Research on the Influence of the ESG Coupling Coordination Degree of Enterprises on Innovation Quality

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Abstract. Research on the specific mechanisms through which the ESG coupling coordination promotes high - quality innovation in enterprises is of great significance. In view of this, this paper first selects Chinese A - share listed companies from 2012 to 2022 as the research objects. The coupling coordination degree model is employed to measure the ESG coupling coordination development index of enterprises. Subsequently, a two - way fixed - effects model is adopted to explore the impact mechanism of ESG coupling coordination on the innovation quality of enterprises, and robustness tests, endogeneity tests, and heterogeneity tests are carried out. Then, this paper also deeply explores whether there are moderating effects of enterprise scale and growth ability in the process of ESG coupling coordination influencing enterprise innovation quality. The empirical results show that, on the one hand, there is a significant positive impact between ESG coupling coordination and enterprise innovation quality. On the other hand, enterprise scale and growth ability play a negative moderating role in the process of ESG coupling coordination influencing enterprise innovation quality. In addition, the effect of ESG coupling coordination on improving enterprise innovation quality varies significantly among enterprises with different operating natures. Based on the above conclusions, this paper puts forward relevant policies and suggestions for the coordinated development of ESG and high - quality innovation in enterprises.

Keywords: ESG coupling coordination degree, Innovation quality, Enterprise size, Growth capacity, Panel data analysis.

1. Introduction

In the context of the global economic transition towards green and low-carbon development, sustainable development has emerged as a widely acknowledged global consensus, driving profound transformations in corporate development models. ESG (Environmental, Social, and Governance) has risen as an emerging investment philosophy, business management approach, and evaluation standard, guiding enterprises to move beyond the sole pursuit of economic profits towards a more comprehensive developmental path that integrates environmental protection, social responsibility, and corporate governance. In this process, innovation, as the core engine of corporate development, is critical to a company's survival and long-term growth. Therefore, examining the impact mechanisms of ESG on corporate innovation quality is of substantial significance for achieving high-quality corporate development. The extant literature indicates that ESG research has expanded across multiple dimensions. In the environmental domain, the focus has been on how companies can effectively reduce their carbon footprint, promote resource recycling, and address climate change. Sun Hongmei and Li Shuiying [1] found that corporate ESG performance plays a significant role in influencing urban carbon reduction goals, illustrating the practical relevance of ESG in the environmental sector. Wang Binhui and Wu Sanni [2] examined the relationship between environmental regulation and green technological innovation, providing theoretical insights for corporate innovation practices in the environmental sphere. Xiong Jun and Sun Xinzhan [3] explored the impact of mandatory environmental information disclosure on corporate green technological innovation, further enriching the research in this domain. In the social dimension, research has focused primarily on issues such as employee welfare, supply chain responsibility, and community

engagement. Zheng Lili et al. [4] empirically analyzed the relationship between corporate social responsibility towards employees and innovation performance, revealing the positive effect of strong employee relations on corporate innovation. Li Jigang and Song Cheng [5] studied corporate ESG performance from the perspective of employment effects, offering new insights into the social dimension of ESG. In the governance dimension, research has predominantly concentrated on the mechanisms of board structure, internal controls, and information disclosure in the implementation of ESG strategies. For instance, Yang Dake et al. [6] examined the experiences of the EU and Germany to understand how corporate governance bodies can respond to the challenges posed by ESG.

Empirical research on corporate innovation quality has also produced a wealth of findings. For example, Yang Zhen and Wang Yue [7] reassessed the relationship between corporate ESG practices and innovation efficiency, finding that ESG initiatives positively promote corporate innovation efficiency. However, the majority of existing studies have primarily focused on the relationship between ESG's single or partial dimensions and corporate innovation. Some studies have investigated the impact of green innovation in the environmental dimension on corporate innovation quality or focused solely on the role of corporate governance structures in innovation decisions. These studies lack a systematic examination of the coupled coordination among the three dimensions of ESG and its influence on corporate innovation quality.

