# Organizational factors, ambidextrous green innovation, absorptive capacity, and a firm's green competitive advantage

**Purpose:** This study aims to investigate the effect of organizational factors (green transformational leadership [GTL] and green knowledge management [GKM]) on a firm's green competitive advantage (GCA). Additionally, the study examines the role of ambidextrous green innovation (GI) as a mediator and green absorptive capacity (GAC) as a moderator in this relationship. The study also explores the multiple pathways leading to enhanced GCA using a configurational approach.

**Design/Methodology/Approach:** A cross-sectional approach was used to collect primary data from manufacturing and service firms in the UAE. Structural Equation Modeling (SEM) and Fuzzy-set Qualitative Comparative Analysis (fsQCA) were used for analysis.

**Findings:** The study found that GTL and GKM have a significant direct effect on GCA, as well as significantly impact exploitative and exploratory GI. EIGI and ERGI were found to mediate the associations between GTL/GKM and GCA significantly. Interestingly, GAC was found to have a significant impact on the GKM-ERGI relationship. Additionally, the study revealed four solutions with different combinations of configurations leading to improved GCA.

**Practical implications –** The study provides valuable insights for policymakers and executives in developed countries to enhance their organizations' GCA through the establishment of green strategic factors and stimulation of ambidextrous GI.

**Originality/Value:** This research contributes to bridging research gaps in the literature and advances our understanding of the interrelationship between organizational factors, ambidextrous GI, GAC, and GCA. Additionally, the study offers methodological significance by combining direct and configurational techniques to address these research gaps.

**Keywords:** Green transformational leadership, Green knowledge management, Ambidextrous green innovation, Green absorptive capacity, Green competitive advantage

## 1. Introduction

Manufacturing firms, especially in developed countries, are realizing the need for green competitive advantage (GCA) as the world moves toward sustainability and conservation of the environment. GCA goes beyond typical competitive tactics by integrating eco-friendly practices into core corporate operations, saving money, improving brand image, and opening new markets (Zameer et al., 2022; Chen and Chang, 2013). It also encourages innovation, which creates sustainable goods and technologies that decrease environmental impact and differentiate organizations, enhancing long-term success (Rehman et al., 2023). In developed regions with strict environmental regulations and growing consumer demand for sustainable products, firms that adopt GCA gain a significant competitive edge, which is essential for their survival and growth in a dynamic market (Gibbs and O'Neill, 2014). Consequently, for firms operating in developed countries, the adoption of GCA is indispensable for enhancing operational efficiency, strengthening market position, and securing sustainable development in an environment marked by heightened global environmental awareness.

Contemporary literature highlights several key factors influencing a firm's GCA, underscoring the pivotal role of strategic organizational elements including leadership (Begum et al., 2022; Majali et al., 2022), green knowledge management (GKM) (Shehzad et al., 2023; Sahoo et al., 2022; Wang et al., 2020a), and Green Innovation (GI) (Zameer et al., 2021; Lin and Chen, 2017; Fatoki, 2021). These components are critical in continuously improving firm performance and enhancing competitive advantage. Consequently, this study aims to investigate the impacts of Green Transformational Leadership (GTL), GKM, and ambidextrous GI on a firm's GCA. Additionally, it examines the potential moderating effect of GAC to provide a deeper understanding of the dynamics that may impede or facilitate the relationship between GKM and ambidextrous GI. This research is anticipated to substantially contribute to the theoretical domains of knowledge management and GI management, guided by specific research motives.

First, in contemporary business, organizational elements like GTL and GKM are crucial for manufacturing companies in developed countries striving for Green Competitive Advantage (GCA). GTL, as outlined by Chen and Chang (2013), is a strategic leadership style that embeds environmental sustainability into an organization's ethos and practices. Begum et al. (2022) highlight GTL's key role in driving environmentally focused goals, spurring innovation, and embedding green practices in operations, particularly in developed economies with strict environmental standards; this approach fosters a culture of environmental responsibility, leading to market distinction and adaptability to sustainability demands. On the other hand, GKM involves organizing, acquiring, and applying eco-relevant knowledge essential for enhancing sustainable methods in organizations (Shehzad et al., 2023; Abbas and Khan, 2022). Albort-Morant et al. (2018) emphasize GKM's role in transforming environmental consciousness into competitive strengths for manufacturing firms. Effective use of knowledge on eco-friendly technologies and practices can improve operational efficiency and resource use, reinforcing GCA (Chen et al., 2014). In developed markets, where environmental regulations are rigorous and consumer awareness is high, adopting GKM is vital for maintaining market competitiveness and enduring success in an eco-aware global market (Gibbs and O'Neill, 2014). Thus, the imperative for manufacturing firms in developed economies to embrace GTL and GKM lies in their potential to drive green initiatives, foster innovation, and ultimately propel the attainment of GCA within an increasingly environmentally conscious marketplace.

Second, in the modern context of sustainable business, GI plays a crucial role in linking strategic drivers like GTL and GKM to enhance GCA in manufacturing firms. Ambidextrous GI, which involves simultaneously pursuing exploitative and exploratory GI, is particularly significant for a firm's sustainable growth (Wang et al., 2020a). It enhances the impact of GTL on GCA, aligning green strategic goals with innovative practices. Ambidextrous GI's role is vital in developed economies where strict environmental regulations and shifting consumer preferences are common (Wang et al., 2020b; Wang et al., 2020a). Here, GTL and GI combine to foster leadership-driven GI practices, emphasizing the development of eco-friendly products and processes (Lin and Chen, 2017).

Similarly, the fusion of GKM with ambidextrous GI enables firms to address sustainability challenges effectively (Shehzad et al., 2023). Ambidextrous GI encourages flexibility in adopting new green technologies while utilizing existing knowledge to create environmentally-aligned innovations (Zhang et al., 2022). In the context of developed economies, where strict environmental policies and changing consumer preferences are prevalent, the role of AGI in linking GTL and GCA is crucial. It ensures that green knowledge is effectively converted into competitive advantages, visible in innovative products, efficient processes, and improved sustainable performance (Abbas and Khan, 2022; Shehzad et al., 2023; Sahoo et al., 2022). Thus, the interplay between organizational strategic factors (GTL and GKM), AGI, and GCA serves as a strategic axis, positioning manufacturing firms in developed nations to navigate the sustainability landscape and derive competitive advantages from their environmental stewardship.

Third, the interaction between GKM, GAC, and ambidextrous GI is crucial for firms to navigate sustainability challenges and capitalize on green economy opportunities. GKM influences ambidextrous GI through knowledge creation, but this process varies depending on the resources and capabilities within enterprises, particularly GAC (Shehzad et al., 2023; Wang et al., 2023; Pacheco et al., 2018). GAC, defined as the ability to comprehend, assimilate, and apply new knowledge, helps firms adapt to changing environments (Gluch et al., 2009). It acts as a catalyst in enriching firms' innovative capabilities, enabling the effective assimilation of green knowledge into ambidextrous GI (Chen et al., 2014). This capacity ensures that knowledge gained through GKM is utilized effectively, promoting both exploratory and exploitative GIs (Zhang et al., 2020). The synergy between GKM, GAC, and ambidextrous GI forms a strategic pathway for manufacturing firms in developed countries to effectively harness external green knowledge, drive innovation, and secure competitive advantages through environmentally conscious practices. However, the extent to which GAC moderates the impact of GKM on ambidextrous GI remains unclear, especially in the context of growing environmental consciousness and efforts to mitigate climate change risks (Idrees et al., 2023b). The study aims to explore how GAC might strengthen or weaken the effects of GKM on ambidextrous GI, suggesting that firms proficient in managing GAC could derive greater benefits from GKM for ambidextrous GI.

This research utilizes the resource-based view theory (Barney, 1991) to create an integrated model, exploring the links between organizational strategic factors like GTL and GKM, with Ambidextrous GI and GCA employing variance-based structural equation modeling (PLS-SEM); the study examines the direct and indirect effects of GTL, GKM, and AGI on GCA. Additionally, it uses fuzzy-set qualitative comparative analysis (fsQCA) to understand the complex and synergistic influences of these factors on GCA. This dual-methodological approach (SEM-fsQCA) is expected to offer valuable insights for manufacturing industry management on achieving sustainable development GCA through GTL, GKM, and AGI.

Based on the identified gaps, the study's research questions are as follows:

**RQ1.** Do organizational factors (GTL and GKM) significantly affect firms GCA?

**RQ2.** Does ambidextrous GI mediate the relationships between organizational factors (GTL and GKM) and GCA?
**RQ3.** Does GAC moderate the relationship between GKM and AGI?
**RQ4.** What multiple pathways exist to attain higher GCA?

## 2. Literature review

This study, anchored in Resource-Based View (RBV) theory, hypothesizes that organizational strategic elements, specifically GTL and GKM, positively influence GCA. It further posits that exploratory and exploitative GI mediate the GTL, GKM, and GCA nexus. Additionally, GAC is theorized to moderate the GKM-GI relationship. Drawing from RBV, the research suggests that organizations with robust GTL and GKM are likelier to produce sustainable goods. The study underscores that GTL and GKM foster ambidextrous GI, contributing to sustainable development with minimal ecological and social impact (Begum et al., 2022; Shehzad et al., 2022a), thereby enhancing GCA. The conceptual model is illustrated in Figure 1.

