadhem. 2023. "Do the Relationship Between Green Marketing Strategies, Green Perceived Value, and Green Trust Enhance Green Purchase Intentions: A Conceptual Study." *International Journal of Scientific and Management Research* 6, no. 7: 176–203. https://doi.org/10.37502/IJSMR.2023.6711.

Ali, A., L. Ma, M. Shahzad, and S. Hussain. 2024. "Managing Stakeholder Pressure for Megaproject Success and Green Innovation: The Key Role of Social Responsibility." *Engineering Management Journal* 36, no. 4: 366–377. https://doi.org/10.1080/10429247.2023.2286177.

Aljohani, A. 2025. "A Decision-Support Framework for Evaluating AI-Enabled ESG Strategies in the Context of Sustainable Manufacturing Systems." *Scientific Reports* 15, no. 1: 23864. https://doi.org/10.1038/s41598-025-09569-9.

Alqaralleh, H. 2023. "Dynamic Connectedness Amongst Green Bonds, Pollution Allowance Policy, Social Responsibility and Uncertainty." *Journal of Risk Finance* 25, no. 1: 80–114. https://doi.org/10.1108/jrf-01-2023-0015.

Amin, N., A. Sharif, M. Tayyab, and Y. Pan. 2025. "Green Technological Advances and Resource Rents as Levers for Carbon Reduction in BRICS: Implications for SDGs 7, 8, 9, 12, and 13." *Sustainable Development* 33, no. 3: 3171–3195. https://doi.org/10.1002/sd.3294.

Anić, I.-D., I. Kursan Milaković, and M. Hirogaki. 2023. "Consumer Response to Store-Related Stimuli in a Crisis: Evidence From Japan and Croatia." *International Journal of Retail & Distribution Management* 52, no. 2: 201–219. https://doi.org/10.1108/ijrdm-12-2022-0520.

Ansari, N., R. A. Zill-E-Huma, S. Huma, and A. Baig. 2026. "The Role of Green Human Resource Management Practices and Eco-Innovation in Enhancing the Organizational Performance." *Vision* 30, no. 1: 121–130. https://doi.org/10.1177/09722629221092133.

Atkinson, P., M. Hizaji, A. Nazarian, and A. Abasi. 2022. "Attaining Organisational Agility Through Competitive Intelligence: The Roles of Strategic Flexibility and Organisational Innovation." *Total Quality Management & Business Excellence* 33, no. 3–4: 297–317. https://doi.org/10.1080/14783363.2020.1842188.

Bataineh, M. J., P. Sánchez-Sellero, and F. Ayad. 2024. "The Role of Organizational Innovation in the Development of Green Innovations in Spanish Firms." *European Management Journal* 42, no. 4: 527–538. https://doi.org/10.1016/j.emj.2023.01.006.

BCSD. 2023. "Maturidade das Empresas em Sustentabilidade." https://bcsdportugal.org/wp-content/uploads/2025/01/BCSD-Retrato-Agregado-2021-2023_v4-1.pdf.

Bebko, C. P., L. M. Sciulli, and R. K. Garg. 2006. "Consumers' Level of Expectation for Services and the Role of Implicit Service Promises." *Services Marketing Quarterly* 28, no. 2: 1–23. https://doi.org/10.1300/J396v28n02_01.

Begum, S., M. Ashfaq, E. Xia, and U. Awan. 2022. "Does Green Transformational Leadership Lead to Green Innovation? The Role of Green Thinking and Creative Process Engagement." *Business Strategy and the Environment* 31, no. 1: 580–597. https://doi.org/10.1002/bse.2911.

Birch, K. 2024. "How Amazon Is Accelerating Sustainability Goals With AI." Sustainability Magazine. https://sustainabilitymag.com/tech-ai/how-amazon-is-accelerating-sustainability-goals-with-ai.

Borre, J. R., G. C. Romero, and J. Ramírez. 2024. "Sustainable Purchasing Trends in New Consumer Generations: AI's Role." *Procedia Computer Science* 241: 539–545. https://doi.org/10.1016/j.procs.2024.08.077.

Borsatto, J. M. L. S., and L. B. L. Amui. 2019. "Green Innovation: Unfolding the Relation With Environmental Regulations and Competitiveness." *Resources, Conservation and Recycling* 149: 445–454. https://doi.org/10.1016/j.resconrec.2019.06.005.

