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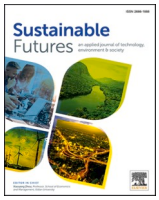

Decoding multi-paths: Context, configuration and capability resonance of ESG performance in SRDI enterprises - configuration analysis based on fsQCA and NCA

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ABSTRACT

Strengthening ESG (Environmental, social, and governance) performance is vital for high-quality green development of Chinese enterprises, especially for a large number of SRDI (Specialization, Refinement, Distinctiveness, and Innovation) enterprises. On this basis, this study develops a "context-configuration-capability" framework, drawing on optimal distinctiveness and existence/non-existence philosophy, combining NCA and fsQCA methods, and uses 87 SRDI listed companies to explore multi-state paths for enhancing corporate ESG performance.. The study finds that: (1) The ESG performance of SRDI enterprises is not driven by a single factor but is the result of the resonance and synergy among context, configuration, and capability conditions; (2) Three paths—strengthening cognition, capital raising, and technological improvement—along with government-driven transformation, can significantly enhance ESG performance in SRDI enterprises; (3) there are complementary and substitutive dynamic relationships between different conditional configurations, further enhancing the diversity and flexibility of the paths; and (4) compared to contextual conditions, configurational conditions and capability conditions produce key resonance effects in improving ESG performance. This study not only enriches the theoretical foundation of the "context-configuration-capability" framework, but also provides practical guidance on multipath resonance for SRDI enterprises in their pursuit of ESG excellence.

1. Introduction

ESG performance (Environmental, Social, and Governance) is a comprehensive indicator used to assess the sustainable development of enterprises. It encompasses the environmental impact of businesses, the fulfillment of social responsibilities, and the transparency of governance structures [1]. Since the introduction of the United Nations Global Compact in 2004, ESG performance has been a central focus of corporate research [2]. In recent years, the ESG performance of small and medium-sized enterprises (SMEs) in China has remained suboptimal [3]. This underperformance is largely attributed to the complex operational model that seeks to balance both economic benefits and social and environmental responsibilities, driven by factors such as economic digitization and policy pressures [4]. Therefore, managing the external **context** and aligning the enterprises' internal **configuration and capabilities** is crucial for optimizing ESG performance in SMEs [5], and represents an essential strategy for ensuring their sustainable future.

The term "SRDI enterprises" refers to businesses characterized by Specialization, Refinement, Distinctiveness, and Innovation. In practice, this concept applies to SMEs exhibiting these attributes [6]. According to the *2023 China SMEs Development Series White Paper* and data from various regional statistical bureaus, nine out of the top ten industries in the distribution of SMEs are comprised of SRDI enterprises [7]. Among the 12,000 companies, over 60 % are deeply involved in high-pollution industries (Traditional manufacturing industries), the rest are mostly high-tech enterprises [8]. Therefore, this article will focus on SRDI enterprises in these two industries. Notably, these industries are major sources of pollution, where the pressures for a low-carbon transition are particularly acute [9]. Previous studies have examined the impact of factors such as organizational structure, operational models, industrial transformation, technological upgrading, and environmental protection concepts in these two industries on ESG performance [10]. It overlooks the interaction mechanisms of ESG performance indicators in the context of imperfect low-carbon economic models. As a result, it fails to

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address the more complex relationships of adaptation and coexistence between the internal configuration, capabilities, and external context of SRDI enterprises [11]. On the other hand, SRDI enterprises are influenced by a range of complex internal and external factors, making their ESG performance a subject of study that involves numerous interrelated causes and effects [12]. If regression analysis is applied to examine the conditional configuration between internal configuration, capabilities, and external contexts, it can only reveal the net effect relationship between a single antecedent condition and the outcome [13]. Moreover, it is not possible to identify the multiple pathways through which a specific combination of conditions influences ESG performance. However, by applying the fsQCA (Fuzzy-set Qualitative Comparative Analysis) method, the underlying reasons for the conditional configuration of the outcome can be examined using attribution logic.

Therefore, drawing on the concept of configuration set theory, this paper focuses on the proposition of ESG performance in SRDI enterprises. Using fsQCA and NCA (Necessary Condition Analysis) methods [14], the paper seeks to address the following questions:

- What conditions influence the ESG performance of SRDI enterprises in the context of digital economy?
- Is there a single condition that constitutes a necessary factor for ESG performance?
- Which pathways of antecedent conditions are critical to enhancing ESG performance?
- What is the heterogeneity of ESG performance improvement in traditional manufacturing and high-tech industries ? How to give theoretical or practical enlightenment to academia and industry ?
- What categories can the promotion pathways be classified into? Can key factors be identified to support the development of China's SRDI enterprises in a high-quality and sustainable manner?

The potential contributions of this study are as follows: This research focuses on the ESG performance of SRDI enterprises, which have previously been overlooked in terms of green development, thus offering a new direction for empirical studies on their ESG performance. It also provides theoretical guidance and practical insights for corporate managers in selecting appropriate ESG improvement pathways based on their specific circumstances. Furthermore, this study offers valuable experience and reference for governments at various levels in formulating and enhancing policies related to the cultivation and green development of SRDI enterprises. Finally, we conclude by emphasizing the robustness of findings, which are supported by the application of multiple analytical methods and the validation of our results across different scenarios.

2. Theoretical basis and research model

2.1. Optimal distinctiveness theory and philosophical thought of transformation of existence and non-existence

In the field of sustainable development, Deephouse introduced the concept of strategic balance for the first time [15], emphasizing that when enterprises pursue the uniqueness of ESG performance, they should also align with industry standards and stakeholder expectations to achieve optimal ESG performance. Building on this, IE Iamandi further explored the multidimensional characteristics of the ESG strategy and advocated that enterprises should seek a balance point by managing the tension between legitimacy and differentiation across each dimension of ESG [16]. This balance point is the optimal distinctiveness of ESG [17]. Enterprises should formulate an ESG development path that is precisely tailored to their particular set of resources, inherent competencies, market positions, and overall strategic aspirations. This path might be more focused on the external context in response to the global appeal for sustainable development. It may also place greater emphasis on capacity building to enhance the social image of enterprises and acquire consumer trust. Alternatively, pay more attention to governance structures to increase corporate transparency and compliance. Each enterprise must carefully design its ESG path, balancing various considerations to forge a strategy that is truly suited to its own needs and aspirations.

The transformation between existence and non-existence is a philosophical concept that embodies the development and change of things. It emphasizes that, under certain conditions, existence and non-existence can transform into each other and promote one another. "Existence and non-existence" is often associated with the Taoist philosophy of the unity of opposites, such as yin and yang, transformation and mutual existence [18]. Lao Tzu said that all things in the world are born of existence, and existence is born of non-existence (Chapter 40 of Tao Te Ching) [19]. Lao Tzu believes that there is no contradiction between existence and non-existence, much like in yin and yang, static and dynamic, which are both opposites, unified, interdependent, and transformative. As the saying goes, "There is no mutual existence, it is difficult and easy to complement each other, the long and short shape each other, the high and the low are inclined, the sound and sound are harmonious, and the front and back follow each other' (Chapter 2 of Tao Te Ching) [20]. It reflects a process of mutual transformation from existence to non-existence or from non-existence to existence. Under this ideological framework, existence and non-existence are no longer fixed attributes but forces that can transform into each other under specific conditions [21]. For SRDI enterprises, in this context, "existence" refers to resources, capabilities, or conditions that are already present or well-established within the enterprise, such as technological infrastructure, organizational strengths, or financial stability. "Non-existence," on the other hand, symbolizes gaps, challenges, or areas that are yet to be developed, such as lack of financial resources, underdeveloped technologies, or insufficient corporate awareness regarding ESG performance. Although their conditions for improving ESG performance will be constrained by factors such as a low-carbon background and digital economy, they can still pursue emerging advantages by enhancing their technological advantages and market position (existence). This includes breakthroughs in specific fields or overcoming weak conditions (non-existence), enabling a shift from weak (non-existence) to strong (existence). This transformation is not merely a process of regression, but rather a strategic adjustment and rebalancing to align with evolving external circumstances and internal needs. Enterprises step outside existing successful models and face unforeseen risks. This process moves from strength to weakness, as enterprises seek to consolidate and overcome existing shortcomings, thereby moving from a position of weakness to strength. These two processes are interdependent and work in tandem to enhance corporate ESG performance.

From both macro and micro perspectives, the two aforementioned theories clarify the mechanism that propels ESG performance in SRDI enterprises. Optimal discrimination theory helps various SRDI enterprises choose appropriate ESG enhancement strategies. The concept of transforming between existence and non-existence further provides transformation and combination notions for strong and weak ESG performance. Rooted in the interdependence and harmonious coexistence of existence and non-existent conditions, the effective coordination of various antecedent variables by enterprises can create synergies to enhance corporate ESG performance. This coordinated transformation process not only embodies the notion of transformation but also offers valuable insights for enterprises in a dynamically evolving environment. It enables enterprises to embrace various existence and non-existence elements, and attain sustainable competitive advantages and high-quality development.

2.2. "Context-configuration-capability" theory and SRDI

In this section, VOSviewer software was utilized to analyze 180 articles in "Web of Science" (WOS Database) themed around "ESG performance of SMEs" The keyword co-occurrence is depicted in Fig. 1.

