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The Missing Carbon Dimension in ESG Evaluation Systems under Carbon Neutrality Targets: A Literature Review and Bibliometric Analysis

Yiting Chen

College of Environmental Science and Engineering, Tongji University, Shanghai, 200092, PR China

Abstract: ***Against the backdrop of global climate governance and China's dual-carbon targets, carbon neutrality has become a systemic agenda linking energy transition, industrial upgrading, and governance transformation. ESG assessment is increasingly connected with carbon governance, disclosure, and low-carbon transition. However, existing ESG rating systems usually place carbon-related indicators under the environmental pillar, lacking an independent carbon-neutrality perspective and thus limiting their ability to capture firms' heterogeneous carbon-governance capabilities. Based on a systematic literature review and bibliometric analysis of Web of Science and CNKI publications, this study finds that research at the ESG–carbon neutrality nexus has shifted from general corporate responsibility assessment toward climate governance and low-carbon transition. Current studies mainly focus on ESG governance and corporate transition, carbon disclosure and capital-market responses, and green finance and resource allocation. Future research should develop carbon-neutrality-oriented ESG assessment frameworks, strengthen the identification of substantive emission-reduction performance, and expand empirical evidence through larger samples and policy-evaluation designs.***

Keywords: Carbon neutrality; ESG; Dual-carbon targets; Bibliometrics; Assessment framework; Low-carbon transition.

1. INTRODUCTION

Climate change has become a defining challenge for global sustainable development. From the United Nations Framework Convention on Climate Change to the Paris Agreement, global climate governance has progressively converged on net-zero transition strategies. Article 4.1 of the Paris Agreement calls for a balance between anthropogenic greenhouse-gas emissions by sources and removals by sinks in the second half of this century, establishing carbon neutrality as a widely recognized principle of global climate governance (United Nations, 1992, 2015). In China, the 2020 commitment to peak carbon emissions before 2030 and achieve carbon neutrality before 2060 marked the strategic acceleration of green and low-carbon transformation (Xi, 2020a, 2020b). Since then, the "1+N" policy framework, the construction of the national carbon emissions trading market, and sector-specific energy-saving and carbon-reduction policies have gradually embedded carbon neutrality into the broader architecture of economic and social development (Central Committee of the Communist Party of China & State Council, 2021; Ministry of Ecology and Environment, 2025; State Council, 2024a, 2026).

For firms, the dual-carbon targets imply a tightening of external environmental constraints and require systematic adjustments in production modes, energy use, technological innovation, and governance structures. At the same time, ESG has become a key framework for evaluating nonfinancial performance and long-term corporate value in both capital markets and green-transition practices (Alsayegh et al., 2020; Lokuwaduge et al., 2022; Tao & Jin, 2015). The carbon-neutrality agenda further expands the scope of ESG research: carbon emissions and climate risk are closely related to the environmental pillar, while the strategic management, information disclosure, and stakeholder coordination required for carbon neutrality also intersect with the governance and social pillars. Carbon neutrality and ESG are therefore naturally interlinked; yet whether existing ESG assessment systems can adequately capture firms' carbon-governance capacity remains an open question.

A substantial body of scholarship has developed around carbon neutrality and ESG as separate research streams. Studies of carbon neutrality have focused on energy transition, carbon-emission accounting, low-carbon technologies, and policy instruments (Fan et al., 2021; Gao et al., 2022; Lin, 2021; Wang et al., 2021). ESG research, by contrast, has primarily examined corporate performance, information disclosure, corporate governance, and financing constraints (Avramov et al., 2022; Huang, 2022a; Xi & Zhao, 2022a). As the dual-carbon agenda advances, research at the intersection of ESG and carbon neutrality has expanded, but

systematic synthesis remains limited. This study reviews and analyzes this emerging field, clarifies the logic through which the two formerly independent agendas are becoming integrated, identifies unresolved research gaps, and proposes directions for future inquiry.

