**Cost Efficiency and Green Product Innovation in SMEs for Emerging Economies: The roles of Green Brand Knowledge and Green Innovation Capability**


## Abstract

This study aims to explore the conditions under which cost efficiency (CE) is positively linked to green product innovation (GPI), with a specific focus on SMEs in emerging economies – a context where the interplay between these variables remains under-explored. While existing literature has addressed CE and GPI individually, there is a paucity of research investigating their interrelationship, particularly within the dynamic environments of SMEs in emerging markets. By integrating internal resources, such as green brand knowledge (GBK) and green innovation capability (GIC), this study offers a novel perspective on how these factors potentially moderate or mediate the CE-GPI relationship. Our findings reveal a paradox: CE, when pursued in isolation, negatively affects GPI, potentially due to the constraints it places on innovation. However, in firms where GBK and GIC are robust, these resources enable better alignment and utilisation of cost-efficiency strategies, thereby fostering innovation. Interestingly, neither GBK nor GIC exhibits significant direct or mediating effects on the CE-GPI relationship, highlighting the complex nature of these interactions. Theoretical contributions and managerial implications are discussed, emphasising the need for a balanced approach to cost efficiency and innovation in SMEs within emerging economies.



**Keywords**: Cost efficiency, Green product innovation, Green brand knowledge, Green innovation capability


## 1. Introduction

*"The smarter our cost efficiency decisions are, the more fluid and effective our product innovation efforts will be" (Author)*

While effective cost management can theoretically free up resources for innovation (Oyegoke et al., 2022), the relationship between CE and innovation is far from straightforward. Numerous studies indicate that an overemphasis on CE can actually impede innovation, particularly in the context of green product innovation (GPI) (Wong et al., 2020; Huang, 2023; Marion and Meyer, 2011). This paradox arises when cost-cutting measures undermine critical activities such as research and development (R&D), which are essential for green innovations (Xiumei et al., 2023). Firms may also shy away from the initial investments required for GPI in their pursuit of immediate cost savings (Rahman et al., 2023; Wong et al., 2020). Thus, while CE is often viewed as a driver of innovation (Wong et al., 2020), its impact on GPI can be counterproductive if not managed with a strategic balance.

In previous studies and literature on GPI, the question of "*how should cost efficiency (CE) positively influence green product innovation (GPI)?*" remains unanswered (e.g. Huang, 2023; Wang et al., 2021). Normatively, CE enables resource savings that could be redirected toward green R&D or sustainable practices (Xiumei et al., 2023). It also reduces production costs, potentially allowing firms to price green products competitively and increase adoption. However, the literature lacks detailed exploration of these mechanisms and lacks empirical evidence to validate this association and its role in achieving GPI. Additionally, many studies have examined CE and GPI in separate contexts, treating them as isolated variables rather than exclusively exploring their potential interaction. This concern limits the understanding of how CE can be strategically leveraged to enhance GPI. Unfortunately, some studies observing green innovation fail to consider the role of CE (*see* Takalo and Tooranloo, 2021), missing an opportunity to connect cost management with innovation outcomes (Weeks and Feeny, 2008). A recent work by Bataineh et al. (2024), for example, addresses the competitive advantages of integrating R&D with green innovation. However, it lacks an exploration of how CE interacts with GPI, which is a crucial factor in understanding the implications of integrating sustainability with business strategy (Wong et al., 2020).

Furthermore, there is a lack of a theoretical perspective for examining the relationship between CE and GPI. Vasileiou et al., (2022), Marion and Meyer (2011) and Williamson (2010) neglect the deeper theoretical underpinnings that could offer richer insights into how CE influences GPI, not merely as a linear cause-and-effect relationship but as a dynamic and multi-faceted interaction. Xu et al. (2022) approach green innovation efficiency from a macroeconomic perspective. While their work contributes to the understanding of green innovation trends in China, it treats cost efficiency more as an input variable rather than exploring its deeper, more intricate relationship with green innovation. This practical focus on input-output efficiency contributes to the lack of a theoretical exploration of how cost efficiency might influence the broader dynamics of green innovation. Moreover, Fang et al.'s (2019) study falls short on its treatment of green innovation as a relatively static concept, rather than acknowledging its dynamic and evolving nature. Green innovation is not a singular event or state that can be fully captured at a given moment. Rather, it is a series of interconnected events, each influenced by previous innovations (Mellett et al., 2018). By treating green innovation as static, Fang et al.

(2019) risk reducing this complex process to mere snapshots that fail to capture the underlying dynamism that drives true innovation.

So, the aim of the current study is to address the above research and theoretical gaps by moving beyond the narrow empirical focus that characterises much of the existing research. In doing so, we also examine the roles of green brand knowledge (GBK) and green innovation capability (GIC), whether they contribute positively to the relationship between CE and GPI in mediating or moderating ways. The complexity of this inquiry lies in the theoretical and practical ambiguities surrounding how CE, an operational strategy aimed at reducing costs and optimising resources, influences GPI, a process that demands significant investments and creativity to achieve sustainability. Their roles as mediators or moderators in the relationship between CE and GPI remain unclear or inconclusive. This research goes beyond simplistic linear assumptions, focusing on whether GBK and GIC act as transformative intermediaries or contextual enhancers in this intricate relationship, offering a deeper and more nuanced understanding of how firms can strategically align cost efficiency with sustainability goals.

As such, this study not only contributes to understanding how CE influences GPI but also seeks to clarify the specific mechanisms through which GBK and GIC might enhance or alter this relationship. This study also seeks to add to this body of research by examining *how* and *under which conditions* CE positively is attributed to GPI. To our knowledge, this is the first study of its kind to observe these dynamics, offering a novel perspective on the interactions of internal resources (GBK and GIC) to the CE-GPI relationship. Some scholars conceptualise GBK and GIC as internal critical resources (Chang et al., 2022). They, for example, use them as predictors of green brand positioning as determinants of new product success (Borah et al., 2023). Contrary to most previous studies, we focus on GPI.

We focus our study on Small and Medium Enterprises (SMEs) in an emerging economy. The rationale is that the discussion of GPI in SMEs within emerging economies is an evolving and increasingly vital area of interest among academics, practitioners, and governments (Singh et al., 2022). This surge in attention is attributed to several factors, including the rising awareness of environmental issues, the recognition of the critical role that SMEs play in economic development, and the unique challenges and opportunities these enterprises face in adopting sustainable practices (Ali et al., 2021; Heenkenda et al., 2022). Unlike large corporations, SMEs in emerging economies often operate with limited resources (de Jesus Pacheco et al., 2017), making the integration of green innovation both a challenge and a potential gamechanger. In this situation, GBK and GIC should not be static assets but are actively shaped by and can shape the firm's approach to cost efficiency and innovation. In exploring the roles of GBK and GIC in the CE-GPI relationship within SMEs, this study applies the Resource-Based View (RBV) theory of the firm.

Many prior studies exploring product innovation have utilised diverse theoretical frameworks such as the theory of resource orchestration (Tang et al., 2023), innovation diffusion theory (Yuen et al., 2020), theory of planned behaviour (Liao et al., 2022)**,** and market orientation framework (Aydin, 2021). While these theories offer valuable insights, they exhibit limitations when applied to the nuanced context of this study, particularly in addressing the complex relationship between CE, GPI, GBK, and GIC. In contrast, the RBV theory emerges as the most appropriate framework, as it provides a robust lens to examine how unique internal resources drive strategic outcomes in resource-constrained and dynamic environments like SMEs in emerging economies. For instance, the theory of resource orchestration highlights the processes by which firms structure, bundle, and leverage their resources to create value (Tang et al., 2023). This theory is instrumental in explaining resource deployment. However, its prescriptive focus on managerial actions and processes (Tang et al., 2023), may overshadow the intrinsic value of resources themselves. Moreover, this theory assumes the availability of diverse resource pools for orchestration (Tang et al., 2023), which may not align with the constrained environments faced by SMEs in emerging economies. The RBV, on the other hand, concentrates on the strategic importance of optimising limited, valuable resources like GBK and GIC, providing a more realistic framework for firms with finite resources striving for sustainable innovation.

## 2. Literature review and hypothesis development

### *2.1 The RBV theory in Product Innovation – Rationale of GBK and GIC*

Considering the extensive body of prior research, the RBV theory offers profound insights into the relationship between firm resources and product innovation. A considerable volume of studies has explored how various organisational resources contribute to innovation capabilities, emphasising the pivotal role of unique, valuable, and inimitable assets in securing sustained competitive advantage. For instance, studies such as those by Kim et al. (2015), Lin and Wu (2014), Kindström et al. (2013) have highlighted that dynamic capabilities – integral to the RBV framework – are critical for firms to continuously adapt and reconfigure their resource base in the face of changing market conditions. In this regard, product innovation is not solely the outcome of possessing advanced technologies but results from the firm's strategic ability to harness, combine, and redeploy its resources over time. Prior studies further emphasise that technological resources, while essential, must be coupled with organisational capabilities such as knowledge management, process integration, and the development of firm-specific routines (Cordeiro et al., 2023; Sheng, 2017; Pitelis et al., 2024). These capabilities enable firms to create products that align with evolving customer demands, ensuring long-term innovation success. Research by Mousavi et al. (2018) builds on this argument by emphasising the role of organisational routines and capabilities in shaping a firm's ability to innovate effectively.

