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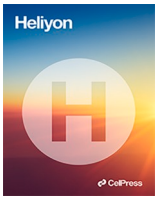

Research article

Growing success with sustainability: The influence of green HRM, innovation, and competitive advantage on environmental performance in the manufacturing industry

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ABSTRACT

President Xi set a long-term mitigation target of carbon neutrality by 2060 in September 2020 to cut carbon emissions and improve environmental performance. As a result, the current study aims to investigate how green human resource management and green innovation affect environmental performance in pursuit of the ultimate objective of carbon neutrality. Furthermore, the research considers the potential mediating effect of a green competitive advantage to clarify the mechanisms by which GHRM and green innovation impact environmental performance. Data from 278 employees in the manufacturing industry of Heilongjiang Province were collected through a questionnaire, for which we used a quantitative random sampling technique. The study employed the Smart PLS-4 structural equation modeling technique and revealed that all three factors significantly influenced environmental performance: green HRM, innovation, and competitive advantage. Resource-based view (RBV) theory served as the theoretical foundation for the study. The study uniquely contributes to the literature on GHRM, green innovation, competitive advantage, and environmental performance.

1. Introduction

In the modern era, sustainability is a crucial factor for business firms, irrespective of their operational activities and the nature of their business. In the growing concern of environmentalists, green organizations, and their pro-environment employees, researchers and the media passionately promote environmental concerns daily to raise awareness of ecological vulnerabilities and ultimately cause behavioral changes [1]. Therefore, academia and policymakers are focusing on carbon emissions and environmental challenges. Global population and economies have experienced significant growth in recent decades, resulting in a significant increase in energy demand [2]. The annual global emissions of greenhouse gases (GHGs) have surpassed 50 billion metric tons of carbon dioxide equivalent ($GtCO_2e$) owing to escalated fossil fuel utilization to fulfill the growing energy requirement [3]. Owing to the growing

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awareness of these trends, there has been a greater emphasis among the global community and policymakers on reducing carbon emissions to tackle the challenges caused by climate change [4]. Global emissions must be drastically reduced over the years to mitigate the worst consequences of climate change and prevent an increase in global temperatures of more than 1.5 °C beyond pre-industrial levels [5]. Estimates indicate that in 2022, carbon dioxide emissions from fossil fuels and cement will rise by 0.9 percent globally to a record-high 37.5 $GtCO_2$. The ongoing dispute between Russia and Ukraine caused a worldwide energy crisis; countries shifted back to this polluting fuel, the main factor driving this expansion. Nevertheless, this increase was smaller than initially anticipated because of the development of low-carbon technology and renewable energy sources, such as heat pumps.

China is currently the world's top carbon emitter, owing to its rapid economic development and urbanization [6]. According to the Statista report, in 2021, China's global carbon emissions were 24.6 %, and its carbon emissions surpassed those of the US in 2007. There are several sources of GHG emissions, but coal-fired energy is the main source, contributing approximately eight $GtCO_2$ annually. China is the largest producer of coal-fired electricity worldwide, so it is responsible for these emissions. Various mitigation efforts have been implemented to acknowledge China's significance in stabilizing the Earth's climate [7]. These include the required energy and carbon intensity targets outlined in the Five-Year Plans (FYPs). Policies aimed mainly at reducing emissions have also been implemented, but they have all been replaced with stricter goals. President Xi, for example, established a long-term mitigation goal for carbon neutrality by 2060 in September 2020. They increased China's Intended Nationally Determined Contributions (INDC) targets to a >65 % decrease in carbon intensity by 2030 from the 2005 levels in December 2020.

The international community's growing concerns about climate change make achieving carbon neutrality vital. The operations of many enterprises are related to natural resources and the environment, either directly or indirectly; as a result, these processes affect environmental sustainability [8]. Businesses now want to transform their operations by incorporating environmental and societal concerns into their business strategies [9]. The idea of 'go green' is being increasingly implemented in several organizational and functional domains. For instance, emerging green practices in various departments include GHRM [10], green finance and accounting [11] green marketing and supply chains [12], and green creativity [13]. GHRM is the term used for the combination of environmental management and human resource development to achieve environmental goals and enhance the resource performance of organizations [10]. Utilizing GHRM techniques provides the basis for developing and maintaining internal competencies to achieve green innovation and environmental performance [14]. However, the scope of research in these fields is predominantly restricted and requires additional practical examination, especially considering the mounting pressure on businesses from their key stakeholders to embrace environmentally sustainable management strategies. Green innovation refers to a company's efforts to procure new and existing products without negatively impacting the environment. Green innovation represents a strategic organizational activity that provides significant opportunities for satisfying customer needs and demands while mitigating adverse environmental effects, producing eco-friendly goods, and preventing ecological damage [15]. The green innovation classification includes product design and manufacturing process components. Initially, green innovation can reduce environmental damage during product procurement, production, and material delivery during the manufacturing process. Next, in terms of product design, green innovation modifies current designs to minimize negative impacts on the environment [16]. It can adopt green practices to mitigate environmental impacts to enhance a company's performance. These activities include implementing green innovation and utilizing green technology to develop goods that have an environmentally friendly system, which results in a competitive advanatge. According to Astuti & Datrini [17], green competitive advantage (GCA) can be used to overcome the tension between environmental management and company performance. A GCA is a circumstance in which a company has stances on environmental management that are challenging for rivals to imitate, allowing the company to benefit from effective ecological tactics.

This study aims to empirically test the association between GHRM, green innovation, and environmental performance with the mediating role of green competitive advantage. The study looks into the direct and indirect effects that can add to the literature and information on companies in China, regarding green competitive advantage resulting from GHRM, green innovation that can improve environmental performance. Therefore, to resolve theoretical deficiencies and investigate the dominant mechanisms behind the link between green HRM, green innovation, green competitive advantage, and environmental performance, this study will solve different questions.

1). Can GHRM improve organizational environmental performance?
2). Can green innovation improve organizational environmental performance?
3). Can GHRM and green innovation improve organizational environmental performance through green competitive advantage?

Our study adds to the existing literature on how organizations can effectively utilize resources to achieve sustainable environmental outcomes in the context of GHRM, green innovation, and environmental performance in the Chinese manufacturing industry. The study utilizes the Resource-Based View (RBV) theory to explain the role of green HRM and green innovation in strengthening firms' ability to optimize green competitive advantage and enhance overall environmental performance. The Resource-Based View (RBV) theory offers in-depth knowledge of the human resources aspect within an organization, providing greater understanding, predictive abilities, and improved management. Achieving a successful green competitive advantage and environmental performance through GHRM and green innovation is a significant indicator of a company's success. This study uses green competitive advantage as a mediator between GHRM, green innovation, and organizational environmental performance. In addition, this will enhance the understanding of publicly listed manufacturing companies in Heilongjiang Province, China, regarding the utilization of Green Human Resource Management (GHRM) and green innovation as means to protect the environment, which will lead to the development of green competitive advantage and potentially result in improved environmental performance for these firms.