Additionally, the moderating roles of enterprise size, growth potential, and business nature in the relationship between ESG coordination and corporate innovation quality remain underexplored and warrant further empirical investigation. Zhang Jianjun et al. [8] studied the impact of enterprise size, age, and business-government relations on medium-sized private enterprises, while Sun Bing et al. [9] explored the relationship between enterprise size and innovation sustainability. However, these studies did not delve into the moderating effect of ESG coordination on corporate innovation quality. Quan Feiguo and Wang Xiaofang [10] examined the relationship between fiscal decentralization, financial structure, and corporate innovation, while Liu Jinfei [11] investigated the relationship between internal governance, profitability, and growth potential with corporate social responsibility. However, these studies insufficiently address the moderating mechanisms of ESG coordination on corporate innovation quality. Fu Yale [12] analyzed the relationship between corporate social responsibility, losses, and profitability, and Wang Yinyin et al. [13] investigated the relationship between corporate social responsibility and profitability under media attention. These studies, however, do not explore the moderating mechanism of ESG coordination in corporate innovation quality. Zhang Sixue and Lin Hanchuan [14] examined the relationship between innovation, social responsibility, and product overseas image, yet did not provide an in-depth analysis of the moderating role of ESG coordination in corporate innovation quality.

In response to this gap, this study uses data from A-share listed companies in China from 2012 to 2022, employing a coupling coordination model and a two-way fixed effects model to explore the impact mechanisms of ESG coordination on corporate innovation quality. This paper also examines the differential impacts of ESG coordination across firms of different types. The primary contributions of this research are twofold: first, it empirically analyzes the impact mechanism of ESG coordination on corporate innovation quality and explores the differential effects across different corporate types; second, it investigates the moderating roles of enterprise size and growth potential in the relationship between ESG coordination and corporate innovation quality. The empirical findings reveal a significant positive relationship between ESG coordination and corporate innovation quality. Moreover, enterprise size and growth potential play a negative moderating role in this relationship. Additionally, the role of ESG coordination in enhancing innovation quality varies significantly across firms with different business natures. This in-depth analysis provides valuable theoretical insights and practical guidance for enterprises aiming to achieve high-quality innovation within the ESG framework, with substantial academic and practical significance.

2. Theoretical Hypotheses and Research Methods

2.1. Theoretical hypothesis

2.1.1. ESG Coupling and Coordination and the Quality of Corporate Innovation

Theoretically, the coupling coordination of corporate ESG and innovation quality has a significant positive impact. Specifically, in the environmental dimension, when companies focus on sustainable development, increase the use of clean energy, and optimize production processes to reduce energy consumption and pollution emissions, they must continuously invest in research and development, driving innovation in environmental technologies[3]. Innovations such as green products or advanced production processes not only attract environmentally conscious consumers but also generate higher economic returns, which in turn provide more financial support for further innovation, creating a virtuous cycle that enhances the quality of corporate innovation. In the social dimension, companies that focus on employee welfare and development, provide a good working environment, training opportunities, and clear career advancement paths, can significantly stimulate employee motivation and creativity, encouraging the generation of innovative ideas and solutions[4]. Additionally, active involvement in social welfare activities enhances a company's social reputation, which helps attract more talented individuals and provides a continuous flow of talent for innovation[5]. In the corporate governance dimension, a well-established governance structure provides a solid institutional foundation for innovation. Integrating ESG goals into strategic planning helps clarify innovation directions and ensures the efficient allocation of innovation resources, thus improving innovation efficiency[7]. Transparent information disclosure strengthens trust with stakeholders and attracts more investors to fund innovation projects, accelerating the transformation of ideas into practical innovations. Based on the above analysis, the following hypothesis is proposed:

H1: The coupling coordination of ESG has a significant positive effect on corporate innovation quality. In other words, the higher the degree of coordination across the environmental, social, and corporate governance dimensions of ESG, the higher the quality of corporate innovation.