Furthermore, the RBV perspective on product innovation is further enriched by studies that have examined the role of intangible resources, such as human capital, organisational culture, and relational networks, in fostering innovation (Costa et al., 2014). Human capital, including the knowledge, skills, and creativity of employees, has been consistently identified as a critical driver of innovation outcomes (Sun et al., 2020; Liu et al., 2017). Similarly, research by Liu et al. (2020) suggests that firms with strong human capital are better positioned to generate new ideas, integrate diverse knowledge, and effectively solve complex problems during the product development process. Additionally, the concept of absorptive capacity – introduced by Kastelli et al. (2024) – provides valuable insights into how firms' ability to recognise, assimilate, and apply external knowledge contributes to their innovation success. By drawing on a range of resources, from proprietary technologies to knowledge networks and dynamic capabilities, firms can craft a multifaceted innovation strategy that is difficult for competitors to replicate. Hence, the body of literature surrounding RBV and product innovation strongly supports the notion that innovation is an endogenous process, deeply rooted in a firm's resource configuration and its capacity to leverage those resources in novel and adaptive ways.

To our knowledge, those themes, in general, can be classified into two main categories: GBK and GIC. GBK refers to a firm's understanding and management of its brand identity. Key themes under this category include human capital, organisational culture, and relational networks because they are fundamental to shaping and sustaining a firm's environmental brand identity, market positioning, and capacity to engage in green innovation (Asiaei et al., 2023; Aftab et al., 2023). GBK, in its essence, represents a firm's deep understanding of environmental expectations, consumer perceptions, and market dynamics, which ultimately influences how the firm is perceived as a leader in sustainability (Abbas and Khan, 2023). We believe that human capital plays a central role in this process by equipping employees with the knowledge, skills, and expertise necessary to understand and implement sustainable practices. According to Arfi et al. (2018), the accumulation of environmental knowledge within the workforce enables the firm to align its operations and innovation strategies with broader environmental goals. Employees, particularly those in key roles, are often the primary agents driving sustainability initiatives and articulating the firm's environmental brand promise. Relational networks further are related to GBK, enabling firms to gather external insights from suppliers, customers, and environmental stakeholders, which can inform the firm's branding strategy and strengthen its position as an environmentally responsible entity (Leonidou et al., 2015; Menguc et al., 2010). These relational networks, then, provide access to critical knowledge about market trends, regulatory developments, and technological advancements in green innovation.

GIC, on the other hand, encompasses a firm's ability to develop and commercialise innovative products or processes that contribute to environmental sustainability (Albort-Morant et al., 2016). Technological resources, dynamic capabilities, and organisational routines can be classified under GIC. It is because they are the core components that enable firms to innovate sustainably, adapt to environmental challenges, and continuously improve their green product offerings. GIC, as a dynamic capability, focuses on a firm's ability to integrate and utilise its resources in ways that facilitate the development of sustainable innovations (Albort-Morant et al., 2016). It involves not only the adoption of existing green technologies but also the creation of new processes, practices, and products that align with environmental goals. Technological resources are at the heart of this process, providing the tools, systems, and expertise needed to drive green innovation. These resources, such as clean technologies, energy-efficient production processes, and environmentally friendly materials, directly impact the firm's capacity to develop new, sustainable products (Dangelico et al., 2017). Together, they form the foundational infrastructure upon which green innovations are built, allowing firms to meet both regulatory requirements and consumer demand for eco-friendly solutions.

Based on this discussion, GBK and GIC are integral to the focus of this study and are conceptualised as significant internal resources. Both GBK and GIC exemplify the unique, valuable, and inimitable attributes that define a firm's resource base, directly contributing to sustained competitive advantage in the context of environmental sustainability and product innovation.

*2.2 GPI in SMEs in emerging economy*

From the perspective of RBV, several key insights have been gleaned regarding GPI in SMEs. It has been well established that the strategic use of intangible assets, such as intellectual capital, green knowledge, and corporate culture, are significantly associated with an SME's ability to innovate sustainably (Ahmad et al., 2021; Ali et al., 2021; de Jesus Pacheco et al., 2017; Heenkenda et al., 2022). Additionally, the RBV framework has shown that SMEs can capitalise on their inherent flexibility and adaptability (Chan et al., 2019), which are often constrained in larger organisations due to bureaucratic inertia. This adaptability allows SMEs to respond swiftly to emerging trends in sustainability and adjust their green innovation strategies accordingly. Terziovski's (2010) study using the RBV theory suggests that the ability to innovate sustainably is heavily influenced by how SMEs manage and utilise their internal resources.

One significant gap, in developing countries, is the limited understanding of how SMEs balance the pursuit of green innovation with cost efficiency, particularly in resource-constrained environments (Ali et al., 2021; Julienti and Ahmad, 2010). SMEs often approach green innovation as a single, monolithic construct (Ahmad et al., 2021). Of course, this leads to a lack of strategic focus and the underutilisation of resources that could otherwise be directed towards creating innovative and sustainable business models (Ramdan et al., 2022). Consequently, SMEs are compelled to prioritise resource allocation based on immediate needs and short-term returns, which may hinder long-term green innovation efforts (Ali et al., 2021). This pragmatic outlook leads them to adopt a transactional mind-set, viewing investments in green innovation through a cost-benefit lens rather than as a long-term strategic imperative. Instead of viewing green innovation as a holistic and integrated part of their business strategy, SMEs treat it as an add-on or a series of discrete transactions (Ahmad et al., 2021; Julienti and Ahmad, 2010; Ramdan et al., 2022). It leads to a fragmented approach to sustainability, where green initiatives are pursued sporadically and without a coherent strategy.

To effectively overcome the challenges associated with such a purely transactional mind-set, SMEs need to adopt a more strategic approach that aligns their sustainability initiatives with broader organisational goals. This shift is crucial for SMEs to not only meet immediate operational needs but also to achieve long-term competitive advantages through sustainable practices. The current study proposes GBK and GIC as alternative mechanisms to control and mitigate the limitations of a transactional mind-set.

*2.3 CE and GPI*

CE, when critically analysed through the lens of the RBV theory (Khanra et al., 2022; Shibin et al., 2020), presents a complex challenge to organisations, particularly those striving for sustainable competitive advantage. The RBV theory emphasises the importance of leveraging valuable, rare, inimitable, and non-substitutable resources to achieve long-term success (El Nemar et al., 2022). However, while CE focuses on minimising costs and maximising resource utilisation (Wong et al., 2020), it can paradoxically inhibit the innovation processes necessary for maintaining a competitive edge. In the context of GPI, this tension becomes more pronounced. Others (Kam-Sing Wong, 2012; Varadarajan, 2017) argue that GPI acts as a strategic resource, offering differentiation in increasingly eco-conscious markets and meeting regulatory standards, which can lead to sustained market leadership. Yet, others point out that the initial costs and risks of green innovation can strain resources and undermine cost efficiency, especially in firms with limited financial capabilities (Duque-Grisales et al., 2020; Owen et al., 2018). We perceive this creates a significant dilemma within the RBV framework. One study shows that an overemphasis on cost-cutting potentially stifle the creativity for successful GPI (De Massis et al., 2018). Additionally, some scholars suggest that the rigid focus on CE leads to a risk-averse culture (Cai et al., 2022). For example, the fear of escalating costs hinders experimentation and the exploration of new, potentially disruptive technologies. This conservative approach is at odds with the dynamic capabilities framework (Inigo et al., 2017), which highlights the need for firms to be agile and responsive to changing market conditions, especially in the context of sustainability and green innovation. Accordingly, we hypothesise:

*H1: The higher the priority on cost efficiency, the more risk-averse a firm becomes, leading to reduced investment in green product innovation due to perceived uncertainties.*

*2.4 CE and GBK*

We propose that GBK emerges as a critical intangible asset that enhances a firm's ability to innovate in green products, for example by leveraging its brand's environmental reputation. Rather than viewing CE as a constraint (Wong et al., 2020; Marion and Meyer, 2011), companies can leverage it as a catalyst for innovation, focusing on how resources are allocated and utilised to maximise the impact of their green initiatives. This optimisation involves strategically using GBK to guide decisions on product development, marketing, and customer engagement (Fernando et al., 2012), ensuring that every dollar spent contributes to both cost reduction and the enhancement of the brand's green credentials. In product development, for instance, GBK can guide the prioritisation of eco-friendly materials and manufacturing processes that reduce costs over the product lifecycle.

We believe that as firms strive to reduce costs, they are often compelled to explore innovative solutions that not only optimise expenditures but also align with sustainable practices. This process involves adopting eco-friendly materials, streamlining production methods, and designing products that minimise environmental impact over their lifecycle. Each of these actions contributes to the accumulation of GPK, as firms gain insights into the complex interplay between cost-saving measures and environmental sustainability. For example, implementing sustainable sourcing practices or energy-efficient manufacturing processes provides firms with valuable knowledge about reducing waste and enhancing product performance, while simultaneously lowering costs. Over time, this cumulative learning is expected to deepen a firm's expertise in developing green products that are both cost-effective and environmentally conscious, creating a competitive edge in sustainability-driven markets.