The rest of this study is organized as follows. First, the literature review and hypotheses development are done in Section 2. The

research methodology is in Section 3, the analysis and results in Section 4, the discussion and implications in Section 5, and the conclusions in Section 6.

2. Literature review and hypothesis development

2.1. Theoretical framework

Resource-based view theory is an extensively applied conceptual framework in contemporary management research [18]. He clarifies the utilization of business strategy and strategic management as the foundations of the resource-based view (RBV), an economic instrument designed to assess the performance of organizations. Strategic internal resources, capabilities, and essential competencies are utilized by organizations in accordance with this theory to achieve long-term market competitiveness. We have used the resource-based view (RBV) theory to explore the impact of GHRM and green innovation on environmental performance in the manufacturing industry of Heilongjiang province, China, mainly chemical, plastic, and raw materials companies with a mediating role of green competitive advantage. RBV broadly conceptualizes enterprises or organizations as collections of resources [19]. These resources can be taken in the form of tangible or intangible assets and have the potential to generate a competitive advantage [18]. The RBV perspective has been expanded to emphasize specific resources, such as knowledge and intangible assets, which possess attributes similar to other resources regarding their ability to provide a competitive advantage. Traditionally, the RBV has been largely employed to explain why companies engage in inter-organizational collaborations.

The RBV theory posits that integrating GHRM practices, green innovation, and competitive advantage can potentially enhance environmental performance [20]. Implementing GHRM strategies enables firms to attract and retain personnel with strong environmental consciousness effectively, thus facilitating their valuable contributions to the organization's overall environmental performance [21]. Employees are a valuable internal resource for organizations [19], therefore, providing employees with proper green training helps businesses grow their human capital, which is a rare, precious, hard-to-replace resource [22]. In the realm of business, green innovation, a crucial component of the resource-based view (RBV), enables companies to create novel technologies and manufacturing techniques that limit waste, decrease energy usage, and encourage cleaner production systems [23]. Concurrently, attaining competitive advantage empowers enterprises to surpass their rivals in terms of environmental performance [24]. GHRM and green innovation jointly enable firms to cultivate a green competitive advantage by nurturing environmentally aware workforces and introducing innovative solutions [23]. In the context of environmental performance, combining resources and talent can offer enterprises a lasting competitive edge.

The below section focuses on formulating hypotheses. We have utilized the RBV theoretical framework, as Barney [18] proposed, to build arguments and present various ideas that will be empirically tested in this study.

2.2. Hypothesis development

2.2.1. GHRM and Environmental Performance

Research suggests that many organizations prioritize green HR practices to address environmental issues [25]. Chowdhury et al. [10] define "green HRM" as the deliberate integration of conventional HRM practices with the environmental priorities of the firm. Furthermore, Zaid et al. [26] emphasized the need to establish links between green human resource management practices and environmental performance.

The evolution of GHRM has led to an increased emphasis in employment advertisements regarding environmental protection and improvement by organizations seeking to attract and hire top talent [27]. GHRM practices aim to facilitate employees' active involvement in organizational environmental management initiatives. This is achieved by integrating environmental objectives into various HR practices, including recruiting employees and hiring, training and development, assessment of performance, and incentives and remuneration [28]. Prior research has also unveiled increasing concerns regarding environmental management and the attainment of sustainable development [29]. In this context, significant emphasis is placed on GHRM, as organizations utilize GHRM strategies to facilitate the development of environmentally sustainable workplaces and practices, contributing to the advancement of a green society. Moreover, attaining environmental goals and targets inside an organization is of the greatest significance [30] and is becoming increasingly relevant to improving environmental performance [14]. Previously, the study looked at how GHRM practices affect the success of industrial organizations in environmental protection [21]. GHRM methods reduce waste and educate employees on energy and water conservation, promoting environmental progress [23]. Roscoe et al. [31] found a significant correlation between GHRM practices and environmental development in Chinese manufacturing enterprises. In Asia, Gilal et al. [32] studied how green practices impact educational institutions' ecological performance, including enrollment, training, compensation, and assessment. GHRM integrates environmental initiatives into strategic planning, ensuring firm survival through security, efficiency, and quality improvement programs.

In subsequent studies, we link GHRM with environmental performance in the manufacturing industry, particularly in Heilongjiang Province's chemical, plastic, and raw materials industries. Using the RBV theory, we predict that GHRM supports the acquisition, deployment, enhancement, and maintenance of human capital capable of generating environmental benefits. With GHRM, organizations obtain a pool of skilled employees committed to delivering environmentally sound outputs, creating opportunities for continuous learning and adaptation. Over time, these investments accumulate and result in improved environmental performance.

Therefore, we propose the following hypotheses.

H1. GHRM is positively related to environmental performance.

2.2.2. GHRM and green competitive advantage

GHRM refers to a system that develops and enforces human resource management strategies to emphasize the influence of a company's actions on the natural environment [22]. GHRM aims to help businesses achieve their environmental goals by attracting and retaining environmentally conscious employees, eco-friendly leadership practices, training programs, incentives, compensation, performance reviews, and an emphasis on corporate social responsibility [33]. Green competitive advantage refers to an organization's ability to differentiate itself from competitors and create a competitive edge by effectively implementing sustainable practices [34]. GCA occurs when a company achieves a market-leading position that competitors find difficult to replicate because of the company's distinctive green initiatives and performance [35]. During the hiring and selection process, hotels can use green practices that are comparable to those of well-known companies, such as the paperless recruitment process at Google to reduce the environmental effect [36], to attract environmentally conscious personnel because greening resources provide businesses with a competitive advantage [34].

Firms integrate green issues into job descriptions, performance reviews, reward and compensation criteria, and employee recruiting to strengthen their environmental efforts for a green competitive advantage [37]. Organizations try to hire people who share their commitment to environmental conservation and green principles, and this approach eventually affects their ability to obtain a green competitive advantage as soon as possible [38]. To turn eco-aware staff members into valuable hotel resources who can help the hotel outperform its rivals in fulfilling corporate environmental targets, hotels teach their eco-aware staff members to increase their green knowledge and abilities [39]. In the context of manufacturing enterprises, Muisyo et al. [34] present empirical evidence that validates the direct favorable influence of GHRM on green competitive advantage. Additional empirical evidence is necessary to support the impact of GHRM on attaining a green competitive advantage.