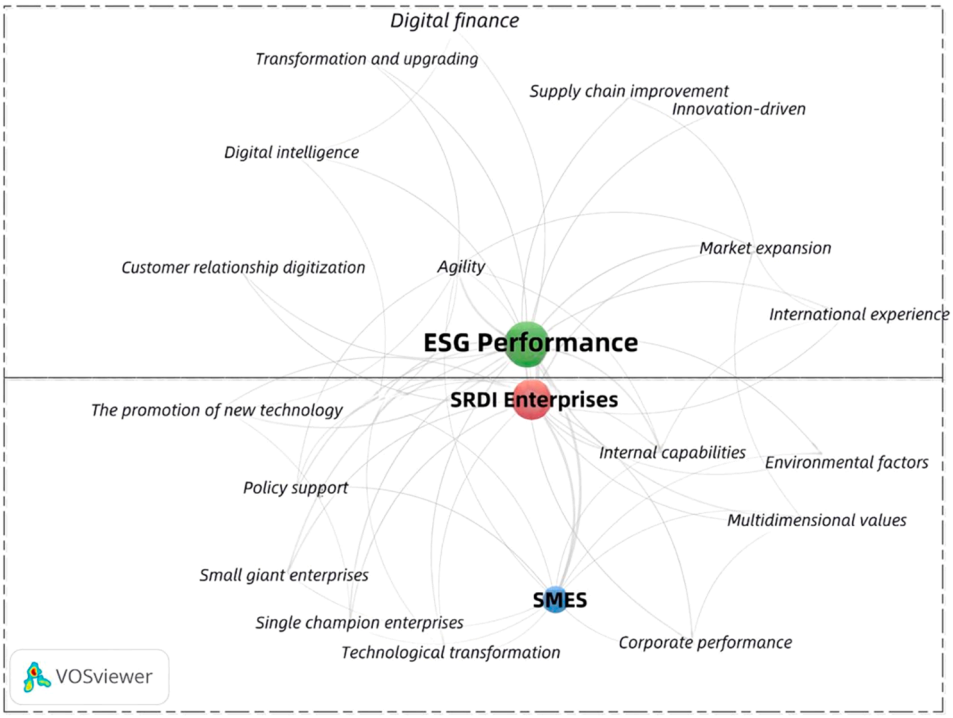

Fig. 1. VOSviewer keyword analysis.

Table 1
Analysis of co-occurrence entries.

Co-occurrence entry	Context	Configuration	Ability
ESG performance	International experience, Market expansion	Agility, Supply chain improvement	Digital intelligence, Digital finance
SRDI enterprises	Policy support, Environmental factors	Internal capabilities, Corporate performance	The promotion of new technology, Technological transformation

Table 1 reveals that the terms frequently co-occurring with ESG performance in SMEs encompass three dimensions: context, configuration, and capability. "SRDI" denote professional skills (capabilities), meticulous production (capabilities), distinctive resources (configuration), and innovative models (context). Consequently, this study tentatively proposes that the "context-configuration-capability" framework is suitable for examining pathways to enhance SRDI enterprises' ESG performance.

"Context-Configuration-Capability" theory, or 3C theory, describes the complex, systematic process of self-innovation each enterprise engages in and the establishment of its core business network under dynamic and complex conditions. It encompasses three aspects: context, configuration, and capability. In light of Teece's research orientation, D et al. introduced the 3C theory from the process of enterprise innovation and performance enhancement into the research domain of SRDI enterprises [22] . On the basis of Rong's expansion of the 3C theory [23], in combination with his concepts of government collaboration, governance structure, and environmental alteration, and considering the elements related to ESG performance, Fang further refined the theory to make it applicable for ESG-related research [24]. Therefore, this study applies this framework to the ESG performance research of SRDI enterprises. SRDI enterprises face a range of critical situational factors throughout their development trajectory, including operational levels and policy incentive mechanisms [25]. An enterprise's allocation strategy involves the strategic deployment of the enterprise's senior management team. It also includes the design of the organizational structure and arrangement of various resources accumulated on its own scale. The capability level focuses on the intrinsic characteristics of the organization, particularly its capacity for technological innovation and its ability to adapt to policy changes, such as pursuing green development. In different development scenarios, enterprises adopt context-configuration-capability strategies tailored to their resources and conditions [26]. The integration of these strategies will directly impact a company's ESG outcomes and result in diverse ESG performance. Therefore, this study begins with the three key dimensions—context, configuration, and capability—and conducts a thorough investigation into the interactions among these dimensions and their mechanisms of action on ESG performance.

2.3. Model construction

(1) Contextual dimension. On the one hand, the theory of economic externality posits that enterprises may generate positive or negative external effects through their economic activities, and these effects are often not internalized by market mechanisms. Specifically, Trahan argues that the theory of economic externalities is a fundamental theoretical pillar of ESG, and these externalities are significant factors influencing corporate ESG performance [27]. However, the investment of SRDI enterprises in clean energy or environmentally friendly technologies generally brings positive external effects, such as reducing pollution and improving public health. However, these positive effects are often not directly translated into economic benefits for enterprises, as the market may not be able to fully reward these actions [28]. Therefore, the government needs to adopt certain policy tools (financial subsidies, tax incentives, market mechanism design) to ensure that external effects are internalized into the cost structure of enterprises, thus comprehensively and profoundly affecting the ESG evaluation system [29]. Therefore, through policy interventions, such as financial subsidies or tax incentives, the government can encourage companies to adopt more environmentally friendly production methods and improve their ESG performance. On the other hand, the resource-based

view believes that companies obtain more capital, technology or expertise through capital raising to invest in sustainable development projects, thereby improving their ESG performance. In the resource-based view, resources include tangible assets (such as capital and equipment) and intangible assets (such as brands, patents and corporate culture) of enterprises [30]. Different enterprises have different kinds and quantities of resources, and the uniqueness and scarcity of these resources can bring competitive advantages to enterprises. Under the background of economic downturn, it is particularly important for SMEs to obtain cash, a scarce resource. After obtaining full economic value, it can create greater social value by effectively managing funds and driving the utilization of other resources. Therefore, the contextual dimension includes two antecedent conditions: financial subsidy and capital raising.

(2) Configuration dimensions. On the one hand, the theory of strategic cognition holds that the cognition of top management team (TMT) affects the formulation and implementation of enterprise strategy. If the TMT recognizes the importance of an ESG strategy for the long-term success of a business, it may place more emphasis on ESG-related decisions and actions. Studies have shown that TMT heterogeneity has a significant negative impact on corporate ESG performance, and the management shareholding ratio can alleviate corporate shortsighted investment and inhibit its negative impact on ESG performance [31]. Furthermore, TMT heterogeneity manifests in academic background and life experience. Studies have demonstrated that the personal background and experience of the TMT are influenced by cognitive level. The stronger their green and digital cognition, the more capable they are to promote the corporation's ESG performance of the corporation [32]. These research findings provide empirical support for understanding the relationship between executive team cognition and a corporation's ESG performance. On the other hand, the U-shaped relationship theory between enterprise size and ESG performance posits that the impact of corporate social responsibility (CSR) fulfillment on ESG outcomes may follow a U-shaped curve. Specifically, both very small and very large enterprises may exhibit a positive influence on ESG performance [33]. SMEs may pay greater attention to their social and environmental impacts owing to their high flexibility, rapid decision-making, and strong reliance on local communities. Therefore, the configuration dimension encompasses two antecedent conditions: TMT cognition, and enterprise size.

(3) Capability Dimension: The theory of innovation-driven development posits that R&D intensity is typically regarded as a crucial indicator of an enterprise's innovation capability. A higher R&D intensity can facilitate the innovation of enterprises in environmentally friendly technologies and social responsibility practices, thereby enhancing their ESG performance. Since innovation achievements are frequently difficult to emulate by competitors, R&D can confer a sustained market position on enterprises, thereby assisting them in establishing long-term competitive advantages [34]. Concurrently, through innovation in environmentally friendly technologies and social responsibility practices, companies can not only elevate their brand image and market competitiveness but also achieve superior performance in ESG. On the other hand, the theory of competitive advantage contends that digital transformation can create competitive advantages for enterprises and enable them to perform better in ESG by enhancing efficiency and innovation capabilities. The utilization of digital technologies can optimize the use of environmental resources and reduce energy consumption; digital platforms can enhance the visibility and influence of corporate social responsibility campaigns; and digital tools can improve corporate transparency and compliance [35]. Hence, the capability dimension encompasses two antecedent conditions, R&D intensity and digital transformation. On this basis, this paper constructs a research model of antecedent variables from three dimensions and six variables selected through previous literature research. For the synergistic relationship of coupling and substitution of these antecedent variables at the core of the first circle, this paper further uses the NCA and fsQCA methods in configuration analysis to infer the ESG performance of SRDI enterprises, as depicted in Fig. 2.

In summary, previous studies have conducted a more in-depth study of corporate ESG performance through regression analysis from a single subdivision field from multiple perspectives such as context, configuration, and capabilities, but have ignored the interdependence between organizational attributes (antecedent conditions) and possible "chemical reactions." Once antecedent conditions present a relevant state, the unique effects of a single condition may be concealed by other conditions. In addition, compared with the context that regression analysis needs to control a large number of variables to ensure the robust results, the antecedent conditions of QCA and the outcome variables do not always show a unified and symmetrical relationship, and the social phenomenon that the conditions are coupled with each other is more in line with common sense and has "authenticity". Hence, multiple configurations of the antecedent conditions of ESG performance require further research.

3. Research design

3.1. Method selection

Following the introduction of the QCA method by Ragin, a renowned sociologist, and its subsequent development by Professor Du Yunzhou, it has been firmly established in complex macro-micro social issues within China and has gradually emerged as a novel approach to management research from the perspective of configuration set theory and qualitative comparative analysis [36]. In contrast to quantitative research based on the backdrop, where each antecedent variable is mutually independent, the QCA method not only enables quantitative research to explore the "net effect" of a single antecedent variable on the outcome variable, but also facilitates the analysis of the patterns within a large number of causal set relationships in social phenomena as a whole [37]. In the digital economy, the ESG performance of SRDI enterprises is determined by multiple factors and features complex cause-and-effect relationships, making it challenging to be explained from an isolated aspect. Additionally, SRDI enterprises in this study originated from SMEs, and their development trajectory coincides with the theory of transformation of strength and weakness and optimal distinction.