Empirically, as CE are negatively attributed to waste and optimises processes (Ahmad et al., 2021), we believe that it reinforces the firm's reputation for being both economically and environmentally responsible (Hong et al., 2022), thereby enhancing GBK and contributing to the firm's long-term competitive advantage. Therefore, from a RBV perspective (Julienti and Ahmad, 2010; Khanra et al., 2022), GBK becomes one of key assets that, when effectively managed, allows firms to innovate in a way that aligns cost efficiency with environmental sustainability. Accordingly, we hypothesise:

*H2: The higher the pursuit of cost efficiency, the more likely a firm is to build and enhance green product knowledge.*

### *2.5 CE and GIC*

Similar to GBK, we suggest that CE and GIC are not mutually exclusive but must be balanced. CE is seen as a tool for enhancing GIC rather than an impediment. It is acceptable that green innovation is a high-cost production and operation behaviour (Li et al., 2022). As argued, it increases enterprises' costs and does not easily bring economic benefits, which leads to a decline in their green economic efficiency (Li et al., 2022). However, Li et al. (2022) overlook the essence of CE improving operational efficiencies. CE, when strategically applied, can enhance GIC. We propose that CE motivates firms to adopt innovative approaches that minimise resource wastage, enhance energy efficiency, and reduce environmental impact throughout the production and operational cycles. These efforts inherently require the development and application of GIC, as firms explore advanced technologies, redesign processes, and implement green supply chain practices. For instance, investments in renewable energy systems, waste reduction technologies, or recyclable materials often incur initial costs but generate substantial cost savings over time by lowering energy consumption and reducing dependency on finite resources. Such strategic decisions highlight the dual role of cost efficiency as both a financial and an environmental driver, fostering a deeper commitment to green innovation as a pathway to achieving sustainable competitive advantage.

Moreover, companies can foster an environment where employees are incentivised to think creatively about how to improve processes and integrate new, more sustainable technologies (Kumar and Rodrigues, 2020). Consequently, it drives the exploration and implementation of advanced green practices and technologies. For example, the funds saved through efficient operations can be invested in developing cutting-edge green technologies or expanding the scale of green initiatives (Yacob et al., 2019), thus enhancing the overall GIC of the organisation. So, it is expected that such an iterative process of cost reduction is associated to valuable insights and innovations that strengthen a company's green capabilities. Accordingly, we hypothesise:

*H3: The higher the emphasis on cost efficiency, the more a firm invests in green innovation capabilities that yield long-term savings and sustainability benefits.*

### *2.6 GBK and GPI*

GBK is a unique and firm-specific resource that varies significantly across firms, depending on their historical commitment to sustainability and environmental stewardship. Unlike more tangible resources, such as machinery or technology, which can be purchased or replaced, GBK is built through continuous engagement with external and internal stakeholders (Watson et al., 2018). It enhances a firm's ability to innovate in ways that are both sustainable and commercially viable (Wu, 2023). For firms with a strong historical commitment to sustainability, GBK becomes a central pillar of their strategic approach, guiding their innovation efforts and differentiating them from competitors who may be newer to the green space (Shehzad et al., 2023). Additionally, GBK is not an isolated resource but is intricately connected to its relationships with key stakeholders such as suppliers, customers, and regulatory bodies (Watson et al., 2018). These relationships play a crucial role in the development, enhancement, and application of GBK (Watson et al., 2018; Borah et al., 2023), making it a dynamic and context-specific resource that drives GPI. Therefore, firms with strong GBK are not only able to create new green products but also to adapt existing products to become more sustainable. Accordingly, we hypothesise:

*H4: The higher the green brand knowledge, the more a firm is driven to innovate green products to stay ahead in the sustainability market.*

## 2.7 *GBK as a mediator for CE and GPI*

As mentioned before, the relationship between CE and GPI is complex. While CE often drives firms to prioritise cost-cutting measures, potentially limiting their capacity for innovation (Wong et al., 2020), we propose GBK provides the necessary knowledge base that can align cost efficiency with the firm's green innovation goals. GBK equips firms with the understanding of green market trends, consumer expectations, and regulatory requirements, enabling them to optimise resource allocation and make informed decisions that do not sacrifice innovation for the sake of cost savings (Mourad and Serag Eldin Ahmed, 2012). For instance, GBK allows firms to innovate within the constraints of cost efficiency by optimising processes, materials, and technologies that align with green objectives. GBK, in this sense, represents a strategic resource that transcends the utilitarian calculus of short-term gains and shifts the focus towards long-term value creation through green innovation (Fernando et al., 2012). This challenges the utilitarian perspective (Marion and Meyer, 2011), by showing that firms do not have to choose between being cost-efficient and being innovative. Instead, with the right knowledge base, they can achieve both, thus creating value not just for shareholders but for a broader range of stakeholders, including customers, communities, and the environment (Panda et al., 2020). In this light, GBK not only bridges the gap between CE and GPI but also enhances the firm's capacity to turn cost efficiency into a strategic advantage rather than a mere operational necessity. Accordingly, we hypothesise:

*H5: The higher a firm's green brand knowledge, the more effectively it acts as a bridge, converting cost-efficient strategies into opportunities for green product innovation.*

## *2.8 GIC and GPI*

GIC is also a valuable resource within the RBV theory due to its ability to enhance a firm's market differentiation. One of the critical aspects of RBV theory is its emphasis on the heterogeneity of resources among firms (Hoopes et al., 2003; Zahra, 2021). This heterogeneity means that not all firms have the same level of GIC, which creates disparities in their ability to innovate green products. In this context, GIC becomes a central element of the firm's capital structure (Wang and Juo, 2021). It influences decisions related to resource allocation, strategic partnerships, and market positioning (Alkaraan et al., 2024). For firms that have consistently prioritised sustainability and environmental responsibility, their GIC is likely a product of years of strategic investments in green technologies, collaborations with environmentally-focused partners, and a corporate culture that emphasises sustainability (Khan et al., 2021). This cumulative knowledge and experience create a unique trajectory that enhances the firm's ability to innovate green products. These firms are not merely reacting to external pressures but are proactively shaping their markets by consistently introducing innovative green products that set industry standards (Hofman et al., 2020). Such a proactive approach, then, reinforces their competitive position and aligns with RBV's emphasis on the importance of a firm's historical path in developing capabilities that are difficult for competitors to replicate. Accordingly, we hypothesise:

*H6: The higher the green innovation capability of a firm, the more effectively it utilizes resources to develop new and innovative green products.*

### *2.9 GIC as a mediator for CE and GPI*

In this context, we perceive that GIC acts as the mechanism through which cost-efficient practices are translated into meaningful green product innovations. Cost efficiency often results in freeing up resources (De Massis et al., 2018). However, without a robust GIC, these freed-up resources might not be effectively utilised for green innovation. In this sense, GIC serves as the bridge that connects cost-saving measures with the development of green products. It can be achieved by ensuring that the resources saved through cost efficiency are strategically invested in areas that enhance environmental performance (Albertini, 2013). For example, a firm that achieves cost efficiency through the reduction of material waste may simultaneously identify ways to use recycled materials in its products (Ranta et al., 2018). GIC, as a mediator, enables firms to recognise these synergies and capitalise on them effectively. So, by embedding environmental considerations into the firm's innovation processes, GIC makes sure that the pursuit of cost efficiency is not seen as being at odds with green innovation, but rather as complementary objectives that can be pursued simultaneously. Accordingly, we hypothesise:

*H7: The higher a firm's green innovation capability, the more effectively it acts as a bridge, converting cost-efficient strategies into opportunities for green product innovation.*

### *2.10 GBK as a moderator for CE and GPI*

The assertion by some scholars – that green innovation necessarily entails substantial investment in new technologies, processes, and materials, leading to increased costs and potentially impacting short-term economic performance (Duque-Grisales et al., 2020; Owen et al., 2018) – represents a narrow and overly simplistic view. The role of GBK in this dynamic offers a more nuanced perspective. A strong understanding of the green brand allows firms or decision-makers to see cost efficiency as part of a larger strategy to build long-term brand equity and consumer trust (Majeed et al., 2022). Within these studies, consumers are increasingly drawn to brands that demonstrate genuine commitment to environmental sustainability (Le, 2022; Oláh et al., 2018), and that cost-saving measures should support, rather than undermine, this commitment. So, the key to successful green product innovation lies in how cost efficiency is applied, and this application is largely determined by the depth of the decision-maker's comprehension of the brand's environmental values and objectives. This moves away from the narrow, transactional focus on immediate financial returns, highlighting the value of intangible assets like GBK, which contribute to long-term brand equity and customer loyalty. Accordingly, we hypothesise:

*H8: Green brand knowledge weakens the typically strong relationship between cost efficiency and risk aversion in green product innovation.*

