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A Study of the Impact of ESG on Corporate Carbon Performance -- Based on the mediating effect of New quality productivity

Ying Wu [1] Yu Liao [1*] Dai-Yun Li [2]

[1] College of School of Economics, Wuhan Textile University, Wuhan 430200, China
[2] College of School of Economics and Management, Guangzhou Institute of Science and Technology, Guangzhou 510000, China
*Corresponding author Email: 825946265@qq.com
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Abstract: To investigate whether corporate ESG can improve corporate carbon performance and facilitate the achievement of China's "dual-carbon" objective, we utilize panel data from China's A-share-listed companies spanning 2015 to 2022. We develop new quality productivity indicators through principal component analysis and empirically assess the impact and mechanisms of ESG on corporate carbon performance using bidirectional fixed-effects, mediated-effects, and moderated-effects models. The influence and mechanism of ESG on corporate carbon performance are experimentally analyzed utilizing a two-way fixed effects model, a mediation effects model, and a moderating effects model. Research indicates that (i) strong ESG performance can markedly enhance corporate carbon performance; this conclusion remains valid following various robustness and endogeneity assessments, including substituting core explanatory variables, lagging explanatory variables by one period, and augmenting the standard error of clustering at the city level. (ii) Mechanism analysis indicates that ESG performance enhances the carbon performance of firms both directly and indirectly by fostering advancements in new quality productivity. (iii) The examination of moderating effects indicates that company financialization enhances the favorable influence of ESG on corporate carbon performance. Heterogeneity study indicates that ESG exerts a more pronounced influence in the eastern area, among non-state-owned firms, and within non-heavily polluting enterprises. Consequently, to advance the low-carbon transformation of the economy, it is essential to stratify the policy design. Incentives for ESG can be enhanced for non-state-owned enterprises, manufacturing sectors, and the eastern region, while technology subsidies or differentiated assessment criteria are required for state-owned enterprises, heavily polluting industries, and the central and western regions to address the structural disparities in ESG practices and to encourage non-manufacturing industries to pursue synergistic avenues of digital transformation and ESG integration.

Keywords: ESG, Carbon performance, New quality productivity, Mediating effect, Moderating effect

I. INTRODUCTION

In recent years, as global climate change escalates and resource limitations tighten, advancing the green and low-carbon transformation of firms has emerged as a crucial option for nations to address the environmental issue. In this context, and in reaction to the problems presented by climate change, the Chinese government committed at the 2020 United Nations General Assembly to reach peak carbon emissions by 2030 and attain carbon neutrality by 2060. This objective indicates a transition from the conventional high-carbon emission paradigm to a more environmentally friendly, low-carbon, and sustainable development framework for China and the globe. Throughout this shift, ESG—Environmental, Social, and business Governance—has gained prominence as a critical metric for assessing business sustainability and social responsibility. Enterprises must not only seek to maximize economic benefits but also improve resource efficiency and minimize environmental impact through innovation, social responsibility, and governance optimization. This is particularly crucial for listed companies, which are expected to lead in advancing low-carbon transformation and high-quality economic development. Nonetheless, throughout implementation, the limitations of the conventional productivity growth model have increasingly become apparent, hindering effective support for the achievement of carbon objectives. The swift advancement of the information technology revolution, encompassing artificial intelligence, big data, digital transformation, and green technology, has significantly altered the essence of productivity. Currently, China's economy has transitioned from high-speed growth to high-quality development, rendering traditional productivity metrics insufficient to adequately capture the new impetus and potential of economic advancement. Consequently, the notion of "new quality productivity" has arisen, which not only enhances and broadens the conventional understanding of productivity but also addresses the demands of economic advancement in the contemporary day. Can good ESG governance enhance company success in reducing carbon emissions?

Presently, ESG research indicates a progression from disjointed analysis to systematic integration, with its theoretical framework transcending a singular focus on financial performance to establish a three-dimensional dynamic coupling of environmental responsibility, social accountability, and governance efficacy[1]. Scholars widely concur that ESG practices generate long-term value through enhanced capital allocation, improved supply chain synergies, and the promotion of low-carbon technology; yet, short-term cost pressures and delayed rewards remain important grounds of contention. Particularly in emerging markets, the unique attributes of the policy landscape and market mechanisms have resulted in notable disparities in the efficiency of the "compliance-innovation" transformation of ESG inputs, while the fragmentation of the global ESG rating system has exacerbated the ambiguity surrounding corporate decision-making. Research on carbon performance is transitioning from static accounting to dynamic capacity development. The initial emphasis on emission measurement has transitioned to the interactive analysis of driving mechanisms and value creation: on one hand, the correlation between carbon emission intensity and financial performance has transcended the conventional “cost-burden theory,” with the technology compensation effect and green premium mechanism increasingly elucidating the symbiotic phenomenon of “emission reduction and profitability”; on the other hand, the novel avenues of supply chain synergy for carbon emission reduction and the empowerment of digital technology are transforming corporate carbon management[2]. Conversely, emerging avenues like supply chain synergy and digital technology empowerment are transforming the strategic framework of enterprise carbon management. Nonetheless, the technical impediment of low-carbon transformation in heavy industries, the insufficient carbon accounting capabilities of small and medium-sized firms (SMEs), and the fragmentation of the global carbon market remain challenges that the academic community must address.Research on company financialization elucidates the "double-edged sword" effect of capital allocation. Financial asset holdings can alleviate financing limitations and furnish capital reserves for green investments; yet, they may also inhibit genuine innovation resources due to arbitrage preferences, a conflict that is especially evident in the framework of shareholder value maximization. The policy environment significantly influences the trajectory of financialization; a bank-dominated financial system may diminish disincentives for innovation, but a competitively neutral policy can limit the regulatory arbitrage of state-owned enterprises (SOEs). The present study focus has transitioned to the processes by which technical governance solutions, including blockchain and ESG financial instruments, can mitigate the inclination towards "deconcentration."