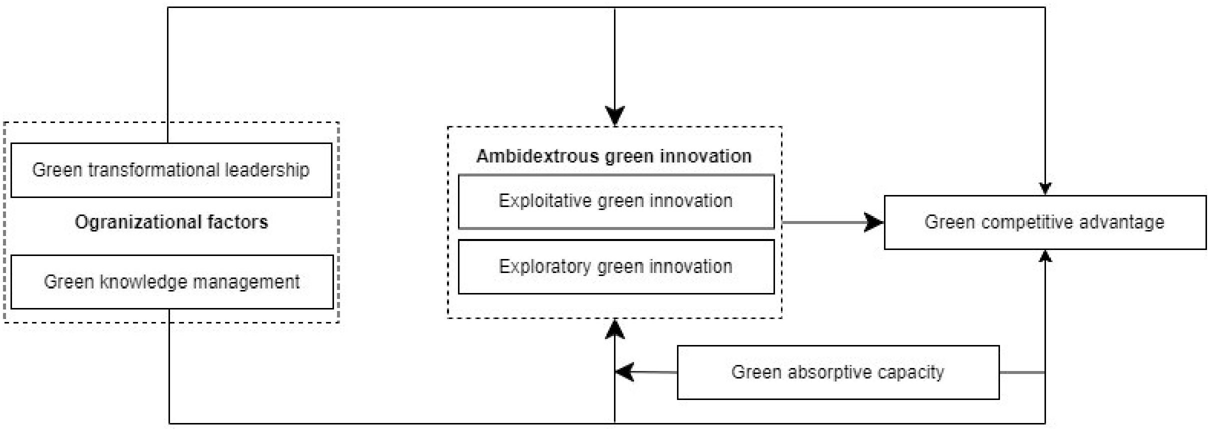


Figure 1.Research model

### 2.1. Green transformational leadership and green competitive advantage

In the contemporary business landscape, manufacturing firms in developed countries increasingly recognize the importance of sustainability for maintaining a competitive edge. The concept of green competitive advantage is central to this, involving the adoption of environmental management practices and GIs (Albort-Morant et al., 2016; El-Kassar and Singh, 2019). Research has consistently shown that such green initiatives not only reduce ecological footprints but also enhance market positioning, operational efficiency, and profitability (Leonidou et al., 2017; Forsman, 2013). These practices include green supply chain management, which differentiates products and services while minimizing risks from poor supplier environmental performance (Laari et al., 2017). Empirical studies highlight that GIs and environmental practices significantly improve firms' competitiveness and economic and environmental performance, leading to enhanced organizational performance (Rehman Khan and Yu, 2021; Martusa, 2013). According to Zameer et al. (2021), companies that take proactive measures to embrace environmentally responsible practices seek to improve their market positioning, operational efficiency, and long-term profitability in addition to minimizing their ecological impact. According to Dang and Wang (2022), incorporating green practices into industrial processes not only minimizes environmental impact but also leads to cost savings and improved brand perception. Additionally, organizational learning and stakeholder and policy pressures play a crucial role in mediating the positive impact of GI on competitive advantage (Tu and Wu, 2021). In line with prior research of Zameer et al. (2020) and Chen and Chang (2013), we define GCA as a firm's capacity to adopt environmental management practices and introduce GIs to achieve competitive advantage.

Leadership has evolved to prioritize environmental sustainability, necessitating leaders to foster a culture of distributed leadership within organizations. GTL has emerged as a key approach in this context, encouraging leaders to motivate and inspire followers toward exceeding environmental performance expectations (Çop et al., 2021). Defined by Chen and Chang (2013) as leadership focused on achieving environmental goals, GTL emphasizes a clear vision for sustainability and encourages subordinates to adopt sustainable behaviors for the benefit of the organization, society, and the environment (Mukonza and Swarts, 2019; Mittal and Dhar, 2016). These leaders cultivate emotional attitudes and broader perspectives critical for creating and implementing sustainability initiatives. They invest in technologies and programs for carbon emission reduction and efficient resource use while promoting a green management culture and encouraging learning from market dynamics to adapt to changing environments (Mittal and Dhar, 2016; Begum et al., 2022).

Research has shown that Transformational Leadership, particularly when practiced by top management, is highly effective in achieving both personal and organizational goals (Bass et al., 2003). Companies that have successfully integrated environmental sustainability into their business operations have reported increased productivity, sales growth, investment returns, market development, and competitive advantage (Chen, 2011; Özgül and Zehir, 2023). Effective communication networks established by leaders with their followers play a crucial role in developing green business strategies, contributing to sustainable business performance. Adopting GTL fosters an environmentally oriented organizational culture, supports proactive environmental strategies, stimulates employee participation in environmental initiatives, fosters green creativity, and encourages workplace green behaviors (Chen and Chang, 2013; Begum et al., 2022; Mittal and Dhar, 2016). This shift leads to a more environmentally friendly corporate image, increased sales and market share, and improved competitiveness (Chen, 2011; Yu and Huo, 2019). Moreover, GTL efficiently utilizes both tangible and intangible resources, reducing environmental burdens while boosting performance and CA (Zameer et al., 2020). Leaders who prioritize environmental concerns and demonstrate visionary traits significantly impact the adoption of eco-friendly practices in manufacturing (Jung et al., 2008). Leadership positively affects environmental performance and competitive advantage by aligning green strategies with broader organizational goals (Padilla-Lozano and Collazzo, 2021). Therefore, GTL is essential for manufacturing firms in developed nations to achieve sustainable competitive advantage through environmentally responsible practices. Based on the above arguments, we propose the hypothesis that GTL will have a positive impact on GCA.

**H1.** GTL positively impacts GCA.

### 2.2. Green knowledge management and green competitive advantage

Within the framework of GKM, knowledge management transcends mere information handling, pivoting towards fostering sustainability. Knowledge emerges as a pivotal internal asset crucial to organizational success (Ooi, 2014). Effective knowledge management enhances competitiveness and efficiency (Yusr et al., 2017), ensuring timely and apt information delivery to employees (Ooi, 2014). Scholars delineate two primary knowledge management dimensions: people management and information management (Abbas and Sağsan, 2019), focusing respectively on implicit and explicit knowledge, the latter integral to innovation. Knowledge management is increasingly recognized as a strategic tool for competitive advantage (Bolisani and Bratianu, 2018), promoting collaboration and external knowledge acquisition, thus reducing R&D needs (Abbas and Sağsan, 2019). This approach facilitates the emergence of sustainable practices and products (Shahzad et al., 2020) and optimizes process management (Qasrawi et al., 2017). Breznik (2018) notes that knowledge-centric organizations excel in innovativeness and adaptability toward sustainable development. Consequently, knowledge management is instrumental in the sustainable development of knowledge assets, with comprehensive consideration of social, environmental, and economic factors (Lim et al., 2017).

GKM encompasses practices that integrate environmental considerations into organizational knowledge processes, enhancing eco-innovation and sustainability performance (Sahoo et al., 2022). By acquiring, sharing, and utilizing environmental knowledge within an organization, GKM benefits businesses in several ways (Abbas and Khan, 2022). First, it spurs innovation by creating eco-friendly products and services that appeal to environmentally conscious consumers, leading to unique offerings that set companies apart from their competitors (Shehzad et al., 2023). Second, GKM builds brand reputation and customer loyalty by showcasing sustainable practices that attract and retain environmentally aware customers (Wang et al., 2020a). Third, it boosts operational efficiency by optimizing resource use, reducing waste, and cutting costs, which also supports environmental goals and enhances profitability (Shahzad et al., 2020). Additionally, GKM aids in regulatory compliance and risk management by helping businesses adhere to stringent environmental regulations, thus avoiding penalties and legal challenges (Wang et al., 2022). Moreover, research indicates that elements such as green shared vision and green knowledge sharing have a substantial impact on sustainable competitive advantage in various sectors, including food processing and manufacturing SMEs (Idrees et al., 2023a). Similarly, green knowledge sharing is shown to improve green dynamic capabilities, green service innovation, and subsequently, green competitive advantage. The adoption of green IT, green product innovation, and green marketing are also key components that contribute to a firm's competitive edge by improving internal operations, relationship management, and market competitiveness (Mao et al., 2016). This compliance is particularly advantageous in industries with significant environmental impacts. Based on these points, the following hypothesis can be proposed.

**H2.** GKM positively impacts GCA.

### 2.3. Green transformational leadership and ambidextrous green innovation

To adapt to environmental challenges, corporations, and societies are increasingly focusing on resilience and incorporating GI into their business strategies. Chen et al. (2006) describe GI as innovations related to green products or processes, such as energy-saving, pollution-prevention, waste recycling, and green design. Various types of GI have been identified, including green process and product innovation (Xie et al., 2019), radical and incremental GI (Chen et al., 2014), green technology (Butt, 2016), and green management (Li et al., 2018). In the current environmental context, prioritizing protection and energy conservation, organizations must develop and implement GI strategies to create value (Wang and Juo, 2021). To effectively tackle environmental concerns, organizations engage in both exploitative and exploratory GI (Wang et al., 2020a), known as ambidextrous GI. This approach allows organizations to explore new opportunities while enhancing existing capabilities, potentially leading to competitive advantages. Exploitative GI involves using existing environmental knowledge to improve green products, whereas exploratory GI uses new information and skills to develop new green markets and products (Chen et al., 2014).

In the realm of organizational studies, the notion of TL has gained substantial attention, particularly in its relation to GI. Underscore this leadership style's visionary and inspirational qualities, which have been instrumental in fostering exploitative GI. Expanding on this, studies by Mittal and Dhar (2016) and Singh et al. (2020) elaborate on how TL aligns organizational resources towards GI, thereby enhancing capabilities in this area, especially in manufacturing sectors of developed economies. While the literature has identified various precursors to GI, including green intellectual capital Rehman et al. (2021), green absorptive capacity Pacheco et al. (2018), and external knowledge adoption Zhang et al. (2020), the unique impact of TL in this context has not been as prominently recognized. This gap in research presents a unique opportunity for further exploration, particularly regarding the influence of TL on GI within the Chinese high-tech sector, as posited by Çop et al. (2021). GTL catalyzes a workforce's creativity, fostering the development and dissemination of green practices (Mittal and Dhar, 2016). Similarly, Mukonza and Swarts (2019) note that GTL aids in GI by integrating market trends, financial resources, and green technologies coupled with relevant employee training. Furthermore, Chen and Chang (2013) highlight GTL's role in generating new knowledge and ideas, thus increasing the likelihood of GI. Majali et al. (2022) reinforce this by linking high-level GTL with the development of green products, suggesting a direct correlation between GTL and innovative outputs. From this perspective, GTL has the potential to enable firms to create new and creative ideas. Therefore, we propose the following hypotheses.

