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Modelling the significance of strategic orientation on green innovation: mediation of green dynamic capabilities

Han Xiao[1], Abdullah Al Mamun[2✉], Mohammad Masukujjaman[2] & Qing Yang[2]

The increasing recognition of environmental concerns has prompted both nations and corporations to adopt green innovation as a significant strategy for addressing environmental risks and promoting sustainable development. To excel in this pursuit, companies must cultivate green dynamic capabilities, infusing environmental considerations into their strategic decision-making processes. The purpose of this study is to investigate the association between strategic orientation components and green dynamic capabilities, as well as their impact on green product and process innovation, in medium-to-large-sized manufacturing firms in China. Employing a quantitative methodology, an online cross-sectional research design was used to gather 582 valid responses through a structured questionnaire. Results indicated a positive association between learning orientation and green dynamic capabilities. Furthermore, green dynamic capability was found to mediate the relationship between learning orientation and green product and process innovation. However, no significant relationship was observed between green entrepreneurial orientation, market orientation, internationalisation orientation, and green dynamic capabilities. By conducting multi-group analysis and studying the context of Chinese manufacturing firms, this research contributes new insights into the relationship between resource-based theory constructs and green innovation, including the integration of green dynamic capabilities. The results emphasise the significance of adopting a learning mindset, developing green dynamic capabilities, and fostering green innovation. These findings offer useful insights for the Chinese manufacturing industry, enabling it to strengthen its competencies in green innovation.

[1] School of Business, Nantong Institute of Technology, Nantong 226000 Jiangsu, China. [2] UKM—Graduate School of Business, Universiti Kebangsaan Malaysia, UKM, 43600 Bangi, Selangor Darul Ehsan, Malaysia. ✉email: almamun@ukm.edu.my

Introduction

As the global population increases, living areas expand, and economies intensify rapidly, various issues and concerns related to the environment and resources begin to emerge and escalate, such as climate issues, resource depletion, environmental pollution, severe industrial waste, and large carbon emissions from manufacturing (Yuan and Cao 2022; Zameer et al. 2021; Xu et al. 2020). Manufacturing firms are an important part of economic and industrial development in most countries and are strongly supported in many developing and emerging countries. However, the growth and expansion of manufacturing companies are significant contributors to environmental issues such as ecological change, natural resource reduction, and pollution of air and water (Kraus et al. 2020). With increasing environmental and resource problems, as well as for attaining sustainable monetary development and future long-term development of manufacturing companies, many nations and companies are concentrating on and executing green innovation, which can solve environmental pollution and resource waste problems caused by companies from the beginning, thus supporting the sustainable advancement of both society and businesses (Yuan and Cao 2022; Sun et al. 2020).

Green innovation, also known as eco-innovation, refers to a transformative process that fosters the development of novel methods, technologies, and production systems, all with the overarching objective of mitigating environmental hazards such as pollution and the adverse impacts associated with resource utilisation (Castellacci and Lie 2017). Green innovation is a useful approach for manufacturing firms to address environmental pollution and resource waste through their production processes. By incorporating green innovation into their operations, medium-to-large manufacturing companies can enhance their existing models and adopt more environment-friendly practices, technologies, and services, which will promote their sustainable growth (Kraus et al. 2020; Sun et al. 2020). Most large- and medium-sized manufacturing companies will promote green innovation through energy-efficient technological innovation and environmentally friendly product and process development. Thus, the separation of green product and green process development is pertinent. Green product innovation primarily focuses on developing environmentally friendly products or services that have a reduced ecological footprint or offer eco-friendly alternatives to existing offerings. On the other hand, green process innovation emphasises improving the environmental performance of production processes, supply chains, or operational practices. By separating the two, researchers can delve deeper into the distinct challenges, strategies, and outcomes associated with each aspect of green innovation. This distinction allows for a more nuanced evaluation of the effectiveness and implications of green innovation efforts.

In addition, green innovation requires organisational extension and implementation with regards to adopting eco-friendly practices and building green dynamic capabilities (Yousaf 2021). Green dynamic capability refers to the strategic decision-making that incorporates an environmental perspective, aiming to attain eco-friendly products and processes (Cheng 2020). Companies with green innovation capabilities are successful in long-term sustainability, and they outperform their competitors overall because their green innovations add sustainability potential, and also possess intangible value and assets, which enable them to effectively utilise their green competencies to quickly and effectively address the requirements of various stakeholders (Singh et al. 2021). In the field of green innovation research, green dynamic capability is a valuable asset for companies to tackle sustainability issues, such as environmental degradation and the quick exhaustion of natural wealth, and it can contribute significantly to firm performance outcomes in terms of firm reputation, asset growth, and profitability (Yu et al. 2022; Ali et al. 2021; Peng 2020). In the progress stage of green innovation in manufacturing companies, developing and enhancing green dynamic capabilities are important, as companies can improve and develop their green organisational capabilities through available resources and knowledge bases to better adapt to dynamic market changes (Qiu et al. 2019). Therefore, green dynamic capability is a vital element that can be used to better realise the needs of stakeholders, and can establish a strong foundation for green innovation. Thus, research targeting green dynamic capabilities can provide management insights to promote corporate green innovation (Yuan and Cao 2022).

Strategic orientation is the all-encompassing method that an organisation uses to develop and carry out its business strategy (Han et al. 2022). It encompasses a diverse range of activities such as market analysis, resource allocation, and innovation. A strategic orientation guides the decision-making process and shapes the company's actions and initiatives to effectively achieve its objectives. Various researchers have addressed strategic orientation with different components and relationships in their studies. For example, Pehrsson (2020) included a bi-dimensional strategic orientation comprising green entrepreneurial orientation (GEO) and market orientation (MRO) to examine firm performance. Similarly, Han and Zhang (2021) adopted a bi-dimensional strategic orientation, exploring the relationship between GEO and learning orientation (LRO) in relation to innovation. Both studies emphasised the interrelated nature of these components, highlighting the relationships between GEO-MRO and GEO-LRO and their impact on dependent variables. In contrast, Uzoamaka et al. (2020) identified isolated components such as entrepreneurial orientation, market orientation, and learning orientation in their review articles. On the other hand, Bagheri et al. (2019) investigated the relationship between internationalisation orientation and firm performance. Given the significant international exposure of companies today, the question of how managers can effectively develop and utilise resources and capabilities to survive in foreign markets while decoupling their international strategy remains a longstanding and concurrent topic in the relevant literature (Gupta et al. 2014). Nevertheless, a thorough examination of existing literature yielded no known comprehensive studies that have concurrently addressed all four aforementioned components. Including multiple orientation types can allow researchers to analyse and compare the effects of different strategic orientations on green dynamic capability or other relevant outcomes.

Currently, the manufacturing industry plays a vital and irreplaceable role in Chinese and global economic growth, serving as their backbone. According to the World Economic Forum (2020), China has the position of being the leading global manufacturing powerhouse, accounting for 28.4% of the total global manufacturing output in 2018. Subsequently, the United States and Japan followed with respective shares of 16.6 and 7.2%. Hence, China's manufacturing firms serve as a significant research subject, given their status as one of the leading progressive manufacturing nations. Inspired by developed countries such as the United States, Japan, and European countries, the Chinese government is actively encouraging large companies to adopt eco-innovation, integrate sustainable growth and development into their operations, address environmental issues, and take responsibility for environmental protection (Yuan and Cao 2022). However, owing to deficiencies in detailed research on strategic orientation, China's manufacturing industry remains in a relatively confused realm in terms of achieving green innovation and exploring green dynamic capabilities (Yousaf 2021; Tseng et al.

2019). However, studies exploring the relationship between strategic orientation and green dynamic capabilities are still limited, and the existing literature has neglected the mediating relationship of green dynamic capabilities between strategic orientation and green product and process innovation (Yuan and Cao 2022; Tseng et al. 2019). Hence, conducting in-depth research to assess the influence of strategic orientation factors on green dynamic capabilities and green innovation is important. Therefore, the research question is: *What relationships exist between strategic orientation, green dynamic capability, and categorised innovation for Chinese medium and large manufacturing organisations?*

To fill this research gap, the purpose of this study is to evaluate the connection between strategic orientation dimensions and green dynamic capabilities and how green dynamic capabilities mediate the relationship between strategic orientation and green product and process innovation. This study is driven by the increasing environmental and resource issues that arise as manufacturing firms grow and expand and the need to adopt green innovation and green dynamic capabilities to address these issues sustainably. This study offers a comprehensive framework that extends the resource-based view (RBV) and dynamic capability theory (DCT) and will certainly help academia and practitioners make informed decisions. Moreover, this study makes a valuable academic contribution through the multi-group analysis (MGA), which enabled the examination of group differences based on factors including a firm's year of establishment, type, and size. By exploring the significance and impacts of a firm's strategic orientation on its green dynamic capabilities and green innovation, this study offers insights into how medium and large manufacturing firms in China can achieve green sustainability through strategic planning and implementation, as well as the development of green dynamic capabilities and development, and improve environmental problems and pollution caused by traditional production methods through green innovation.