2. POLICY EVOLUTION AND RESEARCH REORIENTATION OF CARBON NEUTRALITY

2.1 From Target Announcement to Institutional Embedding

The concept of carbon neutrality has evolved from a scientific understanding of emissions balance into a national strategic objective. The 1992 United Nations Framework Convention on Climate Change established the international objective of controlling greenhouse gases; the 1997 Kyoto Protocol advanced the idea of carbon offsetting through the Clean Development Mechanism, Joint Implementation, and emissions trading; and the 2015 Paris Agreement formally consolidated carbon neutrality as a global target (United Nations, 1992, 1997, 2015). In China, the policy trajectory of carbon neutrality can be divided into three stages: target signaling before 2020, top-level design and market construction during 2021-2024, and sectoral expansion and institutional deepening after 2025.

Key milestones include the 2021 Opinions on Fully, Accurately, and Comprehensively Implementing the New Development Philosophy and Doing a Good Job in Carbon Peaking and Carbon Neutrality, which established the top-level design of the "1+N" policy framework (Central Committee of the Communist Party of China & State Council, 2021); the 2024 Interim Regulations on the Administration of Carbon Emissions Trading, which signaled the formalization of China's carbon-market governance (State Council, 2024a); the 2025 inclusion of steel, cement, and aluminum smelting in the national carbon market, extending coverage from the power sector to key industrial sectors (Ministry of Ecology and Environment, 2025); and the 2026 Outline of the Fifteenth Five-Year Plan, which emphasizes coordinated progress in carbon reduction, pollution control, ecological expansion, and economic growth under the guidance of carbon peaking and carbon neutrality (State Council, 2026). These developments indicate that carbon neutrality has moved beyond the domain of environmental policy and has become a systemic transformation involving economic structure, energy systems, and technological innovation (State Council, 2024b).

2.2 Corporate Carbon Neutrality: From Compliance to Strategy

Within this policy context, research on corporate carbon neutrality has shifted from macro-level technological pathways to micro-level governance mechanisms. Drawing on the resource-based view, Dong et al. (2022) show that carbon-neutrality strategies significantly enhance corporate sustainability, with stronger effects in firms whose boards possess higher levels of human capital. Wang et al. (2023) find that digital transformation promotes carbon reduction by mitigating information asymmetry and improving operational efficiency; in their estimates, a one-unit increase in digital transformation raises green-governance performance by 1.91%. Gao et al. (2023) further confirm that digital transformation reduces corporate carbon emissions through the dual channels of information-asymmetry reduction and operational-efficiency improvement. Chen and Gu (2022) document a significant inhibitory effect of digital transformation on carbon emissions among Chinese manufacturing firms. From the perspective of directors' overseas experience, Liu (2023) finds that internationally experienced directors can significantly reduce corporate carbon emissions, with green innovation serving as a mediating mechanism. Sectoral heterogeneity studies have also examined the differentiated technological pathways of energy-intensive industries such as power generation and steel (Lin et al., 2022; Wang et al., 2022).

Collectively, these studies reveal a critical shift: carbon neutrality is no longer merely a technical issue of emission abatement, but a comprehensive governance agenda involving corporate strategy, organizational architecture, and stakeholder coordination (He, 2023). This shift provides the theoretical basis for embedding corporate carbon-neutrality assessment within the ESG framework.

3. ESG ASSESSMENT SYSTEMS: THE MISSING CARBON-NEUTRALITY DIMENSION

3.1 ESG Frameworks and Rating Practices

ESG evaluates corporate sustainability performance across environmental, social, and governance dimensions (Huang, 2021; Li et al., 2023; Xi & Zhao, 2022b). The environmental pillar generally covers climate-change response, energy efficiency, and green innovation; the social pillar includes employee rights, product quality, and community responsibility; and the governance pillar addresses board structure, executive compensation, and internal control (SynTao Green Finance, 2020). With the development of green finance, ESG has evolved from a supplementary corporate social responsibility framework into a consequential mechanism shaping capital allocation (Ma et al., 2021). Global sustainable investment reached USD 35.3 trillion at the start of 2020; ESG investment accounted for approximately 45% of professionally managed assets in Europe and 33% in the United States, while the corresponding share in China remained below 2% (Global Sustainable Investment Alliance, 2021). As sustainable-development principles have become more widely institutionalized, China's ESG assessment infrastructure has also accelerated (International Institute of Green Finance, 2022).