Here in this study, we utilized the RBV theory to establish the connection between GHRM and attaining a competitive advantage in environmental sustainability [23]. Employees are viewed as the company's human capital from the RBV perspective since they are competent, intelligent, and have experience. Consequently, employees become significant and unique internal assets when addressing outside environmental concerns and improving the company's environmental performance to achieve a competitive advantage [22]. A company offers green training to its personnel to enhance their competencies, proficiencies, and expertise related to sustainability. This enables them to implement the company's green practices and procedures [40]. We propose that GHRM influences green competitive advantage based on the above information.

H2. GHRM is positively related to green competitive advantage.

2.2.3. Green innovation and green competitive advantage

The fundamental component of innovation is the pursuit and effective application of new information throughout the whole production and operating process to generate efficiency benefits [41]. Green product and green process innovations are the two main categories into which green innovation is typically divided [42]. The traditional view of economics says that any attempt to reduce the environmental footprint will make it more expensive and difficult for producers [43]. Green innovation also increases the cost of employing environmentally sustainable technology and strict adherence to environmental regulations, which may adversely affect future financial results [44]. Nevertheless, the Porter hypothesis emphasizes that innovation is an essential predictor of competitive advantage for enterprises. A product's life cycle has gained significance owing to the growing implementation of environmental protection rules and regulations; incorporating such factors into product design decisions is necessary. However, green product and process innovation increase business competitiveness while reducing adverse environmental effects [45]. Recent research has also shown that innovation and environmental management will likely become a competitive advantage's most important performance indicators. Likewise, companies that implement green innovation have a competitive advantage [46].

In addition, companies will save money via green product innovation, increase efficiency, productivity, and product quality, and eventually obtain a competitive edge [47]. Furthermore, implementing green innovation can lead to establishing a favorable corporate image associated with environmental consciousness, developing distinct environmentally friendly product offerings, and the opportunity to enter a novel market segment characterized by eco-friendly products. In a recent study conducted by Zameer et al. [43], the concept of a green competitive advantage was explored. This advantage is achieved through collaborative learning and the ability to manufacture environmentally friendly products for effective environmental management. These factors positively impact a company's ability to create green products and drive innovation in their processes. It can also help enhance the green image and foster competitive advantage.

RBV theory [18] is used in this study to explain the relationship between green innovation and green competitive advantage. According to RBV theory, a company's competitive edge is determined by its distinct and valued resources and competencies. Green innovation is a valuable intangible strategic capability that is uncommon and unreplaceable. Based on these attributes, managers are better equipped to apply green innovation practices to build enduring benefits and advance and become familiar with the complex and dynamic external environment. Finally, we propose the following hypothesis.

H3. Green innovation is positively related to green competitive advantage.

2.2.4. Green innovation and environmental performance

Positive relationships exist between green innovation and a company's overall performance [48]. Businesses might utilize it to increase productivity and balance growing raw material costs [49]. The term "environmental performance" refers to organizational

actions that go beyond merely following rules and regulations to fulfill and surpass social expectations regarding the natural environment [50]. Organizational activities, goods, and resource usage are assessed to maintain compliance with regulatory environmental standards and to address their associated effects [51]. Previous research indicates that several factors can have an impact on environmental performance, including the efficacy of environmentally conscious goods, the use of environmentally friendly procedures, the promotion of product innovation, and the incorporation of environmental sustainability considerations into corporate operations and product development [52]. The concept of green innovation is associated with a company's environmental management strategy and positively affects its environmental performance [53].

Additionally, by cutting waste and related expenses, a company can improve its financial and social performance while minimizing its negative environmental consequences through environmentally friendly products and innovative procedures [54]. Previous research has demonstrated that the idea of "green innovation" should not just be seen as a reactive response to stakeholder concerns but also as proactive corporate intentions and activities targeted at improving environmental performance to gain an edge over competitors [55]. Using the basic concept of the resource-based view (RBV), it is anticipated that a firm will utilize green processes and product innovation as important organizational resources to enhance its environmental performance and gain favor from key stakeholders. Therefore, we propose the following hypotheses.

H4. ***Green innovation is positively related to environmental performance.***

2.2.5. Green competitive advantage and environmental performance

Chen & Chang [56] define green competitive advantage as the strategic adoption of environmental management approaches and the implementation of green technologies by firms to acquire an edge over their competitors. The incorporation of environmentally friendly concepts into a company's competitive advantage is likely to greatly improve the company's environmental performance. Organizations often employ green efforts in today's competitive market to establish themselves as environmentally sustainable [57]. Based on theoretical evidence from previous studies, we suggest in the previous discussion that green HRM and innovation may significantly improve company competitiveness. In this case, it is unclear whether the enhanced competitiveness of green HRM and innovation leads to better environmental performance. Udriyah et al. [58] analyze the literature on the relationship between competitive advantage and financial/corporate success. They find that a company's competitive advantage greatly affects its performance. Anwar [59] conducted a study on small- and medium-sized firms in Pakistan and demonstrated a favorable relationship between competitive advantage and company performance. If the company has a competitive advantage, the relationship between environmental, social, & governance, and financial success may be strengthened [60,61].

The study conducted by Haseeb et al. [62] found similar results, indicating that green competitive advantage can improve organizations' long-term performance. The connection between green competitive advantage and environmental performance was also investigated [63]. RBV theory proposes that a company can gain a competitive advantage by its unique resources and competencies. A company's competitive advantage may enhance its environmental performance if it possesses particular assets and competencies. Adopting green practices can assist the company in mitigating its negative environmental impacts, waste generation, and resource consumption. Consequently, this leads to enhanced environmental performance. Thus, we propose the following hypotheses.

H5. Green competitive advantage is positively related to environmental performance.

2.2.6. Green competitive advantage as a mediator between GHRM and environmental performance

Businesses can improve their environmental image by enhancing their adaptive mechanisms and performance. In this regard, competitive advantage can serve as an attribute of distinction that enables a company to outperform its competitors over time [64]. The relationship between innovation and business performance was examined by Setyawati et al. [65] through the use of competitive advantage as a mediator. The researchers utilized data from Indonesia to ascertain that competitive advantage acts as a mediator in the relationship between innovation and business performance. Similarly, Anwar [59] examined how competitive advantage mediated the effect of business model innovation on the success of SMEs. The research utilized the structural equation modeling (SEM) framework to examine the data collected from Pakistan and found that the association between business model innovation and performance is partially mediated by competitive advantage. Despite extensive studies on enhancing business performance through competitive advantage, none of the previous studies have specifically investigated the influence of green competitive advantage on corporate environmental performance. Muisyo et al. [34] revealed that green HRM in enterprises can help them obtain a green competitive edge and boost their green performance.