Literature review

Theoretical foundation. RBV theory posits that a firm's distinctive competence can be attributed to a competitive edge in the market, and this theory can help a firm systematically integrate internal resources and competitive advantages and solve related problems (Muangmee et al. 2021; Tseng et al. 2019; Ray et al. 2003; Barney 1991). Studies related to the firm's dynamic capabilities extended from the RBV have confirmed that the dynamic capabilities of the firm are mainly used to explain how the firm creates new resources or modifies existing assets to attain its objectives rather than the resources that the firm currently has (Tseng et al. 2019). Teece's study of the RBV model confirms that a firm's resources imply the available tangible stock that the firm currently controls, while dynamic competencies are more akin to proficiency in utilising the said assets to help the firm achieve desired outcomes (Teece et al. 1999). In addition, Xie et al. (2019) postulate that the unique resources a firm has and its unique ability to use them are key factors in creating an advantage in a competitive market. As stated by Muangmee et al. (2021), the strategies formulated and executed by a company are closely tied to the utilisation of resources and the implementation of the firm's dynamic capabilities. The implementation of dynamic competencies is connected to a firm's green innovation. Although RBV is considered a well-known theory in strategic management, it has some criticism. According to Kraaijenbrink et al. (2010), the RBV theory is limited in its ability to explain how firms utilise resources and capabilities in a dynamic market. RBV primarily focuses on maintaining a competitive advantage by leveraging existing resources, but it fails to address how resources are developed and integrated in a rapidly changing market (Smith et al. 2014). To address this limitation, the dynamic capability theory (DCT) was proposed as an extension of RBV, emphasising the importance of innovation in adapting to dynamic environments (Wang et al. 2016).

The dynamic capability theory explains how companies can adapt and reconfigure their resources and capabilities to achieve a long-lasting competitive advantage in a constantly changing competitive environment. Wang and Liu (2023) define dynamic capabilities as the inherent ability of a firm to integrate, develop, adapt, and reshape both internal and external resources in order to effectively respond to changes in the business environment. These capabilities are considered essential for attaining an enduring competitive advantage in a dynamic and evolving business environment. Mu et al. (2017) applied the dynamic capability theory to examine how a firm's strategic orientation influences its performance, particularly in dynamic situations. The study revealed that strategic orientations, such as market orientation, play a significant role in enhancing a firm's performance during challenging times. Additionally, Mitrega et al. (2017) emphasised the importance of dynamic capabilities in driving innovation, including new product development, and enhancing a firm's market orientation.

Several researchers have proposed the integration of different capabilities and theories to enhance and broaden existing models (Bag and Rahman 2023; Vanpoucke and Ellis 2020). Similarly, prior studies have successfully combined different theories to expand the model, as seen in the present study. For instance, Bag and Rahman (2023) integrated resource-based view theory and absorptive capacity theory to explore the impact of innovation capacities on firm performance. Vanpoucke and Ellis (2020) combined the dynamic capability theory (DCT) and stakeholder theory to investigate the influence of stakeholder pressure on strategic change. Therefore, the current study will integrate both theories for their relevance as a basis to evaluate the influence of strategic orientation on green dynamic capabilities and green innovation in Chinese medium and large manufacturing firms. In this study, green dynamic capability is considered a separate construct that is affected by the various strategic orientations that enable it to attain competitive advantage and shape its green sustainability through green innovation.

Hypotheses development

Strategic orientation and green dynamic capabilities. According to strategic marketing and RBV theory, a company's strategy fosters the creation and growth of capabilities to confront challenges, such as market competition, which in turn prepare the firm for future long-term growth (Tseng et al. 2019). Strategic orientation can be seen as the overall approach of an enterprise to developing and implementing its business strategy, which includes a wide range of activities such as market analysis, resource allocation, and innovation (Han et al. 2022). An enterprise's strategic orientation is usually guided by its mission, vision, and values, as well as its goals and objectives. The relationship between strategic orientation and green dynamic capabilities is complex and multifaceted, and both are critical to the development and implementation of an effective sustainability strategy (Han et al. 2022; Green et al. 2008). To segment and deeply evaluate the effects of various strategic orientations on the green dynamic capabilities and green entrepreneurship of firms, strategic orientations are classified into four distinct dimensions for examination and analysis. These four dimensions are: green entrepreneurship orientation, market orientation, learning orientation, and internationalisation orientation. The reasons for which the current study includes multiple strategic orientations are to fill the research gap and address specific situations. For example, market orientation is highly relevant in competitive markets as it emphasises customer-focused strategies. Learning orientation highlights the importance of continuous learning and knowledge development, particularly in dynamic environments. Additionally, an internationalisation orientation becomes pertinent when organisations expand into international markets. By establishing a clear strategic orientation, businesses can enhance their focus and increase their chances of success in the marketplace.

Green entrepreneurship orientation and green dynamic capabilities. The concept of green entrepreneurship orientation is derived from green entrepreneurship theory and entrepreneurial orientation theory, and it typically represents a firm's strategic orientation towards environmental sustainability, innovation, and the creation of new business opportunities through sustainable practices, which involves a proactive approach to sustainability and a willingness to take risks to exploit opportunities for sustainability-related innovation and market opportunities (Guo et al. 2020). Green entrepreneurship explains green innovation, market initiative, and risk-taking in the process and manner of business operations, and the fact that green entrepreneurship requires the assistance of the firm's green dynamic capabilities implies a link between green entrepreneurship orientation and green dynamic capabilities in the firm (Jiang et al. 2018). In addition, green entrepreneurship orientation, as a strategic orientation, can facilitate the innovation and manufacture of green products and processes, thus contributing to the green sustainability of the firm (Guo et al. 2020; Jiang et al. 2018; Teece 2016). The main purpose of the green entrepreneurship orientation is to facilitate the green manufacturing process of the firm and create green products and services, which also entails mobilising and integrating the firm's resources; in other words, the firm's green dynamic capabilities allow it to create and produce products that have a positive influence on nature (Huang and Li 2015). Relying on the results of previous studies, this study argues that green entrepreneurship orientation reflects the strategic posture of firms to engage in green sustainability through their green dynamic capabilities. Thus, we propose the following hypothesis:

H_1: Green entrepreneurship orientation has a positive influence on green dynamic capabilities.

Internationalisation orientation and green dynamic capabilities. Some studies have defined and expanded on internationalisation, which can be used to gain revenue or business for firms in foreign markets. Firms can use internationalisation-related strategies to establish transactional relationships and win-win cooperation with business partners outside their home countries, thus expanding into new markets and finding new growth opportunities through internationalisation (Behyan et al. 2015). According to the capability-based view of competitive strategy, Knight and Cavusgil (2004) argue that a company's capacities can help it overcome its resource constraints in accessing international markets. This implies that a firm's internationalisation needs to be supported by its own capabilities and resources, meaning that a firm's strategic orientation is linked to internationalisation and its capabilities (Behyan et al. 2015; Maksimov et al. 2019). The expansion of businesses on an international scale can present opportunities to access markets that have more stringent environmental legislation or a greater demand for environmentally friendly products. This can incentivize companies to strengthen their capacity for sustainable practices and improve their ability to adapt to green initiatives. The operation of enterprises in multiple nations provides them with exposure to a range of environmental conditions and sustainable practices, which in turn facilitates the accumulation of information that can be used globally. The presence of environmentally advanced competitors in international marketplaces might incentivize organisations to invest in enhancing their skills. Additionally, internationalisation can stimulate innovation, facilitate alliances, and improve risk management with regards to environmental considerations. Therefore, we propose the following hypothesis:

H_2: Internationalisation orientation has a positive influence on green dynamic capabilities.

