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Research on the Role of ESG Performance in Capital Market Pricing Efficiency: An Analysis Based on Stock Price Synchronicity

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ABSTRACT

Firms' active practice of Environmental, Social, and Governance (ESG) development principles holds significant value for enhancing capital market pricing efficiency. Using panel data from Chinese A-share listed firms from 2009 to 2023 and relying on the Hua Zheng ESG rating system, we constructed corresponding indicators to investigate the impact of ESG performance on stock price synchronicity. We find that firms' ESG performance contributes to increased stock price synchronicity. This positive effect of ESG is more pronounced in samples of state-owned firms, large firms, and firms with higher bankruptcy risk. We further reveal the mechanism through which ESG promotes stock price synchronicity, identifying information disclosure quality and analyst attention as two key mediating variables, while information asymmetry exhibits a masking effect. We integrate information efficiency theory and noise theory within a unified analytical framework, advancing the development of relevant theories in emerging markets. The findings offer important insights into optimizing the role of ESG in enhancing capital market pricing efficiency.

1. Introduction

Stock price synchronicity is widely recognized as a key indicator for assessing the operational efficiency of capital markets. Specifically, stock price fluctuations are not solely attributable to a single factor but rather result from the intricate interaction of multiple types of information. Among them, private information within the firm, such as financial status, adjustments in business strategies, and the disclosure of significant events, often acts as a primary driving force for stock price volatility. According to the theoretical framework of the classic capital asset pricing model (CAPM), in addition to the direct influence of firm - specific private information on individual stock returns, individual stock returns are also significantly affected by broader market conditions. These encompass fluctuations in the macroeconomic environment, changes in market sentiment, and the impact of

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policy alterations, among other external factors. Therefore, both firm - specific private information and market noise are two crucial elements that jointly determine stock price synchronicity [1, 2].

Currently, the academic community has developed a relatively mature and systematic theoretical framework regarding these two key determinants, which can be mainly classified into two major theoretical schools. The first is the information efficiency theory. Its core proposition is that stock price fluctuations mainly originate from the disclosure and dissemination of firm - specific information. The more abundant and transparent the characteristic information disclosed by a firm, the lower the stock price synchronicity [3, 4]. Within this theoretical framework, mitigating the information asymmetry confronted by investors is of utmost significance, as it contributes to enhancing the market's information efficiency and resource allocation efficiency [5, 6]. The second is the noise theory. It contends that stock price fluctuations not only mirror the operational factors of a firm but also incorporate disturbances from various non - operational factors. These include the existence of market frictions, the appearance of bubbles, fluctuations in investor sentiment, and other noise factors [7, 8]. The presence of these noise factors propels the co - movement of stock prices with the overall market trend, thereby leading to higher stock price synchronicity [9-11].

The implications of high or low stock price synchronicity vary significantly across diverse market environments. Based on the information efficiency theory, within mature and well - developed market systems, stock price fluctuations predominantly mirror firm - specific information, including financial status, operational strategies, and market outlooks. When stock price synchronicity is high, it implies that this crucial characteristic information has not been fully integrated into stock prices. This suggests relatively low pricing efficiency in the capital market, indicating that the market has deficiencies in information processing and price discovery functions [3, 12]. Nonetheless, the noise theory presents a distinct perspective. It underscores that in less mature market environments, an increase in stock price synchronicity often denotes the effective suppression of noise trading. Subsequently, this indicates an enhancement in capital market efficiency and more healthy and orderly market operations [13]. Specifically, with respect to China's capital market, which is still in a weak - form efficient stage, an increase in stock price synchronicity actually symbolizes a gradual improvement in the pricing efficiency of the capital market. It also signifies the continuous optimization and refinement of the market's price formation mechanism.

With the widespread adoption of environmental, social, and governance (ESG) principles, a growing number of scholars have begun to focus on the economic consequences of this non-financial information disclosure, such as firms' market performance, investor decision-making, and macroeconomic operational efficiency [14-16]. Furthermore, scholars have started exploring the relationship between firms' ESG performance and stock price synchronicity, though a consensus has yet to be reached. Specifically, some scholars argue that ESG enhances the information content of stock prices, reduces accrual-based earnings management, alleviates financial constraints, and lowers the degree of information asymmetry, thereby decreasing stock price synchronicity [17-19]. Conversely, other scholars contend that firms' ESG practices mitigate the impact of noise-driven behaviors on stock prices by improving information disclosure quality and attracting greater analyst attention, consequently increasing stock price synchronicity [20, 21].

At present, research results on this topic are still inconsistent, and the explored mechanisms are relatively limited. Studies tend to concentrate either on reducing information asymmetry based on the information efficiency theory or on improving the quality of information disclosure and increasing analyst attention based on the noise theory. These two potential influences have not yet been incorporated into a unified analytical framework. By synthesizing the existing research, this study makes a significant contribution to the relevant field. We investigate the relationship between ESG

and stock price synchronicity by utilizing data from Chinese A - share listed firms spanning from 2009 to 2023. Different from previous studies, we posit that a higher level of stock price synchronicity reflects remarkable capital market efficiency in the context of China. Considering that China's market remains in the weak - form efficiency state, market efficiency should be mainly manifested through the absorption of market noise to alleviate excessive volatility. This insight is of utmost significance for developing countries with still - developing capital markets.