### *2.11 GIC as a moderator for CE and GPI*

The relationship between CE and GPI is not inherently antagonistic. Instead, GIC acts as a transformative component that transforms the potentially negative influence of CE on GPI into a positive one. Unlike traditional innovation capabilities that focus primarily on technological advancements or market differentiation, GIC specifically addresses the need to innovate in ways that reduce environmental impact (Mendoza-Silva, 2021). While Borah et al. (2023) position GIC as a determinant of new product success, extending this to view GIC as a dynamic moderator offers a more complex understanding of its role. GIC can be seen as a capability that evolves over time, influencing how firms navigate the tension between cost efficiency and green innovation. In this extended view, GIC does not just impact the success of individual products but shapes the firm's overall ability to integrate cost efficiency with green product innovation across multiple projects and over time. This dynamic perspective allows for a deeper exploration of how firms can continuously adapt their GIC to changing market conditions and sustainability demands, ensuring long-term competitiveness (Guo, 2023). We propose that without a strong GIC, a firm's focus on cost efficiency might lead to incremental innovations that offer limited environmental benefits, as cost-saving measures could take precedence over bold, transformative innovations. However, when GIC is strong, it enables the firm to pursue green innovation aggressively, even within a cost-constrained environment. Accordingly, we hypothesise:

*H9: Innovation capability weakens the typically strong relationship between cost efficiency and risk aversion in green product innovation.*

## 3. Methodology

### *3.1 Data collection*

We collected data using questionnaires. The data collection took 8 months to complete. It is important to note that initially, the measurement items were written in English. The rationales were: (a) to avoid any bias that might arise during the process of adopting measurement items from previous research; (b) to maintain the integrity of the original constructs, ensuring that the specificities of the concepts being measured were not lost in translation. Once a draft of the questionnaire was prepared, it was then sent to a professional translation service to be translated into Indonesian. Even though Indonesia is comprised of 34 provinces with diverse cultures, ethnicities, and over 700 local languages, the unifying national language is Indonesian. It serves as the primary medium for communication across the country and is widely used in formal, educational, and everyday settings. Given its universal acceptance and the need for clarity and accessibility in data collection, we translated our questionnaire into Indonesian. This decision ensures that respondents can engage with the content in the language most familiar and comfortable to them. It also reduces potential barriers to understanding and improves the reliability of their responses.

Before distributing the questionnaire to the target respondents, we conducted a pilot study with 12 accounting lecturers. Feedback from these knowledgeable participants, who are familiar with both the language and the context of the study, was invaluable in refining the questionnaire, ensuring that it was not only linguistically accurate but also contextually relevant and easy to understand (Gudmundsdottir and Brock-Utne, 2010). Moreover, the use of a pilot study also provided preliminary insights into the potential variability in responses and helped us to fine-tune the questionnaire further before the full-scale data collection (Gudmundsdottir and Brock-Utne, 2010).

As the focus of the study, the distribution of questionnaires is limited to the East Java province. The rationale is that East Java is a strategic region for examining phenomena such as industrial activities, and socio-environmental dynamics, due to its unique characteristics and significant role in Indonesia's national economy. As one of the most populous provinces in the country, East Java hosts a diverse mix of industries, including manufacturing, agriculture, and services, making it a microcosm of Indonesia's broader economic structure. This diversity allows us to capture varied perspectives and practices, particularly in areas such as sustainability, cost efficiency, and innovation, offering valuable insights that may be relevant to other regions with similar characteristics. Furthermore, East Java has experienced rapid industrialisation and urbanisation, leading to pressing environmental challenges, including waste management, pollution, and resource depletion. These issues make the region an ideal setting for studies focusing on green innovation, cost efficiency, and sustainable development practices. The region is also home to several industrial hubs and economic zones, such as Surabaya, which is not only the second-largest city in Indonesia but also a critical node in the country's logistics and manufacturing networks.

### *3.2 Research Procedure*

We visited SMEs operating in the Province of East Java, Indonesia, to engage directly with business owners and managers. During these visits, we explained the aims and objectives of our research (Bukve, 2019), emphasising the importance of understanding local business practices and the potential impact on regional economic development. For example, we provided detailed information on how optimising SME operations could contribute to broader regional progress, highlighting the mutual benefits of participating in the study. We also clarified the specific data we sought (Bukve, 2019), which included their experiences and perspectives on product innovation to meet market demands. This approach ensured that the SMEs understood the value of their contributions and the relevance of their insights to the research goals. At the same time, we gave an example of our questionnaire.

In the first page of the questionnaire, participants were also thoroughly informed about the study's purpose, ensuring transparency and clarity regarding the research objectives. It also informed data treatment. It provided assurances of anonymity and confidentiality, emphasising that any personal data collected would be securely handled to protect participant privacy. Participants were explicitly asked to consider any concerns they might have about taking part in the study, with a clear option to indicate their voluntary consent by ticking 'yes,' signifying their agreement to participate. In such a Participant Consent, it highlighted their right to withdraw from the study at any point or stage, reaffirming that such a decision could be made freely and without any penalties or repercussions.

When they agreed to participate in the study, we, then, distributed the questionnaires tailored to the specific roles of the individuals we were targeting, such as owners, managers, and assistant managers. We informed the participants that we would collect the completed questionnaires within the next week, allowing them ample time to provide thoughtful and thorough responses. To express our gratitude for their participation and the valuable time they dedicated to our study, we offered small incentives to each participant. This was also to encourage active engagement, reinforcing the importance of their insights for the success of our research.

The current study effectively addresses sectoral heterogeneity by employing nuanced theoretical considerations, ensuring that its findings remain both relevant and meaningful across diverse industry contexts. Recognising that the relevance of key variables such as GPI, GBK, GIC, and CE may vary significantly across sectors, the study takes a flexible and context-sensitive approach to operationalise these constructs. The selection of measurement items in the current study is conducted with meticulous care to ensure their validity, relevance, and applicability, particularly within the Indonesian context. While the study adopts measurement items from prior research to maintain alignment with established methodologies, it does so judiciously, with careful consideration of both theoretical underpinnings and practical realities. This dual-layered approach ensures that the selected items are not only grounded in robust academic frameworks but are also tailored to reflect the operational and cultural nuances of SMEs in Indonesia.

For example, while GPI2 – focused on optimising water usage in production – holds substantial relevance in the food and beverage sector, it may be less applicable in industries like transportation. However, this assertion does not underestimate the significant need for water in daily operations within the transportation sector. While water use may not directly fuel the core transportation function – such as moving passengers or goods – it is a critical resource for maintaining fleet hygiene, ensuring passenger comfort, and adhering to health and safety standards. Every business actor in the transportation sector relies on considerable water resources to manage these auxiliary yet essential processes, including filling water tanks for on-board toilets and washing buses daily. These activities are not peripheral but integral to the smooth functioning and quality assurance of transportation services.

### *3.3 Data: Demographic Respondents*

We used random sampling to ensure an unbiased selection of SMEs within the population, providing every eligible entity an equal chance to participate. However, the practical application of this method faced challenges, as many SMEs declined to participate due to their busy schedules. To maintain the study's validity, we adhered to the Indonesian government's criteria for SMEs, requiring a minimum of IDR 50,000,000 in assets for small enterprises. These criteria were verified before distributing questionnaires, ensuring that the sample aligned with the official definitions.

Out of the 625 questionnaires we distributed to 238 SMEs, we received 87% response rate (around 544 returned questioners). This high return rate was achieved because we provided respondents with a one-week deadline and offered a financial incentive for completing the questionnaire. However, we were unable to process 32 questionnaires due to a few reasons: some participants did not tick "yes" in the Participant Consent section, and others left the survey incomplete, not answering all the questions. Therefore, the total number of questionnaires that were eligible for processing was 512.

[Insert Table 1 Here]

Table 1 provides an overview of the demographic characteristics of the respondents. The gender distribution shows that 66.8% of the respondents are male (342 individuals), while 33.2% are female (170 individuals). In terms of professional roles, the respondents are predominantly assistant managers, accounting for 62.11% (318 individuals), followed by managers at 22.27% (114 individuals), and owners at 15.63% (80 individuals). The respondents represent a variety of industries, with the largest sectors being Home and Office Products (27.31%), Consumer Electronics (14.71%), and Food and Beverage (13.45%). Smaller proportions come from industries like Fashion and Textiles (5.46%), Agriculture (6.30%), and Transportation and Automotive (5.88%).

Regarding educational background, the majority of respondents have an undergraduate degree (50.78%), while a notable 41.60% chose not to disclose their education level. Only a small number of respondents hold a postgraduate degree (2.54%) or a diploma (3.52%). When asked about their company's stance on eco-friendly products, an overwhelming 94.92% of respondents affirmed their companies' commitment to eco-friendly products, with 66.21% having maintained this focus for more than five years. Conversely, 5.08% of respondents were unsure about their company's environmental stance, and 6.25% were uncertain about the duration of their company's eco-friendly initiatives.