The RBV theory provides a viewpoint on how businesses may strategically use their green HRM practices to achieve both environmental sustainability goals and competitive advantage. This suggests that green HRM has the potential to enhance the environmental performance of an organization through the establishment of a competitive edge. However, there have been few studies of this correlation. Therefore, according to a hypothesis, it can be assumed that.

H6. The relationship between green HRM and environmental performance is mediated by green competitive advantage.

2.2.7. Green competitive advantage as a mediator between green innovation and environmental performance

Competitive advantage refers to a company's strong market position and ability to perform better than competitors. Improvements in environmental performance are associated with reduced utilization of energy and various resources and a lower impact on the natural world. Similar benefits include reduced manufacturing costs, increased output, enhanced brand recognition, and attracting clients who care about the environment [66]. Applying concepts and methods from environmental management offers an attractive

approach to enhancing environmental performance [67]. Likewise, an organization can improve the efficacy of its fundamental business strategy by effectively implementing a crucial environmental management approach, known as green innovation, by formulating an environmental plan [68]. Moreover, Wanjiru et al. [69] investigate how competitive advantage mediates the relationship between manufacturing firms' performance and business strategies in Kenya. They discovered that competitive advantage is essential to linking company strategy and implementation. Mutuku et al. [70] used Malaysian managers' data to show that competitive advantage affects hotel strategy and performance. According to Wang [46], implementing green innovation initiatives can provide firms with a competitive advantage and enhance their environmental performance. Similarly, it suggests that by adopting green innovation, a company can get a competitive advantage in the market and enhance its environmental performance. The RBV theory describes how a long-term competitive advantage can be derived from the distinct collection of resources and capabilities linked with green innovation. Adopting and implementing green innovation allows organizations to differentiate themselves, fulfill the growing need for environmentally friendly solutions, and achieve improved environmental performance outcomes. Therefore, we propose the following hypothesis to test this logic.

H7. The relationship between green innovation and environmental performance is mediated by green competitive advantage.

3. Research methodology

3.1. Research model

The conceptual model of this study is shown in Fig. 1. It consists of the EP, GI, and GHRM. The model also includes GCA's mediating effect.

3.2. Sampling and data collection

Surveys are used in primary research to assess the respondent's opinions. This study employed a survey to predict environmental performance and other correlations between variables. Compared to interviews, grounded theory, and experiments, survey research has a higher reach and response rate. The current study used a primary, descriptive, cross-sectional, and quantitative random sampling technique to achieve the research goal of identifying the essential components of sustainability within the manufacturing industry. A pilot study was conducted to assess the validity and reliability of the scale before it was made accessible to the general respondents. The survey was administered to a sample of 30 employees for this purpose. Before being used to collect data, the survey instrument underwent modifications in its final version depending on the results of the pilot test. The adjustments included removing unnecessary items and rephrasing unclear lines. In its revised format, the questionnaire was made clearer and more concise. Finally, in light of previous research, the questionnaire included additional demographic data such as age, gender, current level, and education. After completion, the questionnaire was distributed to the targeted participants. The data was gathered in 2 months between October 2023 to November 2023. Respondents were informed of the scope and aim of the research, and they were promised that their responses would be kept strictly confidential. In the survey's cover letter, we clearly stated the criteria for eligibility to complete the questionnaire as the main participants of the study.

Almost all of the questionnaires were distributed online, and the link was shared with the intended participants via personal connections, alumni, and friends. WeChat and QQ were used to contact the recipients. We sent around 450 questionnaires to employees working in different manufacturing industries. In which 300 employees responded and 150 didn't respond. During the initial examination, we found that some respondents had issues with disengagement and removed all those responses that were filled by non-qualified respondents. Due to this 22 responses were filtered and eliminated before further study. There were 278 replies to the final dataset for further analysis. Smart PLS-4 was used for analysis. The sample consisted of participants from entry-level employees to top-level managers. The data was obtained from the manufacturing industry of Heilongjiang Province, mainly from Chemicals, Plastics, and Raw Materials Companies in Heilongjiang. We know that these firms contribute significantly to climate change and the over-consumption of natural resources. As a result, these manufacturing companies make good samples for GHRM, GI, GCA, and

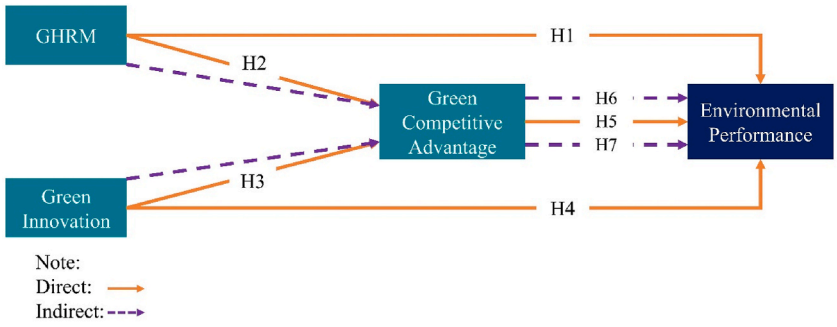

Fig. 1. Conceptual model of the study
Note. Source made by Authors.

environmental performance studies. The survey questionnaire used the same format as earlier research, with English and Chinese translations. The questionnaire was translated into Chinese to facilitate understanding for respondents whose first language is not English.

3.3. Measurements

Each component of the GHRM, GI, GCA, and Environmental Performance components was evaluated on a 5-point Likert scale ranging from "strongly disagree [1]" to "strongly agree [5]." Using a survey scale, the participants were asked to rate the statement about growing sustainability in the manufacturing sector. Measurement variables played a vital role in collecting data and conducting empirical analysis. Similarly, this choice may considerably impact the outcome's reliability and validity. This study focused on GHRM, green innovation, environmental performance, and green competitive advantage. Several observable items were used to represent some of the study's variables. These observable items originate from prior research such as.

3.3.1. Green HRM

We used a 10-item scale from Singh et al. [71] to assess GHRM. The 10 items include the aspects of recruiting and selecting, training and development, and how to handle performance evaluations. A sample item from this scale is, "Great effort goes into selecting the right person." The Cronbach alpha and average variance extracted (AVE) values for this scale were recorded as 0.944 and 0.669 respectively.

3.3.2. Green innovation

Green innovation was evaluated using an 8-item scale adopted from the study of [72]; the sample item includes "choosing materials that consume less energy in product development." The Cronbach alpha and average variance extracted (AVE) values for this scale were recorded as 0.893 and 0.574 respectively.