From both theoretical and practical perspectives, this study addresses its research questions by employing a combination of QCA and NCA to explore the complex causal mechanisms underlying the strong or weak ESG performance of SRDI enterprises. Considering that fsQCA possesses advantages that other QCA methods do not have, it can not only handle the issue of kind and degree but also explore the influence of the combination of multiple antecedent variables on the result variables. Therefore, the fsQCA was selected as the principal research method in this study. Concurrently, in view of the disadvantage of the QCA method, it is not possible to analyze the degree of change trend between antecedent and outcome conditions from a quantitative perspective. Hence, the NCA method of Professor Dul of the Rotterdam School of Management in The Netherlands was utilized as a supplementary approach to enhance the persuasiveness of this study [38].

3.2. Case selection and data collection

To explore how SRDI enterprises navigate ESG challenges, this study focuses on small giant enterprises, which are highly specialized and innovative yet face resource constraints typical of smaller firms. These

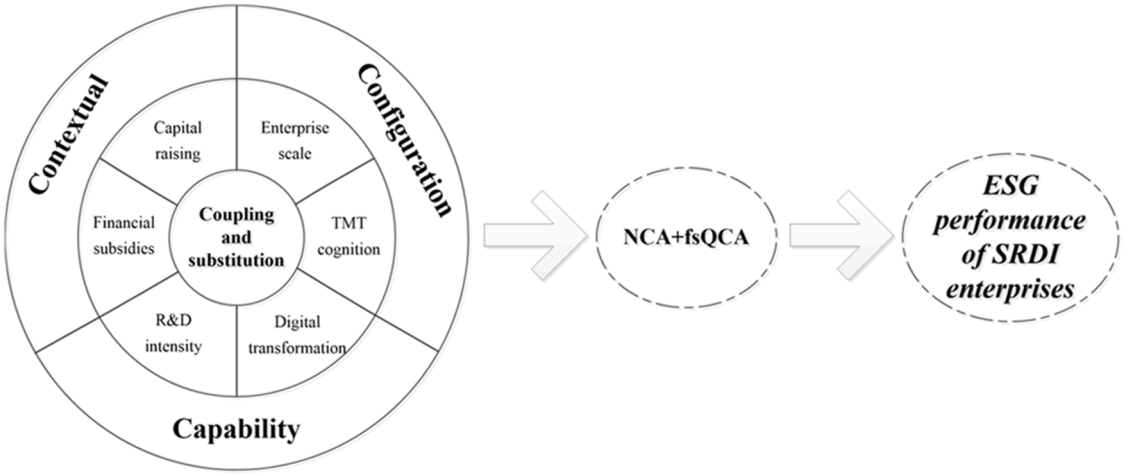

Fig. 2. Conceptual framework of ESG factors and their relationships in SRDI Enterprises: based on fsQCA and NCA.

enterprises strike a balance between agility and competitiveness, making them an ideal focus for examining how smaller firms adapt to the growing pressures of ESG performance. By understanding how small giants address these challenges, we aim to offer insights that could benefit a wider range of SRDI enterprises, particularly in terms of leveraging innovation and strategic focus to improve ESG performance. Given the distinct ESG dynamics between high-pollution and high-tech industries [39], our sample explicitly covers 52 manufacturing enterprises (59.8 %) and 35 high-tech enterprises (40.2 %) from the SRDI one-stop service platform connected to the Beijing Stock Exchange. This industry proportion aligns with the national distribution pattern observed in prior studies [40]. The dual-industry sampling ensures representation of: (1) manufacturing enterprises requiring environmental remediation and regulatory compliance, and (2) high-tech enterprises emphasizing digital sustainability solutions [41].

Because small giant enterprises within SRDI enterprises constitute the core strength of high-quality SMEs, we selected all A-share listed companies with active registration status (excluding abnormal operations) across these two strategic industries. The 87 enterprises' ESG data were triangulated through: (1) CSMAR industry classification codes (CIC 13–43 for manufacturing, CIC 72–75 for high-tech) [42]. (2) WIND database environmental remediation cost items (filtered by industry keywords) [43]. (3) Manually crawled policy documents from provincial Ecology & Environment Bureau portals. This multi-source approach captures both quantitative metrics (e.g., emission intensity) and qualitative industry-specific governance practices [44].

Given the lag in the ESG performance of SRDI enterprises, this study uses data from specialized, refined, and innovative enterprises in 2022 as the baseline period and matches it with the 2023 ESG performance data, which lags by one period, along with corresponding conditional variables.

3.3. Measurement and calibration

3.3.1. Outcome variables

The outcome variable chosen in this study was the ESG performance. To embody the concept of set theory, this study consolidates ESG performance into an ESG scoring system and comprehensively evaluates corporate ESG performance via the ESG scoring system. Moreover, given the disparities in index construction dimensions and update time among numerous ESG rating agencies, drawing on the research findings of Chen and considering the data characteristics of this study, which include a large corporate coverage and a high update frequency, the ESG score of WIND, which is more comprehensive than other ESG scoring systems, was selected [45].

3.3.2. Antecedent conditions

Capital raising. The development tracks of SRDI enterprises primarily focus on high value-added industries, such as high-precision and sophisticated industries, which are characterized by strong profitability. The large amount of cash flow obtained from profits has become the main source for repaying debt and equity cash flows of the main business, thereby reflecting the financing context. Therefore, building on Xu's research results, this study takes the return on equity (ROE) of the CSMAR database as the proxy variable of financing capabilities [46].

Financial subsidies. Financial subsidies reflect the context in which enterprises obtain government funding. Drawing on the common treatment methods of Riedy [47], this study uses the natural logarithm of various government subsidies to enterprises disclosed in the CSMAR database as a measure of the level of financial subsidies.

Enterprise size. The strength of enterprise size reveals its ability to allocate and use resources. Drawing on Hansen's research, this study adopts the natural logarithm of the enterprise's operating income as a proxy for enterprise size [48].

TMT cognition. As the invisible superstructure of the enterprise, apart from internal control, the cognition of the top management team is defined as information based on the top management team's own knowledge, work experience, broad vision, policy grasp, etc., which ultimately helps the enterprise achieve overall cognitive awakening and form a conducive environment. A cognitive structure integrating society and governance specifically includes factors such as cognition of green competitive advantage, perception of corporate social responsibility, and orientation of digital governance innovation. Drawing on Scupola's measurement method [49], this study uses Python to extract text information related to the above three dimensions from the company's annual reports through web crawling.. After obtaining the total number of text word frequencies related to TMT cognition using Nvivo12 Plus, the data are processed using $\ln(x + 1)$ to derive the degree of TMT cognition. Details are presented in Table 2.

Digital transformation. The resources acquired by digital transformation are at the core of SRDI enterprises to gain key competitive advantages. The transformation based on digital technology and data resources involves the digital iteration of the entire enterprise production chain, helping enterprises integrate and rebuild corporate governance structures, green production processes, and focus on the business models of all stakeholders, aiming to promote digital elements and ESG Deep matching of elements. Therefore, this study adopts the comprehensive index of enterprise digital transformation disclosed by the CSMAR database as a proxy for ability level of enterprise digital transformation [50].

R&D intensity. Most scholars select the R&D expenditure disclosed in the annual report of enterprises for standardization to measure R&D

Table 2
TMT cognitive text mining keywords.

Indicator dimension	TMT cognitively related text
Cognition of green competitive advantage	Harnessing Renewable Energy, Reducing Carbon Footprint, Eco-Design, Green Supply Chain Management, Circular Economy Practices, Applying Energy Saving Technologies, Cleaner Production Processes, Environmentally Friendly Packaging, Building Green Brands, Sourcing Sustainable Materials, Managing Water Resources, Conserving Biodiversity, Green Finance, Assessing Environmental Impact
Perception of corporate social responsibility	Social Contribution, Environmental Responsibility, Fair Trade, Community Engagement, Employee Well-being, Transparency, Ethical Standards, Consumer Rights Protection, Cultural Diversity, Sustainability cognition
Orientation of digital governance innovation	Intelligent Audit System, Compliance Automation, Strategic Innovation Management, Organizational Structure Optimization, Leadership Development, Corporate Culture Shaping, Risk Management Innovation, Agile Management, Smart Contract Application, Technology-Driven Process Improvement, Knowledge Management Innovation

intensity. Drawing on Padgett, this study tadopts the ratio of R&D expenditure to operating income as a measure of this index, thereby reducing the impact of extreme values on the subsequent fuzzy membership calibration in fsQCA [51].

3.3.3. Variable calibration

Accurate measurement and variable classification are crucial steps in this study. This process encompasses mapping quantitative data into qualitative sets, and subsequently determining the membership degree of each case within the set. The definition of membership degree is founded upon the fusion of the theoretical framework and empirical data, and it is categorized into three levels: Full Affiliation, Intersection Point, and Completely Unaffiliated, with values ranging within a continuous interval from 0 to 1. Du et al. proposed three calibration techniques for this procedure: the direct assignment, direct calibration, and indirect calibration methods [52]. Among these techniques, the direct calibration method is particularly precise because of its integration of statistical principles, and has been widely employed in empirical research.

In view of the lack of direct comparison benchmarks of six independent variables and one dependent variable faced by this study, this study adopted the data-dependent calibration method (also known as the empirical calibration method), which is employed when neither official external standards nor benchmark-based calibration is available [53]. In this method, the thresholds for full inclusion, intersection, and full exclusion are determined based on the empirical distribution of the data itself rather than relying on external benchmarks or formal standards. Drawing on Karakas's research strategy, this study selected 95 %, 50 %, and 5 % quantiles as the Full Affiliation, intersection, and Completely Unaffiliated reference points of calibration, respectively [54]. To avoid the difficulty of case classification caused by a membership score of exactly 0.5, this study reduced the membership score by 0.001 when the score was 0.5, ensuring that cases could be accurately classified within the subsequent analysis framework. This adjustment facilitates more accurate necessary condition and configuration analyses. The calibration anchor points for each variable are presented in Table 3.