A range of ESG rating systems has emerged domestically and internationally. In China, SynTao Green Finance was among the earliest institutions to engage with environmental finance and responsible investment (SynTao Green Finance, 2021). The Industrial and Commercial Bank of China Green Finance Research Group developed an ESG assessment system that assigns relatively high weight to environmental factors (Industrial and Commercial Bank of China Green Finance Research Group, 2021). Other institutions, including Huazheng Index, RKS Global, the International Institute of Green Finance at the Central University of Finance and Economics, and Harvest Fund, have also entered the field (Huazheng Index, 2022; RKS Global, 2021). Internationally, influential methodologies have been developed by MSCI, Sustainalytics, FTSE Russell, and S&P Dow Jones, while instruments such as the Dow Jones Sustainability Index, the Carbon Disclosure Project, and MSCI ESG indexes have become important in global responsible investment (FTSE Russell, 2022; MSCI, 2022; Sustainalytics, 2022; Theyel, 2000).

Nevertheless, existing systems generally place carbon emissions and climate risk within the environmental pillar rather than treating carbon neutrality as an independent evaluative perspective. Although this approach captures aspects of environmental performance, it weakens the specific constraint imposed by the dual-carbon targets and is insufficient for identifying firm-level differences in carbon-management capability, emission-reduction performance, and low-carbon transition progress.

3.2 Rating Divergence and Greenwashing Risk

ESG assessment systems also face persistent problems of rating divergence and methodological inconsistency. Avramov et al. (2022) report that correlations among six major U.S. rating agencies average below 0.5. Berg et al. (2022) show that rating disagreement undermines the role of ESG in reducing information asymmetry and affects stock demand, price volatility, and firms' external financing costs. More seriously, some firms strategically embellish their environmental performance in ESG reports or make commitments that are difficult to verify, thereby producing greenwashing; others use ESG information to divert investors' attention from weak financial performance (Huang, 2022b). In the context of carbon neutrality, this problem becomes particularly salient: firms may foreground emission-reduction pledges in carbon disclosures while failing to achieve corresponding improvements in energy mix or low-carbon technology investment. The gap between disclosure quality and substantive transition is a direct manifestation of the insufficient independence of the carbon-neutrality dimension in current ESG assessment systems.

4. CARBON NEUTRALITY AND ESG RESEARCH: THREE POINTS OF CONNECTION

4.1 ESG Governance and Corporate Low-carbon Transformation

ESG governance can facilitate corporate low-carbon transformation through three mechanisms. First, it incorporates low-carbon objectives into strategic decision-making and encourages boards to attend more systematically to climate risk. Second, it strengthens environmental management and green innovation, thereby supporting energy conservation and emission reduction. Third, it mobilizes stakeholder coordination and generates collective governance capacity for low-carbon transition. Using Japanese firms as the empirical setting, Keerthana et al. (2023) find that sustainability culture and robust corporate governance jointly promote the realization of carbon neutrality, and that green innovation and governance mechanisms operate synergistically. From an ESG perspective, He (2023) emphasizes the role of ESG in achieving carbon peaking and carbon neutrality and calls for a more complete ESG framework. Du et al. (2022) also show that ESG performance and carbon-disclosure quality among energy firms are important for evaluating climate-governance capacity.

These studies suggest that corporate carbon neutrality requires the joint support of governance structures, organizational culture, and strategy execution (Li & Yang, 2023). Yet much of the existing literature remains concentrated in specific industries or regions, leaving insufficient systematic comparison of heterogeneous governance mechanisms and their effects.

4.2 Carbon Disclosure and Capital-market Responses

Carbon-neutrality targets have increased investors' demand for credible corporate carbon information. Liu (2022) finds that disclosure related to corporate governance and social responsibility in ESG systems significantly affects the financing costs of Chinese manufacturing firms, particularly as ecological-civilization construction deepens. High-quality carbon disclosure can reduce information asymmetry and strengthen investors' assessment of firms' transition capabilities. Broader evidence suggests that ESG performance can mitigate financing constraints (Hu et al., 2023), reduce stock-price volatility (Xi & Zhao, 2022c), improve operating performance (Wang et al., 2022), increase market value (Zhang et al., 2023), and enhance stock returns (Gao et al., 2021).