Bryson, J. R., G. J. D. Hewings, and M. Song. 2025. "Unraveling the Impacts of Green Knowledge Spillovers on Smes' Green Innovation, Economic Performance, and Exporting: Evidence From Germany." *Industrial and Corporate Change*: dtaf053. https://doi.org/10.1093/icc/dtaf053.

Bulo, Y. S., R. E. Halim, and A. Satrya. 2026. "Green Innovation as a Force for Competitive Strategy Development and Sustainable Business Performance: A Systematic Literature Review." *Cogent Business & Management* 13, no. 1: 2624161. https://doi.org/10.1080/23311975.2026.2624161.

Cenci, S., H. Asgharian, L. Liu, M. Rei, and M. Zollo. 2025. "Does Competitive Pressure Drive Effective Corporate Environmental Actions?" *Journal of Cleaner Production* 511: 145585. https://doi.org/10.1016/j.jclepro.2025.145585.

Chen, G., A. Sabir, M. F. Rasheed, L. Belascu, and C.-W. Su. 2024. "Green Marketing Horizon: Industry Sustainability Through Marketing and Innovation." *Journal of Innovation & Knowledge* 9, no. 4: 100606. https://doi.org/10.1016/j.jik.2024.100606.

Damanpour, F., R. M. Walker, and C. N. Avellaneda. 2009. "Combinative Effects of Innovation Types and Organizational Performance: A Longitudinal Study of Service Organizations." *Journal of Management Studies* 46, no. 4: 650–675. https://doi.org/10.1111/j.1467-6486.2008.00814.x.

Dauvergne, P. 2022. "Is Artificial Intelligence Greening Global Supply Chains? Exposing the Political Economy of Environmental Costs." *Review of International Political Economy* 29, no. 3: 696–718. https://doi.org/10.1080/09692290.2020.1814381.

Duong, C. D. 2023. "Applying the Stimulus-Organism-Response Theory to Investigate Determinants of Students' Social Entrepreneurship: Moderation Role of Perceived University Support." *Social Enterprise Journal* 19, no. 2: 167–192. https://doi.org/10.1108/sej-10-2022-0091.

EIS. 2021. "European and Regional Innovation Scoreboards 2021." European Innovation Scoreboard (EIS). https://ec.europa.eu/commission/presscorner/detail/en/qanda_21_3050.

ElHaffar, G., F. Durif, and L. Dubé. 2020. "Towards Closing the Attitude-Intention-Behavior Gap in Green Consumption: A Narrative Review of the Literature and an Overview of Future Research Directions." *Journal of Cleaner Production* 275: 122556. https://doi.org/10.1016/j.jclepro.2020.122556.

El-Kassar, A.-N., and S. K. Singh. 2019. "Green Innovation and Organizational Performance: The Influence of Big Data and the Moderating Role of

Management Commitment and HR Practices." *Technological Forecasting and Social Change* 144: 483–498. https://doi.org/10.1016/j.techfore.2017.12.016.

Fabrizi, A., C. Fiorelli, and V. Meliciani. 2025. "The Role of Green Networks for Environmental Innovation in European Regions." *Journal of Industrial and Business Economics* 52, no. 4: 935–966. https://doi.org/10.1007/s40812-024-00339-8.

Fatima, T., M. W. Akhtar, A. Ejaz, F. Syed, M. Usman, and N. Mouri. 2026. "Linking Strategic Leadership to Innovation and Competitive Advantage: The Roles of Strategic Choices and Organizational Culture in SMEs." *Journal of Business Research* 208, no. January: 116083. https://doi.org/10.1016/j.jbusres.2026.116083.

Fernandes, C. I., P. M. Veiga, J. J. M. Ferreira, and M. Hughes. 2021. "Green Growth Versus Economic Growth: Do Sustainable Technology Transfer and Innovations Lead to an Imperfect Choice?" *Business Strategy and the Environment* 30, no. 4: 2021–2037. https://doi.org/10.1002/bse.2730.

Ferreira, J. J., J. M. Lopes, S. Gomes, and H. G. Rammal. 2023. "Industry 4.0 Implementation: Environmental and Social Sustainability in Manufacturing Multinational Enterprises." *Journal of Cleaner Production* 404: 136841. https://doi.org/10.1016/j.jclepro.2023.136841.