Overall, we make the following two distinctive contributions:

Firstly, a more comprehensive theoretical analytical framework is adopted. This approach addresses the limitations of previous studies that solely relied on a single theoretical basis, thus ensuring the reliability of subsequent findings. Furthermore, for developing countries, enhancing the efficiency of the capital market is of critical importance for promoting the healthy development of the economy. As a result, this study generates novel and policy-relevant academic outputs. Against the backdrop of the rapid development of ESG and its substantial impact on firms' operations, these findings offer empirical support for countries with weak-form efficient capital markets. The subsequent conclusions possess universal reference value for developing nations.

Secondly, in addition to directly examining the impact of ESG on stock price synchronicity, we conduct an in-depth heterogeneity analysis. This provides decision-making references for further promoting ESG principles and better facilitating the coordinated development of different types of firms. Moreover, two synergistic mechanisms through which ESG influences stock price synchronicity are identified. This represents a valuable expansion of both information efficiency theory and noise theory, while also offering methodological guidance for systematically studying the role of ESG in capital markets.

The remainder of this paper is organized as follows: Section II presents the theoretical analysis and research hypotheses; Section III outlines the research design; Section IV analyzes the empirical results, including baseline regression analysis, heterogeneity analysis, and robustness tests; Section V conducts mechanism analysis; and Section VI provides conclusions and policy implications.

2. Theoretical Analysis and Research Hypotheses

The prevailing viewpoints on stock price synchronicity include the noise theory and the information efficiency theory. Chang *et al.,* [22], concentrating on China's capital market, examined the influence of information transparency on stock price synchronicity. They posited that stock price synchronicity in China is in line with the perspective of the "irrational behavior school." Firms adhering to ESG development principles disclose ESG-related reports, which transmit more comprehensive information to external stakeholders. The reduction of information asymmetry between internal and external parties can improve firms' information transparency [23,24]. This allows external investors to have a more profound understanding of firm information, thus promoting more rational decision - making by investors and alleviating noise - induced behaviors. A decline in noise trading may suggest reduced fluctuations in individual stock movements within the market, facilitating the convergence of stock prices towards their intrinsic values and leading to higher synchronicity with overall market trends.

The information efficiency theory posits that stock price fluctuations mainly originate from the explanatory ability of firm - specific information. A higher proportion of firm - specific information content corresponds to a lower level of stock price synchronicity. Nevertheless, in underdeveloped markets, the motivation of firms to disclose ESG and social responsibility information remains a subject of contention. Owing to the generally weaker information - processing capabilities of investors in these markets, social responsibility disclosure may manifest a "masking effect."

Management may utilize social responsibility disclosures to pursue their self - interests, thereby concealing opportunistic and unethical behaviors. Meanwhile, they may present market and industry - level information as firm - specific information, resulting in the incorporation of market and industry factors into stock prices. The prevalence of industry and market information in disclosures "masks" firm - specific information, consequently leading to an increase in stock price synchronicity. The specific mechanism diagram is shown in Figure 1. Based on this, the following hypothesis is proposed:

Hypothesis 1: Firms' ESG performance can enhance stock price synchronicity.

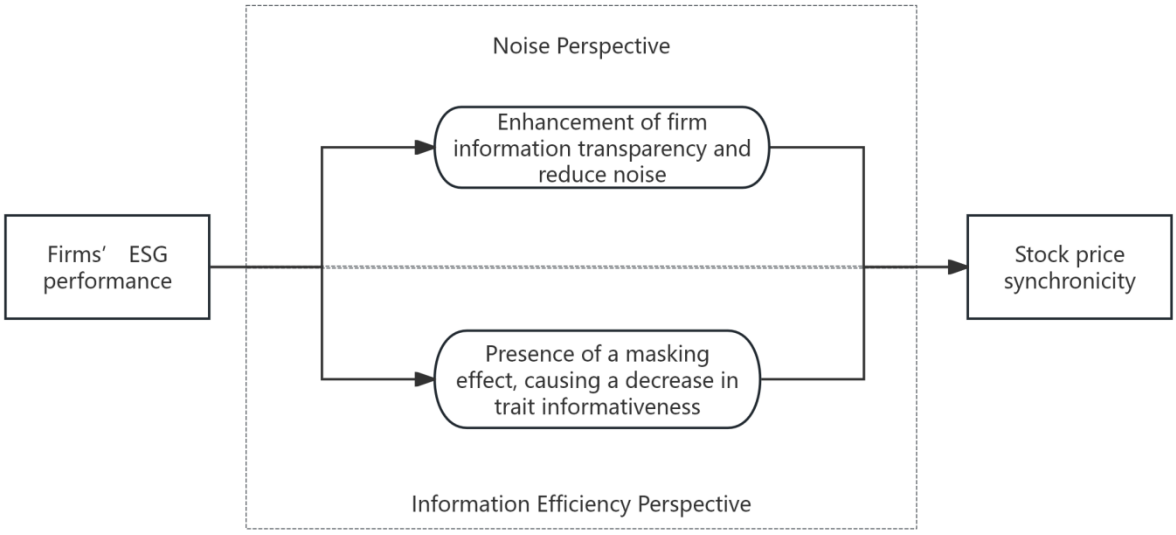

Fig. 1. Theoretical mechanism analysis of the impact of firms' ESG performance on stock price synchronicity