However, disclosure is not equivalent to substantive transition. Some firms emphasize reduction commitments without making material progress in energy-structure adjustment or technological upgrading. Future research therefore needs to distinguish disclosure behavior from actual transition behavior and to identify the difference between genuine low-carbon transformation and greenwashing.

4.3 ESG Investment, Green Finance, and Resource Allocation

ESG investment influences corporate low-carbon transformation through capital-market channels. Li (2023) argues that ESG investment is a key driver of carbon-economy development and that ESG has shifted from an evaluative tool to a mechanism that shapes capital flows. Green finance provides financial support for clean-energy substitution and industrial low-carbon upgrading through bonds, funds, credit, and carbon markets (Ma, 2021). ESG investment, in turn, creates sustained pressure through market pricing and investor preferences. Together, green finance and ESG investment constitute an important financial foundation for carbon neutrality (People's Bank of China et al., 2021).

From the firm perspective, strong ESG performance can facilitate access to lower-cost financing and greater market recognition, thereby enhancing low-carbon investment capacity. Conversely, active low-carbon transformation may also improve ESG ratings (Huang, 2022c). Existing research, however, has not yet sufficiently identified the actual effects of policy instruments. Whether carbon-emissions trading pilots, low-carbon city pilots, and related policy tools genuinely improve corporate ESG performance and carbon-neutrality outcomes--and whether these effects differ across ESG dimensions--requires further empirical testing (Zhang et al., 2023).

5. BIBLIOMETRIC ANALYSIS: SHIFTS IN RESEARCH HOTSPOTS

5.1 Data Sources and Methods

To corroborate the preceding review, this study retrieves publications from the Web of Science Core Collection and the CNKI database. English-language searches used keywords such as “ESG,” “carbon neutrality,” “carbon disclosure,” and “green finance,” while Chinese-language searches used corresponding terms including “ESG,” “carbon neutrality,” “carbon disclosure,” and “green finance.” After excluding conference notices, news reports, and other invalid records, the studycompiled annual publication trends, disciplinary categories, and keywords, and used VOSviewer and CiteSpace to generate knowledge maps.

5.2 Publication Trends and Stage Characteristics

ESG-related research has increased markedly since 2018 and accelerated further around 2022. Publications at the intersection of ESG and carbon neutrality have also grown year by year, with Chinese scholarship showing a particularly pronounced rise after the announcement of the dual-carbon targets. The evolution of the field can be characterized in three stages. The first is the conceptual-introduction stage before 2018, during which ESG research centered on corporate social responsibility and corporate governance, while carbon neutrality had not yet become a core topic. The second is the policy-driven stage from 2020 to 2022, when the dual-carbon targets strengthened the connection among green transition, carbon disclosure, and ESG assessment. The third is the integration stage from 2023 onward, in which research has shifted from separate discussions of ESG performance

or carbon reduction toward the question of how ESG can support low-carbon transition and green value creation.