**H3a.** GTL is positively associated with EIGI.

**H3b.** GTL is positively associated with ERGI.

### 2.4. Green knowledge management and ambidextrous green innovation

Green knowledge management, which involves acquiring, sharing, and utilizing environmentally relevant knowledge within organizations, plays a critical role in promoting ambidextrous GI (Shehzad et al., 2023). The business environment in which an organization operates can impact its capacity for innovation. As society places increasing pressure on manufacturers to adopt sustainable business practices, it is becoming more important for them to acquire green competence (Wang et al., 2023). Effective green knowledge management practices can create a culture of knowledge sharing, allowing firms to explore new environmentally friendly technologies while leveraging existing green competencies (Idrees et al., 2023b). Research also suggests that organizations that are adept at balancing exploration and exploitation of green knowledge are better positioned to achieve sustainable competitive advantage by enhancing eco-efficiency and fostering radical GIs (Wang et al., 2022). Researchers highlighted the relationship between GKM and GI as symbiotic, emphasizing the importance of leveraging knowledge processes to foster dynamic, sustainable innovation in manufacturing firms in developed economies (Idrees et al., 2023a; Abbas and Khan, 2022; Shehzad et al., 2022a). Based on these arguments, the following hypotheses were proposed.

**H4a.** GKM is positively associated with EIGI.
**H4b.** GKM is positively associated with ERGI.

### 2.5. Ambidextrous green innovation and green competitive advantage

The academic literature underscores the crucial role of GI as a strategy for firms seeking to distinguish themselves in the market through environmentally friendly practices. GI, which involves the adoption of sustainable technologies and strict environmental compliance, may result in higher costs but can have long-term financial benefits (Alam et al., 2022). Nonetheless, Zameer et al. (2022) argue that GI is a critical factor in enhancing a firm's competitive edge. The growing emphasis on environmental protection regulations requires considering a product's entire lifecycle during design decisions (Zameer et al., 2020). GI in products and processes can mitigate environmental harm while also strengthening a firm's competitive position (Porter and van der Linde, 1995). Research by Hart (1995) further supports the integration of GI into corporate strategy, demonstrating its role in promoting environmental sustainability, differentiation, cost efficiencies, and improved market standing. Empirical findings by Delmas Delmas and Toffel (2008) show a connection between GI and competitive advantage, with firms that embrace GI strategies often achieving better financial outcomes and market share. As a result, in developed economies, GI is essential for manufacturing firms to maintain their competitive advantage by combining environmental responsibility with strategic business goals. Recent studies indicate that innovation and environmental management are increasingly important indicators of competitive advantage (Zameer et al., 2020; Wang, 2019). Firms that implement GI can achieve competitive superiority through cost savings, efficiency improvements, increased productivity, and product quality. Moreover, GI fosters a green corporate reputation, differentiated environmental product protection, and opportunities to enter new markets with innovative green products.

**H5a.** EIGI is positively associated with GCA.
**H5b.** ERGI is positively associated with GCA.

### 2.6. Mediating role of ambidextrous green innovation

Leaders hold significant influence in shaping organizational structures, systems, and cultures that facilitate the acquisition, dissemination, transformation, and utilization of knowledge (Le and Lei, 2019). Particularly, GTL promotes employee environmental awareness, encourages eco-friendly practices, and fosters green creativity (Mukonza and Swarts, 2019). However, past research has emphasized the need for an effective and practical approach to evaluating GTL's impact on inspiring GI and enhancing performance (Mittal and Dhar, 2016). Top managers, as key leaders in companies, have the potential to significantly contribute to the search for new green knowledge and the improvement of existing green knowledge by establishing a shared vision. By providing appropriate learning opportunities, GTL can enhance employees' ability to address environmental challenges (Özgül and Zehir, 2023). GTL is considered a significant driver of GI within organizations, characterized by visionary, inspirational, and environmentally conscious leadership behaviors. Research by Mukonza and Swarts (2019) highlights the influence of transformational leaders in fostering a culture of sustainability and environmental consciousness, thereby encouraging GI efforts among employees. Moreover, GI has been recognized as a critical determinant for achieving green competitive advantage in strategic management literature. Studies by Zhou et al. (2020) emphasize that firms that adopt environmentally friendly practices through innovative means can gain a competitive advantage by reducing costs, enhancing brand reputation, and meeting evolving consumer preferences. Based on the above discussion, it can be inferred that GI serves as a critical mediator in the relationship between GTL and the achievement of green competitive advantage. Hence, the study proposes the following hypotheses.

**H6a.** EIGI mediates the relationship between GTL and GCA.
**H6b.** ERGI mediates the relationship between GTL and GCA.

GKM is vital for acquiring, disseminating, and leveraging environmentally relevant knowledge within organizations, as demonstrated by (Dangelico, 2017). Boiral et al. (2015) argue that GI, which encompasses both exploitative and explorative dimensions aimed at environmentally friendly practices, is facilitated by this knowledge. Empirical studies by Aragón-Correa et al. (2008) and Wang et al. (2022) show that effective GKM processes significantly impact a firm's ability to innovate sustainably. GI acts as a mediator in this relationship, as it helps translate environmentally conscious knowledge into tangible eco-friendly products, processes, or strategies, ultimately leading to the attainment of green competitive advantage (Sahoo et al., 2022). This reciprocal relationship highlights the crucial role of GI as a mediator between the effective management of green knowledge and the achievement of a sustainable competitive edge within the strategic management domain (Zhou et al., 2021). To encourage the creation of new knowledge, dynamic companies provide systems, including infrastructure, resources, and information, that allow employees to generate knowledge and innovative ideas (Benabdellah et al., 2021; Abbas and Khan, 2022). Organizations must incorporate environmental practices into their research and development activities to comply with dynamic market demands (Abbas and Sağsan, 2019; Shahzad et al., 2020). This involves engaging in activities that promote the production of high-quality products with minimal resources, which benefits both the environment and the company. Based on the above discussion, the following hypotheses are proposed:

**H7a.** EIGI mediates the relationship between GKM and GCA.
**H7b.** ERGI mediates the relationship between GKM and GCA.

### 2.7. Moderating role of green absorptive capacity

The conceptualization of GAC within the context of strategic management is crucial for comprehending how organizations acquire, assimilate, and utilize environmentally relevant knowledge for sustainable development. GAC expands on the concept of absorptive capacity, which refers to an organization's ability to recognize the value of new external information, assimilate it, and apply it to commercial purposes (Cohen and Levinthal, 1990). In the context of environmental sustainability, GAC refers to a firm's capability to identify, assimilate, and exploit environmentally significant knowledge, technologies, and practices (Zhang et al., 2020; Albort-Morant et al., 2018). Studies by Jansen et al. (2005) and Zahra and George (2002) emphasize the significance of this capacity in enabling firms to proactively respond to environmental challenges and leverage opportunities for GI and competitive advantage. Furthermore, Wang et al. (2023) highlight that the development of GAC involves not only the acquisition and assimilation of green knowledge but also the transformation of this knowledge into actionable strategies and sustainable practices, thereby underscoring its pivotal role in fostering strategic sustainability initiatives within organizations.

GKM, which encompasses processes for acquiring, disseminating, and applying environmentally relevant knowledge, has been recognized as critical for promoting GI within organizations (Abbas and Khan, 2022). However, the relationship between GKM and GI is contingent on an organization's green absorptive capacity—the ability to recognize, assimilate, and utilize external environmental knowledge (Shehzad et al., 2023). Research by Zahra and George (2002) reveals that firms with higher green absorptive capacity possess a greater ability to leverage and integrate external green knowledge effectively, thereby amplifying the impact of internal green knowledge management practices on fostering GI. This aligns with the argument of Idrees et al. (2023b) that GAC acts as a catalyst, enhancing the relationship between GKM and GI in the strategic management landscape. GAC allows businesses to incorporate new knowledge into their existing knowledge base, connect it to existing knowledge, and use it to develop GI (Pacheco et al., 2018). Furthermore, the preservation of dissipative attributes directly impacts GI during the design process, such as through leaders' strategies and the approach taken by firms rather than evaluating performance (Zhang et al., 2020). The presence of external actors and multilateralism's implications on GI can lead to the acquisition of new external knowledge (Ben Arfi et al., 2018). Without GAC, senior management may miss opportunities to increase their understanding, learn new information, and reduce the risks associated with green R&D (Nicotra et al., 2014). To be absorbed and commercialized, new knowledge must first be discovered and integrated with existing knowledge (Hong et al., 2019). Therefore, firms should be proactive in seeking new environmental information to stimulate GI and tap into their potential. Based on these considerations, the research proposes the following hypotheses:

**H8a.** GAC moderates the relationship between GKM and EIGI.

**H8b.** GAC moderates the relationship between GKM and ERGI.

### 2.8. Asymmetric modeling

This study extends beyond merely evaluating the direct effects of organizational elements on both ambidextrous GI and GCA, as well as examining the impact of ambidextrous GI on GCA. It employs fsQCA to identify potential causal configurations. These configurations, or "recipes," potentially facilitate enhanced GCA through a synergistic amalgamation of organizational factors, specifically GTL and GKM, in conjunction with elements of ambidextrous GI, encompassing both EIGI and ERGI.