3.3.3. Green competitive advantage

The green competitive advantage was assessed by using a four-item scale. Based on the research of Muisyo et al. [34], we measured a green competitive advantage as "the quality of the green products or services that the company offers is better than that of its major competitors." The Cronbach alpha and average variance extracted (AVE) values for this scale were recorded as 0.817 and 0.646 respectively.

3.3.4. Environmental performance

For the measurement of environmental performance, we adopted a five-item scale that was previously used by Ref. [73]. The study sample item includes such as "environmental activities significantly reduced overall costs." The Cronbach alpha and average variance extracted (AVE) values for this scale were recorded as 0.845 and 0.619 respectively.

For all the above values of Cronbach alpha and average variance extracted (AVE) refer to Table 3.

3.4. Control variables

We employed a range of control variables in our research to ensure the reliability and validity of our findings. The research model incorporated four control variables to account for the potential effects. The variables consist of gender, age, employee's current position, and level of education. Because of the observed impact of prior research on organizations, these variables were controlled for in this study [74].

3.5. Statistical techniques and analysis

Structural equation modeling (SEM) was employed to evaluate the proposed hypothesis. Statistical analysis was performed using SmartPLS 4. According to Hair et al. [75], PLS-SEM is suitable for analyzing simple and complex frameworks. PLS-SEM is a versatile assessment tool developed by Ref. [76]. Similarly, Henseler et al. [77] used a two-step analysis technique. The first step involved assessing the measurement model by conducting a confirmatory factor analysis, which examined convergent and discriminant validity. The second phase emphasized the estimation of structural models through path and mediation analyses.

4. Data analyses and results

4.1. Descriptive analysis

As stated in the preceding section, the participants were told to fill out specific demographic details in the questionnaire. The request for information related to individual identity was not made because participants were assured that any data collected would be utilized solely for the study's objectives as a collective, with no utilization or disclosure of individual identities. The basic demographic data collected included participants' gender, age in years, educational background, and current position. A summary of the demographic information is shown in Table 1.

The gender composition of the participants indicated that 59.4 % were male and 40.6 % were female. Concerning age, the majority

of the participants belonged to the 31–45 age group. Regarding educational background, 23.7 % of the participants possessed less than a Bachelor, 30.9 % had completed a Bachelor, 23.7 % had a Master's degree, and 21.6 % had a PhD degree. Finally, the current position of the employees was classified into various categories, with 28.1 % Middle Manager classification comprising the largest proportion. This concise summary provides an overview of the demographic characteristics of the participants in this study.

4.2. Measurement model assessment

As mentioned before, the measurement model (MM) was evaluated to determine the reliability and validity of the collected data by utilizing convergent and discriminant validity approaches. Convergent validity is attained when the indicators chosen to assess certain constructs exhibit theoretical association. In assessing convergent validity, the study emphasized several important aspects, such as outer loading, alpha, average variance extracted value (AVE), and composite reliability (CR). We used confirmatory factor analysis (CFA) in SmartPLS and the results presented in Fig. 2 and Table 3 indicate that all outer loadings above the 0.70 level illustrate their relevance according to the set criterion [75] up to 0.5 is also acceptable in social sciences.

The findings of Cronbach's alpha and composite reliability (CR) values are presented in Table 3. The results indicate that each construct's Cronbach's alpha and CR values exceeded the threshold of 0.70, as [75] recommended, fulfilling the recognized criteria. Moreover, it is worth noting that Table 3 highlights that the Average Variance Extracted (AVE) value for each construct is above the threshold of 0.50, which is considered acceptable according to the criteria established by Ref. [78]. In addition, for discriminant validity, both, HTMT- Heterotrait– Monotrait rati and Fornell-Larcker criteria were used because it is a widely used and generally accepted criterion in social science research.

The diagonal values of all constructs are more significant than the established threshold (below 0.9) [79], further proving that the Fornell-Larcker criterion was satisfied. Tables 4 and 5 show that the values of each construct are less than 0.9.

4.2.1. Multicollinearity issue and common method variance

Common method variance (CMV) bias is a notable problem within a survey sample, as it is associated with validity and reliability. The data collection process involved gathering exogenous and endogenous variables simultaneously from the same respondent, which raises the possibility of common method bias (CMB) in the dataset [48]. To evaluate CMV, several studies in the field of management suggest employing Harman's Single-Factor test [59]. We utilized this approach to enter every item of the variables for a single-factor test in SPSS. We discovered that the first factor only explained 45.65 % of the variance, which is less than the 50 % threshold ratio. Hence, we confirmed that there is no problem with CMV in the dataset. In addition, we performed the complete collinearity variance inflation factors (VIFs) test for the presence of CMV, as suggested by Ref. [80]. According to Kock [80], a VIF score above 3.3 indicates abnormal collinearity and may indicate common method bias in factor-based PLS-SEM algorithms. Akinwande et al. [81] have shown that VIFs offer an important advantage by identifying which coefficients are influenced by collinearity. The VIF value of GHRM (1.875), green innovation (1.559), green competitive advantage (1.607), and environmental performance (1.499). This suggests that the study's variables are relatively independent and that regression analysis can accurately assess their correlations. As a result, all Variance Inflation Factor (VIF) in the inner model produced through the comprehensive collinearity test is less than 3.3, indicating the absence of common method bias in the model. From Table 2, we can observe the VIF values of the inner model.

Table 1
Summary of demographic profile.

Demographic Data ($N = 250$)	Frequency	Percentage (%)
Gender of Respondent		
Male	165	59.4
Female	113	40.6
Total	278	100
Age		
20–25 Years	50	18
26–30 Years	50	18
31–45 Years	78	28.1
46–50 Years	58	20.9
51 and above	42	15.1
Total	278	100
Education		
Lower than Bachelors	66	23.7
Bachelor Degree	86	30.9
Master's Degree	66	23.7
Doctoral Degree	60	21.6
Total	278	100
Current Position		
Ordinary Employee	69	24.8
Grassroots Supervisors	70	25.2
Middle manager	78	28.1
Top manager	61	21.9
Total	278	100