### *3.4 Measurement*

We measured GPI using five items. Rather than directly adopting the measurement scales used in previous studies, such as those by Xie et al. (2019), we tailored the items to better suit the specific context of our research in SMEs. This process involved careful consideration and adjustments, drawing on insights from conceptual framework works (Dangelico, 2016; Khan et al. (2021), to ensure our measurements were both relevant and robust for our study's objectives. Then, most previous studies observed GBK from the perspective of customers (e.g. Zhou et al., 2021). Contrast to prior studies, we examined it from the perspective of firm. In measuring such variable, we used 6 items by modifying items developed by Borah et al. (2023) and Sahoo et al., (2023). In relation to GIC, we used 5 items modified from Borah et al. (2023) by consulting to Mellett et al.'s (2018) qualitative study. Finally, CE was measured by 5 items. Those are developed by referring to some studies such Edmans et al. (2016), Le et al., (2019) and Bazot (2018).

The current study effectively addresses sectoral heterogeneity by employing methodological strategy and nuanced theoretical considerations, ensuring that its findings remain both relevant and meaningful across diverse industry contexts. Recognising that the relevance of key variables such as GPI, GBK, GIC, and CE may vary significantly across sectors, the study takes a flexible and context-sensitive approach to operationalise these constructs. For example, while GPI2 - focused on optimising water usage in production – holds substantial relevance in the food and beverage sector, it may be less applicable in industries like transportation. To address this, the study adapts its measurements, tailoring the variables to align with the specific challenges and priorities of each sector. In the transportation sector, GPI takes on unique dimensions that align with the operational and environmental priorities of the industry. For example, while GPI in this sector might generally emphasise reducing fuel consumption through the adoption of energy-efficient technologies, it also extends to innovations that optimise water usage during fleet preparation processes. Practical applications include the efficient filling of water tanks for on-board amenities, such as toilets, and the water-intensive cleaning routines required for buses before and after operations. These processes, while ancillary to core transportation functions, represent significant opportunities for environmental improvement through innovation.

### *3.5 Analysis*

We used Partial Least Squares Structural Equation Modelling (PLS-SEM) instead of Covariance-Based Structural Equation Modelling (CB-SEM). The main reason is that our research is to predict and develop theories rather than test and confirm existing ones (Dash and Paul, 2021). PLS-SEM is particularly suited for exploratory research where the primary goal is to identify and model the relationships between variables to generate new theoretical insights (Hair et al., 2019; Dash and Paul, 2021). Unlike CB-SEM, which focuses on verifying predefined models and theories (Dash and Paul, 2021), PLS-SEM allows for greater flexibility in handling complex models with multiple constructs (Sarstedt et al., 2014). As such, this point aligns with our objective to explore the relationships and build new theoretical frameworks, making PLS-SEM the more appropriate choice for our study.

## 4. Finding and analysis

### *4.1 Measurement model assessment*

In carrying out the measurement model assessment, we focused on two critical aspects: convergent validity and discriminant validity. Convergent validity was assessed to ensure that the indicators of a construct are highly correlated and effectively measure the same underlying concept (Cheung et al., 2024). It is typically confirmed through metrics such as factor loadings, composite reliability, and average variance extracted (AVE) (Hair et al., 2019). The result of convergent validity is reported in Table 2. On the other hand, discriminant validity was evaluated to ensure that the constructs in the model are distinct from one another, with each construct uniquely capturing its intended concept (Cheung et al., 2024). It often validated through the Fornell-Larcker criterion, cross-loadings and Heterotrait-Monotrait Ratio (HTMT) (Hair et al., 2019). The result of discriminant validity is reported in Tables 3, 4 and 5.

[Insert Table 2 Here]

As suggested in Table 2, convergent validity was found to be satisfactory. This was confirmed through strong factor loadings, high composite reliability, and an AVE value above the recommended threshold (Hair et al., 2019). For Green Product Innovation, factor loadings ranged from 0.660 to 0.833, with a Cronbach’s alpha of 0.817, CR of 0.873, and AVE of 0.581, indicating a reliable construct with good internal consistency. Cost Efficiency also exhibited strong factor loadings between 0.717 and 0.793, a Cronbach’s alpha of 0.815, CR of 0.871, and AVE of 0.575, further confirming its reliability. Green Brand Knowledge presented somewhat lower factor loadings, ranging from 0.590 to 0.824, but maintained an acceptable Cronbach’s alpha of 0.823, CR of 0.871, and AVE of 0.532, demonstrating adequate construct validity. Finally, Green Innovation Capability showed robust factor loadings from 0.771 to 0.850, with a high Cronbach's alpha of 0.869, CR of 0.905, and AVE of 0.656, indicating a strong and reliable measurement model. Overall, the constructs exhibit good convergent validity, confirming that the indicators within each construct are well-aligned and effectively measure the intended concepts (Hair et al., 2019).

[Insert Table 3 Here]

As previously mentioned, the fornell-larcker criterion presented in Table 3 is used to evaluate the discriminant validity of the constructs.  We compared the square root of the AVE for each construct with the correlations between that construct and others in the model (Hair et al., 2019). For CE, the square root of the AVE is 0.758, which is greater than its correlations with GBK at 0.572, GIC at 0.557, and GPI at -0.216. Similarly, GBK has a square root of AVE of 0.729, higher than its correlations with GIC (0.443) and GPI (-0.115). GIC also meets the discriminant validity criterion with a square root of AVE of 0.810, exceeding its correlations with GPI (-0.158). Finally, GPI shows a square root of AVE of 0.762, higher than its negative correlations with other constructs. These results indicate that each construct is more closely related to its own indicators than to other constructs in the model, confirming adequate discriminant validity across the constructs (Henseler et al., 2015; Hair et al., 2019).

[Insert Table 4 Here]

The cross-loadings presented in Table 4 provide further evidence of discriminant validity by showing how each indicator loads on its associated construct compared to other constructs. The indicators of CE consistently exhibit higher loadings on CE (ranging from 0.717 to 0.793) than on GBK, GIC, or GPI, with cross-loadings not exceeding 0.609. Similarly, GBK indicators load more strongly on GBK (ranging from 0.590 to 0.824) compared to CE, GIC, or GPI, with the highest cross-loading being 0.515. The indicators for GIC show strong loadings on their own construct (ranging from 0.771 to 0.850) and lower cross-loadings on CE, GBK, and GPI. Finally, the GPI indicators load most strongly on GPI (ranging from 0.660 to 0.833), with much lower cross-loadings on the other constructs. These patterns confirm that each indicator is most strongly associated with its respective construct, supporting the discriminant validity of the measurement model (Hair et al., 2019; Henseler et al., 2015).

[Insert Table 5 Here]

Furthermore, Table 5 provides an additional assessment of discriminant validity by measuring the ratio of between-construct correlations to within-construct correlations. The HTMT values between the constructs are all below the commonly accepted threshold of 0.85, indicating good discriminant validity (Henseler et al., 2015). Specifically, the HTMT between CE and GBK is 0.677, between CE and GIC is 0.662, and between CE and GPI is 0.266. The HTMT values between GBK and GIC is 0.551, and between GBK and GPI is 0.155. Lastly, the HTMT between GIC and GPI is 0.186. These low HTMT values confirm that the constructs are distinct from each other, further validating the discriminant validity of the measurement model (Henseler et al., 2015).

*4.2 Hypothesis testing*

Table 6 presents the results of hypothesis testing for the direct effects within the model. The standardised path coefficients ($\beta$), standard deviations (SD), and *p*-values are reported for each hypothesised relationship. The first hypothesis (*H1*) examines the effect of CE on GPI. Table 6 suggests a negative and significant path coefficient ($\beta$ = -0.235, *SD* = 0.055, *p* = 0.000), leading to the acceptance of this hypothesis. The second hypothesis (*H2*) assesses the impact of CE on GBK, showing a positive and significant effect ($\beta$ = 0.572, *SD* = 0.035, *p* = 0.000), thus also is accepted. Similarly, the third hypothesis (*H3*) tests the influence of CE on GIC, which is positively and significantly supported ($\beta$ = 0.557, *SD* = 0.037, *p* = 0.000).

[Insert Table 6 Here]

However, the fourth hypothesis (*H4*) as reported in Table 6, which explores the effect of GBK on GPI, is not supported ($\beta$ = 0.019, *SD* = 0.059, *p* = 0.745) as the relationship is insignificant. Likewise, the fifth hypothesis (*H6*), which posits a relationship between GIC and GPI, is also not accepted ($\beta$ = -0.037, *SD* = 0.055, *p* = 0.494) due to its insignificance. These results highlight that while CE significantly influences GBK, GIC, and GPI, the effects of GBK and GIC on GPI are not statistically significant.

[Insert Table 7 Here]

The insignificant effects of the effects of GBK and GIC on GPI are strengthened by the result of table 7. Specifically, the analysis tested whether GBK and GIC mediate the relationship between CE and GPI. The results indicate that neither GBK nor GIC significantly mediate this relationship, as evidenced by the non-significant path coefficients and *p*-values for both mediation paths: CE -> GBK -> GPI ($\beta$ = 0.011, *SD* = 0.034, *p* = 0.746) and CE -> GIC -> GPI ($\beta$ = -0.021, *SD* = 0.031, *p* = 0.497). As such, *H5* and *H7* are not supported. These findings are consistent with the direct effect results, confirming that GBK and GIC do not play a significant mediating role in the impact of CE on GPI, further reinforcing the conclusion that their influence on GPI requires further studies.

