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Effects of green mining practices on corporate sustainable development: role of green innovation, green organizational commitment, and corporate social responsibility

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Background: China is the top global consumer, importer, and producer of coal, accounting for about half of the world's totals. Yet despite all this progress in renewable energy, coal still provided 56 percent of China's energy consumption, and the country has the fourth-largest reserve globally. However, coal mining also releases enormous amounts of methane, a very potent greenhouse gas. Additionally, it contributes over 70% to the total CO_2 within the country.

Purpose: This study evaluates the effect of green mining practices on green innovation, employee green organizational commitment, and corporate sustainable development in the mining industry of China.

Methodology: The data was collected through an online survey and distributed all over China. For this research, 511 responses were analyzed using SmartPLS 4.1.

Results: The results indicate that green marketing practices have a direct positive and significant effect on green innovation (β = 0.493), organizational commitment (β = 0.476), and organizational sustainable development (β = 0.0.195). The study proves that green innovation significantly affects both organizations' sustainable development (β = 0.262) and their commitment (β = 0.0.293). Additionally, green innovation and organizational commitment significantly mediate the relationship between green marketing practices and corporate sustainable development. Moreover, the study observed that corporate social responsibility significantly moderated the influence of green mining practices on green innovation, organizational commitment, and corporate sustainable development. Cumulatively green mining practices, direct and indirect effects of green innovation and organizational commitment, and moderation of corporate social responsibility explained 67.2% variance in the corporate sustainable development.

Conclusion: The study results further attest that green practices and corporate social responsibility play an essential role in underpinning sustainability and

innovation in the mining sector. They also provide important lessons for policymakers and other industrial stakeholders on improving sustainable development.

KEYWORDS

green mining practices, corporate social responsibility, green innovation, green organizational commitment, corporate sustainable development, mining industry

1 Introduction

China is the world's largest consumer, importer, and producer of coal (Li et al., 2019). The country's coal production in 2023 reached 93.1 exajoules, up 2.0 percent from a year earlier and the highest since 1990 (Textor, 2024c). Despite the huge steps in renewable energy, coal remains very crucial in China's energy mix; it accounted for 61% of electricity generation in 2022 (Slotta, 2024), contributing more than 70% to the nation's CO_2 emissions (Daniel, 2024). This comes with environmental challenges involving habitat destruction and land degradation, which are part of greenhouse gas emissions. The need for sustainable practices is, therefore, brought to the fore (Worlanyo and Jiangfeng, 2021).

Addressing these, among other issues, green mining practices (GMPs) have become significant strategies for the achievement of corporate sustainable development (CSD). GMPs refer to *environmentally responsible methods and technologies used in coal extraction and processing that prioritize sustainability in water, waste, energy, and resource management* (Muduli et al., 2016; Pedro et al., 2017). However, for such a practice to be effective, it requires well-established frameworks with innovative approaches that ensure successful implementation.

CSD is defined as "a balance of *economic, environmental, and social development that meets the needs of the present and does not prevent future generations from fulfilling their needs*" (Baumgartner and Rauter, 2017, *p.* 81). The mining industry bears immense environmental and social impact; hence, CSD principles have to be considered to complement the industry in terms of reduction in emissions, improvement in resource efficiency, and community trust-building aspects (Tian and Wang, 2024). Despite this importance, however, a slight information is known about through which pathways GMPs could influence CSD, with special reference to the mediating factors-green innovation and employee green organizational commitment (GOC).

Green innovation refers to the "*introduction of any new or significantly enhanced process, goods, marketing solution, or organizational change that minimizes the use of natural resources and reduces the emission of harmful substances throughout the entire lifecycle*" (Suleman et al., 2024, *p.* 5). By emphasizing innovative solutions, green innovation has not only supported CSD but also improved operational efficiencies and uptake of strict environmental regulations (Le et al., 2022; Sarfraz et al., 2023). In the same way, green innovation also raises GOC by guaranteeing that the values of the employees are aligned to meet the sustainability goals of the company (Sharma et al., 2021; Silva et al., 2023). While green innovation has many evident benefits for corporate sustainability and employee commitment, a significant research gap exists in relation to the mechanisms by which it mediates the effects (Chen et al., 2024; Qalati et al., 2024). Additionally, future studies were proposed to look into such complex relationships (Sarfraz et al., 2023; Sharma et al., 2021).

GOC refers to *employee intention to showcase their value to an organization by achieving sustainable behavioral characteristics and serves as a cognitive framework, embodying both a feeling of connection and duty toward ecological considerations in the workplace* (Le and Tham, 2024, *p.* 104). GOC is a necessity for CSD since it illustrates the commitment of both the employees and management toward the successful conduct and maintenance of eco-friendly operations within a company (Cao et al., 2024). GOC nurtures a culture where sustainability is the value created, hence motivating involvement in green practices and innovations to reduce negative impacts on the environment and ensure efficiency in resource use (Maheshwari et al., 2020; Wang, 2018). This support influences the attainment of regulatory requirements and has a wider impact on enhancing the reputation and competitiveness of the company in the market (Silva et al., 2023). GOC mediates the relationship between green practices and CSD due to its supporting role in ensuring the persistence with which sustainable initiatives are applied and integrated into the operation of a company (Ren et al., 2022; Sharma et al., 2021). If employees and management are committed to green goals, then green practices would be more likely to be effectively implemented, green innovation would be more readily embraced, and there would be a significant improvement in the firm's overall sustainability performance. This includes a research gap, since many mechanisms remain unclear, specifically those by which GOC mediates the relationship between green practices, green innovation, and CSD; that is, more studies at the empirical level are required to ascertain these dynamics in-depth (Cao et al., 2024; Ren et al., 2022; Sharma et al., 2021).

Corporate social responsibility (CSR) is defined as "operating a business in a manner that meets or exceeds the ethical, legal, commercial and public expectations that society has of business" (Kahreh et al., 2014). It has received much attention in the industry circle, as it is able to positively influence stakeholders' and social images (Masud et al., 2023), green innovation (Padilla-Lozano and Collazzo, 2022), GOC (De Silva & De Silva Lokuwaduge, 2021), and CSD (Anser et al., 2018; Le et al., 2024). CSR can be viewed as a moderator in the relationships that exist between GMP and organizational outcomes represented by green innovation, GOC, and CSD. In that respect, CSR practices align the firms' activities with the expectations of society and the natural environment, through which the trust of the stakeholders is built, and sustainable innovation is fostered (Aguinis and Glavas, 2017; Carroll, 2021). Despite its promising nature, the role of CSR in interaction with GMPs in driving such sustainability outcomes has been studied inadequately within the mining industry. Previously (Ali et al., 2020; Bifulco et al., 2023), have elevated the role of CSR activities by calling for more studies.