2.1.2. The Moderating Effect of ESG Coupling Coordination on Improving the Quality of Enterprise Innovation

In China, large enterprises, especially state-owned enterprises, typically exhibit high organizational complexity and hierarchical structures, which may weaken the positive relationship between ESG coupling coordination and innovation quality [9]. These enterprises are often constrained by historical factors and path dependence, making them prone to the "innovator's dilemma." For instance, in the case of traditional energy companies like PetroChina and Sinopec, despite significant investments in ESG governance, innovation tends to focus more on incremental improvements in traditional energy efficiency rather than exploring disruptive technologies such as hydrogen energy or energy storage. This innovation inertia impedes the transformation of ESG coupling coordination into high-quality innovation outcomes. Furthermore, although large enterprises possess abundant financial and human resources, they may face inefficiencies in resource allocation [8]. Some enterprises allocate ESG investments to "image projects," such as purchasing carbon offset credits or publishing ESG reports, rather than investing in substantial technological innovation. This "ESG opportunism" diminishes the driving effect of ESG on innovation quality.

From an environmental perspective, the large scale and complex management systems of these enterprises result in lengthy decision-making processes, making it difficult to seize innovation opportunities in a timely manner, thereby hindering the enhancement of innovation quality through ESG coupling coordination. Additionally, the irrational distribution of resources leads to some key innovation areas not receiving adequate support, reducing the efficiency and quality of environmental innovation. On the social dimension, the complex organizational structure and high communication costs of large enterprises make it challenging to efficiently advance ESG innovations related to social responsibility, thus undermining the positive impact of ESG coupling coordination on innovation quality. Moreover, large enterprises may overly focus on maintaining existing social relationships

and networks, adopting a conservative stance toward new social innovation concepts and methods, thereby limiting breakthrough innovations [10-11].

From a corporate governance perspective, large enterprises typically have well-established and strict governance structures and processes. Any ESG governance innovations must undergo multiple rounds of review and evaluation, resulting in delayed decision-making and a slow response to market changes and ESG development trends. This weakens the role of ESG coupling coordination in enhancing governance innovation quality. Furthermore, the inherent governance models may result in resources being allocated to maintaining the status quo, rather than supporting more innovative and forward-looking ESG projects, thus limiting improvements in innovation quality. Based on the above analysis, the following hypothesis is proposed:

H2: The size of the enterprise negatively moderates the relationship between ESG coupling coordination and corporate innovation. Specifically, the larger the enterprise, the stronger the inhibitory effect of ESG coupling coordination on corporate innovation.

In the environmental dimension, enterprises with strong growth ability often concentrate a large amount of resources on projects that can quickly bring business growth and economic benefits, resulting in relatively insufficient investment in ESG innovation related to the environment. For example, when researching and developing new environmentally friendly production processes or introducing advanced energy-saving and emission reduction equipment, due to the pursuit of short-term returns under growth pressure, it is difficult to invest sufficient funds and manpower. At the same time, during the rapid expansion process, such enterprises may neglect the environmental optimization innovation of existing production processes, overly focusing on output and market share growth, resulting in slow progress in environmental innovation of enterprises and suppressing the role of ESG coupling coordination in improving the quality of environmental innovation. From the social dimension, enterprises with outstanding growth ability tend to place ESG innovation related to social responsibility, such as employee training and development programs, in a secondary position when pursuing scale expansion [10]. In order to quickly seize the market and improve performance, enterprises may cut resources for innovative projects of employee skill improvement and career development, so that employees cannot obtain sufficient opportunities for knowledge updating and ability expansion, thus affecting the vitality and quality of enterprises in social innovation.In addition, in social activities, enterprises with strong growth ability may pay more attention to shaping their short-term social image, while neglecting the exploration and practice of forward-looking social innovation concepts and methods, hindering the positive promotion of ESG coupling coordination on the quality of enterprise innovation in the field of social innovation.

In the corporate governance dimension, enterprises with strong growth ability usually face a rapidly changing market environment and business needs, which makes enterprises prone to fall into path dependence in ESG governance innovation. Enterprises are accustomed to using the past successful governance models and decision-making mechanisms. When facing the governance innovation needs such as optimizing the ESG decision-making mechanism of the board of directors and improving the transparency of ESG information disclosure [11], due to concerns that changes in the existing model may affect the enterprise growth rate due to uncertainties, they are cautious about innovative proposals. Based on the above analysis, the following hypothesis is proposed:

H3: The growth ability of enterprises plays a negative moderating role between ESG coupling coordination and the quality of enterprise innovation, that is, the stronger the growth ability of enterprises, the stronger the inhibitory effect of ESG coupling coordination on the quality of enterprise innovation.