When we treated GBK and GIC as moderating variables, the results diverged from the prior mediation analysis presented in Table 7. As shown in Table 8, both GBK and GIC significantly moderate the relationship between CE and GPI. Specifically, the interaction effect of CE and GBK on GPI is positive and significant ($\beta$ = 0.100, *SD* = 0.043, *p* = 0.019), leading to the acceptance of hypothesis *H8*. Similarly, the interaction effect of CE and GIC on GPI is even stronger and highly significant ($\beta$ = 0.167, *SD* = 0.043, *p* = 0.000), resulting in the acceptance of hypothesis *H9*.

[Insert Table 8 Here]

*4.3 Additional analysis*

To verify the results of the previous analysis, it is crucial to examine two key aspects: the Variance Inflation Factor (VIF) and the predictive power of the variables observed in the research. Table 9 presents the VIF values, which are used to assess multicollinearity among the variables. The VIF values for CE are 1.000 for both GBK and GIC, indicating no multicollinearity issues. For GPI, the VIF values are 1.791 for CE, 1.539 for GBK, and 1.499 for GIC. Since all VIF values are well below the commonly accepted threshold of VIF (O'brien, 2007), multicollinearity is not a concern. These confirm that the predictors in the model are independent and that the results of the analysis are reliable. Therefore, this assessment strengthens the validity of the findings, ensuring that the observed relationships between the variables are not distorted by multicollinearity.

[Insert Table 9 Here]

Furthermore, we analysed the prediction strength measure by looking at predictive accuracy (*R2*), predictive relevance (*Q2*) and effect sizes ($f^2$). As shown in Table 10, the $R^2$ value for GBK is 0.327, indicating that 32.7% of the variance in GBK is explained by CE. Similarly, GIC has an $R^2$ of 0.310, meaning that CE accounts for 31% of the variance in GIC. However, the predictive accuracy for GPI is much lower, with an $R^2$ of 0.049, suggesting that only 4.9% of its variance is explained by the predictors in the model.

In terms of predictive relevance ($Q^2$), GBK and GIC have $Q^2$ values of 0.167 and 0.200, respectively, indicating that the model has moderate predictive relevance for these variables. GPI, with a $Q^2$ of 0.026, shows low predictive relevance, aligning with the low $R^2$. The effect sizes ($f^2$) for CE on GBK (0.487) and GIC (0.449) are substantial, indicating a strong influence of CE on these variables. However, the effect size of CE on GPI is minimal ($f^2$ = 0.023), reflecting its limited impact on this outcome variable. The effect sizes of GBK and GIC on GPI are negligible, with $f^2$ values of 0.000 and 0.002, respectively, reinforcing the earlier finding that GBK and GIC do not significantly influence GPI.

[Insert Table 10 Here]

## 5. Discussion

### *5.1 Result discussion*

This research aims to examine the role of CE in influencing GPI, with a particular focus on the moderating effects of GBK and GIC. In doing so, the study also explores not only whether GBK and GIC directly affect GPI but also investigates their potential roles as mediating variables in the relationship between CE and GPI. By assessing both the direct and indirect effects, as well as the moderating influences, this research provides a comprehensive analysis of how CE contributes to GPI and how GBK and GIC may moderate or mediate this relationship.

In our study, we found that CE has a negative influence on GPI, suggesting that an overemphasis on cost-cutting might stifle innovation. This negative relationship is often attributed to the tension between reducing costs and investing in new, innovative practices that typically require significant resources (Müller et al., 2021). Some scholars have consistently shown that when firms prioritise cost efficiency above all else, they may inadvertently limit their ability to explore new technologies, develop environmentally sustainable products, or invest in long-term innovation strategies (Fernando et al., 2019). For instance, some research have highlighted that firms focused on minimising costs often adopt a conservative approach to innovation, favouring incremental changes over radical innovation, which can hamper the development of ground-breaking green products (e.g Müller et al., 2021; Moradi et al., 2021). This negative impact could be also explained by the RBV theory's emphasis on the trade-offs that firms face when allocating resources. A firm that focuses heavily on cost efficiency deprioritise investments in innovative processes and technologies, viewing them as non-essential or too risky in the short term. Consequently, the firm's ability to produce innovative green products is compromised, as the resources and capabilities that could support such innovation are either underutilised or inadequately developed.

Under our study, however, when CE is interacted with strong GBK and GIC, the firm's resources are more effectively aligned and utilised, allowing the firm to achieve both cost efficiency and innovation. GBK, for example, enables the firm to leverage its brand's environmental reputation to create value through green products, thereby offsetting the potential drawbacks of a stringent cost focus. Similarly, GIC enhances the firm's capacity to innovate within the constraints of cost efficiency by fostering a culture of continuous improvement and adaptation, which is crucial for developing and marketing green products.

Referring to the RBV theory, such unique combinations of resources and capabilities create synergies that lead to competitive advantages that are difficult for competitors to replicate. In this case, while GBK and GIC do not show a direct or mediating influence on GPI, their role in moderating the relationship between CE and GPI suggests that their true value lies in how they interact with other resources within the firm. This interaction enables the firm to overcome the potential limitations of a cost-focused strategy and instead use it as a foundation for innovative green product development, ultimately supporting the RBV perspective that competitive advantage is achieved through the effective integration and utilisation of a firm's resource portfolio.

### *5.2 Theoretical implications*

The outcomes of the study make significant theoretical contributions to the existing literature on GPI by proposing novel associations, which have not been researched earlier (Dangelico, 2016; Sarkar et al., 2022; Tuan, 2023). This study extends the RBV theory in a new direction. The discovery that CE initially has a negative influence on GPI, which then turns positive when moderated by GBK and GIC. It challenges traditional assumptions within the RBV theory that cost efficiency is typically at odds with innovation, particularly in environmentally sustainable practices. The research findings articulate a paradox where cost efficiency, while traditionally deemed a driver of innovation, manifests a counterproductive impact on GPI when pursued in isolation. This counterintuitive revelation highlights the inherent tension between operational cost reduction and the strategic investments required for sustainable innovation. This point emphasises a fundamental tension within firms – one between the immediate, short-term operational advantages gained through cost-efficiency measures and the long-term investments required for innovative progress, particularly in the context of GPI. The essence of this tension lies in the nature of innovation itself, which is inherently resource-intensive and future-oriented. Cost-efficiency measures, when prioritised excessively, focus on the present, seeking to maximise operational savings, reduce waste, and streamline processes to optimise financial outcomes in the short run. These efforts, even though vital for maintaining a firm's competitiveness in a cost-driven market, often come at the expense of investing in the kind of innovation that requires foresight, experimentation, and sometimes significant upfront costs.

The understanding of how CE interacts with intangible assets like GBK and GIC provides a fresh perspective on how firms can strategically balance cost constraints with the need for innovation, contributing to a more sophisticated and context-dependent application of RBV in the field of green innovation. Cuthbertson and Furseth (2022), in his foundational work on RBV, argued that a firm's ability to gain and sustain competitive advantage is largely contingent on the possession of valuable resources. Cuthbertson and Furseth's (2022) RBV framework primarily focuses on the value of tangible and static resources, such as capital, technology, or physical assets, which firms can leverage to establish a competitive edge. The current study extends this framework by introducing the idea that intangible, dynamic capabilities are equally essential to gaining and sustaining competitive advantage, especially in the context of sustainability and green innovation. This shift in focus towards dynamic, knowledge-based assets reflects the growing importance of adaptability, creativity, and environmental responsibility in achieving long-term success in today's rapidly evolving markets. In particular, the study underlines the notion that resources such as GBK and GIC are not just valuable in isolation but become especially potent when strategically aligned with cost efficiency (CE) strategies.

Furthermore, the insights from this study extend the work of Awan et al. (2021) by offering a deeper understanding of how cost efficiency interacts with green innovation, particularly in the context of knowledge acquisition and environmental investment. Awan et al. (2021) emphasise the importance of knowledge acquisition and environmental investment as key drivers of green product and process innovation, highlighting the need for firms to integrate these elements into their strategic frameworks. The present study complements this by introducing the role of CE as a critical factor in this equation. While Awan et al. (2021) focus on the proactive measures firms take – such as acquiring knowledge and investing in environmental initiatives – the current research reveals that CE, traditionally viewed as a constraint, can also be a strategic asset when moderated by GBK and GIC. Others argue that knowledge and investment are crucial for driving green innovation (Martínez-Ros and Kunapatarawong, 2019; Wu, 2023), but they do not fully address how firms can navigate the potential conflict between maintaining cost efficiency and pursuing innovation. The current research fills this gap by showing that CE does not necessarily inhibit green innovation; instead, it can be leveraged as a positive force when a firm's brand knowledge and innovation capabilities are robust.