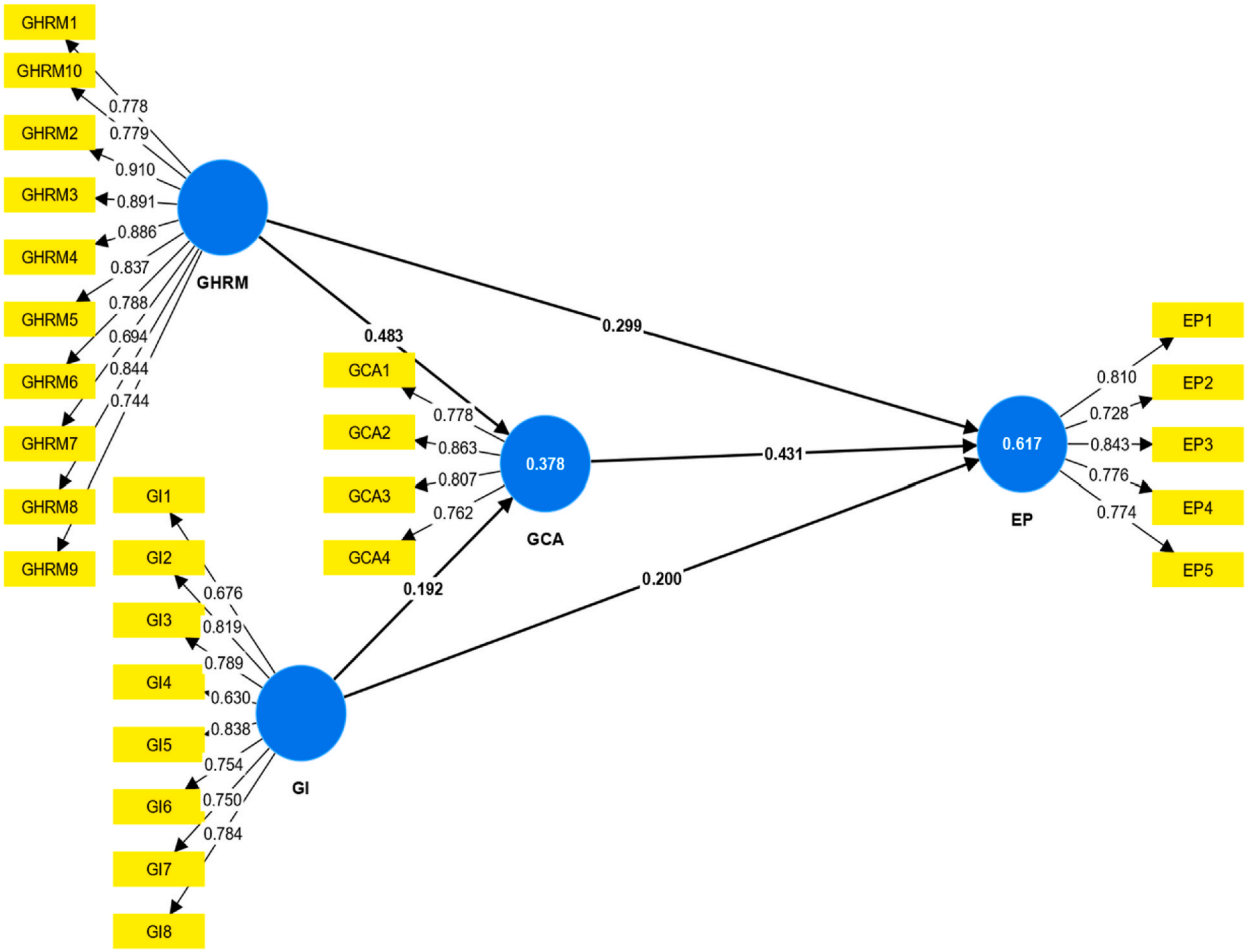

Fig. 2. Measurement model constructed by the authors using SmartPLS 4.

4.3. Structural model assessment/hypothesis testing

The structural model reflects the hypotheses given in the study. After conducting bootstrapping in structural analysis, the graphical representation of path coefficients and p-values are presented in Fig. 3. The analysis of the structural model focused on the ultimate choices made about the hypothesized predictions by looking at the coefficients (**β**), **p**-values, **t**-values, standard error, upper limit, and lower limit. Using the PLS4-SEM approach with an upper level of 97.5 % and lower level of 2.5 % confidence interval and the 5000-bootstrapping technique, these values were obtained. However, when the **p**-value is less than 0.05, the **t**-value is greater than 1.965, and these benchmark levels are used to determine whether the predicted hypothesis is accepted or rejected. The path analysis results in Table 6 indicate that the t-values for all hypotheses exceeded the minimal threshold criterion of >1.965.

Similarly, the **p**-value for all hypotheses was less than the minimum requirement of 0.05. Therefore, based on the analysis of the coefficient value (**β**), **t**-value, and **p**-value, it can be concluded that all hypotheses of the direct effects (H1 to H5) and mediation effects

Table 2
Variance Inflation Factor (VIF) values of the inner model for CMB.

Variables	VIF
GHRM	1.875
GI	1.559
GCA	1.607
EP	1.499

Note: EP = Environment Performance, GI = Green Innovation, GCA = Green Competitive advantage.

Table 3
Convergent validity.

Variables	Items	Factor Loadings	Cronbach Alpha	CR	AVE
Green human resource management	GHRM1	0.778	0.944	0.953	0.669
	GHRM2	0.910			
	GHRM3	0.891			
	GHRM4	0.886			
	GHRM5	0.837			
	GHRM6	0.788			
	GHRM7	0.694			
	GHRM8	0.844			
	GHRM9	0.744			
	GHRM10	0.779			
Green Innovation	GI1	0.676	0.893	0.915	0.574
	GI2	0.819			
	GI3	0.789			
	GI4	0.630			
	GI5	0.838			
	GI6	0.754			
	GI7	0.750			
	GI8	0.784			
Green Competitive Advantage	GCA1	0.778	0.817	0.879	0.646
	GCA2	0.863			
	GCA3	0.807			
	GCA4	0.762			
Environmental performance	EP1	0.810	0.845	0.89	0.619
	EP2	0.728			
	EP3	0.843			
	EP4	0.776			
	EP5	0.774			

Note: CR, composite reliability; AVE, average variance extracted; GHRM, green human resource management; EP, environmental performance; GI, green innovation; GCA, green competitive advantage.

Table 4
HTMT discriminant validity.

Constructs	Environmental performance	Green Competitive Advantage	Green HRM	Green Innovation
Environmental performance				
Green Competitive Advantage	0.838			
Green HRM	0.746	0.672		
Green Innovation	0.641	0.518	0.627	

Table 5
Fornell -larcker discriminant validity.

Constructs	Environmental performance	Green Competitive Advantage	Green HRM	Green Innovation
Environmental performance	***0.787***			
Green Competitive Advantage	0.702	***0.804***		
Green HRM	0.670	0.594	*0.818*	
Green Innovation	0.575	0.471	0.577	***0.758***

(H6 and H7) in this study are accepted or supported, as seen in Fig. 3 and Table 6. One of the core objectives of our research was to determine the mediating role of green competitive advantage. Analysis shows that green competitive advantage (H6 and H7) mediates the association between GHRM and environmental performance and green innovation and environmental performance.