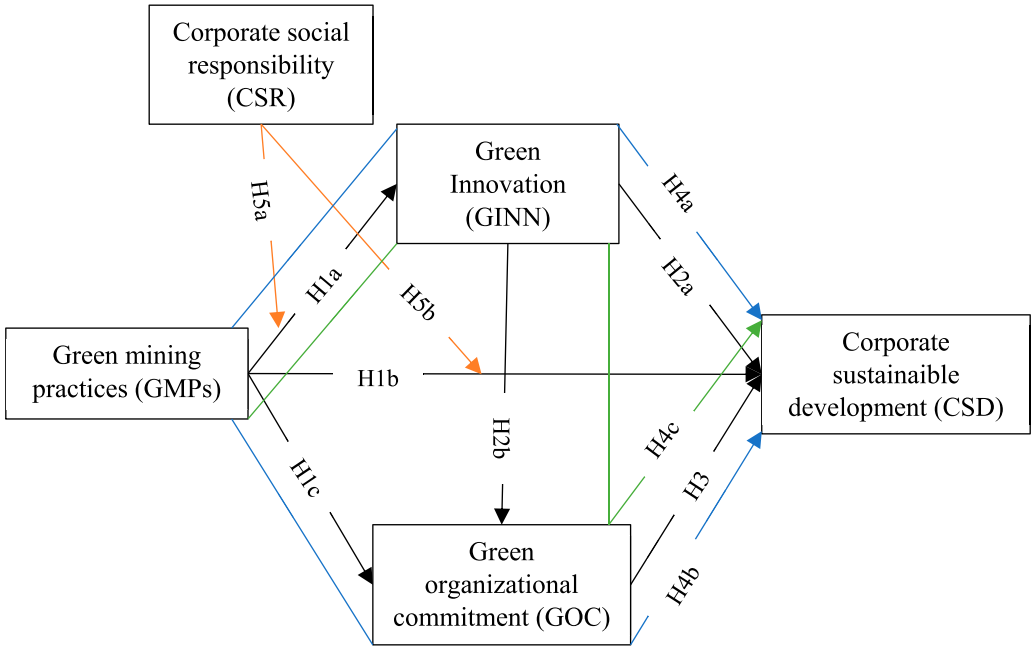

FIGURE 1
Theoretical model.

Based on the research gap identified in the mining industry, the key objectives (ROs) and research contributions are given below, which lead to the model represented in Figure 1:

RO1: To identify predictors of CSD in the mining industry.
RO2: To investigate the intermediating role of green innovation and GOC in the relationship between GMPs and CSD.
RO3: To examine the sequential intermediating impact of green innovation and GOC.
RO4: To evaluate the moderating impact of CSR in improving the effects of GMPs on green innovation and CSD.

2 Literature review and hypotheses formulation

2.1 Triple bottom line theory

TBL theory, given by Elkington (1998), suggests that enterprises should commit to delivering economic, social, and environmental performance. This theory supports the continued adoption of green practices, which is the environmental dimension, promoting practices that lessen ecological interference (Jum'a et al., 2022). GMPs diminished harm to the environment within the mining industry, thereby entrenching the TBL's environmental goals as noted by Hilson (2008) and Tost et al. (2018). CSR aligns with the social dimension, promoting the positive contribution of business to society (Pan et al., 2021). CSR activities are not exclusively linked to the social dimension but also to the environmental dimension since CSR promotes green innovation and GOC by integrating sustainability issues into corporate strategy, as underlined by Aguinis and Glavas (2017) and Carroll (2021). The economic dimension is represented by green innovation and the GOC of employees, which influences both the dimensions of sustainable business growth together with efficiency (Fernando et al., 2019; Hendarjanti, 2022). According to Cainelli et al. (2015) and Cheng et al. (2014), green innovation is essential in minimizing environmental impacts and enhancing competitive advantage. It is also because GOC, highlighting a firm's commitment to sustainability, creates a culture of environmental care that fuels green innovation and leads to CSD. Moreover, GOC, emphasizing a firm's dedication to sustainability, cultivates a culture of environmental responsibility that drives green innovation and contributes to CSD, as noted by Dyllick and Muff (2015) and Lozano (2015). Together, these elements foster CSD, which aims to achieve a balanced integration of TBL principles (Liu et al., 2024). Ultimately, CSD is simply a junction of economic performance with environmental and social responsibilities; it can be placed in line with the holistic approach to sustainability advanced by Dyllick and Muff (2015). According to Bansal (2005), firms that apply TBL to their business conduct have the ability to contribute toward long-term sustainability by reducing risk and tapping new market opportunities. Business integrations through GMPs, CSR, green innovation, and GOC can result in a synergistic effect promoting comprehensive sustainable development.

2.2 Hypotheses formulation

2.2.1 Relationship of GMPs with green innovation, CSD, and employee GOC

Interest in the concept of green practices has been at an all-time high because the concept aims at integrating economic, environmental, and social issues within organizational activities

(Karuppiah et al., 2023). Yet, an incomplete understanding of what constitutes green practices still abounds, and there is a need to keep track of the development in the field (Karuppiah et al., 2024). Additionally, even though this is at an early stage, interest in research relating to industry-based green practices and green innovation from the research community, industries, and policymakers is growing fast (Al-Swidi et al., 2024). Companies are placing greater emphasis on green product design, process improvement, and new technology development under the purview of GMP (Aznar-Sánchez et al., 2019).

Green innovation ensures that only green technologies are to be used and decreases production costs resulting from reduced raw materials, energy, and less generation of waste (Rana and Arya, 2024). Green innovation also requires companies to decrease the cost of cleaner production and reduce pollutants that can be reduced by proper GMPs (Aron and Molina, 2020). In this line, therefore, GMP is among the most important approaches that firms have used to achieve environmental performance, which in turn strengthens green innovation functions (Li et al., 2024). Practices regarding sustainability should be practiced to achieve the goals of green innovation (Suleman et al., 2024). Recently studies recorded a significant connection of green management practices with green innovation (Al-Swidi et al., 2024; Rana and Arya, 2024; Suleman et al., 2024). However, this connection lacks empirical evidence in the context of coal mining, thus, it is proposed that:

H1a: GMPs are positively related to green innovation in the mining companies.

GMPs thus play a very key role in bringing mining in line with sustainable development concepts (Xiao et al., 2024). GMPs help firms to mitigate the environmental impact and use natural resources in a responsible manner. Such companies comply with regulatory requirements, improve their corporate reputation, and foster stakeholder relations (Tian and Wang, 2024). It enhances the social license to operate and can result in better financial performance due to efficiency improvements and cost reductions—eliminated or reduced fines and lower energy costs (Azapagic, 2004; Pedro et al., 2017). Moreover, companies that take part in sustainable practices will attract investment from socially responsible investors, and improve their competitive advantage in sensitive markets (Afum et al., 2020; Salam and Jahed, 2023). Earlier a few studies reported a significant link between construct (Al-Hakimi et al., 2022; Albloushi et al., 2023) in the context of different sectors like manufacturing relative to mining; thus, it is suggested that.

H1b: GMPs are positively related to CSD in the mining companies.