Investigations on the relationship between ESG and carbon performance are in a phase of theoretical refinement. Current findings primarily emphasize the connection between technological innovation, such as clean technology research and development, and institutional design, like carbon information disclosure. However, they overlook three critical issues: first, the inconsistency of ESG ratings results in distorted market signals, diminishing enterprises' incentives to lower emissions; second, there exists a risk of disruptions in the tracing of supply-chain carbon data, which compromises the efficacy of comprehensive value-chain management; and third, "greenwashing" practices obscure the true nature of carbon performance through strategic disclosure, rendering such behavior inadequate for achieving emission reductions. Third, "greenwashing" practices obscure the fundamental nature of emission reduction by deliberate information dissemination. These vulnerabilities underscore the necessity of establishing a verifiable and traceable transmission chain for ESG-carbon performance.The emergence of new quality productivity theory offers a fresh perspective for carbon performance studies. The framework situates productivity evolution within a three-dimensional coordinate system comprising technological revolution, factor reconfiguration, and institutional innovation, highlighting the synergistic development of green technological innovation, digital empowerment, and business ecological reconfiguration[3]. The fundamental advancement consists of demonstrating the intrinsic connection between the reduction of carbon emission intensity and the improvement of total factor productivity; however, empirical validation at the micro-firm level remains inadequate, particularly regarding the specific dynamics of the technology-institution-capital triadic interaction, which requires further analysis.The control of ESG-carbon performance through financialization is intricate. The short-term arbitrage incentive may undermine long-term emission reduction investments in ESG; nevertheless, instruments like green bonds and carbon futures can offer risk mitigation and financial backing for the low-carbon transition. The origin of this contradiction resides in the selection of corporate strategic emphasis—when financialization supports technological advancement instead of dissociating from the organization, it can create a "capital-technology-emission reduction" enhancing loop[4]. The difficulty of how policy design may effectively direct financial resources toward significant emission reduction regions has emerged as a prevalent issue in both theory and practice.There are considerable deficiencies in the current literature regarding multidimensional integration, dynamic mechanisms, and local adaptation: ESG research inadequately addresses the influence of non-financial factors; Carbon performance studies fail to adequately respond to emerging trends such as new quality productivity; and there is a scarcity of empirical evidence to substantiate the distinctive trajectory of ESG-financialization-emission reduction among firms in emerging markets. This study aims to address these theoretical blind spots[5].

The potential marginal contributions of this paper are as follows: Initially, the advancement of the theoretical framework. Limited domestic research on carbon emission reduction pertains to new quality productivity, and even fewer studies examine the correlation between ESG and carbon performance, lacking a systematic theoretical framework and empirical validation; therefore, there is a need for the development of the local context[6]. International scholars often isolate individual elements from ESG or perpetuate the CSR research framework to examine carbon-related issues, while the notion of "new quality productivity" remains underrepresented in their academic discourse, rendering their conclusions inapplicable to the Chinese context. This research offers empirical evidence for the localization of the new quality productivity hypothesis, based on data from Chinese A-share listed enterprises[7]. Third, the enhancement of heterogeneity analysis. This paper examines heterogeneity across four dimensions: ownership characteristics, industry type, geographic location, and pollution levels, elucidating the varying effects of ESG performance on carbon performance in distinct contexts, and offering micro-evidence of firms' enhancement of new quality productivity. The examination of the moderating influence[8]. This study presents corporate financialization as a moderating variable, elucidates its function in the relationship between ESG performance and carbon performance, and offers a novel theoretical viewpoint for mitigating economic “deconcentration.”

II. THEORETICAL ANALYSIS

2.1 Sustainable Development Theory

The creation and progression of the sustainable development theory arise from humanity's methodical contemplation of the adverse externalities associated with industrial civilization. The concept originated from the ecological and environmental warnings presented in Silent Spring during the 1960s, but it has undergone three significant developmental phases to achieve global acceptance. The 1972 United Nations Conference on the Human Environment (UNCHE) was the inaugural event to integrate environmental concerns into the international political agenda[9], presenting the interdependent relationship between the right to development and environmental protection, thereby establishing a dualistic equilibrium between ecology and economy. “ In 1987, the Brundtland Report defined sustainable development as "meeting the needs of the present without compromising the ability of future generations to meet their own needs." In 1987, the Brundtland Report defined sustainable development as “meeting the needs of the present without compromising the ability of future generations to meet their own needs,” established the principle of intergenerational equity, and incorporated social equity into the theoretical framework. In 1992, the Earth Summit in Rio adopted Agenda 21, which advanced the transition from concept to action, highlighting the collaboration of government, enterprises, and society, during which enterprises were expressly recognized as the primary custodians of environmental responsibility.

As we entered the 21st century, the theoretical framework evolved to encompass the interplay between technological innovation and institutional transformation. The 17 Sustainable Development Goals (SDGs) outlined in the 2015 UN 2030 Agenda for Sustainable Development integrated specific environmental metrics, such as clean energy and climate action, with corporate governance structures and stakeholder engagement for the first time, signifying a shift from macro-policy considerations to micro-enterprise practices in sustainable development. This signifies the integration of sustainable development from the macro policy level to micro enterprise practices. Within this theoretical framework, the ESG (Environment, Society, Governance) system has effectively transformed into the operational framework for sustainable development goals at the corporate level: the environmental dimension directly mitigates carbon emission intensity per unit of output through the advancement of clean technology and carbon footprint management[10]; the social dimension indirectly curtails carbon leakage within the value chain by promoting supply chain greening and fostering low-carbon behaviors among employees; and the governance dimension implements a carbon management system. The governance aspect creates a continual improvement process by implementing a carbon management system and disclosing carbon emission data[11]. This triad of pathways positions ESG as a crucial link between corporate micro-decision-making and macro carbon neutrality objectives, while also offering robust theoretical basis for the empirical analysis of the influence of ESG performance on carbon outcomes[12].

2.2 Corporate Social Responsibility Theory

The development of corporate social responsibility (CSR) philosophy illustrates the transition of global business from a profit-centric model to a value-oriented one. The ideological lineage originates from Howard Bowen's notion of “businessmen's social responsibility” in the 1950s, which underscored the necessity for corporate decision-making to transcend economic objectives and address social expectations, thereby establishing the foundation for the subsequent connection between social responsibility and environmental concerns[13]. In the 1960s, Milton

Friedman's "Shareholder Priority Theory" incited vigorous debates, compelling the academic community to develop a more systematic explanatory framework—the CSR pyramid model introduced by Archie Carroll in 1979, which explicitly incorporated environmental responsibility into corporate ethics. At the close of the 20th century, Edward Freeman's stakeholder theory elucidated environmental responsibility, underscoring the significance of corporate accountability to governmental environmental regulations. At the conclusion of the 20th century, Edward Freeman's stakeholder theory elucidated environmental responsibility, underscoring that corporate adherence to governmental environmental regulations and community ecological expectations directly influences its legitimacy[14]. Furthermore, the carbon footprint, as a measurable indicator of environmental externalities, has emerged as a pivotal metric for assessing corporate environmental responsibility. In the 21st century, Michael Porter's theory of shared value advocates for the evolution of corporate social responsibility (CSR) into a strategic framework, encouraging the conversion of social challenges into business opportunities, such as minimizing carbon emission costs via clean technology research and development, meeting environmental obligations, and augmenting competitive advantages, alongside the dual benefit mechanism of "carbon emission reduction - efficiency enhancement."