Füller, J., K. Hutter, J. Wahl, V. Bilgram, and Z. Tekic. 2022. "How AI Revolutionizes Innovation Management – Perceptions and Implementation Preferences of AI-Based Innovators." *Technological Forecasting and Social Change* 178: 121598. https://doi.org/10.1016/j.techfore.2022.121598.

Gandía, J. A. G., A. d. L. Ancillo, and M. T. d. V. Núñez. 2025. "The Role of Artificial Intelligence and Knowledge in Enhancing Corporate Sustainability." *Journal of Innovation & Knowledge* 10, no. 5: 100792. https://doi.org/10.1016/j.jik.2025.100792.

Garza-Reyes, J. A. 2015. "Lean and Green—A Systematic Review of the State of the Art Literature." *Journal of Cleaner Production* 102: 18–29. https://doi.org/10.1016/j.jclepro.2015.04.064.

Gomes, S., J. M. Lopes, and T. Trancoso. 2025. "Customer Experience in Digital Transformation: The Influence of Intelligent Chatbots Toward a Sustainable Market." *International Journal of Innovation Science* 17, no. 4: 803–823. https://doi.org/10.1108/ijis-06-2024-0148.

Gomes, S., J. M. Lopes, M. Travassos, et al. 2023. "Strategic Organizational Sustainability in the Age of Sustainable Development Goals." *Sustainability* 15, no. 13: 10053. https://doi.org/10.3390/su151310053.

Gomes, S., M. Pinho, and J. M. Lopes. 2024. "From Environmental Sustainability Practices to Green Innovations: Evidence From Small and Medium-Sized Manufacturing Companies." *Corporate Social Responsibility and Environmental Management* 31, no. 3: 1677–1687. https://doi.org/10.1002/csr.2657.

Grewal, D., A. Guha, C. B. Satornino, and E. B. Schweiger. 2021. "Artificial Intelligence: The Light and the Darkness." *Journal of Business Research* 136: 229–236. https://doi.org/10.1016/j.jbusres.2021.07.043.

Grewal, D., A. L. Roggeveen, and J. Nordfält. 2017. "The Future of Retailing." *Journal of Retailing* 93, no. 1: 1–6. https://doi.org/10.1016/j.jretai.2016.12.008.

Hafeez, S., K. Shahzad, P. Helo, and M. F. Mubarak. 2025. "Knowledge Management and Smes' Digital Transformation: A Systematic Literature Review and Future Research Agenda." *Journal of Innovation & Knowledge* 10, no. 3: 100728. https://doi.org/10.1016/j.jik.2025.100728.

Hair, J. F. 2014. *A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM)*. Sage.

Hair, J. F., J. J. Risher, M. Sarstedt, and C. M. Ringle. 2019. "When to Use and How to Report the Results of PLS-SEM." *European Business Review* 31, no. 1: 2–24. https://doi.org/10.1108/ebr-11-2018-0203.

Haqqani, K., M. Aleem, S. Mahmood, et al. 2026. "Green Intellectual Capital and Organizational Learning: Pathways to Sustainable Innovation and Firm Performance in Pakistani SMEs." *Journal of Intellectual Capital* 27, no. 7: 22–48. https://doi.org/10.1108/JIC-08-2025-0330.

Herrmann, C., S. Rhein, and K. F. Sträter. 2022. "Consumers' Sustainability-Related Perception of and Willingness-To-Pay for Food Packaging Alternatives." *Resources, Conservation and Recycling* 181: 106219. https://doi.org/10.1016/j.resconrec.2022.106219.

Hervas-Oliver, J.-L., F. Sempere-Ripoll, and C. Boronat-Moll. 2014. "Process Innovation Strategy in SMEs, Organizational Innovation and Performance: A Misleading Debate?" *Small Business Economics* 43, no. 4: 873–886. https://doi.org/10.1007/s11187-014-9567-3.

Hojnik, J., and M. Ruzzier. 2016. "What Drives Eco-Innovation? A Review of an Emerging Literature." *Environmental Innovation and Societal Transitions* 19: 31–41. https://doi.org/10.1016/j.eist.2015.09.006.

Hsu, C. C., K. Choon Tan, S. Hanim Mohamad Zailani, and V. Jayaraman. 2013. "Supply Chain Drivers That Foster the Development of Green Initiatives in an Emerging Economy." *International Journal of Operations & Production Management* 33, no. 6: 656–688. https://doi.org/10.1108/ijopm-10-2011-0401.