4. Data analysis and discussion

4.1. Necessary condition analysis (NCA)

In this section, NCA analysis was performed after installing the Necessary Condition Analysis package using R4.3.1, to explore the potential factors affecting ESG performance. Given the continuity of the data, the CR (Conservative Resolution) method was primarily utilized to estimate the upper range, with the calculated values of the CE (Conservative Estimation) method serving as supplementation for comparison. In the R-Studio software, a necessary test of the calibrated fuzzy set data was conducted. According per the test results presented in Table 4, the precision, upper limit area, and effect size obtained through the utilization of both the CR and CE estimation methods indicated that the necessity of all antecedent conditions was not significant ($p > 0.05$), indicating that the antecedent condition alone did not constitute a necessary condition for influencing the results. Additionally, in accordance with Du Yunzhou et al. [55], when the effect size of a single condition exceeds 0.1 and the P value was significant ($P < 0.05$), the condition was regarded as a necessary condition for the outcome. However, the necessary effect of all antecedent conditions was not significant ($p > 0.05$), suggesting that these conditions were insufficient to trigger the outcome, which reflects that the combined antecedent conditions can form a set relationship with the outcome variables. The bottleneck level refers to the lowest value that the antecedent condition is required to attain to achieve a 100 % ESG performance level within the maximum observation range of the variable. The results presented in Table 5 indicate that enterprise size and TMT cognition need to reach levels of 5 % and 3 %, respectively (< 10 %), further substantiating that all antecedent conditions are not necessary conditions.

The fact that no single antecedent condition is necessary for high ESG performance suggests that achieving high ESG outcomes is not reliant on one particular factor, but rather the combination of multiple, interrelated conditions. This finding aligns with the complexity of ESG challenges, where success is typically the result of several factors working together synergistically. For example, an SRDI enterprise that excels in governance transparency might still fall short in environmental practices without a concerted effort to integrate sustainability across all aspects of its operation [56]. Conversely, a company strong in environmental practices might fail to achieve high ESG performance if it neglects social responsibility or governance considerations. This highlights the need for a holistic approach, where all aspects of ESG—environmental, social, and governance—are integrated into a unified strategy, rather than relying on one factor as a silver bullet for success [57]. This aligns with complex adaptive systems theory, which posits that sustainability outcomes are path-dependent and contextually

Table 3
Calibration anchor points for each condition.

Dimension	Conditions and Results	Target Set	Calibrate anchor points		
			Full Affiliation	Intersection Point	Completely Unaffiliated
Context	Capital raising	Good fundraising	0.527	0.4	0.206
	Financial subsidies	Adequate government grants	17.733	16.33	14.269
Configuration	Enterprise size	Core enterprises in the industry	21.798	20.46	18.922
	TMT cognition	Comprehensive and leading perception	60.966	36.05	23.294
Capability	R&D intensity	Adequate R&D funding	0.241	0.06	0.03
	Digital Transformation	Existence digital transformation	49.589	29.64	22.438
ESG	ESG Performance	Higher ESG score	7.244	5.59	4.78

Table 4
NCA necessity analysis for each condition.

Antecedent condition	Method	Accuracy	Ceiling zone	Scope	Effect size	P value
Capital raising	CR	100 %	0.008	0.950	0.040	0.369
	CE	100 %	0.012	0.940	0.016	0.352
Financial subsidies	CR	100 %	0.009	0.960	0.024	0.167
	CE	100 %	0.013	0.950	0.003	0.167
Enterprise size	CR	100 %	0.018	0.880	0.004	0.129
	CE	100 %	0.002	0.990	0.003	0.129
TMT cognition	CR	100 %	0.004	0.990	0.014	0.057
	CE	100 %	0.003	0.970	0.003	0.068
R&D intensity	CR	100 %	0.010	0.980	0.006	0.093
	CE	100 %	0.005	0.940	0.002	0.094
Digital Transformation	CR	100 %	0.009	0.960	0.004	0.197
	CE	100 %	0.014	0.980	0.001	0.296

Note:

Table 5
Analysis of necessity bottleneck level (%) of NCA.

ESG Performance	Capital raising	Financial subsidies	Enterprise size	TMT cognition	R&D intensity	Digital Transformation
0	NN	NN	NN	NN	NN	NN
10	NN	NN	NN	NN	NN	NN
20	NN	NN	NN	NN	NN	NN
30	NN	NN	NN	NN	NN	NN
40	NN	NN	NN	NN	NN	NN
50	NN	NN	NN	NN	NN	NN
60	NN	NN	NN	NN	NN	NN
70	NN	NN	NN	NN	NN	NN
80	NN	NN	NN	NN	NN	NN
90	NN	NN	NN	NN	NN	NN
100	NN	NN	5.1	3.2	NN	NN

Note: Using CR method, NN means unnecessary.

embedded [58] According to this theory, ESG performance is not the result of a single isolated factor; rather, it emerges from the dynamic interaction of multiple conditions that must adapt to the specific context of the enterprise.

4.2. fsQCA conditional configuration analysis

4.2.1. Necessity analysis based on fsQCA

In fsQCA, knowing the consistency and coverage degree of each antecedent variable is a preliminary step in constructing and solving the truth table. The results are presented in Table 6.

According to Du Yunzhou's research, only when any antecedent condition that constitutes either the existence or non-existence of ESG performance attains a consistency level exceeding 0.9 and a coverage greater than 0.5, can a single necessary condition be regarded as the necessary condition that constitutes either the existence or non-existence of ESG performance. The analysis in Table 6 reveals that the consistency of a single antecedent condition for high ESG performance and weak ESG performance is <0.9, and none of the conditions constitute a necessary condition, which is in line with the conclusion under the NCA method. In other words, no single factor was identified as a necessary condition for high ESG performance.

Table 6
Results of the necessity of using fsQCA analysis for each condition.

Antecedent condition	High ESG Performance		Non-high ESG performance	
	Consistency	Coverage	Consistency	Coverage
Capital raising	0.729995	0.635286	0.635728	0.656814
~ Capital raising	0.605651	0.583416	0.646994	0.739907
Financial subsidies	0.689770	0.616050	0.649027	0.688169
~ Financial subsidies	0.650853	0.609684	0.637888	0.709394
Enterprise size	0.727481	0.635322	0.618406	0.641162
~ Enterprise size	0.589109	0.565291	0.648265	0.738499
TMT cognition	0.549991	0.537690	0.667704	0.774965
~ TMT cognition	0.769816	0.661175	0.601677	0.613499
R&D intensity	0.570857	0.596658	0.592233	0.734872
~ R&D intensity	0.746336	0.606562	0.674947	0.651227
Digital transformation	0.564824	0.521918	0.674269	0.739680
~ Digital transformation	0.718279	0.650035	0.564196	0.606170

Note: "~" represents "NOT" of logical operation.

4.2.2. Conditional configuration analysis

Based on the requisite analysis of the ESG performance of small giant enterprises, this study further undertakes a multi-factor configuration analysis, with the objective of thoroughly examining the influence of the combined allocation of diverse factors within the "context-configuration-capability" framework on ESG performance. When conducting adequacy analyses, Ragin's study was referred to, with an agreement threshold of 0.85 and a PRI agreement of 0.75. The setting of the case frequency can be construed as the initial data cleaning in quantitative research. Given that the sample size is 87, this study adheres to the guidance of Grofman [59] in the QCA methodology and sets the calibration parameter to one, retaining approximately 93 % of the data, with the aim of guaranteeing the scientificity of the results after controlling for all cases that are truncated below the stipulated parameters. Furthermore, considering that the evaluation of ESG performance of SRDI enterprises is in the exploratory stage, there exist numerous interpretative notions in academia and industry, and the focus of attention remains indistinct. This study determined the prognosis of the causal relationship between all antecedent conditions and outcome variables. The judgment analysis (XY Plot analysis) indicates that the antecedent variables and the outcome variables form a "Present or Absent" relationship. Based on this finding, this study formulates truth-table information encompassing six configurations. When the results are derived, the intermediate solutions are primarily reported for sufficient or necessary issues, and the core and marginal conditions are screened in accordance with the path comparison intermediate solutions in the parsimonious solution configuration. The results are presented in

Table 7
Analysis of configuration results of high ESG performance of small giant companies within SRDI enterprises.

Antecedent condition	H1a	H1b	H1c	H2a	H2b	H3
Capital raising		⊗		●	●	●
Financial subsidies	⊗			⊗		●
Enterprise size	●	●	●	●	●	●
TMT cognition	●	●	●	●	⊗	
R&D intensity	●	●		●	●	●
Digital Transformation	●		●	●	●	●
Consistency	0.809	0.899	0.897	0.892	0.853	0.852
Original coverage	0.514	0.406	0.353	0.234	0.202	0.240
Unique coverage	0.124	0.029	0.003	0.017	0.015	0.046
Consistency of solutions	0.868					
Coverage of solution	0.682					

Note: ●indicates that the core condition exists; •indicates that an edge condition exists; ⊗indicates that the core condition is missing; ⊗indicates that the marginal condition is missing; and a blank indicates that a condition may be present or absent.

Table 7. For the individual configurations, the consistency level of the six paths was higher than 0.8. Overall, the overall agreement was 0.868 (greater than the minimum of 0.75) and the overall coverage was 0.682, which explained approximately 68.2 % of the sample cases.

Based on the condition configuration characteristics that lead to high ESG performance combined with the analysis in Table 6, it can be seen that each configuration can provide an explanation for high ESG performance and is a combination of sufficient conditions for companies to improve ESG performance. Based on the optimal distinctiveness theory and philosophical thought of the transformation of existence and non-existence, this paper names the discovered configurations according to different core conditions, and extracts three "optimal paths" that show the strength of conditions: Self-reliance and strengthening cognition (H1a, H1b, H1c), Capital raising and improving technology (H2a, H2b), and relying on the government to promote transformation (H3).