The double dividend mechanism of "carbon emission reduction - efficiency improvement" establishes a theoretical connection between the ESG (environmental, social, governance) framework and carbon performance. The ESG framework can be viewed as an indexed expansion of CSR theory. The environmental (E) dimension pertains to enhancements in carbon performance, achieved by diminishing carbon emission intensity per unit of output value through technological advancements, including investments in renewable energy and the decarbonization of production processes. The social (S) dimension mitigates carbon leakage within the value chain via green supply chain management and low-carbon product innovation. The governance (G) dimension is contingent upon the board of directors' oversight of climate issues and the disclosure of carbon-related information. The governance (G) dimension depends on the board of directors' oversight of climate monitoring, carbon information disclosure, and various institutional frameworks to guarantee the ongoing achievement of emission reduction objectives. According to this rationale, CSR theory elucidates the inherent motivation behind ESG practices that enhance carbon performance — specifically, the internalization of environmental externalities via resource reallocation, technological innovation, and institutional transformation. Furthermore, it highlights the potential moderating influence of financialization: when firms excessively prioritize short-term profits from financial assets, they may undermine long-term ESG-related low-carbon investments. It also indicates the potential moderating influence of financialization: when companies excessively seek short-term gains from financial assets, they may displace ESG-related long-term low-carbon investments, undermine the resource foundation for fulfilling environmental responsibilities, and consequently hinder advancements in carbon performance. This theoretical approach establishes the basis for empirically investigating the relationship between ESG and carbon performance, as well as the constraints of financialization.

2.3 Stakeholder Theory

The development of stakeholder theory has significantly demonstrated the transition from exclusive shareholder value maximization to inclusive value co-creation. The term of "stakeholder," introduced by the Stanford Research Institute in 1963, denotes any group that influences or is influenced by the achievement of business objectives; nevertheless, a rigorous analytical framework had not yet been established at that time. In 1984, R. Edward Freeman, in his book "Strategic Management: A Stakeholder Approach," revolutionized the perception of the firm as a nexus connecting shareholders, employees, consumers, suppliers, and the public. In 1984, R. Edward Freeman, in "Strategic Management: A Stakeholder Approach," pioneered the concept of enterprises as a contractual network linking shareholders, employees, consumers, suppliers, communities, governments, and other diverse entities. He argued that long-term value creation depends on balancing the rights and interests of all stakeholders, establishing a foundation for comprehending the multi-dimensional driving mechanism of ESG (Environmental, Social, Governance) - Environmental Responsibility (E This establishes the basis for comprehending the various driving forces of ESG (environmental, social, and governance). Environmental responsibility (E) addresses governmental environmental regulations and community ecological welfare; social responsibility (S) fulfills employee rights and consumer ethical consumption standards; and governance responsibility (G) upholds investor trust through transparent decision-making[15]. Collectively, these three dimensions are essential for companies to attain legitimacy and support from stakeholders. In the 1990s, Mitchell et al. proposed the theory of stakeholder salience. The categorization of stakeholders according to the three dimensions of power, legitimacy, and urgency elucidates the varied influences of distinct actors on corporate ESG practices: governments compel corporations to enhance their carbon performance via mandatory measures such as carbon quota regulations and carbon taxes; institutional investors leverage the power of “voting with their feet” based on ESG ratings; and consumers shape the market through eco-friendly purchasing behaviors. Consumers engage in eco-friendly purchasing behavior to provide market incentives. This multi-tiered stakeholder pressure network compels enterprises to transition their carbon management from passive compliance to proactive innovation.

In the 21st century, stakeholder theory has become intricately linked with the Sustainable Development Goals (SDGs), and initiatives like the UN's Principles for Responsible Investment (PRI) mandate that companies disclose carbon emissions data and permit stakeholder oversight, thereby transforming carbon performance into a fundamental metric of a company's responsiveness to stakeholders' climate expectations. The ESG framework functions as an implementation tool for stakeholder theory: companies mitigate carbon emissions in their production processes via investments in photovoltaic technology and carbon capture methods (environmental dimension), address regulatory pressures and consumer preferences for low-carbon products through supply chain carbon inventory and product carbon labeling (social dimension), and meet investor demands for ESG investments by establishing sustainability committees and enhancing carbon disclosure systems (governance dimension). This multi-dimensional interaction process converts external stakeholder pressure into internal incentive for carbon governance, ultimately enhancing carbon performance[16]. This theoretical framework elucidates the trajectory of ESG practices aimed at enhancing carbon performance—specifically, acquiring resources and legitimacy through the identification, coordination, and fulfillment of the climate demands of principal stakeholders — while also offering insights into the moderating influence of corporate financialization. When corporations excessively allocate resources to financial assets, they may jeopardize their investment in the low-carbon transformation of their core operations, resulting in diminished investment in both the low-carbon transformation of their business and their workforce. When companies excessively prioritize financial asset allocation, they may jeopardize their investment in the low-carbon transformation of their core operations, leading to deficiencies in stakeholder relations, including employee technical training and community collaboration on environmental protection, thereby diminishing the effectiveness of ESG in enhancing carbon performance.

2.4 Signaling Theory

The progression of signaling theory elucidates the underlying rationale of business behavioral strategies in information-asymmetric markets, and its significance to ESG practices and carbon performance fundamentally reflects the principles of information economics within sustainable development. The theory emerged from the labor market model introduced by Michael Spence in 1973, which posits that individuals with private information convey signals to the external environment through observable actions to mitigate information costs. This principle was later incorporated into capital structure analysis by Stephen Ross in the 1980s, who developed a framework for examining dividend policy and debt financing as indicators of corporate quality. In the late 1990s, the emergence of socially responsible investing prompted a theoretical shift towards the value signaling function of non-financial disclosure. Companies communicated their dedication to sustainable development to the capital market by publishing environmental reports and revealing carbon footprint data. The efficacy of these signals was contingent upon their verifiability and cost differentiation: significant polluters who misleadingly promoted a low-carbon transition would be more impactful than firms that inaccurately claimed a low-carbon transition. The efficacy of this signal is contingent upon its verifiability and cost differentiation: companies with significant pollution will incur substantial regulatory penalties and reputational damage if they misrepresent a low-carbon transition, whereas firms that authentically adopt clean technology innovations will benefit from reduced financing costs by enhancing their ESG ratings[17]. This "split-equilibrium" mechanism has facilitated credible signaling of ESG performance to the capital market, enabling the assessment of a company's capacity to manage its carbon footprint. In the 21st century, signaling theory has been increasingly aligned with the climate change agenda, with carbon performance data (e.g., carbon emissions per unit of revenue, carbon-neutral roadmap) serving as a fundamental conduit for environmental signals. This data not only affects investors' evaluations of climate risk management capabilities but also yields significant financial returns through mechanisms such as premiums on green bond issuance and reductions in carbon tariffs. The governance aspect of the ESG framework, including the creation of a sustainability committee and third-party verification of carbon reports, markedly enhances the credibility of environmental signals by improving the standardization and transparency of information disclosure. Concurrently, stakeholder engagement in the social dimension, such as community environmental dialogues and supply-chain carbon emissions inspections, broadens the audience for these signals, enabling non-financial entities like consumers and suppliers to modify their cooperation strategies in alignment with ESG signals, thereby establishing a foundation for environmental policy formulation and the advancement of a green economy[18].