Jabbour, A. B., I. Laguir, R. Stekelorum, and S. Gupta. 2025. "The Nexus of Artificial Intelligence and Sustainability Performance: Unveiling the Impact of Supply Chain Transparency and Customer Pressure on Ethical Conduct." *Journal of Environmental Management* 379: 124847. https://doi.org/10.1016/j.jenvman.2025.124847.

Jung, J., S. J. Kim, and K. H. Kim. 2020. "Sustainable Marketing Activities of Traditional Fashion Market and Brand Loyalty." *Journal of Business Research* 120: 294–301. https://doi.org/10.1016/j.jbusres.2020.04.019.

Khulbe, M. 2025. "AI's Role in the Implementation of Circular Economy Practices: Optimising Product Life Cycles, Promoting Recycling and Facilitating the Reuse of Materials." In *Industry 5.0: Sustainable Business Practices for a Bright Future*, 155–173. Nova Science Publishers Inc. https://www.scopus.com/inward/record.uri?eid=2-s2.0-105003989514&partnerID=40&md5=a62e71891ae1f96fdaf037a9c6a9cc7b.

Khurshid, A., A. Rauf, S. Qayyum, A. C. Calin, and W. Duan. 2023. "Green Innovation and Carbon Emissions: The Role of Carbon Pricing and Environmental Policies in Attaining Sustainable Development Targets of Carbon Mitigation—Evidence From Central-Eastern Europe." *Environment, Development and Sustainability* 25, no. 8: 8777–8798. https://doi.org/10.1007/s10668-022-02422-3.

Kiba-Janiak, M., K. Cheba, M. Mucowska, et al. 2024. "How to Design a Sustainable Last-Mile Delivery and Returns Business Model From E-Customers' Expectations Perspective?" *Research in Transportation Business & Management* 56: 101194. https://doi.org/10.1016/j.rtbm.2024.101194.

Krakowski, S., J. Luger, and S. Raisch. 2023. "Artificial Intelligence and the Changing Sources of Competitive Advantage." *Strategic Management Journal* 44, no. 6: 1425–1452. https://doi.org/10.1002/smj.3387.

Laurin, F., and K. Fantazy. 2017. "Sustainable Supply Chain Management: A Case Study at IKEA." *Transnational Corporations Review* 9, no. 4: 309–318. https://doi.org/10.1080/19186444.2017.1401208.

Le, N., T. H. H. Le, T. N. Huynh, D. Q. Do, T. K. T. Pham, and T. N. O. Tran. 2025. "Marketing Stimuli and Impulse Buying: The Role of Traits, Reviews and Motives." *Journal of Promotion Management* 31, no. 1: 96–124. https://doi.org/10.1080/10496491.2024.2428965.

Li, X., and S. Li. 2026. "The Green Transformation Path of Chinese Energy Companies: Exploring the Role of Artificial Intelligence and Human-AI Collaboration in the Green Innovation Sustainability." *International Journal of Green Energy* 23: 1–22. https://doi.org/10.1080/15435075.2026.2614026.

Li, X., Y. Zhou, Y. D. Wong, X. Wang, and K. F. Yuen. 2021. "What Influences Panic Buying Behaviour? A Model Based on Dual-System Theory and Stimulus-Organism-Response Framework." *International Journal of*

Disaster Risk Reduction 64: 102484. https://doi.org/10.1016/j.ijdrr.2021.102484.

Liu, S., J. J. Yu, and T. Feng. 2025. "The Impact of Green Innovations on Firm's Sustainable Operations: Process Innovation and Recycling Innovation." *Omega* 130: 103170. https://doi.org/10.1016/j.omega.2024.103170.

Lopes, J. M., and S. Gomes. 2022. "Innovative and Sustainable Business Strategies: The Case of Portuguese SMEs." *IBIMA Business Review* 2: 1–9. https://doi.org/10.5171/2022.714613.

Lopes, J. M., S. Gomes, R. Pacheco, E. Monteiro, and C. Santos. 2022. "Drivers of Sustainable Innovation Strategies for Increased Competition Among Companies." *Sustainability* 14, no. 9: 5471. https://doi.org/10.3390/su14095471.

Lopes, J. M. M., S. Gomes, and T. Trancoso. 2024. "Navigating the Green Maze: Insights for Businesses on Consumer Decision-Making and the Mediating Role of Their Environmental Concerns." *Sustainability Accounting, Management and Policy Journal* 15, no. 4: 861–883. https://doi.org/10.1108/sampj-07-2023-0492.