Moreover, the study breaks new ground by showing that while GBK and GIC do not have a direct or mediating influence on GPI, their moderating effects are critical in reversing the negative impact of CE on innovation. This finding introduces a novel theoretical association within the RBV framework, highlighting the importance of considering how intangible resources like brand knowledge and innovation capability (Borah et al., 2023) transform the strategic implications of tangible resources like cost efficiency. We argue that the RBV's focus on the internal resources of a firm can lead to a neglect of external factors, such as market dynamics or regulatory pressures (see, Julienti and Ahmad, 2010; Khanra et al., 2022; Silvestri et al., 2023), which also play crucial roles in shaping innovation outcomes. In this way, our study also complements and deepens prior studies (Rahman, 2023; Afeltra et al., 2023), emphasising the critical role of intangible resources in overcoming financial constraints and driving sustainable innovation. The current study's findings suggest that GBK and GIC do not merely exist as static resources but function dynamically to influence how CE affects GPI. This aligns with the dynamic capabilities view, where the ability to innovate and respond to environmental challenges depends not just on possessing resources but on how they are managed and combined over time (Alkaraan et al., 2024). So, it can be argued, this supports the idea that the value of resources is often realised through their interaction with other resources (Shehzad et al., 2023).

### *5.3 Managerial implications*

The findings from our research offer several critical managerial implications, particularly for firms that are striving to balance cost efficiency with the need to innovate in the development of green products. The initial discovery that CE has a negative influence on GPI. It suggests that managers need to be cautious about overly aggressive cost-cutting strategies, especially in areas related to environmental sustainability. While cost efficiency is crucial for maintaining competitive pricing and operational effectiveness, our results indicate that an excessive focus on cost reduction may inadvertently stifle innovation, particularly in the green product space where creativity, research and development, and long-term investments are essential. Managers should, therefore, recognise that while cost efficiency is important, it should not be pursued at the expense of innovation. Instead, firms should seek a balanced approach where cost-saving measures are carefully weighed against their potential impact on the firm's ability to innovate and develop sustainable products.

However, the turning point in our research is the finding that the negative influence of CE on GPI can be mitigated and even reversed when CE is interacted with GBK and GIC. The findings underline the necessity for managers to transcend traditional cost-focused approaches and embrace a resource-based perspective that leverages intangible assets for sustainable growth. For SMEs in similar developmental contexts, the dual focus on GBK and green GIC not only addresses the inherent limitations of CE but repositions it as a cornerstone for competitive differentiation in the green economy. GBK functions as a strategic compass, enabling SMEs to interpret and respond to environmental market demands, while GIC operationalizes this insight through innovation in sustainable products and processes. This synergy transforms CE from a reactive cost-containment strategy into a proactive enabler of value creation, ensuring that SMEs are not merely cost-efficient but also innovation-driven. The argument is particularly compelling given that resource-constrained SMEs in emerging markets often operate under stringent economic pressures; in this context, the integration of GBK and GIC provides a pathway to reconcile short-term operational goals with long-term sustainability imperatives. Thus, the strategic cultivation of GBK and GIC equips SMEs to transform sustainability from a regulatory obligation into a competitive advantage that resonates with increasingly eco-conscious consumers.

Finally, the lack of evidence supporting a direct or mediating influence of GBK and GIC on GPI highlights the importance of viewing these variables as contextual rather than standalone drivers of innovation. For managers, this means that GBK and GIC should not be seen as silver bullets that can independently drive green innovation. Instead, their value lies in how they interact with other strategic elements, particularly cost efficiency. Managers should, therefore, adopt an integrative approach, where GBK and GIC are developed and utilised in conjunction with other resources and strategies. This approach requires a holistic understanding of the firm's resource base and how these resources can be effectively combined to achieve the desired outcomes. In practice, this might involve creating cross-functional teams that bring together expertise in brand management, innovation, and cost control, ensuring that these areas are not siloed but are instead aligned towards common goals. Additionally, managers should continuously monitor and evaluate the effectiveness of their strategies, making adjustments as necessary to ensure that the interactions between CE, GBK, and GIC are optimised to support green product innovation. So, this integrative and adaptive approach will help firms navigate the complexities of cost efficiency and innovation, ultimately leading to more successful and sustainable product development.

## 6. Conclusion

The findings of our study invite a critical reassessment of the RBV theory, particularly in the context of its application to green product innovation. Traditionally, RBV suggests that firms gain competitive advantage by leveraging valuable, rare, inimitable, and non-substitutable resources. However, our results challenge this assumption by showing that CE, typically considered a valuable resource under RBV, initially exerts a negative influence on GPI. This finding raises questions about the RBV's ability to fully capture the complexities of how cost-related resources affects innovation, especially in the realm of sustainability. The RBV often assumes a linear or additive relationship between resource utilisation and performance outcomes. The more resources a firm possesses, the greater its complexity for achieving higher performance. For instance, the complexities are attributed to balancing CE and GPI. Our study suggests that the relationship between these two factors is far from straightforward. We perceive that the RBV's linear model fails to consider how different resources interact in dynamic and sometimes counterintuitive ways. For instance, the pursuit of CE, if not carefully managed, can inhibit long-term investments in innovation, particularly green innovation, which requires substantial upfront costs and risk-taking.

Essentially, while the negative impact of CE on GPI is mitigated when moderated by GBK and GIC, the lack of direct or mediating effects of these variables on GPI suggests that RBV may oversimplify the dynamics at play. RBV's emphasis on the direct contribution of resources to competitive advantage does not account for the nuanced ways in which these resources interact with one another, particularly when it comes to intangible assets like GBK and GIC. It is not simply about how many resources a firm possesses, but rather how effectively those resources are optimised through their interaction with other resources. A firm may possess ample resources, but without optimising their use through complementary interactions, these resources can remain underutilised or even counterproductive. In emerging markets, where firms often face resource constraints, this becomes even more critical. GBK and GIC illustrate how firms can leverage intangible assets to create synergies that offset the limitations of CE, transforming it into a facilitator rather than an inhibitor of green innovation.

Therefore, our findings indicate that RBV, in its current form, may not provide a sufficiently robust framework for understanding how firms can effectively manage cost efficiency while driving innovation in green products. The theory's focus on the static value of resources may overlook the importance of strategic interactions and the contextual factors that can significantly alter the impact of these resources on innovation outcomes. Consequently, our research suggests that there is a need to refine RBV, or perhaps complement it with additional theoretical perspectives, to better account for the complex, dynamic nature of resource interactions in the context of green innovation.

**7. Limitations and suggestions for further studies**

This study is not without limitations. One significant limitation is the reliance on the RBV theory as the primary theoretical framework. Although RBV has been instrumental in understanding how firms leverage resources for competitive advantage, our findings suggest that the theory may be inadequate in explaining the nuanced and complex relationships between CE, GPI, GBK, and GIC. This limitation suggests that future research should consider integrating other theoretical perspectives, such as dynamic capabilities or systems thinking, to provide a more comprehensive understanding of how resources interact in the context of green innovation.

Another limitation of our study is the narrow focus on CE, GBK, and GIC as the primary variables influencing GPI. While these variables were chosen based on their relevance to RBV, the lack of significant direct or mediating effects of GBK and GIC on GPI raises questions about whether other factors might be at play. For example, environmental regulations, market demand for green products, and organisational culture (Wang, 2019; Hong et al., 2022) are all potential variables that could influence the relationship between CE and GPI but were not considered in our study. Subsequent studies could adopt a more holistic approach, combining primary data with secondary sources and examining the interplay between internal capabilities, external pressures, and market outcomes. Additionally, the RBV's emphasis on firm-specific resources may overlook the importance of external factors, such as industry trends or technological advancements, that can also drive innovation. Future studies should explore these additional factors and consider how they might interact with CE, GBK, and GIC to influence GPI. By broadening the scope of analysis, the next studies can develop a more holistic understanding of the drivers of green innovation and the limitations of RBV in capturing these complexities.

Moreover, the results of this research appear to hinge significantly on the willingness of SMEs to participate, a factor that introduces potential biases and limits the generalisability of the findings. To address this, future research should explore strategies to enhance participation rates and ensure a more representative sample of the SME population. Further research could adopt mixed-method approaches, combining quantitative surveys with qualitative methods such as interviews or focus groups.

Finally, our study's methodological approach may also limit the generalisability of the findings. The use of cross-sectional data, while suitable for exploring relationships between variables, does not capture the temporal dynamics that are critical to understanding how CE, GBK, and GIC influence GPI over time. RBV traditionally views resources as static assets, but our findings suggest that the impact of these resources on innovation may evolve as firms develop and deploy them in different ways. Longitudinal studies could provide deeper insights into how the influence of CE on GPI changes as firms enhance their GBK and GIC or as market conditions shift. Moreover, qualitative approaches, such as case studies or interviews, could complement quantitative analysis by providing richer, contextual insights into how managers perceive and utilise CE, GBK, and GIC in their innovation strategies. These methodological enhancements would not only address the limitations of our study but also contribute to refining RBV to better account for the dynamic and interactive nature of resources in green innovation contexts.