2.2. Research method

2.2.1. Variable design

Explanatory Variable: ESG Coupling Coordination. In the ESG system, corporate governance is crucial for guiding and ensuring environmental and social practices. The board of directors analyzes

the enterprise's internal and external environment, integrating the ESG concept into strategic planning. Environmentally, it sets energy - conservation and emission - reduction goals, using technology and process optimization. Socially, it plans employee development, promotes training and community participation. Institutionally, it establishes environmental and employee - rights protection systems with supervision mechanisms. Resource - wise, it follows sustainable development principles. The environmental and social dimensions also impact corporate governance. Regulatory tightening and social attention bring risks and opportunities, prompting the governance layer to adjust strategies. Good ESG performance enhances reputation, while poor performance damages it.ESG coupling coordination supports enterprise sustainable development through the interaction of environment, society, and governance. The synergy among these dimensions improves ecological, social, management, and risk - related aspects [1,5,12].:

The ESG coupling coordinated development index in this paper uses data from Huazheng's public database. The CRITIC objective weighting method is adopted, considering indicator variability and conflict. Variability shows indicator dispersion, and conflict reflects indicator correlations. A modified CRITIC method, calculating average correlation, better reflects the overall association among ESG indicators.

Control Variables. In order to control the impact of other characteristics of enterprises on the quality of enterprise innovation, this paper draws on the methods of [3-8], and selects the following control variables: enterprise scale (Size), growth ability (Growth), profitability (Roa), cash flow (Cfo), financial leverage (Lev), ownership concentration (Share), enterprise age (Age), and collateral ability (Tang). The specific definitions are shown in the Table 1.

Table 1. Variable Explanation.

Variable Type	Variable Name	Variable Symbol	Variable Calculation Method
Explained Variable	Quality of Enterprise Innovation	LnCitation	The natural logarithm of the sum of the number of times the patents applied by the enterprise in the next year are cited by others plus 1
Explanatory Variable	ESG Coupling Coordination	ESG	Calculated by the coupling coordination model
Moderating Variable	Enterprise Scale	Size	The natural logarithm of the total assets of the enterprise
	Growth Ability	Growth	Total assets / Operating income
Control Variable	Profitability	Roa	Operating profit / Total assets
	Cash Flow	Cfo	Net cash flow generated from operating activities / Total assets
	Financial Leverage	Lev	Total liabilities / Total assets
	Ownership Concentration	Share	Share The shareholding ratio of the largest shareholder
	Enterprise Age	Age	The number of years since the enterprise was established
	Collateral Ability	Tang	(Net inventory + Net fixed assets) / Total assets

2.2.2. The establishment of the model

The two-way fixed effects model between ESG coupling coordination and the quality of enterprise innovation is as follows:

$$LnCitation_{i,t} = \alpha_0 + \alpha_1 ESG_{i,t} + \alpha_j \sum Controls_{i,t} + \theta_i + \mu_t + \varepsilon_{i,t} \quad (1)$$

where i represents the enterprise, t represents the year, $LnCitation_{i,t}$ is the explained variable used to reflect the quality of enterprise innovation, $ESG_{i,t}$ is the explanatory variable reflecting ESG coupling coordination, $\sum Controls_{i,t}$ is a series of control variables, θ_i is the individual fixed effect, μ_t is the time fixed effect, and $\varepsilon_{i,t}$ is the random disturbance term.

3. Empirical analysis

3.1. Data source

This study selects annual data from A-share listed companies in China between 2012 and 2022 as the initial sample. The following screening and processing procedures are applied: (1) Excluding ST and *ST companies; (2) Removing financial industry firms; (3) Eliminating companies with missing data on key variables; (4) Winsorizing continuous variables at the top and bottom 1% to mitigate the impact of extreme values. The final sample comprises 6,436 observations from 585 listed companies. Data sources include the CSMAR database, with ESG metrics derived from Huazheng's individual and comprehensive scores for E, S, and G ratings. The coupling coordination index is calculated using a coupling coordination degree model based on these ESG scores.