Market orientation and green dynamic capabilities. Scholars contend that companies can develop their unique capabilities through market orientation and use these competencies to enhance their performance and the implementation of strategy-related behaviours, thus gaining an advantage in market competition through the subsequent behaviours of the firm (Tseng et al. 2019; Du and Wang 2022). Market-oriented firms can better understand the market environment and thus improve their own capabilities, such as dynamic and innovation capabilities, and thus, gain sustainable competitive competence (Du and Wang 2022). Based on strategic marketing and dynamic capabilities theory, firms can deploy their market strategies to create the appropriate capabilities to adapt to market changes and competition, which also requires firms to have sufficient capabilities of their own, which in turn influences their subsequent behaviours and consequences, that is, innovation and performance (Tseng et al. 2019; Ardito and Dangelico 2018). Verhoef et al. (2009) point out that market orientation, as a component of strategic orientation, has the potential to boost the creation and improvement of a company's capabilities. Market-oriented companies, by prioritising customer preferences and staying attuned to environmental concerns, are well-positioned to identify sustainability opportunities and develop eco-friendly products, aligning with green expectations. Their investments in market research and insights enable informed decision-making, while their adaptive nature allows them to respond to changing market conditions and evolving environmental regulations. Additionally, market orientation fosters innovation, provides a competitive advantage through green initiatives, and leverages customer feedback to continuously improve sustainability efforts, ultimately enhancing green dynamic capabilities. Hence, this study hypothesises a connection between market orientation and green dynamic capabilities:

H_3: Market orientation has a positive influence on green dynamic capabilities.

Learning orientation and green dynamic capabilities. Previous studies have found that a firm's innovative behaviour is dependent on its capacity to acquire and utilise new conceptions, and this new knowledge can drive the development, adoption, and implementation of new ideas in product, process, or service innovation (Wang et al. 2020; Huang and Li 2017; Sinkula et al. 1997; Fong and Chang 2012). The term "learning orientation" refers to a company's tendency towards active learning, which motivates the firm to continually learn and improve its capabilities (Sinkula et al. 1997). A firm's learning orientation allows it to effectively process external information, which is then applied to its future behaviour (D'Angelo and Presutti 2019; Fong and Chang 2012). Many researchers acknowledge the necessity of a company's learning capability as a key component of the innovation process and see learning as a prerequisite for innovation within a firm (Wang et al. 2020; D'Angelo and Presutti 2019; Sinkula et al. 1997). A learning orientation promotes knowledge acquisition, allowing organisations to stay updated on green technologies and regulations. Also, it encourages experimentation and innovation, enabling the development of innovative green solutions. Likewise, it fosters adaptability, problem-solving skills, and employee engagement while facilitating collaboration with other sustainability-focused entities, collectively enhancing a company's ability to effectively navigate and excel in the realm of environmental sustainability. Therefore, we propose the hypothesis below:

H_4: Learning orientation has a positive influence on green dynamic capabilities.

Green dynamic capabilities and green innovation. Dynamic capabilities are regarded as a firm's capacity to flexibly use and rearrange its assets in response to external and internal alternations (Achi et al. 2022; Mousavi et al. 2018). Green dynamic capability refers to a company's ability to adapt and respond to changes in the external environment related to sustainability, such as changes in consumer demand, changes in regulations, and new technologies (Guo et al. 2020). It relates to a company's ability to identify and respond to sustainability-related opportunities and threats and to continuously develop and improve its sustainability-related knowledge and skills (Guo et al. 2020; Mousavi et al. 2018). Green dynamic capabilities enable companies to integrate their existing resources sustainably, leading to the greening of products and processes and the efficient utilisation of resources (Rodrigo-Alarcón et al. 2018; Teece 2018). A company's capacity to accept ecological management practices quickly is crucial for its success in green innovation, and this ability is largely determined by its green dynamic capabilities (Sun et al. 2020). Joshi and Dhar (2020) highlight the necessity of enhancing green dynamic capabilities to promote long-term green innovation and ecological sustainability in firms. Green dynamic capabilities play a vital role in the realisation of green innovation outcomes such as green product innovation and green process innovation, resource and energy conservation, technological advancements in pollution reduction, and green product design (Ferreira et al. 2020). The link between green dynamic capabilities and eco-friendly creativity, including the innovation of products and processes, is well established in the literature (Chen and Chang 2012). In general, green dynamic capabilities enable firms to identify and exploit opportunities for green innovation, while green innovation contributes to the development of green dynamic capabilities, and both contribute to the development and implementation of effective sustainability strategies that enable companies to succeed in an ever-changing and increasingly sustainable business environment (Yu et al. 2022; Yousaf 2021).

Green product innovation, green process innovation and green dynamic capabilities. According to several studies on green innovation in firms, a consensus among scholars is that green innovation primarily encompasses both products and processes and that a strong green dynamic capability can facilitate such efforts (Ahmad et al. 2022; Yousaf 2021; Ferreira et al. 2020; Chen and Chang 2012). A company with a robust green dynamic capability can promptly realise consumer demand for ecological products and assess competitors' ecological innovations via market research and other methods, allowing them to adjust and improve their own ecological goods and process plans (Yuan and Cao 2022; Mousavi et al. 2018). Green dynamic capabilities are considered a crucial foundation for enterprises to conduct green innovation, and enhancing green dynamic capabilities can directly impact the success and accuracy of green initiatives, leading to more rapid investment in green products and process practices and the promotion of green innovation (Singh et al. 2021). When facing market opportunities for green innovation, companies can utilise their green dynamic capabilities to reconfigure their resources and efficiently execute eco-friendly product development and process upgrades (Yousaf 2021).

The link between ecological processes, product innovation, and green dynamic capabilities has been widely acknowledged in corporate innovation research. Some studies have established a clear causal relationship between green dynamic capabilities and innovation, such as Huang and Li (2015), who found that green dynamic capabilities can positively impact green innovation as a type of green behaviour in their study of the ICT industry in Taiwan. Qiu et al. (2019) discovered that the green dynamic capabilities of manufacturing firms can positively influence green process innovation, thereby enhancing the company's competitive competence. Therefore, the connections among green product innovation, green process innovation, and green dynamic capabilities are posited as follows:

H_5: Green dynamic capabilities have a positive influence on green product innovation.

H_6: Green dynamic capabilities have a positive influence on green process innovation.

The mediating role of green dynamic capabilities. Several studies have shown that an enterprise's green sustainability strategy needs to be considered and advanced based on its own capabilities, and that the process of green innovation in a firm is also relevant to the generation, construction, and development of the organisation's capabilities (Yuan and Cao 2022; Xing et al. 2020; Qiu et al. 2019). Firms can enhance their various competencies through strategic orientations, such as green entrepreneurship and learning, which in turn enhance and develop their dynamic capabilities and provide rich capabilities and resources to support corporate green innovation (Yousaf 2021). Therefore, the strategic orientation of the enterprise can help and promote the enterprise to generate and develop its various capabilities to cope with the subsequent behaviour and development of the enterprise. Then, the enterprise can use its green dynamic capabilities in the subsequent green innovation process, which means that green dynamic capabilities can act as a bridge between green innovation and various strategic orientations of business firms. This study proposes the following hypotheses regarding the impact of green dynamic capabilities as intermediaries:

$H_{7\text{-}10a}$: Green dynamic capabilities mediate the relationship between green entrepreneurship orientation, internationalisation orientation, market orientation, and learning orientation on green product innovation.

$H_{7\text{-}10b}$: Green dynamic capabilities mediate the relationship between green entrepreneurship orientation, internationalisation orientation, market orientation, and learning orientation on green process innovation.

All associations hypothesised above presented in Fig. 1.