Adoption of sustainable practices strongly impacts GOC because this facilitates operations in the organization to reflect the personal environmental values of employees within the organization (Hendarjanti, 2022). Active involvement by companies in these practices signals a commitment to environmental sustainability and helps in building a workplace culture that values sustainability (Sharma et al., 2021). This could be boosting the morale of employees, reducing employee turnover, increasing satisfaction, and creating a feeling of pride and meaning toward one's job (Abdelhamied et al., 2023). Earlier research by Le and Tham (2024) and Maheshwari et al. (2020) reported that employee GOC is affected by green human resource management (Sharma et al., 2021) by green innovation (Silva et al., 2023) by the perception of CSR activities, job satisfaction, and organizational trust. However, these studies have evidenced it largely in the context of manufacturing, while evidence related to the coal mining industry is missing. Thus, it is suggested that

H1c: GMPs is positively related to GOC in the mining companies.

2.2.2 Relationship of green innovation with CSD, and employee GOC

Green innovation is an important element that drives CSD through the introduction of green technologies, processes, and products that mitigate the ecological impacts and, at the same time, improve business sustainable performance (Fernando et al., 2019), social performance (Fosu et al., 2024), environmental performance (Al-Hakimi et al., 2022), and CSD (Albloushi et al., 2023). Green innovation involves designing new solutions and their implementation for resource efficiency, waste reduction, and minimization of environmental pollution, hence very essential for achieving sustainability goals (Agrawal et al., 2024; Al-Hakimi et al., 2022). Enterprises that give due priority to green innovation are most likely to satisfy the statutory requirements, gain market competitiveness, and meet stakeholders' expectations regarding sustainability performance (Le et al., 2022; Rana and Arya, 2024). Fosu et al. (2024) stated that companies engaged in green innovation benefit to the extent of improved firm social performance, combined with a strong corporate reputation—both being two key constituents of CSD. Recent studies also recorded an affluent connection of green innovation with CSD (Le et al., 2024; Le et al., 2022; Waheed et al., 2024). Therefore, the integration of green innovation within corporate strategies not only supports environmental objectives but also fosters long-term economic and social benefits, aligning with the holistic goals of CSD. Hence, it is proposed that.

H2a: Green innovation is positively related to CSD in mining companies.

Green innovation drastically improves employee GOC through the inculcation of a workplace culture that places value and a priority on environmental sustainability (Sharma et al., 2021). In another systematic review, Salim et al. (2019) established a significant relationship between the development of internal innovation capabilities and a culture that influences employee commitment and motivation favorably. Organizations that invest in green innovation demonstrate an exceedingly high level of responsibility towards the ecosystem and sustainability, thereby increasing an employee's attachment to the vision and values of the organization (Alshura et al., 2023). Commitment toward green innovation arouses an employee's eco-friendly behavior (Qalati et al., 2023) and strengthens the bond toward the sustainability goals of one's organization (Shahzad et al., 2023). According to studies by Sharma et al. (2021), effective green innovation practices in organizations identify those employees likely to display high organizational commitment. Since the contributions that the employees are making seem relevant to and complementary to the broader environment objectives, commitment to such initiatives of the organization is heightened, hence facilitating a more empowered and motivated workforce (Ababneh, 2021; Dong et al., 2024). Thus, the following argument is built.

H2b: Green innovation is positively related to GOC in the mining companies.

2.2.3 Relationship of employee GOC with CSD

Employee GOC is a major driver of CSD (Xing et al., 2019) because it deeply orientalizes the sustainability issues within the organizational culture and practice (Roscoe et al., 2019). Basically, commitment to green organizational goals instigates employee readiness toward performing behaviors that support environmental and social initiatives, which are key components of CSD (Cao et al., 2024; Khan et al., 2024; Murtaza et al., 2024). This commitment supports a proactive attitude towards sustainability, whereby workers are driven to innovate, reduce waste, and increase efficiency in their daily operations (Karatepe et al., 2022). Since the employees' values support the organization's objective of sustainability, green practices consistently apply throughout all levels of a company (Al-Swidi et al., 2021; Galpin et al., 2015). This is an integrated approach to enhancing firm outcomes on sustainability but also on social and economic dimensions through cost reduction, better relations with stakeholders, and long-term growth. Recently Ren et al. (2022) and Sharma et al. (2021) evidenced that fostering employee GOC can significantly amplify the overall impact of CSD efforts, leading to a more sustainable and resilient business model. Hence, it is suggested that.

H3: Employee GOC is positively related to CSD in the mining companies.

2.2.4 Mediation of green innovation and GOC

To the best of our understanding, despite the available literature showing apparent proof, there is a lack of research related to both factors' intermediation in the relationship between GMPs and CSD in the mining industry (Suleman et al., 2024), particularly in the Chinese context. Still, related studies are reviewed to establish the relationships. Our research also tries to see if green innovation and employee GOC may act as an important mediator between GMPs and CSD. In this framework, green innovation would operationalize the translation of such practices into place innovative processes and technologies that would better their overall sustainability.

Green practices would be expected to provide the basic practices that lessen negative environmental impact and promote resource efficiency in firm operations (Al-Hakimi et al., 2022). Green innovation enables the development of such breakthrough environmental technologies, including green extraction methods and waste management systems, to be developed to comply with GMP while making great contributions to CSD through reduced ecological footprints with enhanced operational efficiencies (Suleman et al., 2024). The innovation-driven approach ensures that sustainability is not only implemented but also improved continuously to have more robust and effective sustainability outcomes (Albloushi et al., 2023). As Fernando et al. (2019), Rana and Arya (2024), and Sarfraz et al. (2023) highlight, firms that invest in green innovation are better placed to meet their long-term sustainable development goals since innovation drives environmental performance and competitive advantage. Recently, large studies reported the significant mediation of green innovation's role between green human resource management practices and firm environmental or sustainable performance examples Omar et al. (2024) reported in the manufacturing sector of Pakistan, and Rana and Arya (2024) reported is same sector but in India. Additionally, Le et al. (2024) recorded green innovation mediation between CSR practices and CSD in Vietnamese SMEs. Suleman et al. (2024) recorded the role of green human resource management practices and CSD in the Ghanaian mining sector and called for further studies in the context of mining. Therefore, green innovation acts as a pivotal link that enhances the efficacy of GMPs, ensuring that environmental practices translate into CSD.

H4a: Green innovation mediates the relationship between GMPs and CSD in the mining companies.

Our investigation also states that when organizations implement green practices, they not only mean a cut in environmental impacts by organizations but also, in the first place, send a very strong message to employees about organizational values and priorities regarding the environment (Roscoe et al., 2019). This, in turn, enhances GOC, as employees become more committed to and engaged with the company's sustainability mission (Hendarjanti, 2022). High GOC regards a loyal worker who adopts and advocates for green practices, innovates within their duties, and participates in sustainability efforts that further enhance a green practice effect on CSD (Sharma et al., 2021). As highlighted by Le and Tham (2024), employees who are highly committed to their work and organization will be more likely to participate in the organization's sustainability activities and initiatives for the support of successful implementation of green initiatives toward improved overall performance in sustainability. Hence, GOC acts as a significant link through which GMPs' environmental initiatives translate into broader corporate sustainability accomplishments by means of the dedication and innovative potential of employees. In the recent existing literature, Khan et al. (2022) tested the mediation of employee GOC between green human resource management practices and employee green behavior in the textile sector of Pakistan. Ren et al. (2022) reported its mediation between green human resource management practices and firm environmental and financial performance. Accordingly, Le and Tham (2024) also evidenced its mediation between green management practices and firm environmental performance in the manufacturing sector of Vietnam. However, to the best of our knowledge lack of research evidence related to the mining sector. Thus, based on this we propose that

H4b: GOC mediates the relationship between GMPs and CSD in the mining companies.