3.2. Benchmark Results

Table 2 presents the regression results of the impact of ESG coupling coordination on the quality of enterprise innovation. The results in Columns (1) to (3) of Table 2 indicate that regardless of whether control variables and fixed effects are included, the regression results of the impact of ESG coupling coordination on the quality of enterprise innovation are significant at least at the 5% level, showing a significant positive correlation between the two. In summary, good ESG coupling coordination of an enterprise can promote the improvement of the quality of enterprise innovation, thus validating Hypothesis 1.

Table 2. Benchmark Regression Results

	(1)	(2)	(3)	(4)	(5)
	LnCitation	LnCitation	LnCitation	LnCitation	LnCitation
	Benchmark Regression	Inclusion of Control Variables	Inclusion of Time Fixed Effects	Inclusion of Individual Fixed Effects	Two-way Fixed Effects
ESG	1.222***	0.769***	0.142**	0.725***	0.142**
	(17.206)	(11.121)	(2.346)	(10.048)	(2.346)
Age		-1.190***	-4.865***	-4.020***	-4.865***
		(-17.180)	(-37.186)	(-31.355)	(-37.186)
Share		-0.250***	-0.047	-0.086	-0.047
		(-6.271)	(-0.871)	(-1.301)	(-0.871)
Size		1.542***	1.623***	2.081***	1.623***
		(23.324)	(13.327)	(13.815)	(13.327)
Growth		0.000	0.437**	0.565**	0.437**
		(0.001)	(1.992)	(2.074)	(1.992)
Roa		0.103	0.161	0.838**	0.161
		(0.226)	(0.549)	(2.308)	(0.549)
Cfo		0.893	1.328*	0.466	1.328*
		(0.807)	(1.858)	(0.527)	(1.858)
Lev		-0.394	-0.133	-0.500**	-0.133
		(-1.588)	(-0.651)	(-1.964)	(-0.651)
Tang		-0.290***	-0.082*	-0.176***	-0.082*
		(-8.016)	(-1.921)	(-3.320)	(-1.921)
Id	NO	NO	NO	YES	YES
Year	NO	NO	YES	NO	YES
N	5687	5687	5687	5687	5687
R^2	0.049	0.093	0.478	0.193	0.460
F	296.062	72.823	274.139	135.537	270.769

Note: *** indicates $p < 0.01$, ** indicates $p < 0.05$, * indicates $p < 0.10$, the same below; the values in parentheses are t-values.

3.3. Robustness test

Replace the explained variable with its first - order lag term . The one - period lag of the enterprise innovation quality variable is used as the new explained variable. The purpose of this is to take into account that enterprise innovation activities have a certain lag. The impact of ESG coupling coordination on the quality of enterprise innovation may not appear immediately but requires a certain period of time to manifest. By using the one - period lag of the enterprise innovation quality variable, the long - term relationship between ESG coupling coordination and the quality of enterprise innovation can be captured more accurately. Column (4) of Table 3 shows that the regression result is significantly positive at the 1% level, and the test result still supports Hypothesis 1.

Table 3. Robustness Tests

	(1)	(2)
	LLnCitation	LnCitation
	The explained variable is lagged by one period.	Replace the explanatory variable.
ESG	0.156***	0.110**
	(2.664)	(3.030)
Controls	YES	YES
Id	YES	YES
Year	YES	YES
N	5687	5690
R2	0.476	0.479
F	271.214	274.721

Replace the explanatory variable with the coordination index. The coordination index also attempts to capture the synergistic relationship among environmental, social, and governance elements, which is similar to the core concept of ESG coupling coordination. Therefore, the coordination index is used to replace the explanatory variable, the ESG coupling coordination index, for the robustness test. Column (5) of Table 3 shows that the regression result is significantly positive at the 5% level, and the test result still supports Hypothesis 1, indicating that the previous research results are robust.