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**List of Tables**

**Table 1: Demographic Respondents**

| **Characteristics** | **Items** | **Number** | **Percentage** |
|---|---|---|---|
| Gender | Male | 342 | 66.8 |
| | Female | 170 | 33.2 |
| | **Total** | **512** | **100%** |
| Individuals | Owner | 80 | 15.63 |
| | Manager | 114 | 22.27 |
| | Assistant manager | 318 | 62.11 |
| | **Total** | **512** | **100%** |
| Industries participating | Food and beverage | 32 | 13.45 |
| | Fashion and Textiles | 13 | 5.46 |
| | Agriculture | 15 | 6.30 |
| | Health and Beauty | 17 | 7.14 |
| | Construction and Building Materials | 21 | 8.82 |
| | Home and Office Products | 65 | 27.31 |
| | Transportation and Automotive | 14 | 5.88 |
| | Hospitality and Tourism | 26 | 10.92 |
| | Consumer Electronics | 35 | 14.71 |
| | **Total of Industries participating** | **238** | **100%** |
| Individuals' education | Postgraduate | 13 | 2.54 |
| | Undergraduate | 260 | 50.78 |
| | Diploma | 18 | 3.52 |
| | Senior high school | 8 | 1.56 |
| | Prefer not to say | 213 | 41.60 |
| | **Total** | **512** | **100%** |
| Does your company care about eco-friendly products? | Yes | 486 | 94.92 |
| | No | 0 | 0 |
| | Not Sure | 26 | 5.08 |
| | **Total** | **512** | **100%** |
| How long has your company cared about eco-friendly products? | Less than 5 years | 141 | 27.54 |
| | More than 5 years | 339 | 66.21 |
| | Not Sure | 32 | 6.25 |
| | **Total** | **512** | **100%** |

Source: Authors' Data

**Table 2: Convergent validity**

| Variables | Codes | Factor Loading | Cronbach's alpha | CR | AVE |
|---|---|---|---|---|---|
| Green Product Innovation | GPI1 | 0.833 | 0.817 | 0.873 | 0.581 |
| | GPI2 | 0.798 | | | |
| | GPI3 | 0.660 | | | |
| | GPI4 | 0.683 | | | |
| | GPI5 | 0.819 | | | |
| Cost Efficiency | CE1 | 0.754 | 0.815 | 0.871 | 0.575 |
| | CE2 | 0.717 | | | |
| | CE3 | 0.793 | | | |
| | CE4 | 0.759 | | | |
| | CE5 | 0.769 | | | |
| Green Brand Knowledge | GBK1 | 0.766 | 0.823 | 0.871 | 0.532 |
| | GBK2 | 0.715 | | | |
| | GBK3 | 0.824 | | | |
| | GBK4 | 0.699 | | | |
| | GBK5 | 0.590 | | | |
| | GBK6 | 0.761 | | | |
| Green Innovation Capability | GIC1 | 0.805 | 0.869 | 0.905 | 0.656 |
| | GIC2 | 0.815 | | | |
| | GIC3 | 0.807 | | | |
| | GIC4 | 0.850 | | | |
| | GIC5 | 0.771 | | | |

Source: Authors' Data

**Table 3: Fornell-Larcker Criterion**

| Variables | CE | GBK | GIC | GPI |
|---|---|---|---|---|
| CE | **0.758** | | | |
| GBK | 0.572 | **0.729** | | |
| GIC | 0.557 | 0.443 | **0.810** | |
| GPI | -0.216 | -0.115 | -0.158 | **0.762** |

Source: Authors' Data

**Table 4: Cross Loadings**

| Variables | CE | GBK | GIC | GPI |
|---|---|---|---|---|
| CE1 | **0.754** | 0.452 | 0.445 | -0.171 |
| CE2 | **0.717** | 0.400 | 0.427 | -0.154 |
| CE3 | **0.793** | 0.339 | 0.414 | -0.208 |
| CE4 | **0.759** | 0.609 | 0.350 | -0.075 |
| CE5 | **0.769** | 0.341 | 0.478 | -0.222 |
| GBK1 | 0.359 | **0.766** | 0.411 | -0.139 |
| GBK2 | 0.438 | **0.715** | 0.255 | -0.026 |
| GBK3 | 0.476 | **0.824** | 0.199 | -0.041 |
| GBK4 | 0.339 | **0.699** | 0.435 | -0.126 |
| GBK5 | 0.326 | **0.590** | 0.479 | -0.137 |
| GBK6 | 0.515 | **0.761** | 0.257 | -0.068 |
| GIC1 | 0.472 | 0.339 | **0.805** | -0.108 |
| GIC2 | 0.426 | 0.323 | **0.815** | -0.136 |
| GIC3 | 0.448 | 0.411 | **0.807** | -0.128 |
| GIC4 | 0.460 | 0.420 | **0.850** | -0.132 |
| GIC5 | 0.446 | 0.299 | **0.771** | -0.139 |
| GPI1 | -0.159 | -0.068 | -0.123 | **0.833** |
| GPI2 | -0.183 | -0.089 | -0.143 | **0.798** |
| GPI3 | -0.122 | -0.094 | -0.098 | **0.660** |
| GPI4 | -0.173 | -0.097 | -0.086 | **0.683** |
| GPI5 | -0.176 | -0.092 | -0.145 | **0.819** |

Source: Authors’ Data

**Table 5: Heterotrait-Monotrait Ratio (HTMT)**

| Variables | CE | GBK | GIC | GPI |
|---|---|---|---|---|
| CE | - | | | |
| GBK | 0.677 | - | | |
| GIC | 0.662 | 0.551 | - | |
| GPI | 0.266 | 0.155 | 0.186 | - |

Source: Authors’ Data

**Table 6: Direct effect**

| Paths | *β* | Standard Deviation | *P* Values | Note |
|---|---|---|---|---|
| H1: CE -> GPI | -0.235 | 0.055 | 0.000 | Accepted |
| H2: CE -> GBK | 0.572 | 0.035 | 0.000 | Accepted |
| H3: CE -> GIC | 0.557 | 0.037 | 0.000 | Accepted |
| H4: GBK -> GPI | 0.019 | 0.059 | 0.745 | Not Accepted |
| H6: GIC -> GPI | -0.037 | 0.055 | 0.494 | Not Accepted |

Source: Authors' Data

**Table 7: Indirect effect**

| Paths | *β* | Standard Deviation | *P* Values | Note |
|---|---|---|---|---|
| H5: CE -> GBK -> GPI | 0.011 | 0.034 | 0.746 | Not Accepted |
| H7: CE -> GIC -> GPI | -0.021 | 0.031 | 0.497 | Not Accepted |

Source: Authors' Data

**Table 8: Interacted effect**

| Paths | *β* | Standard Deviation | *P* Values | Note |
|---|---|---|---|---|
| H8: CE*GBK-> GPI | 0.100 | 0.043 | 0.019 | Accepted |
| H9: CE*GIC -> GPI | 0.167 | 0.043 | 0.000 | Accepted |

Source: Authors' Data

**Table 9: VIF**

| Variables | GBK | GIC | GPI |
|---|---|---|---|
| CE | 1.000 | 1.000 | 1.791 |
| GBK | | | 1.539 |
| GIC | | | 1.499 |

Source: Authors' Data

**Table 10: Prediction Strength Measure**

| Variables | $R^2$ | *Q2* | GBK ($f^2$) | GIC ($f^2$) | GPI ($f^2$) |
|---|---|---|---|---|---|
| CE | - | - | 0.487 | 0.449 | 0.023 |
| GBK | 0.327 | 0.167 | | | 0.000 |
| GIC | 0.310 | 0.200 | | | 0.002 |
| GPI | 0.049 | 0.026 | | | - |

Source: Authors' Data

**Measurement Items**

*Green Product Innovation* (GPI)

GPI1: Prioritise packaging made from recycled materials.
GPI2: Optimise water usage in production.
GPI3: Avoid the use of harmful plasticisers such as phthalates.
GPI4: Optimise production processes to reduce energy consumption.
GPI5: Create products that can be easily disassembled, allowing for component reuse or recycling at the end of their life.

*Firm's Green Brand Knowledge (GBK)*

GBK1: Understand the preferences of environmentally conscious consumers.
GBK2: Highlight product sustainability in its marketing materials.
GBK3: Recognise the importance of consistency in green brand.
GBK4: Recognise how its green brand equity contributes to the overall brand value and reputation.
GBK5: Understand the strengths and weaknesses of its green brand compared to other green brands in the industry.
GBK6: Evaluate consumer feedback and reviews to gauge the effectiveness of its green branding.

*Green Innovation Capability (GIC)*

GIC1: Provide training to employees to enhance their skills in sustainable practices.
GIC2: Foster effective collaboration across departments (e.g., R&D, design, marketing) to develop green products.
GIC3: Involve customers in the green product development process.
GIC4: Provide the necessary resources and guidance to foster creativity
GIC5: Has deep expertise in sourcing and utilising sustainable, eco-friendly materials.

*Cost Efficiency (CE)*

CE1: Allocate its research and development budget effectively.
CE2: Optimise operational processes in green product development.
CE3: Implement lean manufacturing principles.
CE4: Clearly outline the goals of buying the new (green) technology.
CE5: Minimise waste in production processes.