The fsQCA methodology integrates fuzzy sets and fuzzy logic principles in an asymmetric modeling approach, making it crucial for analyzing models with multiple independent constructs and pronounced inter-construct correlations (Pappas et al., 2019). Unlike symmetric methods like Structural Equation Modeling (SEM) and Multiple Regression Analysis (MRA), the fsQCA can account for confounding variables such as gender, age, and education, which large sample sizes may not adequately mitigate in SEM and MRA (Peng et al., 2008). Additionally, the fsQCA addresses the limitation of correlation and beta coefficients in delineating non-linear associations between independent and dependent variables (Pappas and Woodside, 2021). By identifying numerous solutions leading to identical outcomes, the fsQCA overcomes the analytical constraints of regression analysis in pinpointing independent variables that influence outcomes only in specific instances (Ragin, 2009). The relevance of fsQCA is particularly emphasized in this study as each dimension of organizational factors (GTL and GKM) and ambidextrous GI (EIGI and ERGI) may serve a unique function within the organization. The interplay of these constructs can provide management with insights into optimal configurations for achieving desired outcomes. The fsQCA results are expected to demonstrate a pattern of equifinality, where diverse configurations yield the same result, highlighting the method's capacity to examine the potential dependency of each antecedent state. This approach can enhance understanding of how various configurations of organizational factors and ambidextrous GI dimensions contribute to improved GCA.

**H9**. Various configurations of the organizational factors (GTL and GKM), ambidextrous GI (ERGI and EIGI), and GAC are associated with the GCA.

## 3. Methodology

### 3.1. Research Design and Data Collection

This research employs a cross-sectional design to examine the impact of organizational factors, specifically GTL and GKM, on GCA, with ambidextrous GI acting as a mediating variable and GAC playing a moderating role in the manufacturing and services sectors of the United Arab Emirates (UAE). Data was collected from August to November 2023 through a random sampling technique. Following the prior study of Singh et al. (2022), a representative sample of 179 manufacturing firms was selected using the Yellow Pages search engine (https://www.yellowpages.ae/). The primary data collection instrument was a structured questionnaire distributed to the selected firms after obtaining official approval from their respective management. The questionnaire was disseminated using various methods, including online questionnaires and self-administered procedures. In total, 630 questionnaires were distributed, resulting in 432 responses. However, 27 responses were excluded due to incompleteness or lack of information, leading to a final sample size of 405 responses with a response rate of 64.28%. The detailed demographic profile of the respondents is presented in Table 1.

### 3.2. Measures

Participants were asked to respond to each item using a 5-point Likert scale, ranging from 1 (Strongly Disagree) to 5 (Strongly Agree), allowing for nuanced responses. The questionnaire comprised several scales designed to measure the constructs of interest, including:

- Green Transformational Leadership: This was assessed using a 6-item scale adapted from Chen and Chang (2013).
- Green Knowledge Management: This was evaluated through a 5-item scale, which was derived from the work of Shehzad et al. (2023) and Sahoo et al. (2022).
- Ambidextrous GI: The EIGI and ERGI were examined using four items each, and the scale was based on the work of Wang et al. (2020a) and Shehzad et al. (2023).
- Green Competitive Advantage: This was measured using a 4-item scale, which was taken from Chen and Chang (2013) and Zameer et al. (2020).
- Green Absorptive Capacity: This was assessed via a 5-item scale, which was based on the work of Gluch et al. (2009) and Zhou et al. (2021).

### 3.3 Common method variance bias

The issue of common method variance (CMV) in survey research is of paramount importance (Podsakoff et al., 2003). This problem arises when data is collected from a single source. To evaluate the presence of CMV among constructs, the current study utilized SPSS 25 and conducted Harman's single-factor test, as recommended by (Harman, 1976). The test results, obtained through principal axis factoring and extraction technique, revealed the existence of 28 distinct factors. The first unrotated component accounted for 28.428% of the variation in the dataset, falling short of the 40% threshold recommended by Hair et al. (2016). Moreover, a comprehensive collinearity evaluation test was undertaken using Smart-PLS, a more recent and reliable method proposed by Kock (2015) and endorsed by several social science experts, Shehzad et al. (2022a); Usman Shehzad et al. (2022). The obtained VIF scores were all below the cut-off value of 5, indicating that common method bias is not a concern in the present model.

Table 1. Demographic characteristics

| Characteristics | | Frequency | Percent |
|---|---|---|---|
| Ownership form | | | |
| | Non-State Owned | 183 | 45.2 |
| | State owned | 222 | 54.8 |
| Management level | | | |
| | Top level | 64 | 15.8 |
| | Middle level | 169 | 41.7 |
| | Lower level | 172 | 42.5 |
| Organization size | | | |
| | <100 | 95 | 23.5 |
| | 100-200 | 71 | 17.5 |
| | 201-500 | 81 | 20.0 |
| | 501-1000 | 63 | 15.6 |
| | >1000 | 95 | 23.5 |
| Organization age | | | |
| | < 5 Years | 77 | 19.0 |
| | 6-10 Years | 78 | 19.3 |
| | 11-20Years | 97 | 24.0 |
| | 21-40years | 78 | 19.3 |
| | >40Years | 75 | 18.5 |

## 4. Data analysis

Partial Least Squares Structural Equation Modeling (PLS-SEM) is a preferred method in research, notably for its efficacy in analyzing complex models with multiple variables(Hair et al., 2014). This makes it particularly relevant in social sciences and behavioral research (Shehzad et al., 2022b; Bari et al., 2020). PLS-SEM stands out for its ability to handle non-normally distributed data and small sample sizes, ideal for studies where large samples are not feasible (Hair et al., 2017). Its emphasis on predictive accuracy and maximizing explained variance (R-square) in dependent constructs enhances its utility in exploratory research and decision-making (Hair et al., 2016). Additionally, PLS-SEM's support for both reflective and formative measurement models, combined with its user-friendly nature and accessible software like SmartPLS, make it attractive to researchers, including those presenting to diverse statistical audiences (Ringle et al., 2018). Conversely, Fuzzy-set Qualitative Comparative Analysis (fsQCA) provides deeper insights, identifying key configurations and causal relationships among organizational factors and dimensions of ambidextrous GI with GAC for generating GCA (Pappas and Woodside, 2021). The fsQCA 3.0 software aids in determining the causal combinations necessary to produce specific outcomes.

**4.1. Measurement model results**

Table 2 and Figure 2 demonstrate measurement model results for several constructs: EIGI, ERGI, GAC, GCA, GKM, and GTL, each of which is assessed by multiple items. The items have significant relationships with their respective structures, as shown by the robust factor loadings, which are closer/over 0.70. Variance Inflation Factors (VIF) are within acceptable bounds, indicating that multicollinearity in research data is not a big problem. Cronbach's alpha (Ca) and rho_A scores are typically above the widely recognized threshold of 0.7 for all constructions. Each construct's Composite Reliability (CR) is significantly larger than the 0.7 threshold, assuring internal consistency. The Average Variance Extracted (AVE) for all constructs is more than 0.5, indicating acceptable convergent validity. As a whole, the results show that the model is valid and reliable; in particular, the reliability measures (Cronbach's alpha, rho_A, and CR > 0.7) and validity measures (AVE > 0.5) cover all the bases. Hence, the model is good enough for further assessment.

In Table 3, two approaches are used to test discriminant validity for study variables (GTL, GKM, EIGI, ERGI, GAC, and GCA): the Heterotrait-Monotrait (HTMT) ratio and the Fornell-Larcker criteria. Strong discriminant validity is shown by the HTMT ratios, which are much lower than the cautious criterion of 0.85 or 0.90, depending on the rigorous approach. For example, the HTMT ratio between EIGI and GKM is 0.723, indicating that the constructs are different (Henseler et al., 2015). The Fornell-Larcker criteria is also met since the square root of the Average Variance Extracted (AVE) for each construct (diagonal values) should be greater than its maximum correlation with any other construct (off-diagonal values) (Fornell and Larcker, 1981). The diagonal values, which reflect the AVE square roots, are stronger than the inter-construct correlations, as demonstrated by EIGI's AVE square root of 0.852, which is more than its maximum correlation with GCA of 0.644. These findings show that the measurement model has strong discriminant validity, with each concept assessing separate elements according to the established HTMT and Fornell-Larcker thresholds (Hair et al., 2017).