First and foremost, GMPs lay the foundation with eco-friendly practices that reduce ecological disruption (Onifade et al., 2024). Obviously, such practices are going to foster green innovation, as firms look for innovative ways to improve their environmental performance further (Li et al., 2024; Zhou et al., 2021). Green innovation means better operational efficiency and reduced environmental impacts but also creates a culture of sustainability within the organization (Onifade et al., 2024; Tian and Wang, 2024). This innovation-driven culture further supports GOC, as the employees themselves become more dedicated to the green goals and values of the organization (Sharma et al., 2021). GOC amplifies green innovation through the engagement of employees in sustainability initiatives themselves and, hence, tends to institutionalize green practices within the organizational fabric.

Both green innovation and GOC develop together a synergistic effect that propels CSD and secures a balanced integration of economic, social, and environmental performance. This integrated approach is supported by studies indicating that green innovation and GOC are pivotal for sustainable business practices (Le et al., 2024; Ren et al., 2022; Sharma et al., 2021; Waheed et al., 2024). Previously Rehman et al. (2023) used a proactive environmental strategy and green innovation as serial mediators between green supply chain practices and corporate sustainability outcomes. Thus, it is suggested that

H4c: Green innovation and employee GOC serially mediate the relationship between GMPs and CSD in the mining companies.

2.2.5 Moderation of CSR

CSR initiatives enhance the effectiveness of green practices by embedding environmental and social considerations into the core strategies of companies (Fatima and Elbanna, 2023). This research argued that when CSR is integrated with GMPs, it creates a robust framework that encourages innovation and sustainable practices (Simmou et al., 2023). This integration fosters a culture of environmental responsibility and social accountability, motivating companies to invest in green technologies and innovative solutions (Aguinis and Glavas, 2017; Carroll, 2021). By aligning CSR with GMPs, companies can leverage their social responsibility commitments to drive green innovation, as employees and stakeholders are more likely to support and engage in sustainable practices when they perceive the company's genuine commitment to CSR.

Furthermore, CSR strengthens the relationship between GMPs and CSD by ensuring that environmental and social goals are pursued in a balanced and integrated manner, thereby achieving comprehensive sustainability outcomes (Fernando et al., 2019). Companies that integrate CSR into their GMP strategies are better positioned to achieve long-term sustainability by mitigating risks and enhancing their corporate reputation (Camilleri, 2017). Previously Shafique et al. (2021) employed CSR as a moderator between organizational ambidexterity and green entrepreneurial orientation and found a significant effect in the manufacturing sector of Pakistan. Masud et al. (2023) found a significant effect on the relationship between green human resource management practices and firm sustainable outcomes in the Malaysian manufacturing sector. Ali et al. (2020) confirmed its moderation for the effect of foreign institutional shareholders and corporate financial outcomes. Thus, based on the above discussion, it is suggested that.

H5a: CSR moderates the relationship between GMPs and green innovation in mining companies.

H5b: CSR moderates the relationship between GMPs and CSD in mining companies.

3 Methodology

3.1 Sampling and data collection

Only a quantitative methodology was used to conduct this study. This study was conducted based on the fact that nearly 1,500 coal mining companies are operating in China (Textor, 2024a) and they employ more than 1.5 million workers (Caixin, 2023). Since the number of organizations is not large, therefore to ensure impartiality, probability sampling was used in the form of simple random sampling, due to which generalization to the whole population could be asserted (Azhar et al., 2024). The sample size followed Hair et al.'s (2011) "10-times rule," which states that the sample size should exceed ten times the number of model connections to any latent variable. Pesämaa et al. (2021) recommended 10 responses per item. Therefore, our study aimed for a minimum of 340 responses, which corresponds to 10 responses per item across 34 items among 5 variables.

The data collection period lasted 4 months, from July to October 2023, in multiple waves. Data collection for independent construct GMPs was done in Wave 1, mediators green innovation and GOC in Wave 2, moderator CSR in Wave 3, and dependent constructs CSD in Wave 4. Each wave was 1 month in duration, with two reminders after 10 days. To maximize the response rate and generalizability, the study distributed 600 questionnaires through email, WeChat, and personal visits. Among the top 5 companies which are listed on the Fortune China 500 ranking, China Shenhua Energy, China Coal Energy, Yankuang Energy Group, Shaanxi Coal Industry, and Huaibei Mining Holdings Co., Ltd. (Textor, 2024b). The study distributed 50 questionnaires each; among other companies, a single questionnaire was shared to reduce the probability of bias issues. Despite some limitations, self-reported data and self-administered questionnaires remain very common and appropriate in data collection for behavioral research (Masud et al., 2023).

A structured, closed-ended questionnaire was administered with assurances that the information supplied would be kept confidential and used for matching purposes only and not given to any third party. A web-based survey was created using Google Forms; after that, links for filling out the survey were shared via email and WhatsApp, quite a common method these days (Fan et al., 2024). Reasons for using an online questionnaire included that it was cost-effective, had a reputation as being a useful tool, ease of distribution, its interactive nature, the increased response rate, and was faster compared to traditional tools for conducting survey research (Qalati et al., 2023). The IP address of each participant was recorded to prevent one respondent from clicking on links in each wave, and respondents were informed about this.

Of the 1000 approached participants, 539 responses were received after the end of Wave 4. However, 28 mismatched IP addresses were identified, leaving 511 valid responses. According to Malhotra and Grover (1998), response rates below 20% are unsatisfactory, while rates between 30% and 70% are acceptable (Masud et al., 2023). Therefore, the response rate for this study is satisfactory. Among the respondents, 398 were male and 113 were female.

3.2 Questionnaire design and measures

This questionnaire was in two different parts: parts 1 and 2. Part 1 was on the descriptive information relating to the respondents, and part 2 was on the research variables. Part 2 had 8 items: 3 items for each dimension of GMPs adapted from Onubi et al. (2020a) and Onubi et al. (2020b); 4 items measuring green innovation adapted

from Al-Swidi et al. (2024); 3 items assessing the employees' GOC adapted from Sharma et al. (2021); 5 items measuring CSR adapted from Masud et al. (2023); and 8 items evaluating CSD covering three dimensions—economic, environmental, and social—adapted from Afum et al. (2020) and Bansal (2005). Items were all rated on a five-point Likert scale, ranging from "1" (totally disagree) to "5" (totally agree).