Research methodology

Data collection method. This study is a quantitative study using a cross-sectional design, which in turn provides an in-depth study and exploration of the strategic orientation, green motivation capabilities, and adoption of green innovation among medium and large manufacturing companies in China. In order to establish the measurement accuracy, validity, and reliability of the scale, the study was pre-tested by four academic experts and four practitioners in China prior to the final data collection, and the questionnaire questions were revised and redesigned in time based on the feedback to improve its accuracy and relevance to the Chinese context. Following the recommendations of Faul et al. (2007) and Hair et al. (2021), this study identified a legitimate minimum sample for the study of 146 (considering six predictors, an effect size of 0.15, an alpha-error probability of 0.05, and a power of 0.95) through the G*Power tool, and the data analysis tool used in this study (PLS-SEM) could be analysed

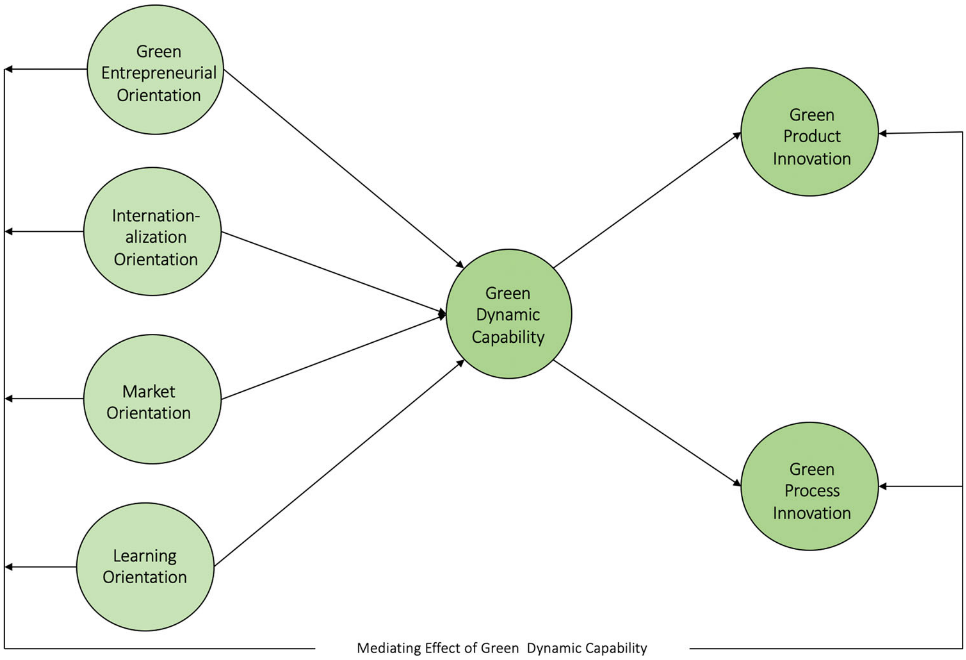

Fig. 1 Research framework. All associations hypothesized in the "Hypotheses development" section are presented. This figure demonstrates the relationship between the four dimensions of strategic orientation and green dynamic capability, which in turn influences green product and process innovation.

with a minimum sample size of 200. This study completed data collection in 2022, and due to China's health management policies during the COVID-19 period, an online questionnaire software called Wenjuanxing (https://www.wjx.cn) was used to design and complete all samples and data collection for this study. Before participating in the survey, all respondents were informed of the general content and purpose of the study's questionnaire and had the right to voluntarily accept or refuse to answer the questionnaire, thus ensuring all respondents' right to information and choice, as well as the security and confidentiality of their personal information.

Considering the specific and specialised nature of the research, purposive sampling was used in this study, which required respondents to have knowledge about the internal strategies and operations of companies (Sekaran and Bougie 2016). Purposive sampling allowed the researchers to target a specific population (possessed unique characteristics) and could provide valuable and relevant information for addressing the research questions (Creswell 2013). The target population was managers of medium- and large-scale production companies in China. The identification of target companies was conducted by utilising the list of enterprises registered with the Chamber of Commerce, in collaboration with the Nantong Institute of Technology in China. Subsequently, this study initiated communication with the respective companies in order to collect data from mid- to high-level managers. In consideration of the professional attributes and schedules of the target population, the online data collection approach adopted in this study increased accessibility to participants who may find it difficult to participate in on-site data collection methods, reduced the potential for subjective bias coming from face-to-face interviews, and in turn improved data quality. Therefore, after identifying the target group of respondents, a purposive sample of 708 executive directors/CEOs and managers of medium and large manufacturing companies that have partnered with Nantong Polytechnic in China were sent an inquiry email with a link to the questionnaire, resulting in 582 complete and valid responses.

Survey instrument. The questionnaire used in this study was based on the extant literature, and its items were adjusted to guarantee the reliability and usefulness of the survey. Furthermore, some questions were reworded to align with particular research requirements and their suitability in the Chinese context. The questionnaire comprised three sections, labelled A, B, and C. Section A served as a screening question to ensure that the participants met the necessary criteria for the study. Section B covered the demographic characteristics of the respondents, such as age, gender, job position, tenure, education level, year of firm establishment, type of firm, firm size, and involvement in cross-border e-commerce. Section C focused on the green entrepreneurship orientation, internationalisation orientation, market orientation, learning orientation, green dynamic capabilities, green product innovation, and green process innovation. All 51 items were evaluated using a 7-point Likert scale, with answers ranging from "strongly disagree" (1) to "strongly agree" (7).

Each scale consisted of approximately five to six items used to gauge the variables. For instance, green entrepreneurship orientation items were adapted from Jiang et al. (2018), internationalisation orientation items from Behyan et al. (2015), market orientation items from Jaworski and Kohli (1993), learning orientation items from Sinkula et al. (1997), green dynamic capabilities items from Yuan and Cao (2022), and green product innovation and green process innovation items from Suriati (2014). The final questionnaire used in this study was translated into Mandarin and then back translated by the Chinese language experts to ensure the accuracy and validity of each questionnaire item and to gather appropriate and reasonable responses from potential participants (respondents), as the original items of all constructs were written in English. The complete questionnaire used to evaluate the variables is provided in "Supporting Material S1. Survey Questionnaire."

Common method bias (CMB). This study employed Harman's single-factor test to assess the impact of common method bias. The single-factor accounted for 31.112%, which falls below

Table 1 Full collinearity test.

	GEO	ITO	MRO	LRO	GDC	GPI	GPN
Variance inflation factors	1.635	1.600	1.611	1.541	1.070	1.549	2.017

GEO green entrepreneurial orientation, *ITO* internationalisation orientation, *MRO* market orientation, *LRO* learning orientation, *GDC* green dynamic capability, *GPI* green product innovation, *GPN* green process innovation.

Harman's recommended threshold of 50% in the one-factor test (Podsakoff et al. 2012). Also, the CMB of the construct variables was assessed using a full-collinearity test following Kock (2017). In this study, all the latent factors were regressed on a commonly generated variable. The results (presented in Table 1) highlight that the variance inflation factor (VIF) scores for green entrepreneurship orientation (1.635), internationalisation orientation (1.600), market orientation (1.611), learning orientation (1.541), green dynamic capabilities (1.070), green product innovation (1.549), and green process innovation (2.017) are well below the standard value of 3.3 (Kock 2017), indicating that collinearity is not present in the data. This finding provides evidence that the CMB did not exert a substantial influence on the outcomes of this study.

Multivariate normality. To select an appropriate data analysis method, it is crucial to assess the multivariate normality of the data. In this study, multivariate normality was assessed using the Web Power online tool (Web Power 2018). The results indicated that the p values for Mardia's multivariate skewness and kurtosis were within the acceptable range of 0.05 (Al Mamun and Fazal 2018). However, the results showed that the data were not normally distributed. Consequently, this study applies the partial least squares structural equation modelling (PLS-SEM) approach to the analysis (Hair et al. 2021).

Data analysis method. SmartPLS 3 was used to test the research framework using PLS-SEM. PLS-SEM was selected for its ability to evaluate early-stage theories and handle complex models (Hair et al. 2021). This technique offers advantages for prediction, the capacity to manage formative constructs, and the greatest capabilities for investigating mediating roles and complex models (Richter et al. 2016). This study utilised PLS-SEM to evaluate the measurement models, including mean-variance extraction, internal consistency reliability, discriminant validity, factor loadings, and cross-loadings, as well as structural models for prediction correlation and multi-group analysis, as stated by Becker et al. (2022). Moreover, the study employed a multi-group analysis (MGA) to categorise the respondents based on years of operation, mode of operation, and size, to deliver a comprehensive assessment of the respondents.

Findings

This study included 582 participants. Their demographic characteristics are presented in Table 2. Most participants were female, accounting for 53.4% of the total, while the remaining 46.6% were male. The largest age group in the sample aged 26–35 years (28.5%), followed by those aged 36–45 years (41.8%), 46–55 years (23.9%), and 56–65 years (4.8%). The smallest age group was represented by individuals aged over 65 years (1.0%). Most participants had a tenure of more than 5 years (76.8%). They were executive directors/CEOs (25.9%), executive or senior managers (56%), and middle managers (18%). In addition, the responding firms covered a wide spectrum of industries (textile manufacturing, 15.8%; petroleum, chemicals, and plastics, 16.7%; electronics equipment, 15.1%; wood, leather, and paper, and others, 11.2%), firm origin (local Chinese firms, 37.8%; multinationals, 45.4%; and international firms, 16.8%), and most firms were involved in cross-border e-commerce (91.9%). Of the

Table 2 Demographic profile.