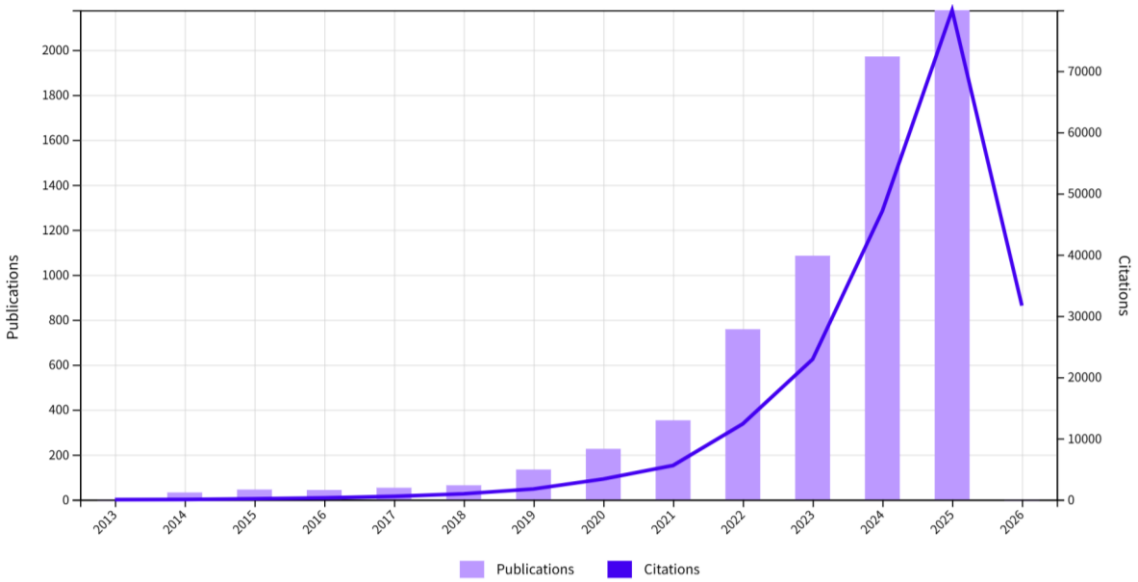

Figure 1: Number of Web of Science Publications and Citation Frequency on "ESG" (2014–2025)

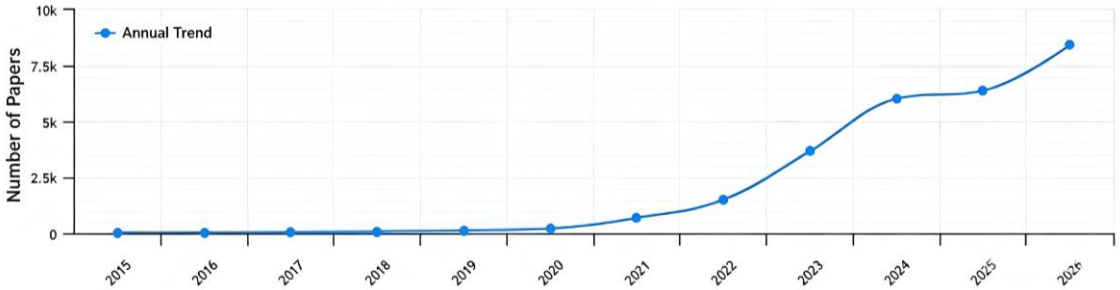

Figure 2: Number of CNKI Publications on "ESG" (2015–2026)

5.3 Disciplinary Distribution and Thematic Structure

The disciplinary distribution shows that environmental science and resource utilization account for the largest share of publications, followed by economics and industrial studies, indicating the multidisciplinary nature of this research area.

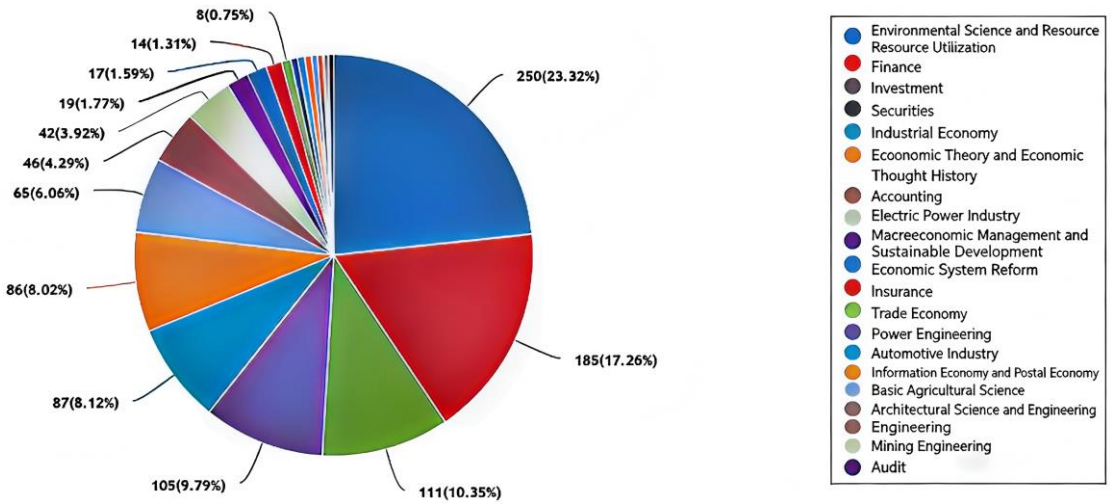

Figure 3: Disciplinary Distribution of Literature on ESG and Carbon Neutrality**

Keyword co-occurrence analysis identifies four major thematic categories.