Lopes, J. M., I. Massano-Cardoso, and F. Silva. 2026. "From AI-Enabled Service Quality to Digital Immersion State: Effects on the Awe Experience in Fashion e-Retail." *Future Business Journal* 12, no. 1: 53. https://doi.org/10.1186/s43093-026-00763-3.

Magistretti, S., C. Dell'Era, and A. Messeni Petruzzelli. 2019. "How Intelligent Is Watson? Enabling Digital Transformation Through Artificial Intelligence." *Business Horizons* 62, no. 6: 819–829. https://doi.org/10.1016/j.bushor.2019.08.004.

Mahajan, S., I. R. Nagesh, B. B. Mishra, S. Sarkar, S. P. Gangadharan, and V. Agarwal. 2025. "Artificial Intelligence and Strategic Governance: Enabling Real-Time Decisions in Complex Business Ecosystems." *Management (Montevideo)* 3: 174. https://doi.org/10.62486/agma2025174.

Mahboub, R., and M. G. Ghanem. 2024. "The Mediating Role of Knowledge Management Practices and Balanced Scorecard in the Association Between Artificial Intelligence and Organization Performance: Evidence From MENA Region Commercial Banks." *Cogent Business & Management* 11, no. 1: 2404484. https://doi.org/10.1080/23311975.2024.2404484.

Martínez-Jurado, P. J., and J. Moyano-Fuentes. 2014. "Lean Management, Supply Chain Management and Sustainability: A Literature Review." *Journal of Cleaner Production* 85: 134–150. https://doi.org/10.1016/j.jclepro.2013.09.042.

Martínez-Ros, E., and F. Merino. 2023. "Green Innovation Strategies and Firms' Internationalization." *Industrial and Corporate Change* 32, no. 4: 815–830. https://doi.org/10.1093/icc/dtac057.

Martín-Rojas, R., A. Garrido-Moreno, and V. J. García-Morales. 2026. "Building Organizational Resilience in SMEs: The Key Role of Digital Technologies, Transformational Leadership, and Innovation." *Review of Managerial Science*: 1–34. https://doi.org/10.1007/s11846-025-00965-z.

Mehrabian, A., and J. A. Russell. 1974. *An Approach to Environmental Psychology*. MIT Press.

Mi, J., Q. Zhang, D. Wang, and Q. Zhang. 2026. "From Cognitive Imbalance to Strategic Rationality: How Does Climate Risk Affect the Green Innovation Bubble in Enterprises?" *Journal of Catastrophology* 41, no. 1: 22–29. https://doi.org/10.3969/j.issn.1000-811X.2026.01.004.

Miraz, M. H., A. Ya'u, S. Adeyinka-Ojo, et al. 2024. "Intention to Use Determinants of AI Chatbots to Improve Customer Relationship Management Efficiency." *Cogent Business & Management* 11, no. 1: 2411445. https://doi.org/10.1080/23311975.2024.2411445.

Mohamed, J. A., A. A. Mohamed, A. Y. Abdulle, and M. M. Osman. 2025. "How Hormuud's WhatsApp Chatbot Services Influence Customer Experience and Loyalty: Using Structural Equation Modeling." *Mathematical Modelling of Engineering Problems* 12, no. 9: 3103–3112. https://doi.org/10.18280/mmep.120914.

Nguyen, H., G. Onofrei, Y. Yang, H. Pham, F. Wiengarten, and M. Nkhoma. 2023. "Handling Customer Green Pressures: The Mediating Role of Process Innovation Among Export-Oriented Manufacturing Industries." *Business Strategy and the Environment* 32, no. 4: 2312–2326. https://doi.org/10.1002/bse.3250.

Nishant, R., M. Kennedy, and J. Corbett. 2020. "Artificial Intelligence for Sustainability: Challenges, Opportunities, and a Research Agenda." *International Journal of Information Management* 53: 102104. https://doi.org/10.1016/j.ijinfomgt.2020.102104.

Nogueira, E., S. Gomes, and J. M. Lopes. 2023. "A Meta-Regression Analysis of Environmental Sustainability Practices and Firm Performance." *Journal of Cleaner Production* 426: 139048. https://doi.org/10.1016/j.jclepro.2023.139048.

Nogueira, E., S. Gomes, and J. M. Lopes. 2025. "The Contribution of the Labour Practices to Organizational Performance: The Mediating Role of Social Sustainability." *Business Ethics, the Environment & Responsibility* 34, no. 3: 832–851. https://doi.org/10.1111/beer.12682.