The ESG signals enable non-financial stakeholders, including customers and suppliers, to modify their collaboration strategies, so generating a multi-faceted incentive for enhancing carbon performance. Increased financialization may distort the signaling mechanism: an over-reliance on short-term gains from financial assets may compel management to reduce long-term ESG-related investments, resulting in "greenwash" noise in carbon performance signals. Additionally, the incentives for statement modification induced by financialization may lead to selective disclosure, such as exaggerating the progress of Scope 3emissions reductions while concealing the extent of those reductions. Simultaneously, financialization may result in selective disclosure (e.g., overstating advancements in Scope 3 emissions reduction while concealing Scope 1 emissions statistics), so undermining the relationship between ESG indicators and actual carbon performance[19]. The moderating effect indicates that financialization may diminish the substantive improvement of carbon performance through ESG practices due to resource crowding out, while also intensifying the capital market's misperception of the efficacy of low-carbon transition via signal distortion. This dual mechanism offers a theoretical framework for empirically investigating the moderating pathways of corporate financialization in the "ESG-Carbon Performance" relationship. This dual mechanism offers a theoretical framework for empirically investigating the moderating role of company financialization in the relationship between ESG and carbon performance.

2.5 New-Quality Productivity Theory

The new quality of productive forces constitutes a revolutionary theoretical framework within the context of socialist political economy with Chinese characteristics, embodying the qualitative advancement of productive forces, with its essence rooted in the dialectical unity of disruptive technological innovation and the comprehensive reconfiguration of production factors[20]. From a philosophical standpoint, it transcends the epistemological constraints of conventional linear progress in productive forces, instigating a quantitative reconfiguration of production factors through an intergenerational technological leap, and effecting a structural transition from "factor-driven" to "paradigm-driven." This qualitative transformation is marked by the non-linear increase in total factor productivity, which reconfigures the principles of value creation within the triadic interplay of technological revolution, industrial transformation, and institutional innovation, thereby establishing advanced productive forces that signify a historical epoch.

The theoretical framework is anchored in the modern interpretation of Marxism's contradictory dynamics between productive forces and production relations. Its kinetic mechanism delineates a threefold breakthrough: firstly, a fundamental advancement in the technological foundation, evident in the reconfiguration of the production function through cutting-edge scientific and technological clusters; secondly, a revolutionary transformation of the factor structure, marked by the emergence of new factors such as data, knowledge, and intelligence, which alleviate the diminishing marginal returns of traditional factors; and thirdly, a systematic reconfiguration of industrial forms, facilitating the transition of the industrial system from mechanical to ecological division of labor, thereby elevating industrial production into an advanced productive force. The third aspect is the systematic reconfiguration of industrial structure, facilitating the transition of the industrial system from mechanical labor division to ecological synergy. This transformation engenders the synergistic evolution mechanism of "technology-industry-system," facilitating a transition in productive forces from quantitative accumulation to qualitative transformation, ultimately achieving a paradigm shift in the mode of production[21].

The structural dimension of the new quality productivity comprises three theoretical pillars: first, the paradigm shift in the driving force of innovation, characterized by a bidirectional feedback loop between advancements in fundamental research and the innovation of application scenarios; second, the time-space compression effect on resource allocation, wherein digital technology mitigates physical barriers to the flow of production factors; and third, the multidimensional leap in value creation, marked by the profound integration of sustainability, digitization, and human-centric values. Their development adheres to the principle of dialectical negation, encompassing the retention of the rational core of traditional productive forces while simultaneously discarding developmental constraints, ultimately leading to the establishment of the material foundation for a new form of human civilization[22]. The fundamental propositions that require elucidation in the present theoretical framework are: how the intergenerational transformation of productive forces, instigated by the technological revolution, can catalyze adaptive modifications in production relations; how the value creation logic of novel elements can reshape the paradigm of economic governance; and how the benefits of the socialist system can be converted into a systematic assurance for the enhanced quality of productive forces. This necessitates the development of a cohesive theoretical framework that connects the behavior of micro-entities, the progression of meso-industries, and the macro-institutional context, in order to elucidate the historical inevitability and practical trajectory of the qualitative transformation of productive forces from the standpoint of historical materialism.

Table 1. New Quality Productivity Index Calculation System

Factors	Subfactor	Indicators(ratio)	Description of indicator values	Weights
Labor force	Labor	R&D salaries	Research and development expenses - salaries and wages/operating income	28
		R&D staff	Number of R&D staff / Number of employees	4
		High-skilled workers	Number of people with bachelor's degree or above / Number of employees	3

Production tool	Materialized labor (Objects of labor)	Fixed assets	Fixed assets/total assets	2
		Manufacturing costs	(Subtotal cash outflows from operating activities + depreciation of fixed assets + amortization of intangible assets + provision for impairment - cash paid for purchases of goods and services - wages paid to and for employees) / (Subtotal cash outflows from operating activities + depreciation of fixed assets + amortization of intangible assets + provision for impairment)	1
	Hard technology	R&D depreciation and amortization	R&D expenses - depreciation and amortization/operating income	27
		R&D lease payments	Research and development expenses - rental expenses/operating income	2
	Soft technology	R&D direct investment	R&D expenses - direct inputs/operating income	28
		Intangible assets	Intangible assets/total assets	3
		Total asset turnover	Operating income/average total assets	1
		Inverse equity multiplier	Owners' equity/total assets	1
	New-Quality productivity			100

3 RESEARCH DESIGN

3.1 Modeling

In order to test the research hypothesis H1, this paper first constructs the following regression model (1):

$$CP_{i,t} = \alpha_0 + \alpha_1 ESG_{i,t} + \sum Controls + \sum Firm + \sum Year + \varepsilon_{i,t} (1)$$

In model (1), CP is an explanatory variable, representing corporate carbon performance; ESG is an explanatory variable, representing the development of corporate social responsibility; Controls is a series of control variables; Firm and Year are fixed for company and year, respectively; ε is a random perturbation term; and the subscripts, i and t, stand for the individual firm and time, respectively;

In order to further explore the mechanism of ESG on carbon emission performance, based on the previous theoretical analysis, and according to the suggestion of the three-step approach to the testing of the transmission mechanism, this paper constructs the transmission mechanism model (2) and (3) to test the hypotheses H2a and H2b;

$$NPRO_{i,t} = \beta_0 + \beta_1 ESG_{i,t} + \sum Controls + \sum Firm + \sum Year + \varepsilon_{i,t} (2)$$

$$CP_{i,t} = \gamma_0 + \gamma_1 ESG_{i,t} + \gamma_2 NPRO_{i,t} + \sum Controls + \sum Firm + \sum Year + \varepsilon_{i,t} \ (3)$$

In models (2) and (3), NPRO is the mediating variable, which indicates new quality productivity, and the rest of the variables have the same meaning as above;

In order to test hypothesis H3, corporate financialization is chosen as the moderating variable and model (4) is constructed

$$CP_{i,t} = \delta_0 + \delta_1 ESG_{i,t} + \delta_2 FINRATIO_{i,t} + \delta_3 ESG_{i,t} \times FINRATIO_{i,t} + \sum Controls + \sum Firm + \sum Year + \varepsilon_{i,t} \ (4)$$

In model (4), FINARTIO is the moderating variable that indicates the degree of financialization of the firm, $ESG_{i,t} \times FINRATIO_{i,t}$ represents the interaction term between ESG and the degree of financialization, and the rest of the variables have the same meaning as above.