3.3 Common method bias

Even though data for the constructs were collected from the same respondents simultaneously, it was argued that there could be a possibility of common source bias (Onubi et al., 2021). To avoid this, scholars supplement that data should be collected in different waves, as we did in our research since data for the constructs is collected from the same respondents simultaneously (Qalati et al., 2023). In this regard, Harman's 1-factor test has been performed, as suggested by (Podsakoff et al., 2003), and recently used by several studies (Masud et al., 2023). However, this approach has been criticized by Pesämaa et al. (2021). According to this method, the single factor derived from all major constructs should account for less than 50% of the variance. In this study, it has been found that only one component explained 34.40% dispersion which is below the 50% threshold. Finally, the study used the variance inflation factor which is recommended while using partial least square structural equation modeling. The retained values were <3.33 recommended standard suggested by Cao et al. (2024).

3.4 Analytical tool

A partial least squares structural equation modeling was estimated using SmartPLS 4.1 for several reasons, which have many advantages over covariance-based SEM, especially in the case of an exploratory nature of research and when dealing with complex models or smaller sample sizes (Cao et al., 2024; Qalati et al., 2023). In particular, PLS-SEM is of interest because it supports formative measurement models and has fewer requirements for data distribution and sample size compared to the other covariance-based approaches (Hair et al., 2019). It is a method of variance-based approach that maximizes the explained variance of the dependent constructs, hence quite relevant for predictive modeling and theory development (Henseler et al., 2015). While CB-SEM focuses on model fit, thus requiring a larger sample size for reliable results, PLS-SEM can become more flexible and robust to the issues of complex relationships and non-normal data distribution, therefore able to arrive at more accurate and reliable insights in practical research scenarios (Hair et al., 2019; Onubi et al., 2021; Qalati et al., 2023; Simmou et al., 2023).

4 Analysis of results and discussion

4.1 Evaluation of measurement model

First, in PLS-SEM using SmartPLS 4.1, assessment of the reflective measurement model is necessary to ensure the reliability and validity of the constructs. This is done in a number of ways: First, internal consistency reliability needs to be checked using Cronbach's alpha (CA) and composite reliability (CR). The acceptable values for both are larger than 0.7 (Hair et al., 2019). Composite reliability is often preferred since it takes account of different outer loadings of the indicators. Second, the convergent validity is checked through the average variance extracted (AVE), which needs to be above 0.5 (Cao et al., 2024; Hair et al., 2019). This is for the simple reason that the construct explains more than half of the variation of its indicators. Third, the respective outer loading of each indicator needs to be significant, but also ideally above 0.65, ensuring that each item reliably measures the intended construct (Hair et al., 2019; Onubi et al., 2021). This research removed two items of the GMPs construct due to a value below 0.65 Table 1 results evidenced that our research reflective model retained values for AVE, CA, CR, and factor loadings.

Another important part of the measurement model assessment is discriminant validity. It is suggested to be checked according to the Fornell-Larcker criterion, where the square root of the AVE for each construct has to be larger than the highest correlation with any other construct (Fornell and Larcker, 1981). A more recent approach to this is the Heterotrait-Monotrait ratio with a threshold value below 0.9, to reflect adequate discriminant validity (Hair et al., 2019; Henseler et al., 2015) (see Table 2). Tables 1, 2 outcomes ensure a reliable and valid reflective measurement model, thereby supporting the robustness of the subsequent structural model evaluations.

4.2 Evaluation of structural model

After the reflective measurement model has been validated, the structural model is estimated to test the hypothesized relationships between constructs and the predictive power of the model. Some important criteria suggested and used to evaluate a structural model are path coefficients, coefficient of determination, effect sizes, and predictive relevance (Cao et al., 2024). First, the study used bootstrapping features with 5000 sub-samples in SmartPLS 4.1 to check that the hypotheses of the study were tested correctly and that the model path coefficients were significant ($p < 0.05$) (see Table 3; Figure 2). According to Table 3, GMPs had a significantly positive influence on green innovation ($\beta = 0.493$, $t = 8.879$, $p = 0.000$), CSD ($\beta = 0.195$, $t = 3.522$, $p = 0.000$), and GOC ($\beta = 0.476$, $t = 9.858$, $p = 0.000$), respectively; hence, supported the H1a–c. Besides, green innovation significantly affected CSD ($\beta = 0.262$, $t = 5.772$, $p = 0.000$) and GOC ($\beta = 0.293$, $t = 5.944$, $p = 0.000$); in this respective confirming H2a and H2b. The findings also confirmed that GOC significantly impacts CSD ($\beta = 0.233$, $t = 5.186$, $p = 0.000$); thus, validating H3. Mediation and moderation effects hypotheses were also supported given their level of significance.

On the other hand, while the R^2 value indicates the amount of variance explained by the independent variables in the dependent variable, a weak relationship is when it equals 0.25, a moderate one is when it is 0.50, and a substantial one if it is 0.75, according to Hair et al. (2019). The results are shown in Table 3; Figure 2, which indicate R^2 values of 63.5% in green innovation, 52.7% in GOC, and

TABLE 1 Factor loading reliabilities and convergent validity.

Constructs	Items	FL	CA	CR	AVE	VIF
Green mining practices (GMPs)	GMPs1	0.786	0.93	0.935	0.615	2.972
	GMPs2	0.759				
	GMPs3	0.792				
	GMPs4	0.804				
	GMPs5	0.826				
	GMPs6	0.757				
	GMPs7	0.771				
	GMPs8	0.705				
	GMPs9	0.808				
	GMPs12	0.826				
Green innovation (GINN)	GINN1	0.813	0.837	0.845	0.672	2.808
	GINN2	0.810				
	GINN3	0.800				
	GINN4	0.853				
Green organizational commitment (GoCM)	GoCM1	0.751	0.878	0.911	0.668	2.500
	GoCM2	0.789				
	GoCM3	0.913				
	GoCM4	0.811				
	GoCM5	0.815				
Corporate social responsibility (CSR)	CSR1	0.695	0.875	0.877	0.669	2.989
	CSR2	0.855				
	CSR3	0.822				
	CSR4	0.887				
	CSR5	0.817				
Corporate sustainable development (CSD)	CSD1	0.735	0.911	0.92	0.618	
	CSD2	0.881				
	CSD3	0.754				
	CSD4	0.707				
	CSD5	0.759				
	CSD6	0.760				
	CSD7	0.829				
	CSD8	0.848				

67.2% in CSD. Typically, 67.2% state that GMPs, green innovation, GOC, and CSR are responsible for 67.2% of changes in CSD. It furthers that they have moderate relationships with CSD (Hair et al., 2019).

The effect sizes, f^2, are also suggested to be used to assess the impact of each exogenous construct on the endogenous construct (Hair et al., 2019). The f^2 value is interpreted as follows: $0.02 \leq f^2 \leq 0.15$ represents a small effect; $0.15 \leq f^2 \leq 0.35$ represents a moderate effect, and $f^2 \geq 0.35$ represents a large effect. Table 3 shows that GMPs have a moderate effect on green innovation with $f^2 = 0.224$ and GOC with $f^2 = 0.196$ and a small effect on CSD with $f^2 = 0.031$. In addition, green innovation has a small effect on CSD with $f^2 = 0.074$ and GOC with $f^2 = 0.074$. Moreover, GOC also has a small effect on CSD with $f^2 = 0.066$. Lastly, CSR also has a small effect on the relationship of GMPs with green innovation ($f^2 = 0.025$) and CSD ($f^2 = 0.021$).