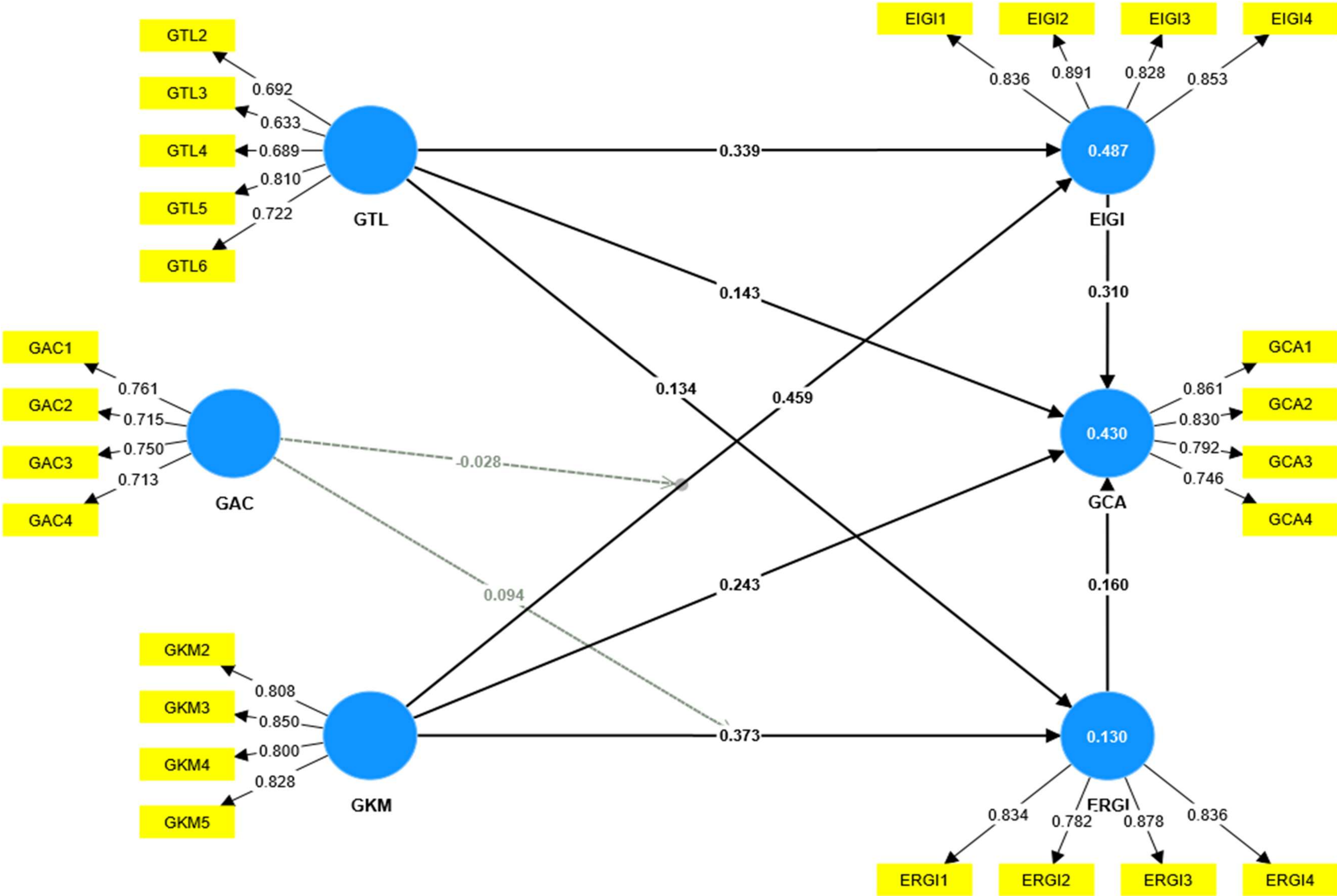


**Figure 2**. Measurement model

Table 2. Measurement model results

| Constructs | Items | FL | VIF | Ca | rho_a | CR | AVE |
|---|---|---|---|---|---|---|---|
| EIGI | EIGI1 | 0.836 | 2.135 | 0.875 | 0.880 | 0.914 | 0.727 |
| | EIGI2 | 0.891 | 3.124 | | | | |
| | EIGI3 | 0.828 | 2.390 | | | | |
| | EIGI4 | 0.853 | 2.008 | | | | |
| ERGI | ERGI1 | 0.834 | 1.905 | 0.854 | 0.877 | 0.901 | 0.694 |
| | ERGI2 | 0.782 | 1.750 | | | | |
| | ERGI3 | 0.878 | 2.152 | | | | |
| | ERGI4 | 0.836 | 2.080 | | | | |
| GAC | GAC1 | 0.761 | 1.382 | 0.718 | 0.719 | 0.824 | 0.540 |
| | GAC2 | 0.715 | 1.440 | | | | |
| | GAC3 | 0.750 | 1.507 | | | | |
| | GAC4 | 0.713 | 1.264 | | | | |
| GCA | GCA1 | 0.861 | 1.848 | 0.825 | 0.853 | 0.883 | 0.654 |
| | GCA2 | 0.830 | 2.296 | | | | |
| | GCA3 | 0.792 | 2.104 | | | | |
| | GCA4 | 0.746 | 1.463 | | | | |
| GKM | GKM2 | 0.808 | 2.214 | 0.840 | 0.844 | 0.893 | 0.675 |
| | GKM3 | 0.850 | 2.467 | | | | |
| | GKM4 | 0.800 | 1.820 | | | | |
| | GKM5 | 0.828 | 1.837 | | | | |
| GTL | GTL2 | 0.692 | 1.317 | 0.758 | 0.774 | 0.836 | 0.506 |
| | GTL3 | 0.633 | 1.417 | | | | |
| | GTL4 | 0.689 | 1.512 | | | | |
| | GTL5 | 0.810 | 1.863 | | | | |
| | GTL6 | 0.722 | 1.665 | | | | |

Table 4 displays the R-square and $Q^2$ values for three constructs: EIGI, ERGI, and GCA. The R-square values indicate the proportion of variance in the dependent variable explained by the model and are 0.487 for EIGI, 0.130 for ERGI, and 0.430 for GCA. These values suggest that the model explains 48.7% of the variance in EIGI, 13% in ERGI, and 43% in GCA. The $Q^2$ values, which assess the predictive relevance of the model using Stone-Geisser's test, are 0.340 for EIGI, 0.084 for ERGI, and 0.259 for GCA. A $Q^2$ value greater than 0 indicates that the model has predictive relevance for the respective construct (Hair et al., 2016). In this case, all constructs demonstrate predictive relevance, with EIGI having the highest (0.340), followed by GCA (0.259) and ERGI (0.084). The thresholds for R-square are interpreted based on the context and complexity of the model, while values above 0 for $Q^2$ indicate predictive relevance.

### 4.2. Hypotheses results

Table 5 and Figure 3 present the results of hypothesis testing for direct, mediating, and moderating effects in a research model involving various relationships. Each hypothesis (H1 to H8b) tests a specific relationship using path coefficients (β), standard deviation (STDEV), t-statistics, p-values, and confidence intervals (2.5% and 97.5%).

#### 4.2.1. Direct Effects

Regarding the direct effects, the study's findings demonstrate significant relationships across multiple hypotheses. For instance, Hypothesis H1 (GTL -> GCA) reveals a positive effect ($\beta = 0.143$, $P = 0.005$), indicating that GTL positively influences GCA. Similarly, Hypothesis H2 (GKM -> GCA) shows a significant enhancement of GCA ($\beta = 0.243$, $P < 0.001$). The impact of GTL on EIGI and ERGI is significant as per Hypotheses H3a ($\beta = 0.339$, $P < 0.001$) and H3b ($\beta = 0.134$, $P = 0.013$), respectively. Furthermore, GKM's influence on EIGI and ERGI is supported by H4a ($\beta = 0.459$, $P < 0.001$) and H4b ($\beta = 0.373$, $P < 0.001$). Lastly, EIGI and ERGI's effects on GCA are also significant, as demonstrated in H5a ($\beta = 0.310$, $P < 0.001$) and H5b ($\beta = 0.160$, $P = 0.001$). Therefore, hypotheses H1-H5 are supported.

#### 4.2.2. Mediating Effects

Regarding the mediating effects, the results indicate significant indirect relationships. Hypothesis H6a (GTL -> EIGI -> GCA) shows a β of 0.105 ($P < 0.001$), suggesting that EIGI mediates the relationship between GTL and GCA. In Hypothesis H6b (GTL -> ERGI -> GCA), with a β of 0.021 ($P = 0.032$), ERGI mediates the impact of GTL on GCA. Similarly, the mediating role of ERGI in the relationship between GKM and GCA is evident in H7a ($\beta = 0.060$, $P = 0.010$). Additionally, EIGI also mediates the relationship between GKM and GCA, as indicated in H7b ($\beta = 0.142$, $P = 0.001$). Thus, H6a to H7b are supported

Table 3. Discriminant validity

| Constructs | EIGI | ERGI | GAC | GCA | GKM | GTL |
|---|---|---|---|---|---|---|
| Hetrotrait monotrait ratio | | | | | | |
| EIGI | | | | | | |
| ERGI | 0.253 | | | | | |
| GAC | 0.428 | 0.073 | | | | |
| GCA | 0.644 | 0.381 | 0.356 | | | |
| GKM | 0.723 | 0.329 | 0.671 | 0.629 | | |
| GTL | 0.644 | 0.294 | 0.314 | 0.538 | 0.504 | |
| Fornell-Larcker criterion | | | | | | |
| EIGI | 0.852 | | | | | |
| ERGI | 0.232 | 0.833 | | | | |
| GAC | 0.345 | 0.042 | 0.735 | | | |
| GCA | 0.577 | 0.336 | 0.287 | 0.809 | | |
| GKM | 0.628 | 0.286 | 0.522 | 0.544 | 0.822 | |
| GTL | 0.538 | 0.242 | 0.240 | 0.451 | 0.418 | 0.712 |

Table 4. Coefficient of determination and predictive relevance

| | Coefficient of determination | predictive relevance | | |
|---|---|---|---|---|
| | R-square | SSO | SSE | $Q^2$ (=1-SSE/SSO) |
| EIGI | 0.487 | 1620.000 | 1069.920 | 0.340 |
| ERGI | 0.130 | 1620.000 | 1483.848 | 0.084 |
| GCA | 0.430 | 1620.000 | 1200.682 | 0.259 |