Based on the aforementioned theoretical analysis and model design, the analysis makes the following assumptions:

H1: Good ESG performance can significantly improve a firm's carbon performance.

H2a: Effective ESG governance enhances firms' new quality productivity levels.

H2b: NQP plays a significant mediating effect between ESG performance and carbon emission performance.

H3: There is a significant positive moderating effect of corporate financialization in the impact of ESG performance on carbon emission performance.

3.2 Selection of variables

(1) Corporate carbon performance

In this paper, we refer Yu He [23] to define corporate carbon performance (CP) as the ratio of operating income (RMB 10,000) to total carbon emissions (tons), i.e., operating income per unit of carbon emissions. Among them, the total carbon emissions are calculated as combustion and fugitive emissions + production process emissions + waste emissions + emissions due to land use change (forest to industrial land).

(2) ESG rating data

Combining the relevant literature and the actual situation of the country, this paper chooses the ESG data of CSI as the core explanatory variables, and replaces the CSI ESG data with Bloomberg ESG data in the robustness test.

(3) New quality productivity

Referring to Jia Song [24] firms' new quality productivity measures for the construction of the indicator system. In addition, instrumental variables are added to this dataset for matching, and the chosen instrumental variable is total factor productivity of enterprises.

(4) Financialization of enterprises

The ratio of profits from financial channels such as investment income, gains and losses from changes in fair value and other comprehensive income of non-financial enterprises to operating profit is used as an indicator to measure the degree of financialization of enterprises. Profit from financial channels = (investment income + gain from changes in fair value + loss from other comprehensive income), and the degree of financialization = profit from financial channels / operating profit.

(5) Control variables

Referring to previous studies on carbon performance, this paper selects the following control variables: firm size, firm age, gearing ratio, equity concentration, return on net assets, gross sales margin, cash ratio, and operating income growth rate, and the definitions of each variable are shown in the following table.

Table 2. Definition of variables

Variable type	Variable name	Variable Description
Explanatory variable	ESG performance (ESG)	CSI Disclosure Corporate ESG Score
Explained variable	Corporate Carbon Performance (CP)	Operating income per unit of carbon emissions
Intermediary variable	New Prime Productivity (NPRO)	Referring to Song Jia et al. (2024) enterprise new quality productivity measurement method for the construction of the indicator system, details are shown in Table
Moderator variable	Financialization of enterprises (FINRATIO)	(Investment income + Gain on fair value changes + Loss on other comprehensive income - Operating profit)/Operating profit
Control variable	Enterprise size (Size)	Natural logarithm of total assets for the year
	FirmAge	ln(current year - year of incorporation + 1)
	Gearing ratio (Lev)	Total liabilities at the end of the year / Total assets at the end of the year
	Shareholding Concentration (Top 10)	Number of shares held by top ten shareholders / Total number of shares
	Return on net assets (ROA)	Net profit / average balance of total assets
	Gross profit margin on sales (GProfit)	(Operating Revenue - Operating Costs) / Operating Revenue
	Cashflow	Net cash flows from operating activities / total assets
	Revenue growth rate (Growth)	Operating income for the current year / Operating income for the previous year - 1

3.3 Data sources and processing

Based on the content of this paper's research and the availability of data, this paper selects the financial report form data of A-share listed enterprises and the ESG rating data of CSI from 2015 to 2022, and performs the following processing on the relevant sample data: ① Eliminate the samples of ST and *ST listed enterprises with poor operation; ② Eliminate the samples with missing ESG indexes; ③ Eliminate samples of the financial industry and the real estate industry; ④ Perform Winsor2 tail reduction processing. The final sample size of 14,046 is obtained. Among them, ESG data are from Wind database, corporate carbon performance is calculated based on the collected carbon emissions, new quality productivity is calculated using entropy method with reference to Song Jia's method, and the rest of control variables are from CSMAR database.

4 EMPIRICAL ANALYSIS

4.1 Descriptive statistics

The results of descriptive statistics show that the mean value of corporate carbon performance (CP) is 0.470, and the standard deviation is 0.529, indicating that the carbon performance of different enterprises varies greatly, and the carbon performance of some enterprises is significantly higher or lower than the mean value, with the minimum value of 0.00486 and the maximum value reaching 18.46, showing a wide distribution of extreme values.The mean value of ESG performance is 4.055, and the standard deviation is 1.120, with a minimum value of 1 and a maximum value of 7.750, reflecting significant differences in ESG performance. The mean value of firm size (Size) is 22.69 with a standard deviation of 1.386, and the minimum and maximum values are 17.64 and 28.64, respectively, indicating that the sample firms span a wide range of sizes.

Table 3. Descriptive statistics

Variables	Sample Size	Average Value	(Statistics) Standard Deviation	Upper Quartile	Minimum Value	Maximum Value
CP	14,046	0.470	0.529	0.529	0.005	18.460
ESG	14,046	4.055	1.120	1.120	1.000	7.750
Size	14,046	22.690	1.386	1.386	17.640	28.640
Lev	14,046	0.449	0.201	0.201	0.008	2.290
ROA	14,046	0.034	0.075	0.075	-1.130	1.285
GProfit	14,046	0.270	0.173	0.173	-0.862	0.964
Cashflow	14,046	0.052	0.074	0.074	-1.686	2.222
Growth	14,046	0.381	15.990	15.990	-0.965	1.878
Top10	14,046	55.420	15.120	15.120	1.310	101.200
FirmAge	14,046	3.036	0.275	0.275	1.792	4.025

4.2 Benchmark regression analysis

The results of the regression between ESG performance and corporate carbon performance are shown in the table, where column (1) does not include control variables, column (2) does not fix individual and time effects, and column (3) includes the first two. In the baseline regression analysis, the effect of ESG performance on corporate carbon performance (CP) is significantly positive, with a coefficient of 0.025 before the inclusion of control variables, which increases to 0.031 after the inclusion of control variables, and both are significant at the 1% level, indicating that the enhancement of ESG performance of enterprises can significantly improve their carbon performance. The coefficients of firm size (Size) range from 0.024 to 0.046 and are significant at the 1% or 5% level, suggesting that larger firms usually have better carbon performance, possibly due to their resource and technology advantages. The coefficient of Return on Assets (ROA) is significantly positive in some models, suggesting that more profitable firms may invest more resources in carbon reduction.

Table 4. Benchmark regression analysis

	(3)
	CP
ESG	0.031 ***
	(0.001)
Size	0.046**
	(0.033)
Lev	0.061
	(0.366)
ROA	0.484 ***
	(0.000)
GProfit	-0.738 ***
	(0.000)
Cashflow	-0.142
	(0.152)
Growth	0.000**
	(0.042)
Top10	-0.003**
	(0.020)
FirmAge	1.653 ***
	(0.000)
Firm	Yes
Year	Yes
_ cons	-5.388 ***
	(0.000)
N	14046
adj. R^2	0.191

Note: ***, ** and * indicate significant at the 1%, 5% and 10% levels, respectively, estimated using firm-level clustering robust standard errors with p-values in parentheses, below.