(1) **Self-reliance and strengthening cognition.** Configuration H1 (H1a, H1b, H1c) contextual conditions are non-existent (weak), and the configuration conditions are existence (strong), which shows the effect of great enterprise configuration conditions driving the ESG performance of small giant enterprises, that is, while focusing on the main business to increase revenue, the TMT configuration model to improve cognitive level.

The core variables of this model are the enterprise size and TMT cognition. The consistency of the three paths was 0.809, 0.899, and 0.897, and the original coverages were 0.514, 0.306, and 0.353, respectively. On an average, approximately 51 %, 41 %, and 35 % of the sample cases in the three paths can be explained. Most enterprises have achieved high ESG performance (practical manifestation of a company's ability to achieve and sustain positive ESG outcomes in its operations) using this configuration model. The common characteristic shared by these enterprises is that, without considering the financing through equity and creditor rights, the enterprises in this configuration prioritize their core business, focusing on expanding the scale of operations and increasing operating income.. When receiving fewer financial subsidies, the TMT primarily utilizes the cash flow from the core business to enhance the team's cognition and learns from benchmark enterprises through public learning, industry conferences, and other methods. Digital innovation governance is employed to develop corporate follow-up strategies to quickly achieve high ESG performance. Therefore, the modality referred to as "self-reliance and strengthening cognition." The fundraising ability and government subsidies for paths H1a and H1b are weak. Enterprises on these two paths can promote high ESG performance through deep plowing technology and tap the potential of digital transformation. Therefore, the configuration is suitable for enterprises with strong business strengths and focuses on improving TMT cognition.

Typical companies in this configuration are Tianan New Materials (Guangdong), Yinbang Co. Ltd. (Jiangsu), and Dawn Co. Ltd. (Shandong). Consider the Tianan New Materials as an example. The company has been in operation for >10 years. In recent years, its financing capabilities have been relatively weak, and its financial subsidies have been insufficient. However, the company has increasingly focused on its core business while simultaneously enhancing the cognitive level of its executives. In the field of intelligent materials and environmentally friendly new materials, Tianan New Materials has progressively transitioned from traditional "high-carbon, high-pollution" products to "environmentally friendly new materials" products, which possess stronger core competitive advantages, enabling the company to secure a leading position in the industry and achieve high ESG performance.. In its ESG strategies, while the company's focus on innovation in environmentally friendly materials allows it to stand out in the market (differentiation), it also aligns its ESG strategy with industry standards by adhering to sustainability certifications and complying with environmental regulations. For instance, it integrates its green product innovation with widely recognized sustainability certifications (such as LEED or ISO 14,001) to ensure that their products meet the environmental expectations of customers and regulators while maintaining a distinct competitive edge in eco-friendly construction materials [60]. It is precisely because of the context of digital transformation and energy conservation and carbon reduction that the "strength" of the group's enterprise size and TMT cognition, coupled with the "weakness" of other conditions, undergoes mutual transformation, thereby stimulating the potential for enhancing ESG performance and guiding Tianan New Materials towards a path of digital innovation and high-quality development in energy conservation and carbon reduction..

(2) **Capital raising and improving technology.** Configuration H2 (H2a, H2b) has strong contextual conditions and extremely strong capability conditions, but weak configuration conditions; that is, when the enterprise lacks financial subsidies and its own enterprise resource accumulation is weak, it relies on the capital-raising ability and the enterprise's own hematopoietic profit function and fully devotes itself to technology research and development.

The core variables of this model are capital raising, R&D intensity, and digital transformation. The consistencies of the two paths were 0.892 and 0.853, respectively, and the original coverage rates were 0.234 and 0.202, respectively. Overall, 43 % of the sample cases were configured in this manner, leading to high ESG performance. The configuration achieved high ESG performance. The commonality between two paths in the configuration is that when the level of government subsidies is weak, the SRDI small giant enterprises in this configuration raise funds through equity and debt financing and are committed to technology research and development and digital transformation to achieve high ESG performance. Therefore, this mode is named as "Capital raising and improving technology" as a whole. Separately, the TMT cognition level of path H2a is higher and the financial subsidy level of H2b is higher. For these two paths, financial subsidies and TMT cognition can be used as auxiliary variables that replace each other. That is, increasing the coordinated cognition of the TMT or increasing the level of government subsidies in the case of high R&D intensity can improve the ESG performance of giant small enterprises.

Typical companies with this configuration include Zhonghaida (Guangdong), Yijiahe (Jiangsu), and Gaoling Information (Guangdong). Taking Haida as an example, the size of this company is relatively small. However, the company has been dedicated to the research and development of Global Satellite Navigation System (GNSS) core technology for an extended period, and has accumulated a significant number of independent intellectual properties and software copyrights. It is a national high-tech and outstanding software enterprise. For numerous years, it has led the innovation and development of the entire industry

with forward-looking technology and is among the leading GNSS enterprises with significant scientific research strength in China. Simultaneously, owing to its inherent industry characteristics, digital transformation was initiated earlier, and has accumulated a wealth of experience and data in this field. Under the social backdrop of a dual carbon and digital economy, its accumulated R&D advantages facilitate the enhancement of financing capabilities and the realization of the synergy of all advantageous resources, ultimately achieving high ESG performance. It is precisely because of the mutual transformation between the group's R&D intensity and digital transformation that the 'strength' of capital financing capabilities and the 'weakness' of other conditions create a synergy, reinforcing ESG performance.

(3) **Relying on the government to promote transformation.** Configuration H3 has strong contextual and configuration conditions, but weak capability conditions; that is, it is a configuration model that relies on government subsidies for technological transformation while strengthening the company's own strength.

The core variables in this model are financial subsidies and enterprise size. The consistency of the path was 0.852 and the original coverage rate was 0.240, explaining approximately 24 % of the cases. A small number of enterprises have achieved high ESG performance through this configuration model. Although the government has full policy support for corporate R&D, low R&D investment and slow progress in digital transformation do not prevent some companies from obtaining financial subsidies or increasing enterprise size through other channels. On the other hand, perhaps because of the corporate characteristics of "turning around in a disaster," companies with substantial revenue capabilities are gradually seeking more government resources to transform and improve ESG performance in the context of the digital economy. Therefore, the whole mode is termed "relying on the government to promote transformation."

Typical companies with this configuration include Zhongfu Shenying (Jiangsu), Zhongjian Technology (Jiangsu), and Hongya CNC (Guangdong). Consider Zhongfu Shenying as an example: It is the first company listed on the Science and Technology Innovation Board of the carbon fiber industry and is favored by the capital market. While the scale of the enterprise is expanding day by day, as a subsidiary of China National Building Materials Group Co., Ltd., it boldly assumes national responsibilities, mastering the core technology of the entire carbon fiber production process, and receives substantial government subsidies. Its accumulated financial advantages and industry-leading position further enhance its R&D intensity, enabling the complementary advantages of all resources, which in turn contribute to high ESG performance. It is precisely because the 'strength' of financial subsidies and the 'strength' of enterprise size interact with the 'weakness' of other conditions that a synergistic force is created, reinforcing ESG performance."

4.2.3. Complementary substitution relationship between conditional configurations

Combined with the above six paths, this section further summarizes the complementary substitution relationship between conditions after determining the configuration relationship between antecedent conditions and outcome variables. The relationship between these conditions is shown in Fig. 3. The upper part of the figure is the complementary relationship between the two core variables, and the lower part is the substitution relationship between the other core variables. The two are connected by plus signs to jointly introduce the high ESG performance of SRDI enterprises. Through configurations H1a, H1b, and H1c, it can be seen that enterprise size and TMT cognitive level appear simultaneously. In other words, there is a complementary relationship, and the path disappears immediately if and only if only one of the two conditions appears. The finding that strong TMT cognition complements enterprise size suggests that larger organizations can effectively leverage the cognitive capabilities of their TMT to enhance ESG performance. In the

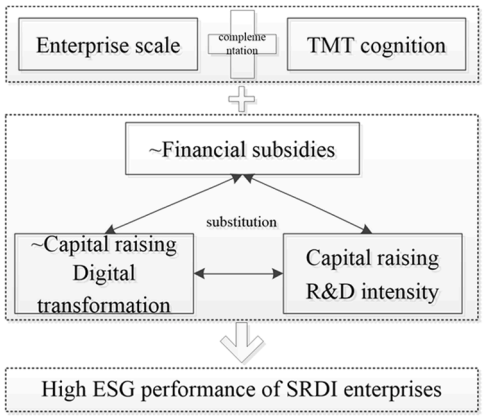

Fig. 3. Pathways to high ESG performance: complementary and substitution relationships in SRDI enterprises.

context of resource allocation, this implies that large firms with extensive resources should focus on utilizing their TMT's strategic insights to direct resources toward integrating ESG practices across operations. This aligns with resource-based theory, which posits that firms with abundant resources should invest in intangible assets like TMT capabilities to maintain a competitive advantage [61]. Research has shown that organizations with both large-scale operations and high-level strategic cognition are better positioned to develop and execute comprehensive ESG strategies [62]. Combining the H2 and H3 configurations, it can be seen that enterprise size and TMT cognition still need to be combined with other existing conditions, such as financial subsidies, capital raising, R&D and digital transformation. This shows that strong enterprise size and advanced TMT cognition are the two core forces that improve the ESG performance of enterprises.