Finding the coefficient of determination ($\mathbf{R^2}$) is the second step in the structural model analysis process [82]. The coefficient of determination measures the variance in endogenous constructs created by external constructs [82]. According to Rigdon [83], the coefficient of determination is also known as the predictive power of the sample. The predictive power of the sample increased as the coefficient of determination increased. The range of $\mathbf{R^2}$ values is from 0 to 1. Furthermore [84], proposed that an $\mathbf{R^2}$ value of 0.13 should be considered as low, 0.33 as moderate, and 0.67 as high. The coefficients of determination for endogenous construct values greater than 0.67, which are regarded as stronger, are provided in Table 7.

5. Conclusion

This study investigates the GHRM and green innovation effect on the manufacturing industry's environmental performance in

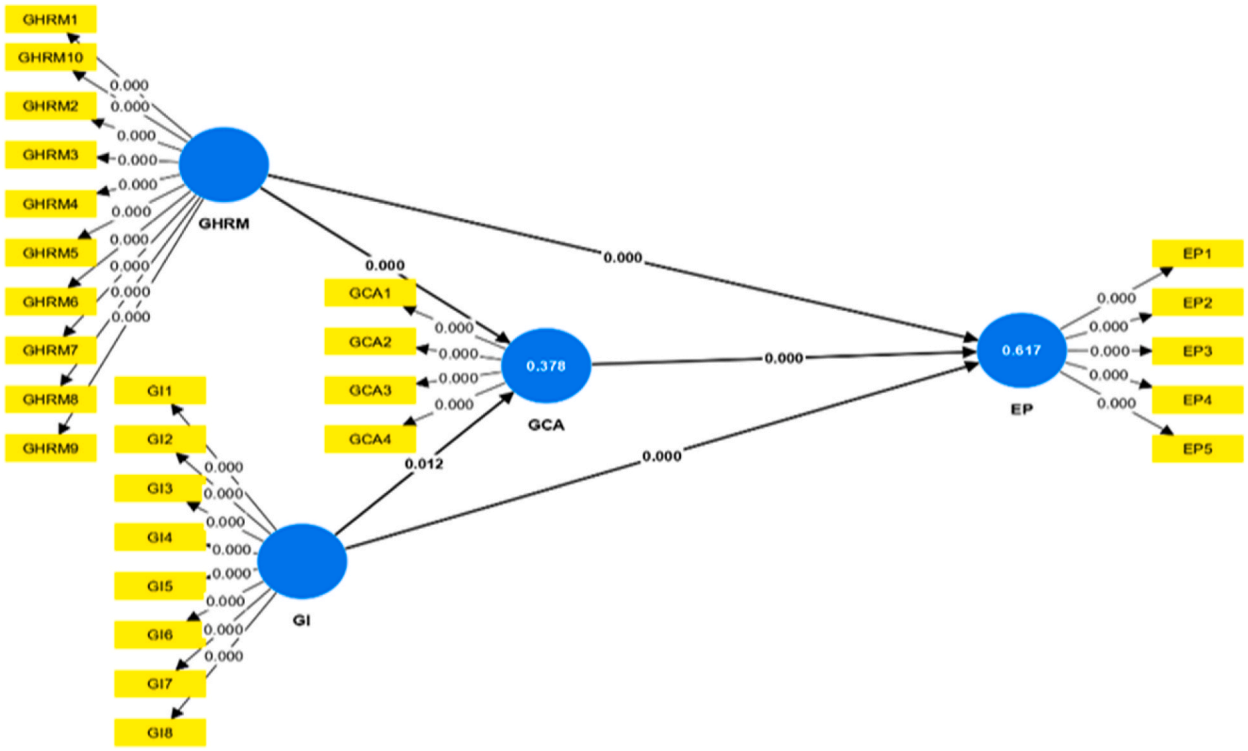

Fig. 3. Structural model constructed by the authors using SmartPLS 4.

Table 6
Hypotheses testing.

Hypothesis	Relationships	β	*t*-values	*p*-values	Decision
Direct effects					
H1	GHRM → EP	0.299	5.087	0.000	Supported
H2	GHRM → GCA	0.483	5.557	0.000	Supported
H3	GI → GCA	0.192	2.525	0.012	Supported
H4	GI → EP	0.2	4.054	0.000	Supported
H5	GCA → EP	0.431	7.007	0.000	Supported
Mediating effects					
H6	GHRM → GCA→ EP	0.208	5.018	0.000	Supported
H7	GI → GCA→ EP	0.083	2.147	0.032	Supported

Note: β, Beta coefficient; SD, standard deviation; t, t-statistics; P, p-value; GHRM, green human resource management; EP, environmental performance; GI, green innovation; GCA, green competitive advantage.

Table 7
Assessment of *R* square.

Variables	R^2
Environmental performance	0.613
Green competitive advantage	0.373

Heilongjiang Province, China, through the mediating role of green competitive advantage. Drawing upon the theoretical framework of the RBV theory posited by Ref. [85], this study proposed a hypothesis that suggests a significant and positive correlation between GHRM and environmental performance. The anticipated findings are expected to contribute empirical support in favor of the proposed correlation. This study validates prior research by Refs. [86,87], giving evidence that GHRM leads to improvements in environmental

impact. The outcomes are observed by the availability of data on the specific implementation of GHRM practices in the manufacturing industry of Heilongjiang Province, China, especially in chemicals, plastics, and raw material companies. In addition, research evidence supports the link between environmentally friendly (green) innovations and environmental performance, indicating a considerably favorable association between the two. The findings of these investigations are consistent with those of earlier research [51,88].

Similarly, the mediation analysis results provide robust evidence to support the presented hypotheses H6 and H7. Specifically, H6 proves that green competitive advantage mediates GHRM practices and environmental performance. Additionally, H7 green competitive advantage serves as a mediator between green innovation and environmental performance. In this way, we extend the analysis and show that green HRM can improve green competitiveness and environmental performance. Muisyo et al. [34], found that green HRM can help firms establish a green competitive edge and improve green performance by creating talent, motivation, and opportunities. Xie et al. [89] emphasized the significance of green innovation as a fundamental factor that significantly influences environmental practices. We discovered that green innovation can strengthen a green competitive advantage while improving environmental performance. Our results support Zameer et al. [63] study, which found that adopting green innovation by businesses can significantly boost both green competitiveness and environmental performance.