4.3 Robustness Tests

In the robustness test, the effect of ESG performance on corporate carbon performance (CP) remains significantly positive and both are significant at the 1% level, further validating the reliability of the conclusion that ESG performance has a positive effect on carbon performance. Column (1) incorporates the use of city-level clustering standard errors into the main regression to further ensure the reliability of the results. Column (2) uses Bloomberg ESG data (ESG_Bloomberg) as an alternative core explanatory variable, at which point the coefficient coefficient is 0.007, also significant at the 1% level, indicating consistency of findings across ESG data sources. The coefficient of column (3) lagged one-period ESG performance (L.ESG) is 0.144 and is significant at the 1% level, indicating that the impact of ESG performance on carbon performance is persistent, and that firms' long-term ESG investments lead to sustained carbon performance improvement. The introduction of control variables (CV) and firm fixed effects (Firm) and year fixed effects (Year) further enhances the robustness of the model. Overall, the results of the robustness test further consolidate the conclusions of the benchmark regression analysis, indicating that the positive impact of ESG performance on carbon performance is robust across different data sources, time horizons, and model settings, which provides a strong empirical support for firms to achieve carbon emission reduction and sustainable development by improving ESG performance.

Table 5. Robustness test

	(1) CP	(1) CP	(1) CP
ESG	0.080 ***		
	(0.000)		
ESG_Bloomberg		0.007***	
		(0.000)	
L.ESG			0.144***
			(0.009)
CV	Yes	Yes	Yes
Firm	Yes	Yes	Yes
Year	Yes	Yes	Yes
City	Yes	No	No
Constant	-43.001 ***	-1.806 ***	44.024 ***
	(0.000)	(0.000)	(0.000)
N	4199	14046	14046
adj. R^2	0.474	0.136	0.078

Note: Column (1) uses standard errors for city-level clustering.

4.4 Tests for mediating effects

In the mediation effect test, the direct effect of ESG performance on corporate carbon performance (CP) is significantly positive, with a coefficient of 0.031 and significant at the 1% level, indicating that ESG performance can directly enhance corporate carbon performance. Meanwhile, the effect of ESG performance on new quality productivity (NPRO) is also significantly positive, with a coefficient of 0.038, and significant at the 5% level, indicating that ESG performance can indirectly improve carbon performance by enhancing the productivity and technological innovation capacity of enterprises. The direct effect of new quality productivity (NPRO) on carbon performance is also significantly positive, with a coefficient of 0.017 and significant at the 1% level, further validating the mediating role of NPRO between ESG performance and carbon performance. The results of the mediation effect test indicate that ESG performance not only directly improves carbon performance, but also indirectly improves carbon performance by promoting NPRO.

Table 6. Mediating effects test

	(2) NPRO	(3) CP
ESG	0.038**	0.031 ***
	(0.050)	(0.000)
NPRO		0.017 ***
		(0.003)

Size	0.198 ***	0.047**
	(0.000)	(0.030)
Lev	-1.154 ***	0.061
	(0.000)	(0.365)
ROA	-2.478 ***	0.507***
	(0.000)	(0.000)
GrossProfit	0.093	-0.733 ***
	(0.470)	(0.000)
Cashflow	2.552 ***	-0.156
	(0.000)	(0.123)
Growth	-0.001	0.000**
	(0.241)	(0.040)
Top10	-0.003**	-0.003**
	(0.035)	(0.018)
FirmAge	-0.560 ***	1.643 ***
	(0.000)	(0.000)
_cons	3.006 ***	-5.463 ***
	(0.000)	(0.000)
Firm/Year	Yes	Yes
N	14046	14046

4.5 Moderating effects test

In the moderating effect test, the direct effect of ESG performance on corporate carbon performance (CP) is significantly positive (with coefficients ranging from 0.030 to 0.040, all significant at the 1% level), suggesting that an increase in corporate ESG performance can directly improve carbon performance. The moderating effect of the degree of corporate financialization (FINRATIO) is reflected by the interaction term (ESG × FINRATIO), whose coefficients range from 0.015 to 0.018 and are significant at the 1% level, suggesting that the higher the degree of corporate financialization, the stronger the contribution of ESG performance to carbon performance. This result suggests that firms with a high degree of financialization may obtain more resources (e.g., investment income or cash flow) through financial channels, thus more effectively transforming ESG inputs into practical actions for carbon reduction. In addition, the coefficient of the financialization variable (FINRATIO) itself is significantly positive (0.020 to 0.024), suggesting that moderate financialization may indirectly support carbon performance enhancement by enhancing firms' financial flexibility. The moderating effect test reveals the positive and reinforcing role of corporate financialization in the relationship between ESG and carbon performance, suggesting that financialization not only directly supports carbon performance, but also amplifies the positive impact of ESG. The implication for corporate managers is that when promoting ESG strategies, they need to make reasonable use of financialization tools to optimize resource allocation, but they need to be wary of the risk of over-financialization that may lead to de-realization, so as to achieve a balance between environmental benefits and financial health.

Table 7. Moderating effects test

	(1) CP	(2) CP
ESG	0.030 ***	0.040 ***
	(0.000)	(0.000)

FINRATIO	0.020 ***	0.024 ***
	(0.000)	(0.000)
ESG x FINRATIO		0.018 ***
		(0.000)
Size	0.044***	0.040 ***
	(0.014)	(0.004)
Lev	-0.017	0.018
	(0.055)	(0.744)
ROA	0.327***	0.432 ***
	(0.073)	(0.000)
GrossProfit	-0.558***	-0.560 ***
	(0.088)	(0.000)
Cashflow	-0.138*	-0.125
	(0.080)	(0.125)
Growth	0.000***	0.000 ***
	(0.005)	(0.005)
Top10	-0.004***	-0.004 ***
	(0.000)	(0.000)
FirmAge	1.552***	1.569 ***
	(0.041)	(0.000)
_cons	0.351 ***	-4.990 ***
	(0.000)	(0.000)
Firm/Year	Yes	Yes
N	13694	13694
adj. R^2	0.186	0.206

4.6 Heterogeneity test

The results of the heterogeneity test indicate that the effect of corporate ESG performance on carbon performance is significantly different among different types of enterprises, industries and regions. Specifically, ESG enhancement in non-state-owned enterprises has a significant contribution to carbon performance (β =0.062, p<0.01), while the role of ESG in state-owned enterprises fails the test of significance (β=-0.023, p=0.297), which may originate from the fact that state-owned enterprises are bound by the stronger administrative objectives, and the market transformation efficiency of ESG inputs is lower; enterprises in heavy pollution industries ESG performance is not significantly associated with carbon performance (β=0.001, p=0.963), while the carbon reduction effect of ESG in non-heavily polluted industries is significant (β=0.048, p<0.01), implying that the marginal utility of ESG in highly polluted industries is weakened by the technology path dependence or the squeeze on environmental compliance costs; looking at the sub-industries, the ESG of manufacturing enterprises has a significant effect on the improvement of carbon performance (β=0.054, p<0.01), but non-manufacturing enterprises show a negative effect (β=-0.062, p<0.05), which may be related to the fact that non-manufacturing industries (e.g., services) lack physical emission reduction grips, and the linkage mechanism between ESG inputs and carbon performance has not yet been matured; at the regional level, the carbon performance gain of ESG in the eastern region is significant (β=0.041, p& lt;0.01), while the effect is not significant in the central and western regions, reflecting that the more perfect market mechanism and green financial support system in developed regions amplify the environmental benefits of ESG.