	N	%		*N*	%
Gender			Education		
Male	271	46.6	Diploma/ Advanced diploma	67	11.5
Female	311	53.4	Bachelor's degree or equivalent	326	56.0
Total	582	100.0	Master's degree or equivalent	102	17.5
			PhD or DBA	87	14.9
Age group			Total	582	100.0
18–25 years	0	0			
26–35 years	166	28.5	Position		
36–45 years	243	41.8	Executive Director/ CEO	151	25.9
46–55 years	139	23.9	Executive or senior management	326	56.0
56–65 years	28	4.8	Middle management	105	18.0
More than 65 years	6	1.0	Total	582	100.0
Total	582	100.0			
			Firm established		
Tenure			Less than 1 year	6	1.0
Less than 1 year	22	3.8	1–5 years	26	4.5
1–5 years	113	19.4	6–10 years	154	26.5
6–10 years	293	50.3	11–15 years	233	40.0
11–15 years	108	18.6	16–20 years	111	19.1
16–20 years	29	5.0	More than 20 years	52	8.9
More than 20 years	17	2.9	Total	582	100.0
Total	582	100.0			
			Type of firm		
Firm origin			Textiles manufacturing	92	15.8
Chinese (Local)	220	37.8	Petroleum, chemicals and plastics	97	16.7
Chinese (Multinational)	264	45.4	Electronics equipment	88	15.1
International	98	16.8	Food production	42	7.2
Total	582	100.0	Metal manufacturing	46	7.9
			Wood, leather and paper	65	11.2
Degree in cross-border eCommerce engagement			Pharmaceutical products	35	6.0
None	53	9.1	Non-metallic mineral products	18	3.1
≤20%	151	25.9	Automobile manufacturing	51	8.8
21%–30%	213	36.6	Transportation	28	4.8
31%–40%	102	17.5	Waste resources	7	1.2
41%–50%	26	4.5	Other manufacturing	13	2.2
More than 50%	37	6.4	Total	582	100.0
Total	582	100.0			
			Firm size		
			Medium enterprise	434	74.6
			Large enterprise	148	25.4
			Total	582	100.0

Table 3 Reliability and validity.

Variables	No. items	Mean	Standard deviation	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted	Variance inflation factors
GEO	5	5.177	1.185	0.862	0.884	0.899	0.640	1.477
ITO	6	5.188	1.057	0.872	1.015	0.895	0.590	1.463
MRO	5	5.207	1.180	0.864	1.027	0.897	0.637	1.540
LRO	6	5.433	1.014	0.848	0.893	0.884	0.562	1.397
GDC	5	4.988	1.624	0.949	0.951	0.961	0.831	1.000
GPI	6	5.368	1.025	0.859	0.894	0.894	0.584	-
GPN	6	5.283	1.118	0.855	0.867	0.892	0.579	-

GEO green entrepreneurial orientation, *ITO* internationalisation orientation, *MRO* market orientation, *LRO* learning orientation, *GDC* green dynamic capability, *GPI* green product innovation, *GPN* green process innovation.

respondents, 74.6% were medium-sized enterprises, 25.4% were large enterprises, and most firms had been established for more than 5 years (94.5%).

When analysing the outer measurement model, it is crucial to establish the validity and reliability of the questionnaire. The measurement's internal consistency is dependent on reliability and can be evaluated using various methods such as Cronbach's alpha, composite reliability, and Dijkstra-Hensele's rho. The results in Table 3 indicate that the scores of all measures for these indicators are above the suggested standard of 0.70, indicating good internal reliability (Hair et al. 2021).

By contrast, validity is divided into two categories: convergent and discriminant. The former was established by evaluating the average variance extracted (AVE) and factor loadings, with values of each latent variable exceeding 0.5, in this study (Hair et al. 2017). This supports the acceptable convergent validity of the latent variables. Discriminant validity, on the other hand, is established by the Fornell-Larcker criterion and heterotrait-monotrait ratio of correlations (HTMT). The results from the Fornell-Larcker criterion showed that the square root of the AVE of each latent variable exceeded that of the other items (Fornell and Larcker 1981). Furthermore, HTMT values recorded in this study were below 0.9 (Fig. 2), which supports effective distinction (Henseler et al. 2015). The loading values of all items were higher than 0.5, which exceeded the cross-loading scores (Fig. 3), thereby establishing the discriminant validity of all items.

This study first assessed the potential for multicollinearity, which refers to high inter-correlation among the independent variables in a model. The results in Table 3 indicate that the variance inflation factor (VIF) values are between 1.000 and 1.5400, which is within the acceptable range of <5 as reported by Hair et al. (2021). Therefore, multicollinearity was omitted, and the correlation structure in the measurement model was deemed appropriate. The explanatory power of the structural model was evaluated using the coefficient of determination (R^2). The blindfolding method was adopted to evaluate the correlation pattern. As shown in Table 5, the R^2 values range from 0 to 1; a higher value indicates a model's stronger explanatory power (Hair et al. 2017).

The results of the path analysis are presented in Table 4. The outcome indicates that green entrepreneurship orientation (H1: $\beta = -0.008$, $p > 0.05$), internationalisation orientation (H2: $\beta = 0.032$, $p > 0.05$), and market orientation (H3: $\beta = 0.038$, $p > 0.05$) were insignificantly related to green dynamic capabilities, except learning orientation (H4: $\beta = 0.208$, $p < 0.05$) which is found significant on the same connection. The result also found that green dynamic capabilities is significantly connected to green product innovation (H5: $\beta = 0.197$, $p < 0.05$) and green process innovation (H6: $\beta = 0.29$, $p < 0.05$). In this study, the significance level was evaluated at 90% confidence interval. The results, as shown in Table 5, indicate that the confidence intervals of H4, H5, H6, and H8 did not include zero between the 5 and 95% intervals, thereby implying that these hypotheses were supported. Based on these results, $H_{10a\text{-}b}$ were supported and H_{1-3}, was not supported, but H_{4-6} were supported.

According to the findings in Table 5, green dynamic capabilities was not significantly related to green product innovation through the relationship of green entrepreneurship orientation (H7a: $\beta = -0.001$, $p = 0.435$), internationalisation orientation (H8a: $\beta = 0.006$, $p = 0.259$), and market orientation (H9a: $\beta = 0.007$, $p = 0.255$). However, learning orientation (H10a: $\beta = 0.041$, $p = 0.04$) was found significantly (positively) impacting green product innovation. Likewise, green dynamic capabilities did not have a significant (positive) indirect influence within the relationship of green entrepreneurship orientation (H7b: $\beta = -0.002$, $p = 0.433$), internationalisation orientation (H8b: $\beta = 0.007$, $p = 0.255$), and market orientation (H9b: $\beta = 0.008$, $p = 0.203$) on green product innovation, while learning orientation (H10b: $\beta = 0.044$, $p = 0.03$) had a significant positive effect on green process innovation. The outcome of the indirect effects signified that there was a statistically significant weight with a 90% confidence interval that did not contain zero between the 5% and 95% CI. Based on these results, $H_{10a\text{-}b}$ were supported, whereas H7a-b, H8a-b, and H9a-b were not supported. All significant associations highlighted in the final model (Fig. 4) below.

The effect size, as defined by Cohen (2013), was quantified using the f^2 score. A score of 0.35 or higher is considered a large effect size, a score between 0.15 and 0.35 is medium, and scores less than 0.02 are considered small effect size. The results in Table 5 show that the effect size for the impact of green entrepreneurship orientation, internationalisation orientation, and market orientation on green dynamic capabilities is small, with a moderate impact of learning orientation on green dynamic capabilities. Meanwhile, the impact of green dynamic capabilities on green product innovation and green process innovation is substantial, with effect sizes of 0.040 and 0.047, respectively.

Multi-group analysis (MGA). Since the assessment by PLS-SEM always uses a complete dataset, it defaults on all data from a single homogeneous population, which is usually unrealistic in practical studies. Hair et al. (2021) suggested the use of a multi-group analysis to address these issues. The measurement invariance of the composite model (MICOM) of the integrated model was used to examine the measurement invariance of subgroups. The findings of the MICOM permutation p values are greater than 0.05, except for learning orientation and green product innovation, among the subgroups based on firm size. As 19 of 21 p values were greater than 0.05, this study assumed equal invariance among subgroups.