From another perspective, there is a substitution relationship between "weak financial subsidies and weak capital raising + digital transformation" or "strong capital raising and strong R&D intensity". The first configuration—weak fiscal subsidies + weak fundraising + strong digital transformation—suggests that firms with limited financial support can still achieve high ESG performance if they effectively leverage digital transformation as a key enabler. This is particularly relevant for firms in rapidly evolving industries where digital technologies can enhance operational efficiency, improve governance structures, and drive sustainable innovations, even in the absence of significant external funding [63]. The second configuration—strong fundraising + strong R&D intensity—indicates that firms with access to significant capital and strong research capabilities can compensate for limited digital transformation efforts by investing heavily in R&D and innovation, which can also drive high ESG performance. This aligns with dynamic capabilities theory, which emphasizes the importance of resource orchestration—the ability of firms to effectively integrate, reconfigure, and deploy resources [64]. These two configurations suggest that digital transformation and capital raising/R&D intensity can act as substitutes for each other in achieving high ESG outcomes, depending on the specific resources available to the firm. In practice, firms that lack access to financial resources or external funding may still thrive by focusing on digitally-driven innovations that enhance operational efficiency and create sustainable products and services. On the other hand, firms with access to capital can prioritize fundraising and R&D to enhance their ESG performance through technological innovations and the development of green technologies.

Comparing the three paths in configuration H1, it can be seen that the two core antecedent conditions are not sufficient to fully achieve high ESG performance and still need to be fully combined with the following antecedent conditions (weak financial subsidies, weak capital raising + strong digital transformation, strong capital raising + strong R&D intensity). From a horizontal comparison, the improvement of

R&D intensity requires raising a large amount of funds to strengthen ESG performance, while digital transformation is a comprehensive scoring indicator involving strategy, organization, and technology and may rely more on the company's own scale strength and TMT cognition.

4.3. Industrial heterogeneity in configurational paths to high ESG performance

The comparative analysis of configurational pathways between the high-tech industries (H1, H2) and traditional manufacturing (H3, H4) reveals distinct industrial heterogeneities in antecedent conditions and digital transformation enablers driving high ESG performance, as shown in Table 8. These differences align with institutional theory [65] and resource-based view [66], where industry-specific resource endowments and institutional pressures shape divergent ESG configurations.

4.3.1. High-tech industries

(1) Policydriven scale synergy (H1)

The core antecedents of H1 are financial subsidies and enterprise size. This configuration aligns with Mazzucato's mission-oriented innovation framework, where subsidies act as catalytic investments for scaling ESG initiatives in large enterprises (enterprise size●) [67]. The high unique coverage (0.112) indicates niche applications, such as subsidized R&D alliances for renewable energy technologies. Industry specificity is manifested in TMT cognition (⊗) and capital raising (⊗) are non-essential, reflecting high-tech firms' reliance on external innovation ecosystems over internal leadership or financing.

(2) Digital-technology coevolution (H2)

The core antecedents of H2 are R&D intensity + Digital transformation. This pathway exemplifies Teece's dynamic capabilities [68], where R&D investment intensity(●) and digital tools synergize to achieve broad ESG impact (original coverage=0.426). The configuration may be particularly effective in deploying AI-driven ESG analytics and blockchain-enabled supply chain transparency [69]. Policy interaction is that Financial subsidies (⊗) are absent, suggesting mature technologies in H2 bypass policy dependence through market-driven commercialization.

4.3.2. Traditional manufacturing

(1) Structural capital primacy (H3)

The core antecedents of H2 are Capital raising + Enterprise size. Aligned with Williamson's transaction cost economics [70], this configuration demonstrates how capital-intensive industries rely on structural financing capital (●) and scale economies size (●) for ESG retrofitting (e.g., factory decarbonization). The industry-high consistency (0.817) reflects institutionalized compliance practices. Digital transformation (⊗)is irrelevant, confirming Leonard-Barton's capability rigidities in traditional manufacturing [71].

Table 8
Analysis of configuration results of high ESG performance of High-Tech industry.

Antecedent condition	High-tech		Traditional manufacturing	
	H1	H2	H3	H4
Capital raising			●	
Financial subsidies	●	●		●
Enterprise size	●	●	●	●
TMT cognition	⊗		●	●
R&D intensity	●	●	⊗	
Digital Transformation	●	●		⊗
Consistency	0.790	0.801	0.817	0.822
Original coverage	0.418	0.426	0.356	0.244
Unique coverage	0.112	0.039	0.013	0.019
Consistency of solutions	0.857			
Coverage of solution	0.699			

4.3.3. Subsidy-leadership compensation (H4)

This path validates Hambrick and Mason's upper echelons theory [72], where TMT cognition (●) compensates for structural deficiencies. Financial subsidies (●) enable incremental improvements (e.g., energy efficiency retrofits), but low unique coverage (0.019) indicates minimal innovation. R&D intensity (⊗) and digital transformation (⊗) remain non-factors, highlighting manufacturing's disconnection from technological frontiers.

4.3.4. Cross-industry innovation type comparison and promotion path analysis

According to March's dual framework of Exploration and Exploitation [73]: Exploratory innovation is the pursuit of long-term competitiveness (high uniqueness, low consistency) through the experimental application of new knowledge / technology. Exploitative innovation are optimize existing resources and processes to achieve short-term efficiency (low uniqueness, high consistency). Based on the heterogeneity analysis of the two industries in the previous part, this section further explores the core logic and policy leverage differences behind the path, and traces the final theory based on its actual performance, as shown in Table 9.

High-tech ESG excellence hinges on technology-policy-market triads (H1/H2), while manufacturing relies on structural-institutional dyads (H3/H4). Digital transformation is a high-tech differentiator, confirming Pavitt's industrial innovation taxonomy [74].

As shown in Table 10, to optimize ESG performance across industries, policymakers and firms should adopt differentiated configuration strategiesanchored in industrial innovation regimes. High-Tech industry prioritizes H2-type configurations(R&D● + Digital●) : (1) Allocate ≥15 % of subsidies to ESG-digital convergence technologies (e.g., AI-driven carbon accounting), leveraging Mazzucato's mission-oriented innovation framework [75]; (2) Reform IP regimes to accelerate H1-to-H2 transitions, reducing exploratory innovation risks (unique coverage 0.112 → 0.150). Traditional Manufacturing should strengthen H3-H4 hybrid configurations: (1) Design transition finance instruments (e.g., ESG-linked bonds) targeting capital-scale synergies (current H3 coverage 0.356 → 0.400). (2) Mandate TMT training programs to enhance leadership-driven innovation (H4 unique coverage 0.019 → 0.035), per Hambrick and Mason's upper echelons theory [76].

4.4. Further discussion

After analyzing the configuration path, complementary substitution relationship, and cross-industry characteristics of SRDI enterprises, we believe that echoing more industry-wide cases will better demonstrate the diversity of SRDI enterprises and their ESG strategies. The integration of digital economy elements provides an additional layer of complexity, influencing both environmental performance and governance structures. In particular, the energy industry and high-tech industry, with their rapid digitalization processes, present unique opportunities for integrating innovative, sustainable practices into their core operations. Digitalization enables these industries to adopt cleaner energy technologies, improve resource efficiency, and enhance real-time ESG reporting and transparency. Therefore, this section further focuses on these two industries to illustrate how digital transformation interacts with environmental and governance factors, thereby affecting ESG performance.

4.4.1. Diversity of SRDI enterprises across industries

SRDI enterprises span a wide variety of industries, including energy,

Table 9
Data analysis and innovation type mapping.

Configuration Path	Core Logic	Policy Lever	Innovation Type	Theoretical Anchoring
H1 (High-Tech)	Subsidy-driven scaling	R&D alliance grants	Exploratory Innovation	Subsidy-driven new technology pilots (such as green AI) are in line with Mazzucato's (2015) mission-oriented innovation.
H2 (High-Tech)	Market-driven digitization	IP commercialization incentives	Exploitative Innovation	The large-scale application of mature technologies (such as blockchain ESG reports) reflects the dynamic capabilities of Teece (2007).
H3 (Manufacturing)	Structural capital accumulation	Transition finance mechanisms	Exploitative Innovation	Compliance optimization of capital and scale (Williamson, 1985).
H4 (Manufacturing)	Leadership-subsidy compensation	TMT training subsidies	Incremental Innovation	Leadership-Driven Marginal Improvement (Hambrick & Mason, 1984).

Table 10
Cross-industry innovation configuration comparison.

Dimension	High-Tech	Manufacturing
Dominant Innovation Type	Coexistence of Exploratory (H1) and Exploitative (H2)	Dominance of Exploitative (H3) and Incremental (H4)
Core Differentiation	High uniqueness (H1: unique coverage=0.112) → Technological breakthroughs	High consistency (H3: consistency=0.817) → Process optimization
Role of Digitalization	Digital-driven solution scaling (H2: unique coverage = 0.426)	Digital marginalization (H4: original coverage = 0.244) → Instrumental adoption

technology, manufacturing, and others. Each industry faces distinct challenges and opportunities in terms of ESG performance, which influence their strategies and resource allocation.

Companies in the energy industry face unique environmental challenges due to the high environmental impact of their operations. ESG strategies in the energy industry are often focused on reducing carbon emissions, transitioning to renewable energy, and improving energy efficiency. For example, firms like Longi Green Energy in China have made significant strides in solar energy technology and have aligned their ESG strategies with global climate change goals [77]. Energy companies are also heavily influenced by regulatory pressures related to environmental protection, and their ESG strategies often involve significant investment in clean technologies and carbon offset initiatives.

In contrast, companies in the technology industry tend to emphasize innovation-driven ESG strategies, focusing on digital transformation, data privacy, and ethical use of AI. Technology firms like Huawei or Tencent are heavily involved in developing sustainable digital solutions that help other industries reduce their environmental impact. ESG strategies in the technology industry often center around governance and social responsibility, ensuring that technology solutions not only meet environmental standards but also support ethical business practices [78]. These companies are typically more focused on social and governance-related ESG issues due to their role in digital transformation and the increasing scrutiny of data security and corporate governance.