Nogueira, E., J. M. Lopes, and S. Gomes. 2025. "The New Era of Artificial Intelligence in Consumption: Theoretical Framing, Review and Research Agenda." *Management Review Quarterly*: 1–35. https://doi.org/10.1007/s11301-025-00531-7.

Nwachukwu, C., and H. M. Vu. 2022. "Service Innovation, Marketing Innovation and Customer Satisfaction: Moderating Role of Competitive Intensity." *SAGE Open* 12, no. 2: 1–12. https://doi.org/10.1177/21582440221082146.

Olawade, D. B., O. Z. Wada, A. C. David-Olawade, O. Fapohunda, A. O. Ige, and J. Ling. 2024. "Artificial Intelligence Potential for Net Zero Sustainability: Current Evidence and Prospects." *Next Sustainability* 4: 100041. https://doi.org/10.1016/j.nxsust.2024.100041.

Ozen, O., and E. Ozturk-Kose. 2023. "Management Innovation: The Role of Internal, External Factors, and Business Group Affiliation." *Journal of Business Research* 164: 113964. https://doi.org/10.1016/j.jbusres.2023.113964.

Pant, M., A. S. Virdi, and D. S. Chaubey. 2020. "Examining the Effect of Marketing Innovations on GPMA: A Study Using the PLS–SEM Approach." *Global Business Review* 21, no. 4: 1025–1036. https://doi.org/10.1177/0972150918779160.

Peruchini, M., G. M. da Silva, and J. M. Teixeira. 2024. "Between Artificial Intelligence and Customer Experience: A Literature Review on the Intersection." *Discover Artificial Intelligence* 4, no. 1: 4. https://doi.org/10.1007/s44163-024-00105-8.

Qi, H., Y. Liu, H. Chen, and P. Failler. 2025. "The Impact of Enterprise Digitalization on Green Total Factor Productivity: Evidence From Chinese Provinces." *Sustainability* 17, no. 8: 3707. https://doi.org/10.3390/su17083707.

Ramadani, V., R. D. Hisrich, H. Abazi-Alili, L.-P. Dana, L. Panthi, and L. Abazi-Bexheti. 2019. "Product Innovation and Firm Performance in Transition Economies: A Multi-Stage Estimation Approach." *Technological Forecasting and Social Change* 140: 271–280. https://doi.org/10.1016/j.techfore.2018.12.010.

Rashid, A., N. Baloch, R. Rasheed, and A. H. Ngah. 2024. "Big Data Analytics-Artificial Intelligence and Sustainable Performance Through Green Supply Chain Practices in Manufacturing Firms of a Developing Country." *Journal of Science and Technology Policy Management* 16, no. 1: 42–67. https://doi.org/10.1108/jstpm-04-2023-0050.

Reppmann, M., S. Harms, L. M. Edinger-Schons, and J. N. Foege. 2025. "Activating the Sustainable Consumer:The Role of Customer Involvement in Corporate Sustainability." *Journal of the Academy of Marketing Science* 53, no. 2: 310–340. https://doi.org/10.1007/s11747-024-01036-7.

Rodríguez-Rebés, L., R. Ibar-Alonso, L. M. R. Gómez, and J. Navío-Marco. 2024. "The Use and Drivers of Organisational Eco-Innovation in European SMEs." *Research in International Business and Finance* 70: 102297. https://doi.org/10.1016/j.ribaf.2024.102297.

Roxas, B. 2022. "Eco-Innovations of Firms: A Longitudinal Analysis of the Roles of Industry Norms and Proactive Environmental Strategy." *Business Strategy and the Environment* 31, no. 1: 515–531. https://doi.org/10.1002/bse.2907.

Sánchez-Sellero, P., and M. J. Bataineh. 2022. "How R&D Cooperation, R&D Expenditures, Public Funds and R&D Intensity Affect Green Innovation?" *Technology Analysis & Strategic Management* 34, no. 9: 1095–1108. https://doi.org/10.1080/09537325.2021.1947490.

Sapag, P., L. P. Rastrilla, and A. R. García. 2023. "TikTok: New Media, Old Propaganda—State of the Art and Possibilities for Political Communication." In *Fast Politics: Propaganda in the Age of TikTok*, edited by L. Pérez Rastrilla, P. Sapag M, and A. Recio García, 3–19. Springer Nature Singapore. https://doi.org/10.1007/978-981-99-5110-9_1.