Table 1: Keyword co-occurrence analysis identifies four major thematic categories

Thematic category	Core keywords	Research meaning
Sustainable development and corporate performance	ESG; corporate performance; social responsibility; long-term value	Early research interpreted ESG through the lenses of responsibility and value creation.
Green finance and capital markets	Green finance; ESG investment; financing costs; investor behavior	Studies examine the effects of ESG on capital allocation and financing conditions.
Carbon disclosure and climate governance	Carbon disclosure; carbon neutrality; climate risk; environmental information	This theme emphasizes the importance of carbon-information transparency under the dual-carbon targets.
Low-carbon transition and circular economy	Low-carbon transition; circular economy; green innovation; energy transition	Research extends from firm-level assessment to supply chains and energy structure.

The VOSviewer keyword co-occurrence network indicates close connections among ESG, carbon neutrality, sustainable development, CSR, and performance. CiteSpace clustering (Q = 0.783; S = 0.931) identifies major clusters including the Chinese stock market, green finance, circular economy, brand loyalty, sustainable development, and low-carbonization. The temporal proximity between carbon-neutrality and sustainable-development clusters confirms that the integration of ESG and carbon neutrality is becoming a new research frontier.

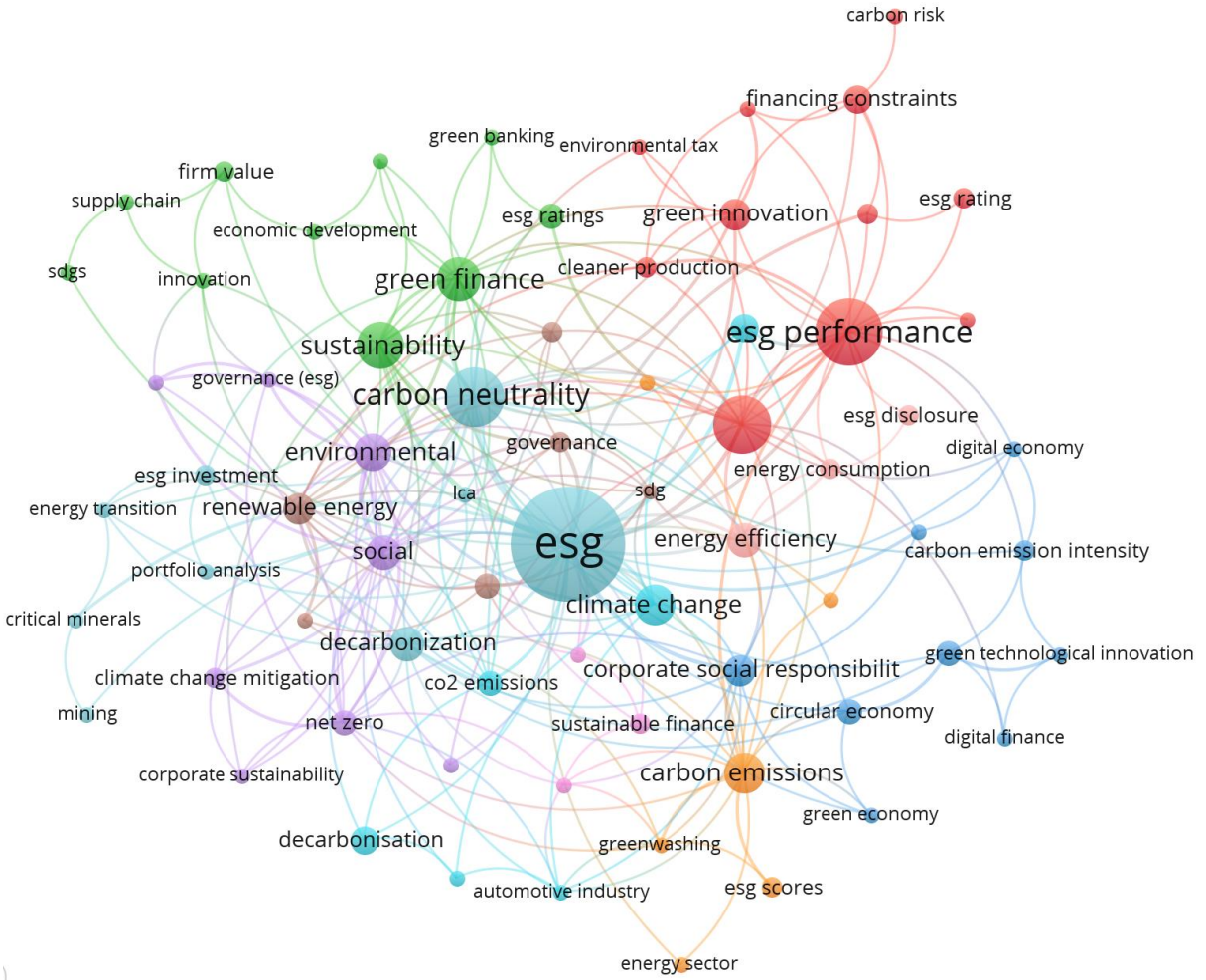

Figure 4: Keyword Co-occurrence Network Map

Burst-keyword analysis for 2021-2025 shows that “sustainability” and “carbon neutrality” maintain strong citation intensity, while “finance,” “investment,” and “performance” remain current hotspots. This pattern is consistent with the directions identified in the literature review, namely governance mechanisms, information disclosure, green finance, and corporate low-carbon transformation.

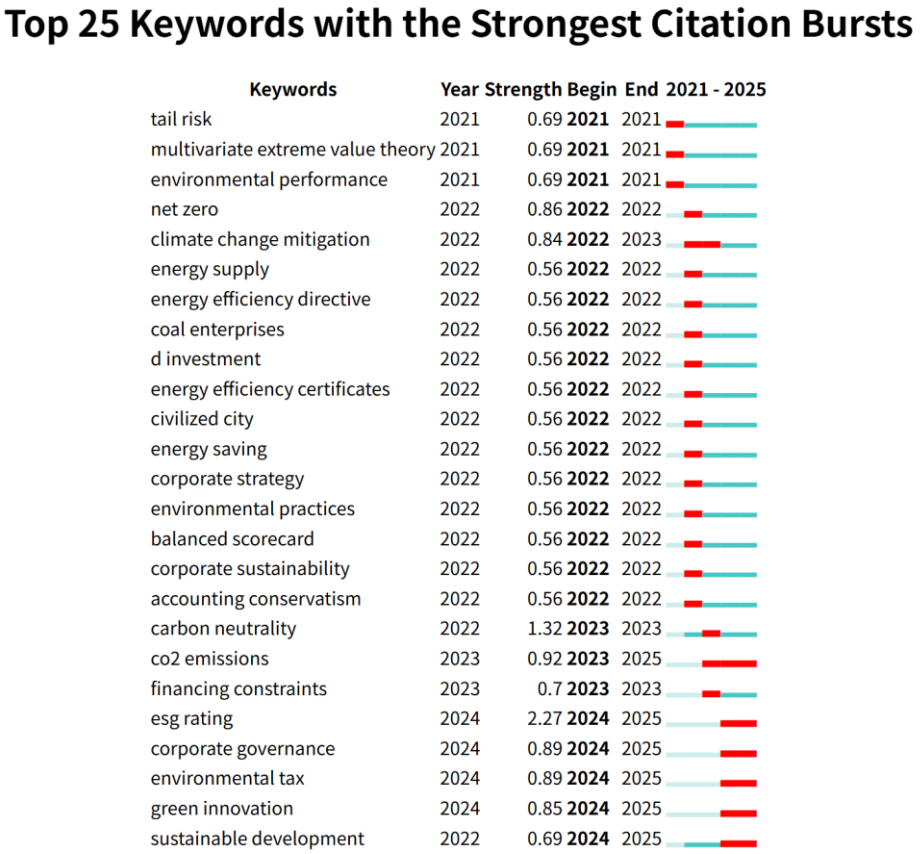

Figure 5: Cited Keyword Analysis of Carbon Neutrality and ESG (2021–2025)