The mediation between green HRM, green innovation, and environmental performance was demonstrated by our study, which further advanced our understanding by looking at the mediating function of green competitive advantage. Competitiveness has been connected in several studies to both market and financial performance [62,90]. To expand the scope of the current body of knowledge, we looked at the relationship between environmental performance and green competitive advantage in our study. The findings suggest an important correlation between the attainment of a competitive advantage through environmentally friendly practices and overall performance in terms of environmental impact. The concept of green competitive advantage can be considered distinct from conventional interpretations because it incorporates green principles. The findings of this study align with Chen and Chang's [56] idea that an organization pursuing competitive advantage will adopt environmental management practices.

5.1. Theoretical implications

The research is based on the Resource-Based View (RBV) theory, which considers organizations as collections of resources that might be material or intangible. Our study adds to the existing literature on how organizations can effectively utilize resources to achieve sustainable environmental outcomes by applying the RBV to the contexts of GHRM, green innovation, competitive advantage, and environmental performance in the Chinese manufacturing industry. Using prior research by Grant & Baden-Fuller [91], Lavie [92], and others, our work underlines the potential of strategic alliances in establishing a competitive advantage by exploiting heterogeneous and immobile resources. This perspective improves our understanding of how collaborations and partnerships in the manufacturing business can improve environmental performance by leveraging complementary resources and competencies. Our study established and emphasized, for the first time, the significant role that green competitive advantage can play in enhancing environmental performance. This article also connected GHRM and green innovation to environmental performance, yielding fresh insights. The positive correlation that has been shown between GHRM and green innovation, green competitive advantage, and environmental performance has led to new theoretical insights that enhance the RBV theory. This study also proposed and supported green competitive advantage as a mediating mechanism between GHRM, green innovation, and environmental performance.

The study emphasizes the importance of integrating GHRM practices with RBV theory to improve a firm's environmental performance through green recruitment, training, performance management, incentives, remuneration, and goal setting. This theoretical implication improves our knowledge of how HRM initiatives can support environmentally friendly and sustainable business practices. The study recognizes the importance of green innovation in developing environmentally sustainable processes, products, and services. By connecting green innovation, our study advances the theoretical understanding of how businesses might use innovative approaches to compete with other organizations in terms of environmental performance.

Overall, this study uses RBV theory to examine the links between GHRM, green innovation, environmental performance, and green competitive advantage. This study intends to improve understanding of how Chinese manufacturing enterprises, particularly Heilongjiang chemical, plastic, and raw materials companies, may implement sustainable practices and achieve environmental goals.

5.2. Practical and managerial implications

This study offers practical and managerial applications for decision-making and policy formulation in addition to its theoretical consequences. In practical implications, the study findings will help manufacturing companies in Heilongjiang Province regarding green talent acquisition and retention, training and capacity building, performance evaluation and incentives, encouraging employee participation, collaborative partnerships, investing in research and development, operational efficiency, market differentiation, stakeholder engagement, regulatory compliance, reduced environmental footprint, long-term sustainability, and enhanced corporate social responsibility (CSR).

Similarly, this study's findings have significant implications for managers, enabling them to prioritize green HRM practices and green innovation to attain a competitive advantage and align firm performance with environmental regulations. Consequently, to improve their operations and support environmental sustainability, manufacturing enterprises should implement green practices, which will make a substantial contribution to sustainable development. Moreover, the research findings indicate that manufacturers should increase their utilization of resources and capabilities to enhance their competitiveness, as competitiveness plays a crucial role in improving the environmental performance of enterprises. In this context, policymakers should adopt business-friendly regulations for industries that create competitive environments in the country. This allows companies with a competitive advantage to invest more

in environmental sustainability. Consequently, organizations and decision-makers are advised to collaborate for sustainable environmental growth.

5.3. Future directions and limitations

After its theoretical and practical implications, this study has significant limitations and offers directions for future research. First, the sample size for this study was intentionally kept small to ensure an accurate representation of the chemicals, plastics, and raw material companies in Heilongjiang Province's manufacturing industry that participated in the analysis. This specific aspect limits the generalization of all chemical, plastic, and raw material industries. Hence, the findings of this study indicate the need to expand the scope of future research to encompass Chemicals, Plastics, and Raw Materials Companies fully, incorporating cross-sectional investigations. Second, the study used a closed-ended survey questionnaire; therefore, surveying instrument design errors are possible. We targeted respondents who were likely to understand the terminology employed in the survey. Data-gathering strategies for future studies could include open-ended interviews and questionnaires using the grounded theory approach. Thirdly, this study's scope was constrained to feedback provided by personnel currently employed in the relevant industry. Therefore, future research efforts should include the collection of viewpoints and inputs from the inside and outside stakeholders. This will allow for a comprehensive evaluation of the influence and effectiveness of green environmental management and related policies. This study examines the relationship between green HRM, innovation, competitive advantage, and environmental performance. Further study efforts may investigate additional components, such as digital technology, big data, green images, and the green workforce, to determine their potential as fundamental components for improving environmental performance.

5.4. Final remarks

The current study was conducted in China, a country with many cultural norms and values. Our study provides empirical support to understand the relationship between GHRM, green innovation, and environmental performance. We also examined and provided support for the mediating role of green competitive advantage in the relationship between GHRM, green innovation, and environmental performance. Furthermore, it offers RBV as a theoretical foundation for the positive impacts of green HRM and green innovation in strengthening firms' ability to optimize green competitive advantage and enhance overall environmental performance. This study enhances the existing body of knowledge by investigating the gap in sustainability aspects and environmental performance, which provides practical implications for employees, managers, and business organizations. This paper collected relevant literature and organized it by key variables.

Ethics statement

All of the experimental procedures performed in this study involving human participants were in accordance with the ethical standards of the Institutional Review Board (IRB) in the School of Management at Harbin Institute of Technology, approval number 2023–22. Participation in this online survey is entirely voluntary. All participants provided informed consent to take part in the study voluntarily.

Declaration of generative AI

During the preparation of this work, Azhar Ud Din used Quillbot And B. AI to improve language and readability for readers. After using this tool, the author reviewed and edited the content as needed and took full responsibility for the content of the publication.

Data availability statement

Data sharing does not apply to this article. The dataset associated with this research is not publicly available due to the privacy and confidentiality commitments made to the study participants. Ensuring the protection of respondent privacy was of utmost importance in this research, and as such, the raw data cannot be made openly accessible. Although it can be requested from the corresponding author on a reasonable request.

CRediT authorship contribution statement

Azhar Ud Din: Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Conceptualization. **Yang Yang:** Supervision, Funding acquisition. **Rui Yan:** Investigation, Data curation. **An Wei:** Writing – review & editing, Funding acquisition. **Majid Ali:** Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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