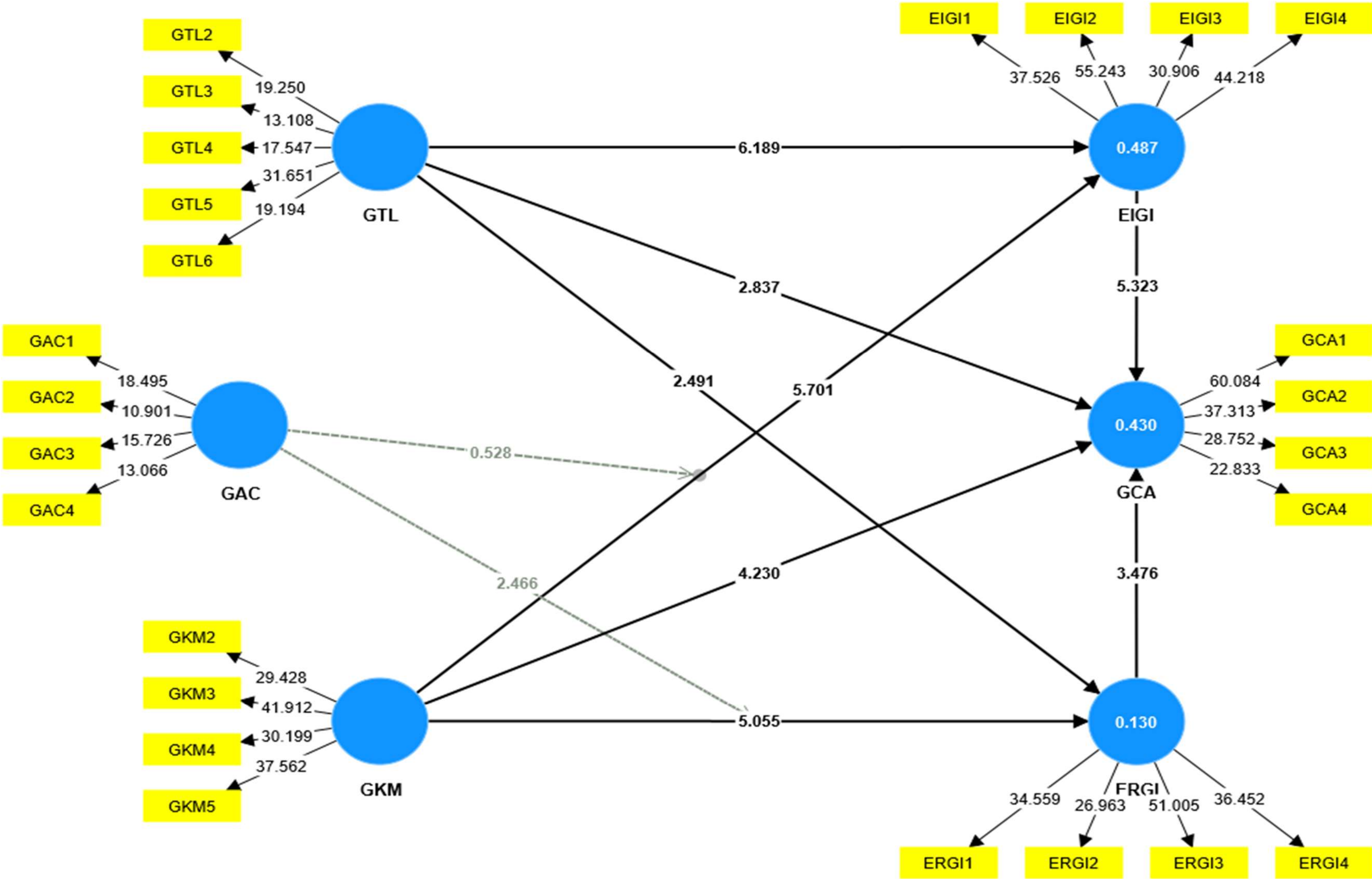


**Figure 3**. Structural model

Table 5. Hypotheses results

| Hypotheses | IV | | Med/Mod | | DV | β | STDEV | T statistics | P values | BCI-LL | BCI-UL | F-square | Conclusion |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Control effects** | | | | | | | | | | | | | Not sig. |
| +Ve | Ownership | -> | | | GCA | -0.031 | 0.086 | -0.366 | 0.715 | -0.200 | 0.137 | | Not sig. |
| +Ve | Organization size | -> | | | GCA | 0.016 | 0.029 | 0.561 | 0.575 | -0.040 | 0.073 | | Not sig. |
| +Ve | Organization age | -> | | | GCA | -0.033 | 0.031 | -1.063 | 0.289 | -0.094 | 0.028 | | Not sig. |
| +Ve | Ownership | -> | | | EIGI | -0.064 | 0.078 | -0.827 | 0.408 | -0.217 | 0.089 | | Not sig. |
| +Ve | Organization size | -> | | | EIGI | -0.026 | 0.026 | -1.009 | 0.314 | -0.078 | 0.025 | | Not sig. |
| +Ve | Organization age | -> | | | EIGI | -0.020 | 0.028 | -0.724 | 0.470 | -0.076 | 0.035 | | Not sig. |
| +Ve | Ownership | -> | | | ERGI | 0.030 | 0.072 | 0.415 | 0.678 | -0.111 | 0.171 | | Not sig. |
| +Ve | Organization size | -> | | | ERGI | 0.027 | 0.024 | 1.116 | 0.265 | -0.020 | 0.074 | | Not sig. |
| +Ve | Organization age | -> | | | ERGI | 0.010 | 0.026 | 0.377 | 0.706 | -0.041 | 0.061 | | Not sig. |
| **Direct effects** | | | | | | | | | | | | | |
| H1 | GTL | -> | | | GCA | 0.143 | 0.051 | 2.837 | 0.005 | 0.047 | 0.246 | 0.025 | Sig. |
| H2 | GKM | -> | | | GCA | 0.243 | 0.058 | 4.230 | 0.000 | 0.131 | 0.357 | 0.060 | Sig. |
| H3a | GTL | -> | | | EIGI | 0.339 | 0.055 | 6.189 | 0.000 | 0.239 | 0.455 | 0.181 | Sig. |
| H3b | GTL | -> | | | ERGI | 0.134 | 0.054 | 2.491 | 0.013 | 0.028 | 0.240 | 0.017 | Sig. |
| H4a | GKM | -> | | | EIGI | 0.459 | 0.081 | 5.701 | 0.000 | 0.291 | 0.604 | 0.210 | Sig. |
| H4b | GKM | -> | | | ERGI | 0.373 | 0.074 | 5.055 | 0.000 | 0.238 | 0.526 | 0.082 | Sig. |
| H5a | EIGI | -> | | | GCA | 0.310 | 0.058 | 5.323 | 0.000 | 0.197 | 0.424 | 0.087 | Sig. |
| H5b | ERGI | -> | | | GCA | 0.160 | 0.046 | 3.476 | 0.001 | 0.071 | 0.251 | 0.040 | Sig. |
| **Mediating effects** | | | | | | | | | | | | | |
| H6a | GTL | -> | EIGI | -> | GCA | 0.105 | 0.023 | 4.635 | 0.000 | 0.064 | 0.154 | | Sig. |
| H6b | GTL | -> | ERGI | -> | GCA | 0.021 | 0.010 | 2.141 | 0.032 | 0.004 | 0.043 | | Sig. |
| H7a | GKM | -> | EIGI | -> | GCA | 0.142 | 0.041 | 3.449 | 0.001 | 0.071 | 0.229 | | Sig. |
| H7b | GKM | -> | ERGI | -> | GCA | 0.060 | 0.023 | 2.583 | 0.010 | 0.022 | 0.112 | | Sig. |
| **Moderating effects** | | | | | | | | | | | | | |
| H8a | GKM | x | GAC | -> | EIGI | -0.028 | 0.053 | 0.528 | 0.597 | -0.118 | 0.086 | | Not sig. |
| H8b | GKM | x | GAC | -> | ERGI | 0.094 | 0.038 | 2.466 | 0.014 | 0.023 | 0.174 | | Sig. |

#### 4.2.3. Moderating Effects

The study's findings on moderating effects revealed mixed results. Hypothesis H8a (GAC x GKM -> EIGI), which proposed a moderating effect of GAC on the relationship between GKM and EIGI, was not supported (β = -0.028, P = 0.597), indicating that GAC did not significantly alter this relationship. However, Hypothesis H8b (GAC x GKM -> ERGI), which proposed a moderating effect of GAC on the relationship between GKM and ERGI, was supported (β = 0.094, P = 0.014), suggesting that GAC significantly moderates this relationship, highlighting the specific conditions under which GKM influences ERGI through the presence of GAC. Therefore, H8a was rejected, and H8b was supported.