TABLE 2 Discriminant validity analysis using Fornell-Larcker and Heterotrait-Monotrait criterion.

Constructs	CSR	CSD	GINN	GMPs	GoCM
Corporate social responsibility (CSR)	0.818	*(0.801)*	*(0.835)*	*(0.889)*	*(0.814)*
Corporate sustainable development (CSD)	0.744	0.786	*(0.822)*	*(0.786)*	*(0.736)*
Green innovation (GINN)	0.735	0.734	0.82	*(0.858)*	*(0.726)*
Green mining practices (GMPs)	0.813	0.74	0.769	0.784	*(0.736)*
Green organizational commitment (GoCM)	0.753	0.708	0.659	0.701	0.818

Note: normal font value represents Fornell-Larcker values, in contrast, italic value represents HTMT, values.

Besides, predictive relevance Q^2 is assessed with a blindfolding procedure; values above zero would mean that the model has predictive relevance for the respective endogenous constructs (Hair et al., 2019; Qalati et al., 2023). Our study Q^2 values range from 0.326 to 0.411, which is above the benchmark of zero (see Table 3). Moreover, these estimates assure that the structural model is not only statistically significant but has practical meaning, too, and therefore, the insights gained into the nature of the relationships between constructs are robust.

4.3 Evaluation of mediation effect

The assessment of the green innovation and GOC mediation effect between GMPs and CSD includes measuring their indirect effect. This procedure involves testing the significance of direct paths from GMPs to green innovation, GOC, and CSD, and then the paths from green innovation and GOC to CSD. Bootstrapping yields confidence intervals and p-values for these indirect effects; a $p < 0.05$ is considered to be a significant mediation effect. Table 3, indicates that all indirect hypotheses H4a–H4c were supported. The green innovation significantly and indirectly affected the relationship of GMPs with CSD ($\beta = 0.129$, $t = 5.101$, $p = 0.000$). Besides, GOC also indirectly impacted the connection of GMPs with CSD ($\beta = 0.111$, $t = 5.130$, $p = 0.000$). In addition, green innovation and GOC also sequentially–partially mediated GMPs link with CSD ($\beta = 0.034$, $t = 3.459$, $p = 0.001$).

Moreover, the variance accounted for (VAF) is computed to quantify the extent of mediation; the VAF ranging from 20% to 80% represented partial mediation, above 80%, it is referred to as full mediation, and below 20% indicates no mediation (Cao et al., 2024; Qalati et al., 2023). Specifically, this refers to whether the addition of green innovation and GOCC significantly increases the explanatory power of the model, as expressed by changes in the R^2 value of CSD.

$$VAF_{GINN} = \frac{Indirect\ effect}{Total\ effect} = \frac{0.129}{0.622} = 20.7\%$$

$$VAF_{GOC} = \frac{Indirect\ effect}{Total\ effect} = \frac{0.111}{0.344} = 32.6\%$$

The above results evidenced the confirmation of mediation that GMPs have direct and indirect effects on CSD through improvements in green innovation and increasing employee GOC to sustainability. Given the VAF test values which fall in the range of 0.20–0.80, it is concluded that these factors partially mediated the relationships.

4.4 Evaluation of moderation effect

The moderation effect of CSR on all the links between GMPs and green innovation, CSD, and GOC can be evaluated as follows: To begin with, it is required to create the interaction terms by multiplying the standardized scores of the moderator CSR with the independent variable GMPs. The next step is that these interaction terms need to be added to the structural model. The moderation effects are estimated with their significance level, indicating that the moderation effect is significant. Table 3 shows that the interaction effect is significant; therefore, H5a and H5b are validated.

As suggested by Hair et al. (2019), the change in R^2 values (ΔR^2) of dependent variables green innovation, CSD, and GOC before and after including the interaction terms is checked, which will help to determine how strong the moderation effect is. The difference or ΔR^2 can be noticed between Figure 2 with the moderator and Figure 3 without the moderator. A large increase in R^2 would suggest that CSR significantly moderates the GMP effects on respective dependent variables green innovation, CSD, and employee GOC.

The f^2 for moderation is also checked in Table 3, where the values 0.02, 0.15, and 0.35 reflect small, medium, and large effects, respectively (Chin et al., 2003). The comprehensive assessment ensures that the moderating role of CSR in enhancing the impact of GMPs on green innovation and CSD is robust and meaningful.

5 Result discussion and implications

This research results show that GMPs are significantly associated with a positive effect on green innovation, CSD, and employee GOC in the context of coal mining companies working in China. All path coefficients from GMPs to green innovation, CSD, and employee GOC were positive and significant, thus confirming H1a–c. These outcomes propose that the adoption of GMPs enhances green innovation, improves CSD, and boosts the commitment of employees toward green initiatives. In particular, the positive effect of GMPs on green innovation exhibits that enterprises implementing green practices and technologies, comprising green mining, formulate innovative solutions to reduce firm's environmental effects (Aznar-Sánchez et al., 2019; Fosu et al., 2024; Onifade et al., 2024; Suleman et al., 2024). Specifically, this

TABLE 3 Evaluation of structural model.

Hypothesis	Relationships	Beta	S.D	*t*-value	Decision	f^2	R^2	Q^2
Total effect	Green mining practices → Corporate sustainable development	0.468***	0.053	8.879	Supported			
Direct effect								
H1a	Green mining practices → Green innovation	0.493***	0.050	9.875	Supported	0.224	0.635	0.411
H1b	Green mining practices → Corporate sustainable development	0.195***	0.055	3.522	Supported	0.031	0.672	0.402
H1c	Green mining practices → Green organizational commitment	0.476***	0.048	9.858	Supported	0.196	0.527	0.326
H2a	Green innovation → Corporate sustainable development	0.262***	0.045	5.772	Supported	0.074		
H2b	Green innovation → Green organizational commitment	0.293***	0.049	5.944	Supported	0.074		
H3	Green organizational commitment → Corporate sustainable development	0.233***	0.045	5.186	Supported	0.066		
Indirect effect								
H4a	Green mining practices → Green innovation → Corporate sustainable development	0.129***	0.025	5.101	Supported			
H4b	Green mining practices → Green organizational commitment → Corporate sustainable development	0.111***	0.022	5.130	Supported			
H4c	Green mining practices → Green innovation → Green organizational commitment → Corporate sustainable development	0.034**	0.010	3.459	Supported			
Interaction effect								
H5a	Corporate social responsibility x Green mining practices → Green innovation	0.128**	0.037	3.473	Supported	0.025		
H5b	Corporate social responsibility x Green mining practices → Corporate sustainable development	0.108*	0.037	2.956	Supported	0.021		

Note: *p < 0.05, **p < 0.001, ***p < 0.000.