Companies in the manufacturing industry often face significant resource efficiency challenges, as their operations tend to be more resource-intensive and polluting. For instance, manufacturers like Tianan New Materials (which we mentioned in the study) are focused on sustainable production techniques and improving supply chain sustainability. In this industry, ESG strategies are heavily oriented toward environmental innovation, such as waste reduction, energy efficiency, and sustainable sourcing. Companies also emphasize worker welfare and health and safety, which are critical elements of the social aspect of ESG in industries like textiles, chemicals, and automotive manufacturing.

4.4.2. Industry-specific differences in ESG strategies

The ESG strategies of SRDI enterprises in the energy, technology, and manufacturing industries differ due to the unique environmental, social, and regulatory challenges each industry faces. For example:

Energy industry companies are more likely to prioritize environmental aspects of ESG due to the direct environmental impact of their operations, with a strong emphasis on sustainable energy and carbon footprint reduction [79]. Technology firms, on the other hand, focus more on governance and social responsibility, with ESG strategies centered around data privacy, ethical use of AI, and corporate transparency [80]. Manufacturing companies balance environmental and social aspects, with a strong focus on resource efficiency and sustainable supply chains, along with employee welfare and community engagement [81] .

4.4.3. R&D and digitalization

Digitalization plays a transformative role in how companies approach R&D, particularly in the context of sustainable innovation. The integration of digital technologies enables firms to accelerate their R&D processes, improving product development and increasing the efficiency of sustainable innovations. For example, big data, AI, and IoT technologies can help optimize product designs, reduce waste, and create more energy-efficient solutions, all of which directly contribute to environmental sustainability [82].

Moreover, digital tools can enable firms to conduct rapid prototyping, collaborate with external partners, and scale up green innovations more effectively, which is crucial for industries that face high environmental costs, such as manufacturing and energy. In the context of SRDI enterprises, R&D driven by digital technologies is essential for maintaining competitive advantage while simultaneously advancing sustainable practices, thus improving both environmental and social dimensions of ESG.

4.4.4. Digitalization and governance

Governance is another area where digitalization has a profound impact. The use of digital technologies facilitates better corporate governance by improving transparency, accountability, and decision-making processes. Blockchain and distributed ledger technologies have become essential tools in ensuring transparency in supply chains and financial transactions, especially in industries like manufacturing and energy where the risk of corruption and inefficiency can undermine ESG efforts [83].

Additionally, digital governance platforms enable firms to track their ESG performance in real-time, integrate sustainability goals into daily operations, and ensure compliance with evolving regulations. This shift towards digital governance enhances the firm's ability to address social responsibility issues such as labor rights, data privacy, and community impact, which are crucial for achieving strong social and governance performance under ESG frameworks.

4.4.5. Impact of digitalization and governance on ESG performance

Overall, digitalization is not just a contextual factor but also a powerful driver of ESG performance across all dimensions. The digital economy provides firms with the tools to improve resource efficiency, enhance supply chain sustainability, and drive social innovation, all of which contribute to improving their overall ESG performance. By adopting smart technologies and integrating them into their ESG strategies, firms can create more sustainable business models that lead to long-term value creation for both stakeholders and society at large [84].

Strong governance practices, including transparency and effective stakeholder engagement, are linked to improved ESG performance in SRDI enterprises. Research suggests that firms with robust governance structures tend to perform better across environmental and social dimensions due to the integration of ethical decision-making and long-term sustainability goals into their corporate strategy [85]. In SRDI enterprises, good governance practices enable firms to navigate the complexities of sustainability regulations, market demands, and technological advancements, fostering a culture of continuous improvement and responsible growth. Specifically, SRDI enterprises in high-pollution industries that adopt strong governance practices in environmental management, such as regular reporting on emissions and waste management, often outperform competitors that lack transparency or fail to engage stakeholders effectively. In contrast, high-tech SRDI enterprises benefit from transparent governance by ensuring that their innovations are in line with global ESG standards and that their governance practices support ethical tech development.

4.5. Robustness test

To ensure the validity and reliability of our findings, we conducted systematic robustness tests following established practices in fsQCA research [86]. These tests assessed the sensitivity of configurations to parameter adjustments and temporal data shifts, addressing potential concerns about overfitting or context dependency.

4.5.1. Threshold sensitivity analysis

Drawing on Fiss, we tested the stability of configurations by varying the frequency threshold for case inclusion [87]. Increasing the threshold by 10 % (from baseline to stricter criteria) resulted in a slight decrease in unique coverage (Table 9: unique coverage dropped from 0.135 to 0.028 for H2) but maintained core configurations (H1-H3) with consistency above 0.79. Conversely, lowering the threshold expanded coverage (original coverage for H1 rose from 0.514 to 0.617 in Table 10) without compromising consistency (>0.73). This aligns with Rihoux's observation that threshold adjustments primarily affect coverage, not core causal logic [88].

4.5.2. Temporal robustness with 2024 ESG data

To evaluate temporal generalizability, we replicated the analysis using 2024 ESG performance data (Table 10). Comparing the data in Table 7, we can find that, despite minor fluctuations in unique coverage (e.g., H3 dropped from 0.046 to 0.003), the core configurations retained high consistency (>0.78 across all hypotheses), echoing García-Castro and Aguilera's finding that robust configurations exhibit temporal invariance when antecedent conditions are theoretically anchored [89]. Notably, enterprise size (consistently present in all solutions) and digital transformation (● in 5/6 hypotheses) emerged as stable drivers, supporting their role as "necessary conditions" [90].

4.5.3. Condition sensitivity analysis & consistency-coverage tradeoffs

Following Greckhamer et al., we perturbed antecedent conditions to identify sensitive nodes [91]. Removing financial subsidies (⊗in H1a/H2a) reduced H1a's consistency from 0.809 to 0.782, indicating its contextual importance in capital-constrained firms [92]. Conversely, TMT cognition displayed asymmetric robustness: its absence (⊗in H2b) uped consistency (0.853 → 0.870), whereas its presence (● in H1-H2a) stabilized solutions even when other conditions varied. This aligns with the upper echelons theory's emphasis on managerial agency [93].

Further, as recommended by Marx et al. we examined the consistency-coverage frontier across robustness checks [94]. While the 2024 data slightly reduced overall solution coverage (from 0.868 to 0.744), consistency remained above the 0.70 benchmark [95], confirming that our findings prioritize explanatory rigor over exhaustive empirical scope—a tradeoff justified in policy-relevant studies [96]. Owing to space limitations, refer to Tables 10 and 11, and do not repeat the analysis. The conclusions of this study are robust. From another perspective, this paper also passed the sensitivity analysis.

Table 12

Table 11
Increase the frequency of cases.

Antecedent condition	H1 (formerly H1a)	H2 (formerly H2a)	H3 (formerly H3)
Capital raising		●	●
Financial subsidies	⊗	⊗	●
Enterprise size	●	⊗	●
TMT cognition	●	●	●
R&D intensity	●	●	⊗
Digital Transformation	●	●	●
Consistency	0.799	0.892	0.892
Original coverage	0.514	0.234	0.234
Unique coverage	0.135	0.028	0.039
Consistency of solutions	0.868		
Coverage of solution	0.597		

Table 12
Replacement ESG performance as 2024 data.

Antecedent condition	H1a	H1b	H1c	H2a	H2b	H3
Capital raising		⊗		●	●	●
Financial subsidies	⊗			⊗		●
Enterprise size	●	●	●	●	●	●
TMT cognition	●	●	●	●	⊗	
R&D intensity	●	●		●	●	●
Digital Transformation	●		●	●	●	●
Consistency	0.782	0.790	0.856	0.824	0.870	0.887
Original coverage	0.617	0.509	0.351	0.272	0.209	0.264
Unique coverage	0.108	0.042	0.015	0.031	0.009	0.003
Consistency of solutions	0.730					
Coverage of solution	0.744					

5. Conclusions and policy implications

5.1. Conclusions

Under the impact of the epidemic, market competition has intensified, SMEs is weak, the ability to mitigate risks is limited, and the consequences have been significant. The ESG development index experienced a sharp decline. In the context of the symbiotic logic of multiple factors, such as the digital economy and low-carbon models, the development of SRDI policies has facilitated the gradual recovery of SMEs, though they have not yet returned to pre-epidemic levels. Therefore, this study ocuses on A-share listed small giant enterprises within SRDI enterprises as research samples, applies bibliometric methods to derive the "context-configuration-capability" theory, and constructs a research framework based on this theory. Beginning with six antecedent condition—capital raising and financial subsidies in the context dimension, TMT cognition and enterprise size in the configuration dimension, and R&D intensity and digital transformation in the capability dimension—this study employs two complementary analytical methods, NCA and fsQCA, integrated with set theory and configuration thinking, to analyze the multiple configurational paths leading to ESG performance in SRDI enterprises and draws the following conclusions:

(1) A single antecedent condition is not sufficient to constitute a necessary condition for high ESG performance. The results of the NCA and fsQCA analyses jointly show that the emergence of high ESG performance reflects a high level of overall complexity, and the integration of various conditions of contextual, configurational, and capability-based conditions is the primary driver of its improvement. (2) From a configuration perspective and utilizing the fsQCA method, this study identifies three configurational paths leading to high ESG performance, based on differences in core conditions: self-reliance and strengthening cognition, capital raising combined with improving technology, and reliance on government to foster transformation. Complex and nuanced complementary and substitutive relationships exist among the core antecedent conditions within the context, configuration, and capability framework, highlighting multiple pathways to achieving high ESG performance. (3) The company's own scale, growth in net profit, strengthening of the TMT's cognition of green technologies, increased R&D investment, accelerated digital transformation, and continued financial subsidies from external governments serve as the foundation for China's SRDI enterprises under the coupling of contexts under the coupling of various contexts.. High-quality green development offers diverse ESG improvement strategies and insights for transforming and integrating existing and nonexistent conditions. (4) This study reveals significant industrial heterogeneity in the configurational paths to high ESG performance between the high-tech and traditional manufacturing industries, particularly highlighting the critical role of digital transformation in driving ESG outcomes in high-tech firms. These differences underscore the impact of industry-specific resource endowments and institutional pressures on shaping divergent ESG strategies, with high-tech firms focusing on exploratory innovation driven by technology, while traditional manufacturing firms emphasize compliance and incremental innovation

5.2. Policy implications

First, based on the idea of transforming non-existence into existence, companies need to pay attention to the matching transformation of "non-existence" and "existence" conditions to strengthen ESG performance. It is difficult for a single-dimensional element to promote the ESG performance of an enterprise, and it is impossible to sum up the conditions of each dimension. Instead, multiple conditions must be considered. For example, enterprises that raise funds and strengthen technology receive fewer financial subsidies and have relatively weak enterprise sizes. On the basis that short-term technology investment cannot receive positive feedback, they can change their thinking and seek help from the government to compensate for the risk of cash flow shortage, boosting the transformation of weak conditions into strong conditions.