In this study, the measurement invariance between the two groups of firms established for =/< 10 years and greater than 10 years was examined using the MICOM procedure (Table 6). The

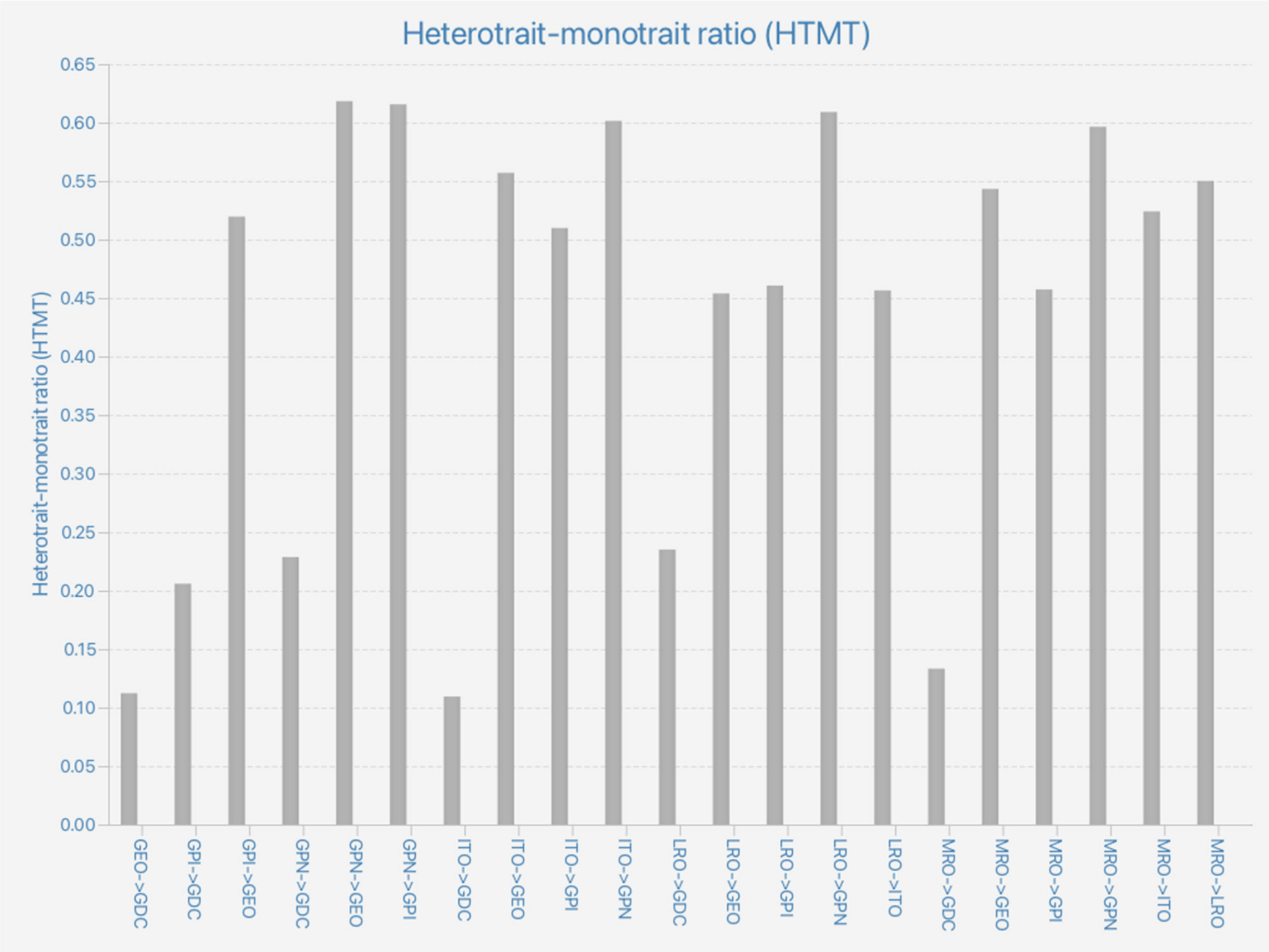

Fig. 2 Heterotrait–monotrait ratio (HTMT) matrix. The heterotrait-monotrait ratio (HTMT) of correlations is employed as a means to evaluate the discriminant validity. When the HTMT score is less than 0.90, it indicates that there is discriminant validity between two reflective notions.

permutation p values for all the factors exceeded 0.05, indicating partial measurement invariance. The results showed no significant variance between the two groups of firms regarding years of firm establishment in any of the hypothesised relationships (Table 6). Second, based on firm type—(1) Group 1: Locals, (2) Group 2: Multinational/International—the results of the permutation test for all the factors showed that the p values were higher than 0.05 besides H4, for which $p = 0.011$ shows that based on different firm types the learning orientation has different effects on green dynamic capabilities. Finally, based on the different firm sizes—Group 1: Medium; (2) Group 2: Large—the internationalisation orientation has different effects on green dynamic capabilities, and green dynamic capabilities has different effects on green process innovation. The findings in Table 6 indicate that there are no notable variations between the two groups with respect to firm size for the relationships outlined in H1, H3, H4, and H5.

Discussion

This study investigates the influence of strategic orientation factors on the green dynamic capabilities of medium and large manufacturing firms in China through resource-based theory, as well as the indirect influence on the green innovation of firms, and identifies the mediating influence of the green dynamic capabilities of companies. Based on the corresponding model correlations and analysis of the research data, only some of the relationships in this study proved to be positive and significant. Some of the correlations are elaborated below.

Firstly, regarding the link between each firm's strategic orientation and the firm's green dynamic capabilities, the results of the study show that there is no significant link between the three strategic orientations of green entrepreneurship, market and internationalisation, and the firm's green dynamic capabilities, while there is a significant link between the learning orientation. Usually, firms' green entrepreneurship, marketing, and internationalisation strategies are strategies that are designed to guide the firm to understand its customers, competitors, and market environment and do not affect the firm's internal dynamic capabilities (Farida and Setiawan 2022). The reasons for this result may be related to the Chinese manufacturing firms' own circumstances, such as a lack of awareness and knowledge of green entrepreneurship and its significance in driving sustainable development programmes. Therefore, they may not have included it in their strategic positioning, which could explain the lack of a significant relationship between green entrepreneurship and green dynamic capabilities (Papadas et al. 2017). At the same time, most focus on short-term profitability and prioritise short-term profits over long-term sustainability goals, which in turn may lead to neglecting sustainability issues and a lack of investment in green dynamic capabilities (Li and Liu 2014). Alternatively, the lack of a significant relationship between market and internationalisation strategy orientation and green dynamic