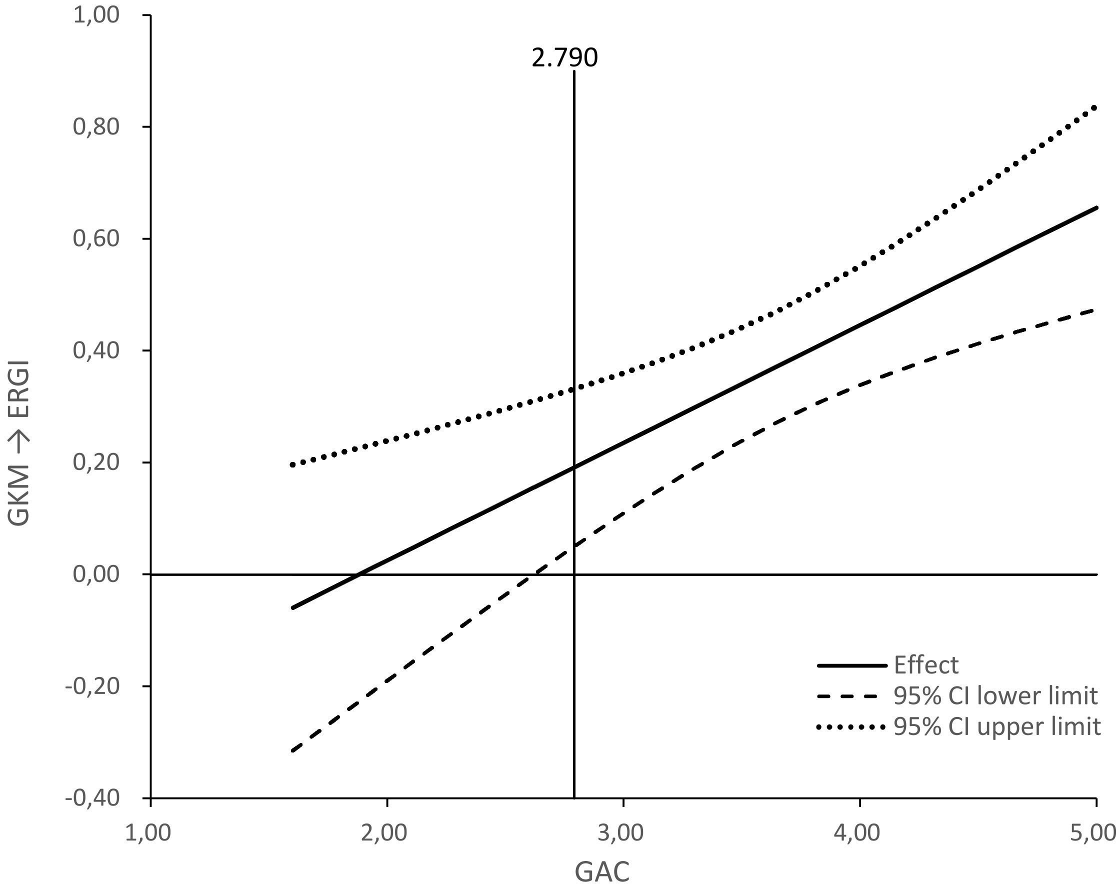


**Figure 4** Moderating effects of GAC on the influence of GKM on ERGI with Johnson-Neyman point.

To further investigate the moderating effect of GAC on the relationship between GKM and two aspects of ambidextrous GI, we performed a conditional process analysis using PROCESS Model 1 with 5000 resamples to obtain bias-corrected confidence intervals for the proposed effects and examine the proposed interaction at various moderation levels (Hayes, 2017). We confirmed the moderating effect of GAC on the GKM and ERGI relationship using this alternate estimating method. We then used an analysis established by Johnson and Neyman (1936) to investigate the interaction. Since our moderator GAC is a continuous arbitrary variable, we used the Johnson-Neyman technique to identify regions in its range where the independent variable's effect on the dependent variable is and is not significant (Hayes and Matthes, 2009). The Johnson-Neyman point marks the boundary between these two regions. For H8b, the Johnson-Neyman point, indicating significance at $p < 0.05$ ($t= 2.037$), is situated at 2.790 on the 1–5 scale for the GAC moderator (illustrated in Figure 4).

### 4.3. fsQCA results

The research employed fsQCA to evaluate the antecedent conditions (strategic organizational factors, ambidextrous GI, and GAC) to achieve high GAC.

#### 4.3.1 Calibration

The fsQCA method involves converting data into fuzzy sets, which are then categorized into completely in, totally out, or between specified groups. These sets can have any value between 0 and 1. Variables can be calibrated either explicitly or fuzzily, with varying degrees of belonging ranging from 0 to 1. The analysis typically uses three calibration limit values: 0.05 for complete non-membership, 0.50 as a crossover point, and 0.95 for complete membership. The process of allocating fuzzy values to cases and selecting input parameters is at the researcher's discretion but must be transparent. In this study, the direct approach for calibrating data was used, and the 95th, 50th, and 5th percentiles were used as the cut-off values.

Table 6. Necessary conditions analysis

| | Outcome: GCA | |
|---|---|---|
| Conditions | Consistency | Coverage |
| GTL | 0.786 | 0.756 |
| ~GTL | 0.552 | 0.597 |
| GKM | 0.788 | 0.754 |
| ~GKM | 0.539 | 0.586 |
| EIGI | 0.825 | 0.765 |
| ~EIGI | 0.504 | 0.569 |
| ERGI | 0.797 | 0.760 |
| ~ERGI | 0.562 | 0.615 |
| GAC | 0.702 | 0.701 |
| ~GCA | 0.516 | 0.536 |

### 4.3.2. Necessary condition analysis

In fsQCA, a 'necessary condition' is a factor that must be present for a particular outcome to occur. Their consistency and coverage scores determine the strength of these conditions. A consistency score above 0.9 is considered strong evidence for a necessary condition in fsQCA, while scores above 0.8 are often seen as indicative but not definitive (Ragin, 2009). In Table 6, the 'EIGI' condition has the highest consistency (0.825) and coverage (0.765), suggesting it is a strong necessary condition for GCA, although slightly below the ideal threshold of 0.9 for consistency. 'ERGI,' 'GTL,' and 'GKM' also have fairly high consistency and coverage scores (above 0.75), indicating they are relevant and fairly consistent necessary conditions for GCA but not as strong as EIGI. The negated conditions (indicated by the ~ symbol), on the whole, show lower consistency and coverage, implying that their absence is less critical in determining the outcome. Specifically, 'GAC' and its negation '~GCA' display the lowest consistency and coverage, suggesting they are weaker necessary conditions compared to others. Overall, while EIGI emerges as the strongest necessary condition for GCA in the study results, none of the conditions reach the more definitive threshold of 0.90 in consistency (Pappas and Woodside, 2021). This suggests that while these conditions are relevant and consistent with the presence of GCA, they may not be solely sufficient to guarantee the outcome.

Table7. Results intermediate solution

| *Configurations for Green competitive advantage*<br>GCA = f (GTL, GKM, EIGI, ERGI, GAC) | | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| **Organizational factors** | | | | | |
| *GTL* | | ⬤ | ⬤ | | |
| *GKM* | | | ⬤ | ● | ● |
| **Ambidextrous GI** | | | | | |
| *EIGI* | | ● | | ● | ● |
| *ERGI* | | ● | ⊗ | ● | ⊗ |
| GAC | | | ● | ⊗ | ● |
| Raw coverage | | 0.609 | 0.312 | 0.429 | 0.367 |
| Unique Coverage | | 0.155 | 0.028 | 0.015 | 0.034 |
| Consistency | | 0.896 | 0.886 | 0.916 | 0.892 |
| Solution coverage: | 0.732 | | | | |
| solution consistency: | 0.863 | | | | |

**Notes:**

GTL=Green transforamtional leadership; GKM=Green knowledge mangement; EIGI=Exploitative green innovation; ERGI=Exploratory green innovation; GCA=Green competitive advantage; GAC=Green absorptive capacity;

⬤ Indicate Core condition; ● indicates the core condition; ⊗ absent; and blank space indicates “do not care”.

#### 4.3.3. Solution

The fsQCA analysis uncovered four distinct configurations that reveal different combinations of conditions leading to GCA, as displayed in Table 7. Configuration 1 identifies GTL and ERGI as core conditions, suggesting their substantial impact on achieving GCA. Configuration 2 emphasizes the role of GKM and GAC, indicating their significance in the context of GCA. In Configuration 3, the combination of GKM and EIGI is central, while Configuration 4 highlights a unique pathway where the absence of ERGI, coupled with GKM and GAC, leads to GCA. The raw coverage values, ranging from 0.312 to 0.609, show the proportion of GCA cases each configuration explains, with Configuration 1 accounting for the most. Although lower, the unique coverage values indicate the individual contribution of each configuration in explaining GCA. The consistency values, all above 0.86, demonstrate a high level of reliability in these configurations leading to GCA. The overall solution coverage of 0.732 suggests that these configurations collectively explain a significant portion of GCA instances, while the solution consistency of 0.863 indicates a strong overall reliability of these pathways.

## 5. Discussion

The current research conducted a comprehensive investigation of the relationship between strategic organizational factors, ambidextrous GI, and GCA with the moderating role of GAC. The study aimed to address the question of why establishing strategic organizational factors is crucial for ambidextrous GI and how ambidextrous GI impacts GCA. Furthermore, the research examined the combined influence of organizational factors (GTL and GKM) and ambidextrous GI (EIGI and ERGI) dimensions on GCA. The study utilized the RBV theory (Barney, 1991) as its theoretical foundation. The results of the study significantly contribute to both theoretical and practical initiatives in the fields of leadership, knowledge management, and GI management.

First, the study found that organizational factors have a significant impact on GCA, emphasizing the importance of these factors in establishing GCA. The findings revealed that GTL positively influences GCA. This may be due to GTL fostering a culture of sustainability, encouraging environmentally friendly practices, and a long-term environmental focus. This leadership style cultivates a workforce dedicated to green initiatives, driving the development of sustainable products and methods. These results align with the findings of Begum et al. (2022), Chen and Chang (2013), and Majali et al. (2022). Additionally, GKM was found to have a positive impact on GCA. This suggests that GKM enhances the firm's environmental efficiency by promoting prudent resource use, sharing sustainable practices, and adhering to environmental regulations. This reduces costs and waste, allowing the firm to adapt to changing green standards and technologies. This finding supports the ideas of Shehzad et al. (2023) and Abbas and Khan (2022), who established that GKM not only reduces costs and waste but also enhances the firm's ability to adapt to new green standards and technologies to stimulate GCA successfully. Overall, the study emphasizes that incorporating these green strategic variables is not just an ethical choice but also a strategic need for companies aiming to preserve their competitive advantage in the face of strict environmental restrictions.