3.4. Endogeneity test

The first-order lag term of the explanatory variable is used as an instrumental variable for the endogeneity test. The F statistic is very large, reaching 484.97, indicating a significant linear relationship between the instrumental variable and the endogenous explanatory variable, and it can statistically well explain the changes in the endogenous explanatory variable. The value of the Cragg-Donald Wald F statistic is 484.97, which is far greater than all the critical values, suggesting that the instrumental variable is not a weak instrumental variable. It can effectively explain the changes in the endogenous explanatory variable, avoiding the problems of estimation bias and the failure of statistical inference caused by weak instrumental variables.

Table 4. Endogeneity Test

	(1)	(2)
	LnCitation	LnCitation
	Regression Results of the First Stage	Regression Results of the Second Stage
ESG	0.304***	0.632***
	(22.02)	(z=3.10)
Controls	YES	YES
Id	YES	YES
Year	YES	YES
N	5110	5110
R^2	0.795	0.795
F-test	484.97	484.971
LM	496.24	496.238

Moreover, the model is identifiable, and there is a significant correlation between the instrumental variable and the endogenous explanatory variable, meeting the correlation requirement of the instrumental variable. The p-value of the LM test is 0, which is significant at the 1% level, indicating that the model is identifiable. In summary, it is reasonable to select the first-order lag term of the explanatory variable as an instrumental variable for the endogeneity test. Column (1) of Table 4 shows the regression results of the second stage of the endogeneity test using the instrumental variable method. The coefficient of ESG coupling coordination is significant at the 1% level, indicating that the previous research conclusions are robust.

3.5. Heterogeneity test

There is a significant heterogeneity in the influence of the business nature of the company on the impact of ESG coupling coordination on the quality of enterprise innovation. For state-owned enterprises, the regression results are shown in Column (2) of the Table 5, which are significant at the 5% level. As an important pillar of the national economy, state-owned enterprises need to implement national strategic policies. Under this policy orientation, they can obtain more resources such as financial subsidies, tax preferences, and government project support by virtue of policy advantages, providing a material foundation for innovation activities. At the same time, state-owned enterprises have a strong sense of social responsibility, and their business objectives take into account both social and environmental benefits. The ESG concept highly coincides with their social responsibilities, prompting them to combine long-term development goals with innovation strategies and focus on improving the quality of innovation to achieve sustainable development. Moreover, state-owned enterprises have a complete governance structure and a standardized decision-making mechanism, and can establish a special department responsible for the formulation and implementation of ESG strategies. They can better integrate resources and coordinate interests in the improvement of ESG coupling coordination, and improve the scientific nature and efficiency of innovation decision-making. For non-state-owned enterprises, the regression results are shown in Column (1) of the Table 5, and the regression results are not significant. The possible reasons are as follows: Non-state-owned enterprises face resource constraints and short-term profit pressure. Limited resources are often invested in projects that can quickly generate economic benefits, and they do not pay enough attention to long-term ESG-related investments and innovation activities. Moreover, financing difficulties also limit the promoting effect of ESG on the quality of innovation.

Table 5. Heterogeneity Test

	(1)	(2)
	LnCitation	LnCitation
	Non-state-owned Enterprises	State-owned Enterprises
ESG	0.111	0.162**
	(1.117)	(2.128)
Controls	YES	YES
Id	YES	YES
Year	YES	YES
N	2338	3349
R2	0.478	0.482
F	112.357	163.493

3.6. Further analysis

The bidirectional fixed adjustment effect model is shown below:

$$LnCitation_{i,t} = \alpha_0 + \alpha_1 ESG_{i,t} + \alpha_2 ESG_{i,t} adjust_{i,t} + \alpha_j \sum Controls_{i,t} + \theta_i + \mu_t + \varepsilon_{i,t} \quad (2)$$

where i represents the enterprise, t represents the year, $\mathrm{LnCitation_{i,t}}$ is the explained variable used to reflect the quality of enterprise innovation, $\alpha_1 \mathrm{ESG_{i,t}}$ is the explanatory variable reflecting ESG

coupling coordination, $adjust_{i,t}$ is the moderating variable, specifically referring to enterprise scale and growth ability,$\sum Controls_{i,t}$is a series of control variables, θ_i is the individual fixed effect, μ_t is the time fixed effect, and $\varepsilon_{i,t}$ is the random disturbance term. The empirical results are shown in Table 6.