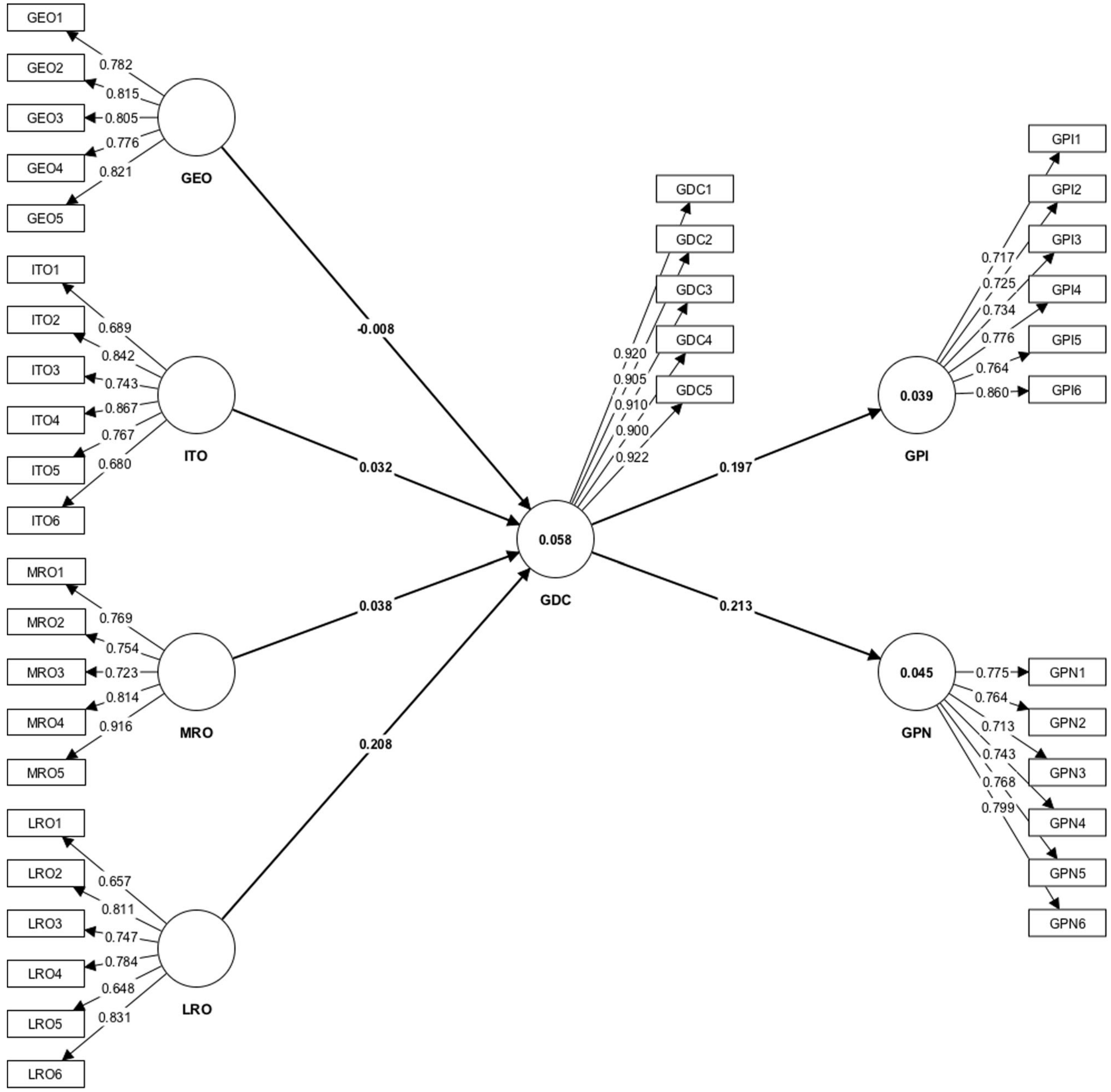

Fig. 3 Measurement model. Highlighting the loading values, coefficients, and R^2 values.

capabilities may be due to cultural and institutional factors, such as the fact that some manufacturing firms in China are state-owned and thus may have institutional barriers that hinder the development of green dynamic capabilities, as well as a regulatory framework that does not incentivize sustainability initiatives (Shen et al. 2023; Zhou and Li 2010).

In contrast to the results of previous studies, the effects of the three strategic orientations of green entrepreneurship, market, and internationalisation on firms' green product innovation and green process innovation were not significant under the indirect effect of firms' green dynamic capabilities. Such results differ from the findings of Akhtar et al. (2021), Muangmee et al. (2021) and Shehzad et al. (2023), but with Papadas et al. (2017), the results are consistent with those of Papadas et al. The formation of this result may be related to the neglect of green dynamic capabilities and green innovation in Chinese manufacturing firms. Most Chinese manufacturing firms do not have a clear understanding of green innovation and mostly follow the trend, imitating or emulating the strategies and behaviours of industry leaders (Shen et al. 2023). Both insufficient development of green dynamic capabilities and inadequate implementation of strategies by firms may lead to the inability of strategic orientations such as green entrepreneurship, marketing, and internationalisation to have a significant impact on green product and process innovation. At the same time, the fact that the development of green dynamic capabilities by firms requires significant resources and financial support has become one of the main reasons why many firms do not pay attention to the development and evolution of green dynamic capabilities.

Distinguishing the negative results of the three strategic orientations of green entrepreneurship, marketing, and internationalisation, learning-oriented strategies have a positive impact on firms' green dynamic capabilities and green innovation of products and processes mediated by green dynamic

Table 4 Hypothesis testing.

Hypothesis		Beta	CI Min	CI Max	*t* Value	*p* Value	Decision
H_1	GEO → GDC	−0.008	−0.069	0.072	0.172	0.432	Not supported
H_2	ITO → GDC	0.032	−0.023	0.113	0.625	0.266	Not supported
H_3	MRO → GDC	0.038	−0.024	0.112	0.852	0.197	Not supported
H_4	LRO → GDC	0.208	0.130	0.279	4.528	0.000	Supported
H_5	GDC → GPI	0.197	0.134	0.276	4.529	0.000	Supported
H_6	GDC → GPN	0.213	0.149	0.288	5.045	0.000	Supported
Specific indirect effects							
H_{7a}	GEO → GDC → GPI	−0.001	−0.013	0.017	0.165	0.435	Not supported
H_{8a}	ITO → GDC → GPI	0.006	−0.005	0.024	0.646	0.259	Not supported
H_{9a}	MRO → GDC → GPI	0.007	−0.005	0.024	0.823	0.205	Not supported
H_{10a}	LRO → GDC → GPI	0.041	0.020	0.070	2.643	0.004	Supported
H_{7b}	GEO → GDC → GPN	−0.002	−0.015	0.017	0.168	0.433	Not supported
H_{8b}	ITO → GDC → GPN	0.007	−0.005	0.026	0.660	0.255	Not supported
H_{9b}	MRO → GDC → GPN	0.008	−0.005	0.026	0.832	0.203	Not supported
H_{10b}	LRO → GDC → GPN	0.044	0.021	0.074	2.745	0.003	Supported

GEO green entrepreneurial orientation, *ITO* internationalisation orientation, *MRO* market orientation, *LRO* learning orientation, *GDC* green dynamic capability, *GPI* green product innovation, *GPN* green process innovation.

Table 5 Effect size.

	Green dynamic capability	Green product innovation	Green process innovation
Green entrepreneurial orientation	0.000		
Internationalisation orientation	0.001		
Market orientation	0.001		
Learning orientation	0.033		
Green dynamic capability		0.040	0.047

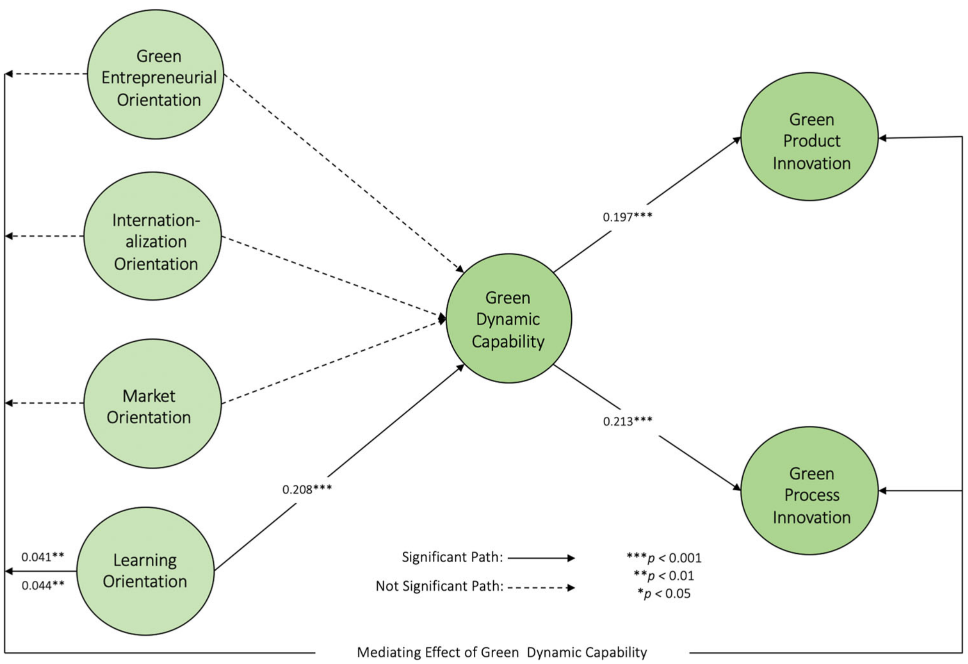

Fig. 4 Final model. Emphasizing the statistically significant relationship, as indicated by the beta and *p* values.

capabilities. This result supports the findings of previous studies on learning-oriented strategies and green innovation (Wang et al. 2020; Huang and Li 2017; Fong and Chang 2012). This may be because learning-oriented strategies emphasise self-controlled learning based on environmentally friendly knowledge enhancement, which can simply develop green dynamic capabilities. This, in turn, can help firms obtain green innovations for their products and processes. Thus, a learning-oriented strategy not only directly influences the green dynamic capabilities of the exploring firm but also indirectly influences the green product and process innovations of the firm through green dynamic capabilities.

Table 6 Multi-group analysis.