Second, based on the idea that fsQCA studies the same goal using different routes, the complementary substitution relationship between antecedent conditions can also help enterprises choose effective promotion paths. Under the self-reliance and strengthening cognitive-driven models, there are two core antecedents that are not sufficient to fully achieve high ESG performance. The antecedents of weak financial subsidies, weak capital raising and high ESG performance, and strong capital raising and strong R&D intensity still need to be fully combined. Simultaneously, the improvement of R&D intensity requires raising a large amount of funds to strengthen ESG performance, which is a comprehensive scoring indicator involving strategy, organization, and technology, and relies more on the company's own scale strength and TMT cognition. For example, enterprises should focus on cultivating internal strength, enhancing the TMT strategic vision from the perspective of cognitive upgrading, and strive to achieve high-quality green development.

Third, based on the theory of optimal distinctiveness, companies must strengthen ESG performance according to corporate conditions, pay attention to differences in specific conditions, and then choose their own appropriate "optimal" improvement path. Compared with the contextual dimension conditions of enterprises (capital raising, financial subsidies), the allocation (TMT cognition, enterprise size) and capability conditions (ESG performance, R&D intensity) of enterprises play a more significant role in improving their ESG performance.

Fourthly, from the perspective of the role of antecedent variables, financial subsidies play a key role in several ESG performance paths of SRDI enterprises. Policymakers should consider implementing financial instruments that specifically address the barriers faced by SRDI enterprises in accessing capital. This could involve offering preferential interest rates on loans to businesses that adopt environmentally sustainable practices or meet specific green criteria. Additionally, guaranteeing loans for enterprises focused on sustainable development can help mitigate the perceived financial risk, encouraging banks to lend to such projects. This approach would make green finance more accessible and foster growth in the industry. Fifth, from the industry point of view, the traditional manufacturing industry with high pollution needs more continuous change. Combined with industry heterogeneity analysis. To promote the transition of high-pollution industries towards sustainable practices, targeted financial subsidies should be designed to support innovation in emission reduction and resource efficiency. This could include offering additional financial support for R&D in cleaner technologies, providing tax breaks or direct subsidies for implementing environmentally friendly processes, and creating innovation grants that reward companies developing novel solutions to minimize pollution. These measures would not only stimulate innovation but also accelerate the adoption of cleaner practices across high-impact industries.

Therefore, if an enterprise wants to strengthen ESG performance, it

must regard the acquisition of funds as a basic condition but not a critical one, and the development of its own allocation and improvement of its own capabilities will guide SRDI enterprises to strengthen ESG performance at a higher level.

5.3. Managerial implications

The absence of standalone necessary conditions in our analysis implies that ESG excellence requires orchestrated interactions between environmental, social, and governance dimensions. To translate this insight into practice, we propose a three-phase implementation framework, supported by the following actionable strategies:

(1) Systemic Materiality Mapping with Dynamic Prioritization. Traditional materiality assessments often treat ESG factors as static and isolated. To capture interdependencies, practitioners should: 1) Adopt hybrid materiality tools combining quantitative metrics (e.g., SASB's industry-specific standards) with qualitative stakeholder perception analysis (e.g., GRI's multi-stakeholder dialogues). For instance, a pharmaceutical firm might map how climate-related supply chain disruptions (environmental) amplify risks to equitable drug access (social), necessitating governance reforms in supplier diversity tracking. 2) Leverage AI-driven scenario engines (e.g., tools like Clarity AI or Sustainalytics) to simulate how combinations of ESG investments (e.g., renewable energy adoption + employee upskilling programs) generate multiplicative effects. A case in point is Microsoft's 2022 analysis showing that pairing carbon-neutral data centers with digital literacy initiatives in underserved communities boosted both operational efficiency and social license to operate by 23 % [97].

(2) Cross-Functional Governance Architectures. Siloed ESG management perpetuates fragmented outcomes. To foster synergy: 1) Establish ESG "Control Towers": Create centralized units with veto power over departmental budgets, tasked with enforcing cross-KPI alignment. Unilever's Sustainable Living Plan exemplifies this approach: its Chief Sustainability Officer chairs a committee that reviews all R&D and marketing expenditures against 12 interconnected ESG targets, blocking initiatives that fail to address at least two dimensions (e.g., a recyclable packaging design must also incorporate fair labor practices in supplier factories) [98]. 2) Implement "ESG Impact Multiplier" Incentives: Tie executive compensation to combination metrics rather than isolated goals. For example, a mining company could reward leaders based on the joint improvement of water stewardship (environmental), indigenous community partnerships (social), and board diversity (governance), with bonuses scaled by proven synergistic effects (e.g., a 1 % reduction in water use + 5 % increase in local hiring triggers a 15 % bonus uplift) [99].

(3) Adaptive Learning through Coalition Building. Complex ESG challenges demand collective intelligence: 1) Form Industry-Academia-Policy Consortia: Collaborative platforms like the WEF's Alliance of CEO Climate Leaders enable firms to share data on "ESG configuration failures" (e.g., renewable energy projects that worsened labor disputes) and co-develop best practices. The Danish Wind Energy Cluster's 2023 report demonstrated how such consortia reduced trial-and-error costs by 41 % in offshore wind projects integrating biodiversity safeguards [100]. 2) Pilot "ESG Sandboxes": Test high-risk initiatives in controlled environments. Banco Santander's 2023 sandbox experiment in Brazil paired green mortgages (environmental) with financial inclusion algorithms, discovering that tailored credit scoring models incorporating both factors reduced default rates by 18 % while expanding clean energy adoption in low-income neighborhoods [101]

(4) The complementary and substitution relationships we identify underscore the need for firms to align their strategic focus with their organizational capabilities. Larger firms can leverage their scale to implement comprehensive ESG strategies informed by TMT cognition, while smaller firms should ensure that their TMTs' are capable of making high-quality strategic decisions that address resource constraints and maximize the impact of their ESG efforts. This approach is consistent with contingency theory, which suggests that organizations must adapt their strategies based on both internal capabilities and external conditions [102]. In practical terms, this means that managers in large firms should prioritize investments in leadership development and data analytics tools that enable TMTs' to make more informed, strategic decisions regarding ESG. Conversely, managers in smaller firms should foster an environment that encourages quick decision-making and strategic agility within their TMT, enabling them to prioritize the most impactful ESG initiatives despite resource limitations.

5.4. Research limitations and prospects

This study innovatively analyzes the ESG performance of SRDI enterprises based on the idea of mutual transformation between existence and non-existence in Chinese Taoist philosophy and the improved 3C framework. There are still the following limitations and areas of improvement worthy of further exploration: First, although it is known that the context, configuration, and capability factors that affect the development of SRDI enterprises evolve with the advancement of the enterprise life cycle. However, because the sample of SRDI enterprises changes greatly in China's policies, and the ESG performance data of SMEs are disclosed very late, the data that can be obtained in this study are only cross-sectional data, ignoring the dynamic evolution of context, configuration, and capability factors. Future research may consider optimizing the sample-matching method, collecting more years of data after waiting for a period of time, and using the dynamic QCA method for qualitative comparative analysis of time series. Future scholars can explore the impact of these conditions on improving the ESG performance of SRDI enterprises in dynamic changes, aiming to improve the coverage and effectiveness of case configurations. Second, the focus on taking SRDI "small giant" listed companies as a sample-while most SRDI firms are not listed-partially limits the generalizability of the conclusions.

In addition, looking forward, future research could explore the application of AI and big data technologies in real-time monitoring of ESG performance. These tools could offer deeper insights into the dynamics of ESG activities, enabling enterprises to assess their performance continuously and adjust strategies as needed. For example, AI could be used to analyze large-scale data sets on environmental, social, and governance metrics, detecting patterns and offering predictive insights for proactive ESG management.

Moreover, comparative studies across different countries or regions could provide valuable perspectives on global trends and differences in ESG performance. These studies could help identify best practices, as well as the socio-economic, political, and regulatory factors that influence the ability of SRDI enterprises to implement successful ESG strategies in diverse settings. By examining international variations in ESG approaches, researchers could uncover broader insights into how globalization impacts the development and adoption of ESG practices in SRDI enterprises.

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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.

Data availability statement

All study data are available upon request, please contact the corresponding author if required

The data that support the findings of this study are available from the corresponding author, ZZ, upon reasonable request. The company data used in this study was accessed through official databases, including the CSMAR database, WIND database, and manually crawled text analysis materials. These sources provide publicly available data that is widely used in academic research. The data from these platforms were anonymized to protect the identities of individual companies. Since the data utilized in this study is publicly available and does not involve direct interaction with the companies themselves, there were no specific consent requirements for accessing the data. However, we have ensured that all data used in the analysis adheres to confidentiality agreements and data protection regulations. The research follows the ethical guidelines set forth by the institutions responsible for managing these databases to ensure that the data is handled with integrity and respect for privacy.

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