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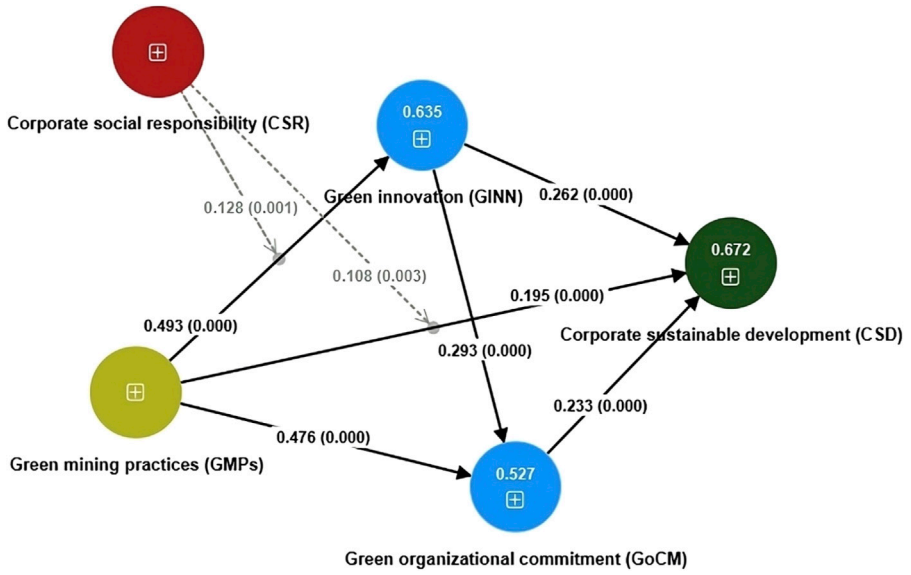

FIGURE 2
A structural model comprising moderator.

study results confirm the results of Aznar-Sánchez et al. (2019), who established that GMPs lead to improved innovation in environmental technologies, thus reiterating and supporting our findings on the role of GMPs in promoting green innovation. Our study further supports the findings of Bataineh et al. (2024) and Zhou et al. (2021), who indicated that a firm committed to eco-friendly practices is likely to engage in R&D activities with the view of improving green technologies for increased innovation.

Further, the strong positive relation of GMPs with CSD, as observed in this study, goes in line with the results from Le and Tham (2024) and Shahzad et al. (2023), who argued that with sustainability practices, a firm can achieve its long-term sustainability goals of enhancing not just ecological performance but also economic and social performances. Our findings extend this literature by confirming that those mining companies that actively pursue green practices enhance environmental performance while making reasonably significant contributions to broader sustainability objectives (Qalati et al., 2024; Rana and Arya, 2024). This indicates an inclusive nature of sustainability where ecological, social, and economic dimensions are linked through the adoption of GMPs.

Similarly, the findings also evidenced the positive influence of GMPs on employee GOC are supported by previous research, in which a values-oriented work environment leads to higher levels of organizational commitment among employees (Karatepe et al., 2022; Sharma et al., 2021). Our results suggest that in organizations that put more emphasis on GMPs, the commitment of employees towards organizational goals and green initiatives is more evident because their personal environmental values seem to be congruent with the organization's green goals. This finding has been supported by Wang (2018) when he posited that employee engagement in

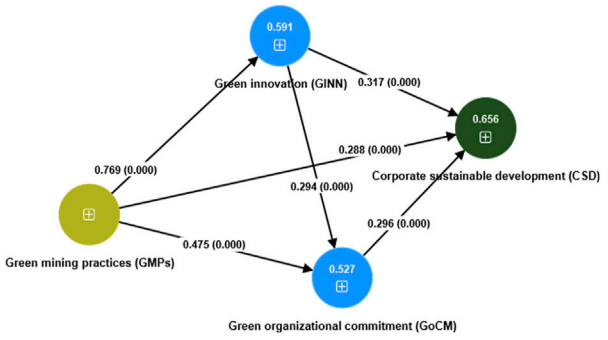

FIGURE 3
A structural model comprising without moderator.

environmental practices provides the necessary drive towards the attainment of organizational sustainability.

Furthermore, the study also found that green innovation positively influences both CSD and employee GOC, thereby confirming H2a and H2b. These findings suggest that an organization that invests in green innovation not only enhances its environmental performance but also helps to achieve broader corporate sustainability goals. This finding aligns with Fernando et al. (2019) and Le et al. (2022), who evidenced improved sustainability metrics due to green innovation within firms. Agrawal et al. (2024) and Rana and Arya (2024) also derived the same inferences that green innovation significantly reduces waste and enhances the efficiency of resources toward long-term sustainability. The value addition of this study is that this work has established a double-barreled effect of green innovation on organizational sustainability outcomes in terms of environmental performance and employee commitment toward sustainability goals.

Moreover, the green innovation-employee GOC positive effect observed in this research is consistent with earlier literature. For example, Dong et al. (2024) showed that a firm with a high level of green innovation encourages employees to be more connected with the sustainability goals of the business and hence amplifies the commitment to go green. This is also confirmed by Xie et al. (2024) and Alshura et al. (2023) finding that the presence of green innovation elicits heightened environmental awareness among employees, further fueling their commitment toward organizational green goals. To this end, our research contributes to this literature by putting an emphasis on green innovation as important in shaping the attitude of employees toward sustainability and everything green (Chen et al., 2024).

This study's findings also evidenced a positive and significant connection between GOC and CSD, thereby confirming H3. This result emphasized how the commitment of employees will drive more desired sustainability performance for the firm. For instance, employees with a greater commitment to sustainability will proactively behave by suggesting ways of innovation to improve green performance or by following the policies that concern green issues in the corporation (Ababneh, 2021; Karatepe et al., 2022; Wang, 2018). The results of the study are supported by Sharma et al. (2021), who obtained a high and positive association of employee commitment to sustainability with firm sustainability performance, which, of course, is suggestive that employee engagement serves as an essential element for the successful implementation of sustainability. The studies by Ren et al. (2022) also point to a finding that an organization with highly committed employees usually performs better in both environmental and financial sustainability measurements, wherein this study can ascertain the important role played by employee commitment for CSD.

The present study provided evidence for H4a–H4c, suggesting that green innovation and employee GOC mediate the association between GMPs and CSD. More precisely, H4a was supported, meaning that GMPs lead to green innovation, which, in turn, facilitates higher levels of CSD, as also validated by the studies of Omar et al. (2024) and Rana and Arya (2024). The studies positioned green innovation as a significant driver of sustainability outcomes; this study extends this growing body of research by showing that the adoption of green practices in the mining context is a means to green innovation and, finally, to firm sustainability. Additionally, the H4b result means that, through green practices, employees are instilled with a sense of environmental responsibility and commitment that will eventually increase the overall sustainability performance of an organization. This has proven to be in accordance with Ren et al. (2022) and Le and Tham (2024), who mentioned that the materialization of sustainability objectives requires employees' commitment to green goals. The study findings further extend this research by showing how green practices and employee engagement cooperate in an integrated manner to enhance sustainability. Such a view was also supported by Rehman et al. (2023), who indicated that green innovation, when coupled with environmental strategies, mediates the relationship between sustainable supply-chain practices and sustainable organizational performance.