Associations		Firm established ≤10 years (*N* = 186) >10 years (*N* = 396)		Firm type Local (*N* = 220) Multinational/International (*N* = 362)		Firm size Medium (*N* = 434) Large (*N* = 148)	
		Difference		Difference		Difference	
		Beta	*p* value	Beta	*p* value	Beta	*p* value
H_1	GEO → GDC	−0.071	0.225	0.042	0.314	0.255	0.079
H_2	ITO → GDC	0.159	0.072	0.039	0.338	0.321	0.037
H_3	MRO → GDC	0.026	0.451	0.13	0.101	−0.269	0.204
H_4	LRO → GDC	0.025	0.399	−0.227	0.011	0.088	0.352
H_5	GDC → GPI	0.099	0.130	0.037	0.318	0.115	0.45
H_6	GDC → GPN	−0.075	0.198	−0.075	0.188	0.142	0.049

GEO green entrepreneurial orientation, *ITO* internationalisation orientation, *MRO* market orientation, *LRO* learning orientation, *GDC* green dynamic capability, *GPI* green product innovation, *GPN* green process innovation.
Source: Author's data analysis.

Finally, the findings show that the green dynamic capabilities of the Chinese manufacturing firms can significantly contribute to their green product and process innovations, which is similar to the results of Chen and Chang's (2012) study on green product development. Yousaf (2021) and Dangelico et al. (2016), in their studies on green innovation in manufacturing industries, explain the connection between green dynamic capabilities and green innovations, which is consistent with the findings of this research, implying that green dynamic capability is a key prerequisite for green innovation in producing firms and that the strength of a firm's green dynamic capabilities can be directly related to the rate of green innovation outcomes. These findings confirm that green dynamic capabilities can effectively help enterprises add both internal and external assets, such as innovation and knowledge resources, and thus provide a solid foundation for subsequent green innovation.

Implications

Theoretical implications. This study enriches academia on green innovation and green dynamic capability by integrating the RBV and DCT theories to clarify the connection between firms' strategic orientation, green dynamic capability, and green innovation. However, the influence of a company's strategic orientation on its green innovation through its green dynamic capability has not yet been explicitly tested. A central finding of this study is that learning-oriented green dynamic capability can help Chinese manufacturing firms enhance their green innovation success rates. Furthermore, borrowing from the DCT theory, this study added green dynamic capability as a mediator between a firm's strategic orientation and green innovation. Previous studies on dynamic capabilities highlight the importance of continual alignment, development, and regeneration of assets in response to both external ecological changes and internal firm challenges (Lavie 2006; Yuan and Cao 2022). However, most manufacturing firms rarely explore and examine their own green dynamic capability, implying that many green dynamic capabilities may overlook their importance. In addition, this study reveals the importance and key influence of learning orientation in strategic orientation on green dynamic capability and green innovation, which in turn effectively offers a comprehensive theoretical model for the field of green sustainability and ecological management in enterprises. This research brings new clarity to the relationship between green dynamic capability, green product innovation, and green process innovation through the integration of RBV and DCT theories.

As a new context, this study takes the Chinese manufacturing firms as an example to open up their green dynamic capability and the development of green innovation in Chinese settings. The study identifies that the learning orientation of firms is a key factor in enhancing their green dynamic capability and promoting green innovation, and it provides directions for firms to nurture and develop their green dynamic capability. Additionally, the study also contributes to academia with new frontiers of analysis, such as the use of multi-group analysis. Using MGA analysis, this study tested group differences in terms of a firm's year of establishment, type, and size. The outcome indicated that there were no notable disparities between the two groups with regard to the age of the company (10 years or younger), size of the firm (medium or large), or type of firm (local or multinational), except for learning orientation, which had significant differences based on the type of company. This outcome will aid future studies in retesting and confirming the results.

Practical implications. Practically, as the concepts related to environmental protection and green development begin to be accepted and adopted by an increasing number of companies, the business environment and strategy development of Chinese manufacturing companies become highly dynamic and complex, and many companies face many difficulties and challenges in accepting green dynamic mechanisms and conducting green strategies (such as green innovation and pro-environmental behaviour). The development of green dynamic capability effectively addresses these difficulties. Therefore, an increasing number of companies are focusing on developing and strengthening their green dynamic capability. The learning orientation of enterprises can effectively strengthen green dynamic capability and thus promote green innovation. Therefore, Chinese manufacturing firms can enhance their overall green dynamic capabilities by using several measures. For example, Chinese manufacturing firms should actively add the learning and training of green knowledge to their sustainable development strategies and assist R&D staff in acquiring eco-friendly knowledge and enhancing their innovative thinking regarding sustainability. This can efficiently and quickly help enterprises improve their green dynamic capability and complete green innovation practices by improving their capabilities and laying the foundation for their green sustainable development. In addition, companies can make changes in the supply chain to supply sufficient assets and capabilities to sustain their green innovation behaviour.

In addition, green dynamic capability plays a mediating role between learning orientation and green innovation, which implies that managers of Chinese manufacturing firms should use innovation knowledge and green knowledge learning as proactive strategic behaviours and key tools to enhance their green innovation capabilities. However, previous studies have shown that employees' learning of new knowledge and skills affects their job performance and satisfaction, which, in turn, has a negative influence on enterprise performance. Simultaneously, employee learning and training can lead to additional development and time costs and may have a negative influence on the implementation and management of an enterprise strategy. However, the outcome of this study shows that the price of learning orientation in companies is exchanged for an increase in green dynamic capability and green innovation success rates, which, in turn, helps companies steadily engage in long-term sustainable development.

Conclusions

This study empirically analysed the connection between the strategic orientation of the Chinese manufacturing companies, and their green dynamic capability and green innovation by extending the resource-based model. The findings of this study confirm that among strategic orientations, only learning orientation has a positive effect on firms' green dynamic capability. However, no significant relationships were observed between green entrepreneurial orientation, market orientation, internationalisation orientation, and green dynamic capabilities. Simultaneously, the firm's green dynamic capability is confirmed to be a key factor influencing its green product innovation and green process innovation, thus demonstrating the validity of green dynamic capability as a mediating variable in the model. The results of the MGA analysis revealed that there were no significant differences between the two groups in terms of company age, firm size, or firm type, except for learning orientation, which exhibited significant differences based on the company type. It is essential for firms to shift their focus from short-term profitability to long-term sustainability goals. This involves aligning strategic orientations, such as market and internationalisation strategies, with sustainability objectives. These efforts will not only benefit the environment but also enhance the competitiveness and resilience of the firms in an evolving business landscape that increasingly demands environmentally responsible practices.

The research has certain limitations. First, the prime target of this study was the medium- to large-scale manufacturing companies in China; therefore, there are limitations in terms of sample scope and size. The sample is not fully representative of all manufacturing firms in China, and this research only studied manufacturing firms. Future studies could expand this framework to encompass other sectors related to sustainable growth and environmental protection, such as regenerative agriculture and recyclable construction, and examine the situation and applicability of the green dynamic capability and strategic orientation to different industries and firms. Second, this study only considered the connection between strategic orientation and green dynamic capability and the indirect relationship with green innovation and did not consider the direct connection between strategic orientation and green innovation. Therefore, future studies may look at more dimensions of strategic orientation to explore the key strategic orientations that can influence the green dynamic capability and green innovation of enterprises and thus provide more effective references for firms' eco-friendly sustainable development strategies. Third, this study considers and adopts the RBV and DCT models in the research on green dynamic capability and green innovation, ignoring other models that are also applicable to the study of green innovation, such as the social resource-based view (S-RBV), natural resource-based view (N-RBV), and open innovation theory. Therefore, future research may consider combining several other models mentioned earlier to explore more deeply the connection between the variables this study considers or with other new constructs. Finally, a potential limitation of the paper is the applicability and cultural suitability of the adapted questionnaire scales in the Chinese context. Despite efforts to align the questions with research requirements and the translation process by language experts, there may still be a loss of nuances and subtleties from the original English items. This could introduce bias or misinterpretation in participant responses, impacting the scale's validity and reliability. Further research and validation of the adapted scale within the Chinese context would enhance the robustness of the findings. In addition, the study employed the same scale for both the dependent and independent variables, which could potentially introduce CMB despite precautions taken. To mitigate this issue, future research is recommended to utilise distinct scales for different variables to ensure independence and reduce the risk of CMB.

Data availability

The original contributions presented in the study are included in the article/Supplementary Material (S2. Dataset), further inquiries can be directed to the corresponding author/s.

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Author contributions

HX, MM and QY: conceptualisation, investigation, methodology, writing—original draft preparation. AAM: conceptualisation, methodology, formal analysis, writing—review and editing.

Competing interests

The authors declare no competing interests.

Ethical approval

The Human Research Ethics Committee of School of Business, Nantong Institute of Technology approved this study (BS-NIT-2023-0416). This study has been performed in accordance with the Declaration of Helsinki.

Informed consent

Written informed consent for participation was obtained from respondents who participated in the survey.

Additional information

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Correspondence and requests for materials should be addressed to Abdullah Al Mamun.