Second, the study findings confirm that organizational factors significantly impact ambidextrous GI. Specifically, research indicates that GTL positively influences both aspects of ambidextrous GI (EIGI and ERGI). This may be due to GTL's visionary approach, which embeds environmental stewardship into the organization's ethos, motivating and guiding employees toward eco-friendly innovations. Their commitment to sustainable practices sets a standard, building a trustful environment where green initiatives are encouraged and valued. The study findings support prior studies by Shehzad et al. (2022a) and Begum et al. (2022). Additionally, GKM also reveals a positive impact on ambidextrous GI capabilities encompassing EIGI and ERGI. Effective GKM ensures that valuable insights and experiences regarding green practices are captured and shared throughout the organization, leading to a more informed and skilled workforce capable of contributing to both explorative and exploitative GI. These findings align with prior studies by Sahoo et al. (2022), Wang et al. (2023), and Shehzad et al. (2023). In summary, this dual strategic focus enables manufacturing firms to successfully engage in ambidextrous GI, balancing the exploration of new green technologies and processes with the exploitation of existing ones to improve environmental performance while maintaining competitive advantage.

Third, the study results indicated that ambidextrous GI has a positive impact on a firm's GCA. The study findings suggest that ambidextrous GI, which combines exploitative and explorative GI, is essential for enhancing a manufacturing firm's competitive advantage. Exploitative innovation focuses on refining and improving existing green technologies, processes, and products, resulting in cost savings, better resource management, and compliance with environmental regulations. On the other hand, explorative innovation involves experimenting with new green technologies and practices, enabling firms to develop sustainable solutions and set industry standards. The study findings align with the studies of Shehzad et al. (2023), Wang et al. (2020a), and Asiaei et al. (2023). The synergy of both approaches allows manufacturing firms to continuously improve their environmental performance while also fostering breakthroughs in green technology and remaining competitive in the rapidly changing landscape of sustainability.

Fourth, previous research has demonstrated that GAC moderates GI fostering (Idrees et al., 2023b; Wang et al., 2023). The literature also emphasizes the need to explore the potential moderating mechanism of organizations' capability attributes on the association between organizational factors and innovative practices (Wang et al., 2020a; Shehzad et al., 2023). To address these theoretical gaps, the current study investigated whether or not GAC moderates the relationship between GKM and ambidextrous GI, specifically EGI and ERGI. The results indicate that GAC significantly moderates the impact of GKM on ERGI but plays an insignificant moderating role in the GKM and EIGI relationship. The probable explanation is that firms with high GAC are better able to acquire, share, and use green information in their processes to promote exploratory GI, but they may mismanage existing environmental knowledge required for exploitative GI since they are more ecologically entrepreneurial, proactive, and open to taking risks.

The fsQCA results indicate that none of the factors, including organizational elements, ambidextrous dimensions, and GAC alone, can explain high-level GCA. Our study reveals the complex relationship between these factors in achieving GCA. The most robust solution for high GCA, as shown in Solution 1 in Table 7, suggests that for 60.9% of the respondents in our sample, high GTL, along with EIGI and ERGI, leads to high GCA. Achieving GCA is a multifaceted process that requires a combination of strategic elements rather than a single determinant. GTL and GKM play a crucial role in this process, emphasizing the need for a guiding vision and effective management of green-oriented knowledge within organizations. Leadership that actively promotes sustainable practices creates a conducive environment for innovation and green strategies. Additionally, managing green knowledge effectively is vital for translating this vision into a competitive advantage. The interplay between EIGI and ERGI highlights the need to refine existing green processes and explore new sustainable avenues. GAC complements these factors by enabling organizations to assimilate and apply external green knowledge effectively, which is essential for staying updated with emerging sustainable practices. These findings are consistent with previous studies (Shehzad et al., 2022a; Donate and Sánchez de Pablo, 2015) that have shown that organizational factors such as GTL and GKM stimulate GCA. Our study also demonstrates the existence of equifinality, which is gaining momentum in the management literature (Fiss, 2011), where combinations of organizational factors and ambidextrous GI, along with GCA, result in a high degree of GCA. As a result, our research suggests a comprehensive strategy for attaining GCA, in which innovation, knowledge management, leadership, and GAC combine to provide competitive advantage and sustainability in the modern, environmentally conscious corporate world.

### 5.1. Theoretical contribution

This study enhances the RBV theory by integrating the concepts of GTL, GKM, ambidextrous GI, and GAC to explain the attainment of a firm's GCA. By examining an integrated model, the research contributes to the literature in several ways, offering theoretical insights. Firstly, the study extends RBV by recognizing GTL and GKM as critical green organizational resources that drive GCA. This addition to RBV highlights the significance of leadership and knowledge management in the context of environmental sustainability, an area that has been relatively under-explored in RBV literature. Secondly, the research investigates the mediating role of ambidextrous GI, specifically ERGI, and EIGI, providing insights into how firms can balance and leverage both explorative and exploitative GI. This mediation analysis incorporates a dynamic capability perspective into the RBV framework, emphasizing the role of innovation processes in transforming green-oriented resources and capabilities into CA, thereby extending the existing research of Shehzad et al. (2023) and Wang et al. (2020a).

Thirdly, the moderating role of GAC in the GKM-GI relationship enriches the existing understanding within RBV by showcasing how the capacity to absorb external green knowledge can enhance the effectiveness of internal green knowledge management, thereby amplifying the impact of GI on CA. Finally, the research employs the SEM-fsQCA methodology, which allows for a comprehensive examination of the complex interrelationships and configurations of GTL, GKM, AGI, and GAC. The fsQCA, in particular, contributes to theory by identifying specific conditions under which these resources and capabilities most effectively lead to CA. This approach addresses the call for more configurational analyses in management research and provides a more holistic understanding of how multiple organizational factors interact to drive environmental sustainability and CA.

Fourthly, the GAC's moderating effect on the relationship between GKM and GI contributes to the existing understanding of RBV by demonstrating how the ability to absorb external green knowledge can improve the effectiveness of internal green knowledge management, thereby intensifying the impact of GI on GCA. Finally, the SEM-fsQCA methodology allows for a comprehensive examination of the complex interrelationships and configurations of GTL, GKM, AGI, and GAC. The fsQCA component, in particular, identifies specific conditions under which these resources and capabilities most effectively lead to GCA, thereby addressing the need for more configurational analyses in management research. This approach provides a more holistic understanding of how multiple organizational factors interact to drive environmental sustainability and competitive advantage.

### 5.2. Practical Contributions

This study, rooted in RBV theory, offers substantial practical implications for the realm of sustainable business practices, particularly in developed economies. It delves into the intricate interplay among key organizational factors—GTL and GKM—and their impact on a firm's GCA. The research emphasizes the crucial role of GTL and GKM in fostering an environment that promotes sustainable practices and innovation. For businesses, this translates into actionable insights: prioritizing environmental leadership and integrating green knowledge processes into their strategic frameworks can significantly enhance their competitive position in the green market.

One of the core findings of this research is the mediating role of ambidextrous GI, which encompasses exploratory and exploitative aspects, plays a mediating role in the relationship between organizational factors and green competitive advantage. Balancing innovation efforts by developing new green technologies while effectively utilizing existing sustainable practices is crucial for firms to achieve immediate environmental goals and ensure long-term sustainability and competitiveness. The study also reveals the moderating role of green absorptive capacity in enhancing the influence of green knowledge management on GI. Firms need to invest in building their capacity to effectively assimilate and apply green knowledge to maintain a competitive edge in the rapidly evolving green sector.

The research identifies various configurations of organizational factors, GI and GAC, that correspond with higher GCA, providing businesses with multiple strategic pathways to achieve GCA. Policymakers can use these findings to develop strategies that encourage the adoption of sustainable practices in businesses. In contrast, industry leaders can use these insights to drive innovation in sustainability, enhancing their market positioning while contributing to environmental stewardship.

### 5.3. Research limitations

The present study delves into the complex relationship among organizational elements, ambidextrous GI, GAC, and GCA, yet faces certain methodological and theoretical constraints that pave the way for further investigation. Utilizing a dual-method approach that merges SEM with fsQCA, the research provides an extensive overview but might fall short of fully grasping the intricacies of non-linear dynamics and the interplay between variables. Advancing the research in this field could involve the adoption of more sophisticated analytical techniques and the incorporation of detailed qualitative methods to capture these complexities better. The study's foundation in RBV theory emphasizes internal organizational skills, possibly neglecting significant external environmental influences. By integrating supplementary theoretical frameworks, such as the stakeholder theory or institutional theory, a more thorough comprehension of the external factors impacting green competitive advantage may be attained. Moreover, the emphasis on certain organizational characteristics, such as GTL and GKM, may restrict the comprehension of other significant components. Subsequent research should investigate a wider array of organizational aspects, such as corporate social responsibility, green intellectual capital, or stakeholder engagement approaches. Furthermore, the results' generalizability may be improved by broadening the scope of the study to cover a wider variety of sectors and geographical locations, increasing global knowledge of green competitive dynamics. In conclusion, greater insights into obtaining green competitive advantage may come from investigating moderating and mediating factors beyond ambidextrous GI and green absorptive aptitudes, such as environmental policy frameworks and organizational agility. While providing useful insights, this study emphasizes the need for continuous research to enhance and expand the understanding of green competitive advantage in many organizational and environmental situations.

### 5.4. Conclusion

The purpose of this study was to investigate how organizational factors contribute to GCA through ambidextrous GI and to examine the moderating impact of GAC using primary data from a UAE manufacturing and services firm. The findings showed that both aspects of organizational factors, GTL and GKM, significantly stimulate GCA. Additionally, the research indicated that ambidextrous GI, encompassing EIGI and ERGI, are important for organizational activities and increase the association between strategic organizational factors and GCA, addressing the study's second purpose. The study also found empirical evidence of the moderating influence of GAC on GKM and ERGI, highlighting the importance of a firm's capability to absorb environmental knowledge to enhance exploratory GI. Furthermore, the results showed a clear pattern of equifinality and four solutions with different combinations of configurations leading to improved GCA, suggesting that no single condition, whether organizational dimension or ambidextrous GI, is sufficient to explain high-level GCA on its own.

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