Moreover, H4c results ascertained the sequential mediation of green innovation and employee GOC. This outcome signifies that GMPs first result in the adoption of green innovation, then the fostering of employee GOC, which ultimately enhances CSD. This sequential mediation shows that the variables are integrated to promote sustainability. Green innovation acts to translate GMPs into practical and innovative solutions, which then cultivates a committed workforce to realize the goals of sustainability. That shows the importance of approaches toward holistic sustainability, in that innovative practices and employee engagements work synergistically in realizing corporate sustainability (Le et al., 2024; Ren et al., 2022; Sharma et al., 2021; Waheed et al., 2024).

Lastly, results also supported the moderation effect of CSR on green innovation and CSD; this confirmed H5a and H5b. In H5a, the research outcomes suggest that an organization strongly committed to CSR will stand a better chance of realizing improved innovation outcomes from its green practices. CSR is supportive of a favorable setting and innovative thinking toward the development of new technologies and eco-friendly processes. This confirms earlier work by Simmou et al. (2023), who were of the view that CSR can turn out to be a useful driver in innovating business approaches that deal with matters better in line with societal needs. Moreover, McWilliams and Siegel (2011) found that CSR activities typically generate new capabilities and technologies that further improve environmental performance. Additionally, for the H5b, results indicate that organizations with effective CSR activities would be able to translate GMPs into more considerable CSD. The CSR activities develop the trust of the stakeholders and legitimacy, the two core elements of the CSD process. The current research, therefore gets significant support from research from Ali et al. (2020). They hypothesized that CSR would encourage firm financial outcomes through the development of trust and collaboration among stakeholders. Furthermore, it can be said that the practice of CSR by the company improves CSD by improving green practices (Masud et al., 2023).

5.1 Theoretical implication

The results also provide some theoretical implications. First regarding the TBL theory, which requires a balance between social, environmental, and economic performance (Jum'a et al., 2022; Pan et al., 2021). The study results identify GMPs as positively and directly influential in green innovation, CSD, and GOC, hence reaffirming that environmental practices are part of the integral quest for sustainable development (Albloushi et al., 2023; Salim et al., 2019). Indeed, the adoption of GMPs enables mining companies to innovate and develop a committed pool of employees who contribute towards sustainability performance in all dimensions of the triple bottom line. It supports the literature that views environmental sustainability as a driver of long-term economic performance and social wellbeing (Fernando et al., 2019; Hendarjanti, 2022; Jum'a et al., 2022). These results also support the resource-based view that had identified green practices as offering not only unique resources but also acting as a catalyst for innovation and commitment to enhance overall corporate sustainability (Al-Hakimi et al., 2022; Al-Swidi et al., 2024; Suleman et al., 2024).

Second, a substantial impact of green innovation on both CSD and GOC, as well as GOC on CSD, strengthens the theoretical assumption that employee involvement and innovation are the main drivers of CSD; therefore, it is obliged to the stakeholder theory,

which states that satisfying the interests of several stakeholders is important for long-term success (Fosu et al., 2024; Murtaza et al., 2024; Silva et al., 2023; Simmou et al., 2023).

Third, the study added scale to the coal mining industry which lacks literature (Onifade et al., 2024) and intermediating impacts of green innovation and GOC further underscore the pathways through which green practices are channelized to evoke sustainable outcomes (Le and Tham, 2024; Le et al., 2024; Omar et al., 2024; Rana and Arya, 2024; Ren et al., 2022), thus placing appropriate emphasis on the focus that TBL theory places on integrated performance (Dyllick and Muff, 2015; Pan et al., 2021).

Last, the positive moderating effect of CSR signifies that CSR activities help enhance the effectiveness of green practice; hence, this finding may be regarded as evidence for the assertion that social responsibility is a constituent element in the attainment of holistic sustainability (Awa et al., 2024). These findings enrich the literature by providing empirical data that CSR and green practices are not only compatible but also mutually enforcing to promote the overall sustainability of the mining industry.

5.2 Practical implication

The findings also have some practical implications for managers and policymakers in the mining industry. First of all, the positive outcomes of GMPs on green innovation, GOC, and CSD mean that mining companies have to pay great attention and spend valuable investment in GMPs (Onifade et al., 2024; Xiao et al., 2024). For that, managers must integrate green practices into the mainstream of business to comply with environmental regulations, stimulate innovation, and enhance employee engagement (Le and Tham, 2024; Rana and Arya, 2024; Suleman et al., 2024). The training programs, green behavior incentives, and investments in eco-friendly technologies may facilitate the establishment of a culture of sustainability. This may improve organizational performance and raise stronger commitments from employees towards the goals set regarding the environment by the company, thus contributing to CSD.

For policy-decision makers, evidence of the significant mediation effects of green innovation and GOC between GMPs and CSD, as well as the positive moderation effect of CSR, may suggest that supportive policies and frameworks are called for. Policies encouraging and supporting GI and CSR activities would further amplify the benefits of GMPs. Incentives in the form of tax breaks, research funding for green technology, and sterling examples recognition programs will attract and enhance green practices for mining companies. Second, several CSR reporting regulations can be enacted to ensure that CSR reporting will not just become a performative exercise but actually usher in sustainable development. This could be actualized through policymaking that would foster the environment for green practices and CSR in creating a more sustainable and responsible mining industry.

6 Conclusion

This research, guided by four research objectives and grounded in the TBL theory, proposed a model that comprises ten hypotheses. Utilizing data accumulated from the employees working in the mining industry of China and analyzed through SmartPLS 4.1, this study observed that GMPs facilitate green innovation, improve CSD, and enhance employees' GOC. The results prove that GMPs contribute to enhancing environmental technologies and contribute to wider sustainability. More precisely, GMPs positively impact green innovation, CSD, and GOC.

The study further evidenced the mediating and moderating role of green innovation and employee GOC in the GMPs-CSD relationship. Green innovation is considered to be the significant driver in converting GMPs into sustainable performance, while at the same time, employee GOC amplifies these kinds of efforts. Furthermore, innovating CSR enhances the performance of GMPs, thus offering support for its long-term sustainability. These results, therefore, suggest that those organizations that have considerable CSR commitments will be relatively better placed in terms of the effective implementation of GMPs. Indeed, an integrated approach to green practices, employee involvement, and CSR would yield far more comprehensive and robust outcomes for mining companies in terms of sustainability performance.

The cross-sectional design is limiting regarding causal inference, so longitudinal studies are recommended. The results also cannot be generalized since the data were obtained from only one sector, and so a concentration on several industries in future studies will enhance the external validity. Third, self-reporting biases might bring problems with the data, incorporating objective performance measures and mixed methods to provide a more panoramic view. Other conditioning variables that could also be moderating and/or mediating the GMPs and CSD relationship include organizational culture, leadership styles, and types of specific CSR activities. Potential trade-offs from economic, environmental, and social objectives in the TBL framework should also be considered when balanced and resilient strategies for sustainability are being developed for mining companies.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by the Ethics Review committee at Weifang University of Science and Technology. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

YJ: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration,

Resources, Software, Supervision, Validation, Visualization, Writing–original draft, Writing–review and editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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