Table 6. Moderating effect

	(1)	(2)
	Enterprise Scale	Growth Ability
ESG	1.765***	0.158***
	(10.865)	(2.606)
ESG×Size	-2.834***	
	(-10.102)	
ES×Growth		-1.347**
		(-2.408)
Controls	YES	YES
Id	YES	YES
Year	YES	YES
N	5687	5687
R2	0.471	0.478
F	265.908	274.345

For large - scale enterprises, especially state - owned enterprises, their large size and complex organizational structures make them prone to organizational inertia and the resource curse. Although they invest heavily in ESG governance, due to path dependence and lengthy decision - making processes, their innovation directions mostly focus on incremental improvements (such as enhancing traditional energy efficiency) rather than disruptive technologies (such as hydrogen energy and energy storage technologies). In addition, ESG - related policies in China, such as the "dual - carbon" goal, mainly impose mandatory constraints on large enterprises, leading them to prefer "defensive innovation" (such as installing pollution control equipment) rather than "pioneering innovation" (such as developing new energy technologies), which further weakens the positive impact of ESG on innovation quality. As shown in Column (1) of the chart, the interaction term is significantly negative at the 1% level, indicating that enterprise scale has a negative moderating effect on the impact of ESG coupling coordination on the quality of enterprise innovation. This validates Hypothesis

For high - growth enterprises, especially technology start - ups and rapidly expanding private enterprises, the pressure of short - term performance and the resource crowding - out effect are significant. To meet the capital market's expectations for short - term performance, these enterprises often prioritize resource allocation to businesses that can generate quick cash (such as market expansion) rather than long - term ESG - related innovation (such as green technology R & D). Meanwhile, despite the government's introduction of policies to support green finance and technological innovation, high - growth enterprises find it difficult to obtain low - cost capital support due to their small scale and low credit ratings, resulting in a disconnect between ESG investment and innovation quality. As shown in Column (2) of the chart, the interaction term is significantly negative at the 1% level, indicating that growth ability has a negative moderating effect on the impact of ESG coupling coordination on the quality of enterprise innovation. This validates Hypothesis 3.

4. Conclusions

Based on the data of Chinese A-share listed companies from 2012 to 2022, this paper employs various methods, such as the coupling coordination degree model and the two-way fixed effects model, to thoroughly investigate the relationship between ESG coupling coordination and the quality of enterprise innovation, as well as the moderating effects of enterprise scale and growth ability. The

study finds that ESG coupling coordination provides sustainable momentum for enterprise innovation by integrating the environmental, social, and governance dimensions. It optimizes resource allocation, enhances enterprise competitiveness, and thus has a significantly positive impact on the quality of enterprise innovation. Moreover, this conclusion remains robust after a series of robustness tests. However, enterprise scale and growth ability negatively moderate this positive relationship. Specifically, for enterprises with large scales or strong growth abilities, the promoting effect of ESG coupling coordination on the quality of innovation is inhibited. Furthermore, there are notable differences in how ESG coupling coordination improves the quality of innovation across enterprises with different business natures. Based on these findings, the following policy recommendations are proposed:

(1) For large enterprises: Policies should guide these enterprises to overcome organizational inertia and optimize the decision-making process. The government could establish specialized consulting services to assist in streamlining management processes, simplifying ESG innovation decision-making, and improving resource allocation efficiency. Additionally, enterprises should be encouraged to engage in industry-university-research cooperation with scientific institutions and universities to address ESG innovation challenges and accelerate the commercialization of innovation achievements. For small and medium-sized enterprises (SMEs): The government needs to increase financial support and establish dedicated funds for the research and development of environmental technologies and social responsibility projects.

(2) For enterprises with strong growth potential: In addition to the incentive policies mentioned above, the government should strengthen guidance to help these enterprises establish long-term development strategies. This can be achieved through industry summits, the publication of industry development reports, and other measures to highlight the importance of sustained ESG innovation for their long-term success. Enterprises should be encouraged to allocate resources effectively and increase investment in ESG innovation.

(3) For enterprises with weaker growth potential: The government can provide technical assistance and training services to help these enterprises enhance their ESG capabilities and innovation levels, gradually fostering their growth potential.

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