Sarstedt, M., N. F. Richter, S. Hauff, and C. M. Ringle. 2024. "Combined Importance–Performance Map Analysis (cIPMA) in Partial Least Squares Structural Equation Modeling (PLS–SEM): A SmartPLS 4 Tutorial." *Journal of Marketing Analytics* 12, no. 4: 746–760.

Schwaeke, J., C. Gerlich, H. L. Nguyen, D. K. Kanbach, and J. Gast. 2025. "Artificial Intelligence (AI) for Good? Enabling Organizational Change Towards Sustainability." *Review of Managerial Science* 19, no. 10: 3013–3038. https://doi.org/10.1007/s11846-025-00840-x.

Sheng, R. 2022. "Chapter 12–3-D Printing in the Footwear Industry." In *3D Printing*, edited by R. Sheng, 103–110. Academic Press. https://doi.org/10.1016/B978-0-323-99463-7.00012-8.

Silvério, A., C. I. Fernandes, and T. K. Maran. 2025. "Do Green Innovation Strategies Exist? Past, Present and Future Trends in Literature." *European Journal of Innovation Management* 28, no. 11: 154–186. https://doi.org/10.1108/EJIM-12-2024-1427.

Silvestre, B. S., and D. M. Ţîrcă. 2019. "Innovations for Sustainable Development: Moving Toward a Sustainable Future." *Journal of Cleaner Production* 208: 325–332. https://doi.org/10.1016/j.jclepro.2018.09.244.

Sinemus, K., S. Zielke, and T. Dobbelstein. 2025. "Improving Consumer Satisfaction Through Shopping App Features: A Kano-Based Approach." *Journal of Retailing and Consumer Services* 85: 104243. https://doi.org/10.1016/j.jretconser.2025.104243.

Singh, S. K., M. Del Giudice, C. J. Chiappetta Jabbour, H. Latan, and A. S. Sohal. 2022. "Stakeholder Pressure, Green Innovation, and Performance in Small and Medium-Sized Enterprises: The Role of Green Dynamic Capabilities." *Business Strategy and the Environment* 31, no. 1: 500–514. https://doi.org/10.1002/bse.2906.

Singh, S. K., M. Del Giudice, R. Chierici, and D. Graziano. 2020. "Green Innovation and Environmental Performance: The Role of Green Transformational Leadership and Green Human Resource Management." *Technological Forecasting and Social Change* 150: 119762. https://doi.org/10.1016/j.techfore.2019.119762.

Song, W., G.-Z. Wang, and X. Ma. 2020. "Environmental Innovation Practices and Green Product Innovation Performance: A Perspective From Organizational Climate." *Sustainable Development* 28, no. 1: 224–234. https://doi.org/10.1002/sd.1990.

Song, W., and H. Yu. 2018. "Green Innovation Strategy and Green Innovation: The Roles of Green Creativity and Green Organizational Identity." *Corporate Social Responsibility and Environmental Management* 25, no. 2: 135–150. https://doi.org/10.1002/csr.1445.

Sultan, P., H. Y. Wong, and M. S. Azam. 2021. "How Perceived Communication Source and Food Value Stimulate Purchase Intention of Organic Food: An Examination of the Stimulus-Organism-Response (SOR) Model." *Journal of Cleaner Production* 312: 127807. https://doi.org/10.1016/j.jclepro.2021.127807.

Sun, J., P.-J. Chen, L. Ren, et al. 2021. "Place Attachment to Pseudo Establishments: An Application of the Stimulus-Organism-Response Paradigm to Themed Hotels." *Journal of Business Research* 129: 484–494. https://doi.org/10.1016/j.jbusres.2020.10.005.

Talwar, S., F. Jabeen, A. Tandon, M. Sakashita, and A. Dhir. 2021. "What Drives Willingness to Purchase and Stated Buying Behavior Toward Organic Food? A Stimulus–Organism–Behavior–Consequence (SOBC) Perspective." *Journal of Cleaner Production* 293: 125882. https://doi.org/10.1016/j.jclepro.2021.125882.

Tian, H.-H., S.-Z. Huang, and O. Cheablam. 2023. "How Green Value Co-Creation Mediates the Relationship Between Institutional Pressure and Firm Performance: A Moderated Mediation Model." *Business Strategy and the Environment* 32, no. 6: 3309–3325. https://doi.org/10.1002/bse.3301.