This result suggests that policy design needs to be stratified: ESG incentives can be strengthened for non-state-owned enterprises, manufacturing industries, and the eastern region, while state-owned enterprises, heavily polluting industries, and the central and western regions need to be supported by technology subsidies or differentiated assessment standards to bridge the structural gap in ESG practices, and to promote the non-manufacturing industries to explore synergistic paths between digital transformation and ESG.

Table 8. Heterogeneous groupings1

	CP			
	Nationalized business	Non-state enterprise	Service industry	Non-manufacturing industry
ESG	-0.023	0.062 ***	0.054 ***	-0.062**
	(0.297)	(0.000)	(0.000)	(0.027)
Controls	Yes	Yes	Yes	Yes
_cons	-8.203 ***	-3.340 ***	-4.998 ***	-7.565 ***
	(0.000)	(0.000)	(0.000)	(0.000)
N	5908	7776	10951	3095
adj. R^2	0.164	0.237	0.214	0.154

Table 9. Heterogeneous groupings2

	CP	
	Heavily polluting enterprises	Non-heavily polluting enterprises
ESG	0.001	0.048 ***
	(0.963)	(0.000)
Controls	Yes	Yes
_cons	-5.187 ***	-5.393 ***
	(0.000)	(0.000)
N	4087	9959
adj. R^2	0.227	0.181

Table 10. Heterogeneous groupings3

	CP		
	Eastern part	Western part	Central section
ESG	0.041 ***	0.008	0.003
	(0.000)	(0.688)	(0.870)
Controls	Yes	Yes	Yes
_cons	-5.121 ***	-4.388 ***	-7.500 ***
	(0.000)	(0.000)	(0.000)
N	9415	2552	2079
adj. R^2	0.185	0.226	0.191

5 CONCLUSIONS AND POLICY RECOMMENDATIONS

This paper demonstrates through empirical analysis that corporate ESG performance significantly enhances carbon performance improvement via multiple pathways. The ESG framework actively encourages the implementation of low-carbon technologies and enhances resource efficiency in enterprises by integrating environmental accountability, social collaboration, and governance enhancement, exemplified by the closed loop of emission reduction via investments in clean energy and management of supply chain carbon footprints. New quality productivity serves as a crucial intermediary between the two, while technological innovation and factor reorganization (e.g., industrial internet, circular economy model) substantially diminish carbon emission intensity per unit of output, thereby validating the transmission logic of "ESG inputs - new quality productivity leap - optimization of carbon performance." The transmission logic is confirmed. Simultaneously, the financialization of businesses enhances the environmental advantages of ESG via green financial instruments and oversight of capital markets. Heterogeneity analysis indicates that ESG significantly improves carbon performance, particularly in non-state-owned enterprises, manufacturing sectors, and eastern enterprises, highlighting the synergistic effects of market-oriented mechanisms, industrial traits, and regional resource endowments. This indicates that ESG functions not merely as a compliance instrument, but also as a systematic innovation catalyst for facilitating low-carbon transition, offering empirical proof that enhanced productivity can aid in achieving the "dual-carbon" objective.

The empirical evidence necessitates policy interventions calibrated to enterprise heterogeneity and China’s institutional realities. To address the systemic ‘discrimination in access to financing’ against non-SOEs revealed in our study, provincial governments should collaborate with the People's Bank of China (PBOC) to implement a dual-track financing mechanism, integrating mandatory quotas with risk mitigation tools. First, introduce *ESG Credit Allocation Mandates* requiring regional commercial banks to dedicate no less than 15% of their annual green loan portfolios to non-SOEs with accredited BBB+ or higher ESG ratings (certified by PBOC-recognized agencies like Sino-Securities ESG). Second, establish provincial *Green Bond Guarantee Pools*—modeled on Zhejiang’s 2023 pilot—where governments cover 50% of underwriting risks for qualified private enterprises issuing transition-themed green bonds, directly aligning with Category B ("Transition Activities") of PBOC’s *Green Bond Endorsed Projects Catalogue (2021)*. Concurrently, the China Banking and Insurance Regulatory Commission (CBIRC) should adjust risk-weighting factors for ESG loans to non-SOEs (e.g., reducing capital reserve requirements by 0.5x for BBB+-rated exposures), incentivizing banks to overcome collateral-driven lending biases. To ensure scalability, this system should integrate with the national *Corporate ESG Database* launched by the Ministry of Ecology and Environment in 2024, enabling automated eligibility verification and reducing compliance costs by ~30% based on Suzhou Industrial Park’s sandbox testing.

Capitalizing on the unique ecological endowment of central/western provinces, we propose a "Carbon-Plus Ecosystem" framework that converts natural capital into tangible compliance benefits and market advantages. Core to this approach is establishing provincial-level Eco-Carbon Trading Platforms in renewable-rich regions (e.g., Gansu’s wind corridors, Sichuan’s hydropower basins), where enterprises can offset up to 30% of mandatory carbon quotas by investing in verified ecological projects—including grassland restoration, desert greening, or biodiversity conservation—with carbon sequestration volumes quantified via the National Forestry and Grassland Administration’s *Methodology for Forest Carbon Sink Accounting (2023)*. To maximize policy synergy, these offsets should be automatically convertible into tradable China Certified Emission Reductions (CCERs) under the national carbon market, while provincial governments provide additional fiscal incentives such as land-use priority rights for participating firms (e.g., 20% faster approval for industrial land in Inner Mongolia’s zero-carbon zones) and value-added tax rebates equivalent to 15% of eco-investment costs (anchored in Article 9 of the State Council’s *Western*

Development Revitalization Plan 2021-2030). Crucially, this mechanism embeds a dynamic calibration feature where the offset cap (initially 30%) adjusts annually based on regional carbon intensity reduction targets from the Ministry of Ecology and Environment ' s *Provincial Carbon Budget Allocation Scheme*, preventing market distortion. Implementation-wise, the National Development and Reform Commission (NDRC) should integrate this platform with its "Ecological Asset Voucher" pilot in Yunnan/Gansu, using blockchain for real-time auditing of carbon-ecosystem equivalence.