6. DISCUSSION AND FUTURE RESEARCH AGENDA

6.1 Existing Contributions and Core Gaps

Existing research has established a foundation for understanding corporate low-carbon transformation through conceptual clarification, mechanism analysis, and applied studies. The central gap, however, lies in the limited ability of current ESG assessment systems to reflect the independence and systemic requirements of the carbon-neutrality agenda.

This gap appears in four respects. First, carbon emissions, climate risk, and low-carbon transition are usually incorporated into the environmental pillar, which weakens the specific evaluative constraint imposed by the dual-carbon targets (Huang, 2023). Second, many studies prioritize information disclosure over actual emission-reduction performance, making it difficult to identify greenwashing behavior (Li & Yang, 2024). Third, samples are often concentrated in particular industries or regions, limiting cross-regional and cross-industry comparison (Xi & Zhao, 2023). Fourth, policy effects remain insufficiently identified; the extent to which different policy tools promote corporate ESG performance in practice still requires further testing (Zhang et al., 2024).

6.2 Directions for Future Research

First, future studies should construct carbon-neutrality-oriented ESG assessment systems, or ESG-C frameworks. On the basis of the traditional three-pillar ESG structure, such frameworks should introduce a distinct carbon-neutrality dimension and evaluate carbon-policy management, carbon-production performance, and emission-reduction capability as relatively independent components. This design would more accurately capture corporate carbon-governance performance. It also requires a clear boundary between the environmental and carbon dimensions: the environmental pillar should focus on broader ecological impacts, whereas the carbon dimension should emphasize full-life-cycle greenhouse-gas management, carbon-asset operations, and investment in low-carbon technologies.

Second, future research should strengthen the identification of substantive emission-reduction performance. Indicators such as carbon-emission intensity, energy-use efficiency, green-technology innovation input, and achieved emission reductions should be incorporated to link disclosure behavior with actual performance. A disclosure-performance matching approach would help distinguish genuine low-carbon transformation from greenwashing.

Third, heterogeneity analysis should be expanded. Using broader firm samples, future research can combine spatial analysis, industry comparison, and policy evaluation to examine how the ESG-carbon neutrality relationship differs between energy-intensive industries and low-carbon services, pilot and non-pilot regions, and alternative policy-tool settings.

Fourth, greater attention should be paid to policy effects and underlying mechanisms. By incorporating carbon-emissions trading, low-carbon city pilots, the national carbon market, and other policy instruments, future studies can evaluate the actual effects of dual-carbon policies on corporate ESG performance and carbon-neutrality outcomes, and identify whether policy pressure operates through green innovation, alleviation of financing constraints, governance optimization, or other channels.

7. CONCLUSION

This study reviews and bibliometrically analyzes research at the intersection of carbon neutrality and ESG. The findings indicate that carbon neutrality has expanded from an emissions-balance target into a systemic transition agenda, while ESG has evolved from a nonfinancial performance assessment tool into a framework for evaluating long-term value. The two agendas intersect clearly in corporate low-carbon transformation, carbon-governance performance, and green finance. Yet current ESG assessment systems still lack an independent carbon-neutrality dimension.

The bibliometric evidence confirms that ESG-carbon neutrality research is moving from general assessments of corporate responsibility toward climate governance and low-carbon transition. Research hotspots concentrate around sustainable development, green finance, carbon disclosure, and low-carbon transformation. Future scholarship should develop carbon-neutrality-oriented ESG assessment systems, strengthen the evaluation of substantive corporate carbon-governance capacity, and use larger samples and policy-evaluation methods to support the improvement of corporate green governance and capital-market assessment frameworks.

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