Tran, Q. P., A. D. Do, D. L. Ha, P. T. Bui, D. K. Nguyen, and N. H. D. Tran. 2025. "Value Co-Creation and Customer Satisfaction Mediation on the Service Innovation and Generation Z Consumers' Repurchase Intention in Vietnam." *Cogent Business & Management* 12, no. 1: 2466811. https://doi.org/10.1080/23311975.2025.2466811.

Tran, T. A. P. 2025. "The Role of Customer Expectations and Competitive Pressure in Shaping Firm Innovation Decisions Towards Sustainability: Mediating Effects of Innovation Perception." *Cogent Business & Management* 12, no. 1: 2462272. https://doi.org/10.1080/23311975.2025.2462272.

Van, H., M. Abu Afifa, and D. Bui. 2025. "Green Innovation and Sustainability Reporting: Linking Environmental Practices to Sustainable Competitive Advantage Through a Moderated Moderation and Mediation Model." *Business Strategy and the Environment* 34, no. 7: 8100–8117. https://doi.org/10.1002/bse.70022.

Vebrianti, R., M. Aras, M. S. S. Putri, and I. A. Swandewi. 2025. "AI Chatbots in E-Commerce: Enhancing Customer Engagement, Satisfaction and Loyalty." *PaperASIA* 41, no. 2b: 248–260. https://doi.org/10.59953/paperasia.v41i2b.445.

Vieira, V. A. 2013. "Stimuli–Organism-Response Framework: A Meta-Analytic Review in the Store Environment." *Journal of Business Research* 66, no. 9: 1420–1426. https://doi.org/10.1016/j.jbusres.2012.05.009.

Vinuesa, R., H. Azizpour, I. Leite, et al. 2020. "The Role of Artificial Intelligence in Achieving the Sustainable Development Goals." *Nature Communications* 11, no. 1: 233. https://doi.org/10.1038/s41467-019-14108-y.

Vuong, T. K., T. N. Lam, and H. M. Bui. 2024. "Sustainable Consumer Behaviour in the Fast-Moving Consumer Goods Sector: Moderating Role of Competitive Intensity in Green Marketing." *Business Strategy & Development* 7, no. 4: e70047. https://doi.org/10.1002/bsd2.70047.

Wamba, S., C. Guthrie, M. M. Queiroz, and S. Minner. 2024. "ChatGPT and Generative Artificial Intelligence: An Exploratory Study of Key Benefits and Challenges in Operations and Supply Chain Management." *International Journal of Production Research* 62, no. 16: 5676–5696. https://doi.org/10.1080/00207543.2023.2294116.

Xu, A., Y. Zhu, and W. Wang. 2023. "Micro Green Technology Innovation Effects of Green Finance Pilot Policy—From the Perspectives of Action Points and Green Value." *Journal of Business Research* 159: 113724. https://doi.org/10.1016/j.jbusres.2023.113724.

Xu, X.-Y., S.-Y. Wu, and H. Jing. 2017. "Explore the Differences Between Perceived Service Quality and Customer Satisfaction Based on Customer Expectation of Service Attributes." *International Journal of Services, Technology and Management* 23, no. 3: 219–236. https://doi.org/10.1504/IJSTM.2017.085476.

YuSheng, K., and M. Ibrahim. 2019. "Service Innovation, Service Delivery and Customer Satisfaction and Loyalty in the Banking Sector of Ghana." *International Journal of Bank Marketing* 37, no. 5: 1215–1233. https://doi.org/10.1108/ijbm-06-2018-0142.

Zameer, H., Y. Wang, and H. Yasmeen. 2020. "Reinforcing Green Competitive Advantage Through Green Production, Creativity and Green Brand Image: Implications for Cleaner Production in China." *Journal of Cleaner Production* 247: 119119. https://doi.org/10.1016/j.jclepro.2019.119119.

Zhang, F., and L. Zhu. 2019. "Enhancing Corporate Sustainable Development: Stakeholder Pressures, Organizational Learning, and Green Innovation." *Business Strategy and the Environment* 28, no. 6: 1012–1026. https://doi.org/10.1002/bse.2298.

Zhao, J., and B. Fariñas. 2023. "Artificial Intelligence and Sustainable Decisions." *European Business Organization Law Review* 24, no. 1: 1–39. https://doi.org/10.1007/s40804-022-00262-2.