To resolve the critical data gap in service-sector emissions—where current national carbon inventories cover <15% of digital economy actors—we advocate a two-pronged strategy combining mandatory granular accounting standards with shared digital infrastructure. Immediate priority should be given to formulating industry-tailored carbon footprint guidelines under ISO 14064 framework within 24 months, specifically targeting cloud computing, fintech, and logistics sectors, with compliance mandated for enterprises exceeding RMB 1 billion annual revenue (covering ~80% of sector emissions). These standards must enforce Scope 3+ measurement requiring hyperscalers like Alibaba Cloud and Tencent Cloud to disclose embedded emissions of downstream user activities — e.g., calculating per-API-call carbon intensity via standardized PUE-to-CO_2 conversion factors certified by the National Institute of Metrology. Concurrently, a National Green Cloud Audit Platform should be launched under the Ministry of Industry and Information Technology (MIIT), consolidating real-time energy data from all tier-IV+ data centers and automating verification through AI-powered carbon ledger systems (validated by Shenzhen ' s pilot reducing reporting errors by 40%). To incentivize adoption, a 15% corporate income tax rebate should be granted to firms deploying MIIT-certified AI energy optimization tools — mirroring Tencent ' s Net Zero Accelerator model — with eligibility conditional on achieving >20% year-on-year carbon productivity gains as measured against the platform' s benchmarks. Crucially, this infrastructure must interlink with the NDRC ' s "Eastern Data Western Computing" project, directing low-carbon data flows to renewable hubs (e.g., Guizhou ' s hydro-powered clusters) while enforcing PUE ⩽1.25 thresholds through the Revamped Data Center Grading Scheme (2025).

Data Availability Statement

Data are available in specialized financial databases, processed by the authors.

References

[1] Luo, L., & Tang, Q. (2023). The real effects of ESG reporting and GRI standards on carbon mitigation: Internation al evidence. Business Strategy and the Environment, 32(6), 2985–3000.

[2] Cong Y, Zhu C, Hou Y, Tian S and Cai X (2022) Does ESG investment reduce carbon emissions in China?. *Front. E nviron. Sci.* 10:977049. doi: 10.3389/fenvs.2022.977049

[3] Chu, H., Niu, X., Li, M., & Wei, L. (2025). Research on the impact of new quality productivity on enterprise ESG pe rformance. International Review of Economics & Finance, 99, 104009. https://doi.org/10.1016/j.iref.2025.10400 9

[4] Xie, Y. (2024). The impact of ESG performance on corporate sustainable growth from the perspective of carbon sentiment. Journal of Environmental Management, 367, 121913. https://doi.org/10.1016/j.jenvman.2024.12191 3

[5] Lu, J., & Li, H. (2024). The impact of ESG ratings on low carbon investment: Evidence from renewable energy co mpanies. Renewable Energy, 223, 119984. https://doi.org/10.1016/j.renene.2024.119984

[6] Geng, Y., Zheng, Z., Yuan, X., & Jiménez-Zarco, A. I. (2025). ESG performance and total factor productivity of ent erprises: The role of digitization. Research in International Business and Finance, 77, 102920.

[7] Xue, Q., Jin, Y., & Zhang, C. (2024). ESG rating results and corporate total factor productivity. International Revie w of Financial Analysis, 95, 103381. https://doi.org/10.1016/j.irfa.2024.103381

[8] Huang, R., Zhu, Z., Ruan, R., & Lou, X. (2024). Linking low-carbon practices with ESG performances: Exploration evidence from the configurational perspective. Journal of Cleaner Production, 435, 140532.

[9] Lee, C. L., & Liang, J. (2024). The effect of carbon regulation initiatives on corporate ESG performance in real est ate sector: International evidence. Journal of Cleaner Production, 453, 142188. https://doi.org/10.1016/j.jclepr o.2024.142188

[10] Yuan, Y., Dai, H., & Ma, J. (2025). The Impact of Corporate ESG Performance on Supply Chain Resilience: A Media tion Analysis Based on New Quality Productive Forces. *Sustainability*, *17*(10), 4418. https://doi.org/10.3390/su1 7104418

[11] Parris, T. M., & Kates, R. W. (2003). CHARACTERIZING AND MEASURING SUSTAINABLE DEVELOPMENT. Annual Re view of Environment and Resources, 28(Volume 28, 2003), 559-586. https://doi.org/https://doi.org/10.1146/ann urev.energy.28.050302.105551

[12] Springett, D. (2003). Business conceptions of sustainable development: A perspective from critical theory. Busi ness Strategy and the Environment, 12(2), 71–86. https://doi.org/10.1002/bse.353

[13] Lindgreen, A. and Swaen, V. (2010), Corporate Social Responsibility. International Journal of Management Revi ews, 12: 1-7. https://doi.org/10.1111/j.1468-2370.2009.00277.x

[14] Lee, M.-D.P. (2008), A review of the theories of corporate social responsibility: Its evolutionary path and the roa d ahead. International Journal of Management Reviews, 10: 53-73. https://doi.org/10.1111/j.1468-2370.2007.00 226.x

[15] Chan, E. Y. (2025). Moral Signaling in Startups: How ESG Claims Shape Stakeholder Judgments and Ethical Legi timacy. Journal of Business Ethics. https://doi.org/10.1007/s10551-025-06039-0

[16] Talan, G., Sharma, G. D., Pereira, V., & Muschert, G. W. (2024). From ESG to holistic value addition: Rethinking su stainable investment from the lens of stakeholder theory. International Review of Economics & Finance, 96, 103 530. https://doi.org/10.1016/j.iref.2024.103530

[17] Bafera, J., & Kleinert, S. (2022). Signaling Theory in Entrepreneurship Research: A Systematic Review and Resea rch Agenda. *Entrepreneurship Theory and Practice*, *47*(6), 2419-2464. https://doi.org/10.1177/10422587221138 489

[18] Fu, L., Boehe, D. M., & Orlitzky, M. O. (2021). Broad or Narrow Stakeholder Management? A Signaling Theory Per

spective. *Business & Society*, *61*(7), 1838-1880. https://doi.org/10.1177/00076503211053018

[19] Lee, M. T., Raschke, R. L., & Krishen, A. S. (2022). Signaling green! Firm ESG signals in an interconnected environ ment that promote brand valuation. Journal of Business Research, 138, 1–11. https://doi.org/10.1016/j.jbusres. 2021.08.061

[20] Fan Gao. (2023). The logic behind the proposal of "new quality productivity," its multidimensional connotati ons, and its significance for the times. Review of Political Economy., 14 (06), 127-145.

[21] Wen Zhou & Lingyun Xu. (2023). On New Quality Productivity: Its Characteristics and Key Focus Areas. Reform, (10), 1-13.

[22] Zheng Xu, Linhao Zheng & Mengyao Cheng. (2023). The intrinsic logic and practical concepts of new quality pro ductivity empowering high-quality development. Contemporary Economic Research, (11), 51-58.

[23] Yu He, Qingliang Tang & Kaitian Wang. (2017). Carbon Performance and Financial Performance. Accounting Res earch, (02), 76-82+97.

[24] Jia Song, Jinchang Zhang & Yi Pan. (2024). The Impact of ESG Development on Corporate New Quality Producti vity: Empirical Evidence from Chinese A-Share Listed Companies. Contemporary Economic Management.*, 46* (0 6), 1-11. doi:10.13253/j.cnki.ddjjgl.2024.06.001.