When firms implement ESG development principles, they are obligated to disclose relevant social responsibility information. This approach mitigates the drawbacks of solely disclosing financial and corporate governance information [25-28], thereby elevating the quality of information disclosure of listed firms. If ESG reports present distinctive information not encompassed by other disclosures, market price discovery mechanisms will trigger corresponding adjustments in stock prices. Specifically, higher - quality information disclosure empowers firms to divulge more idiosyncratic information, leading to lower stock price synchronicity [29].

Nevertheless, in underdeveloped markets, firms' ESG reports frequently fail to adequately disclose authentic and detailed firm - specific information. Firms may choose to issue vague, generalized, and low - quality reports to boost their visibility, utilizing other media channels to amass reputation and draw the attention of the market and investors [30, 31]. In such circumstances, ESG performance may be regarded as speculative behavior [32]. These reports usually contain a large amount of irrelevant market and industry - level public information and often exhibit similarities across different reports [22], thus reducing information disclosure to a means of pursuing self - interest [33]. When investors rely on such reports, they gain no in - depth understanding of firm - specific information. Even with an increase in disclosure, investors only acquire more market and industry - level public information, which can only reduce market noise, ultimately resulting in higher stock price synchronicity [34]. The specific mechanism diagram is shown in Figure 2.

Based on the above analysis, the following hypothesis is put forward:

Hypothesis 2: ESG enhances stock price synchronicity through the improvement of information disclosure.

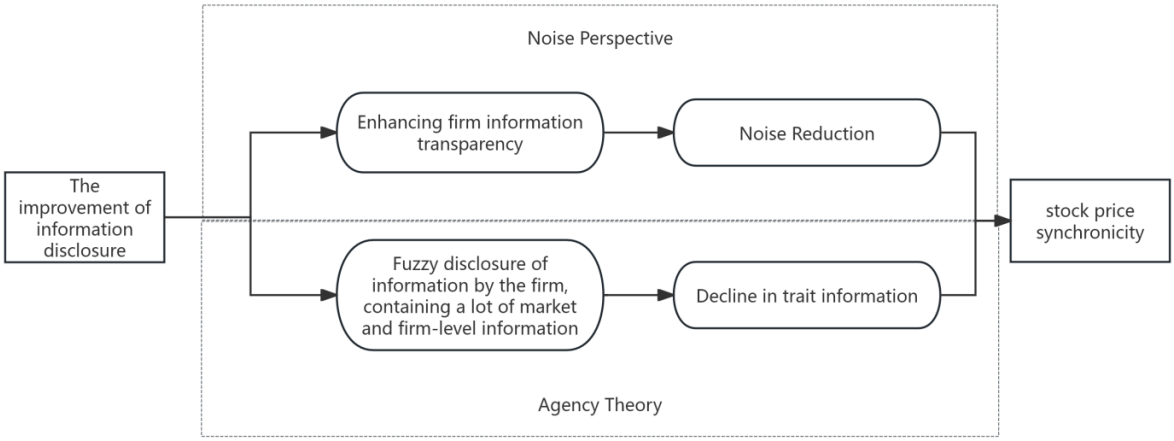

Fig. 2. Mechanism analysis of the effect of firm disclosure quality on stock price synchronicity

The presence of information asymmetry generally leads to an elevation in stock price synchronicity. This phenomenon arises because the information asymmetry between managers and investors gives rise to the leakage of private information and a heightened level of uncertainty. In such a situation, investors with limited information are more prone to be influenced by market sentiment and macro - economic factors. Consequently, they place greater reliance on market - level information when making investment decisions. As a result, the movement of individual stock prices exhibits a high degree of correlation with the average market movement, thereby augmenting stock price synchronicity. Therefore, the more pronounced the degree of information asymmetry, the higher the stock price synchronicity. Firms actively involved in ESG practices alleviate information asymmetry through the disclosure of social responsibility reports, which in turn contributes to the reduction of stock price synchronicity.

Noise theory posits that immature markets are frequently inundated with a significant amount of noise, and this noise is positively correlated with information transparency. An increase in analyst coverage enhances information transparency, enabling ordinary investors to access relevant information more readily and form consistent assessments of stock prices. Consequently, noise interference in stock prices is reduced, and synchronicity is strengthened [35-37]. The specific mechanism diagram is shown in Figure 3.

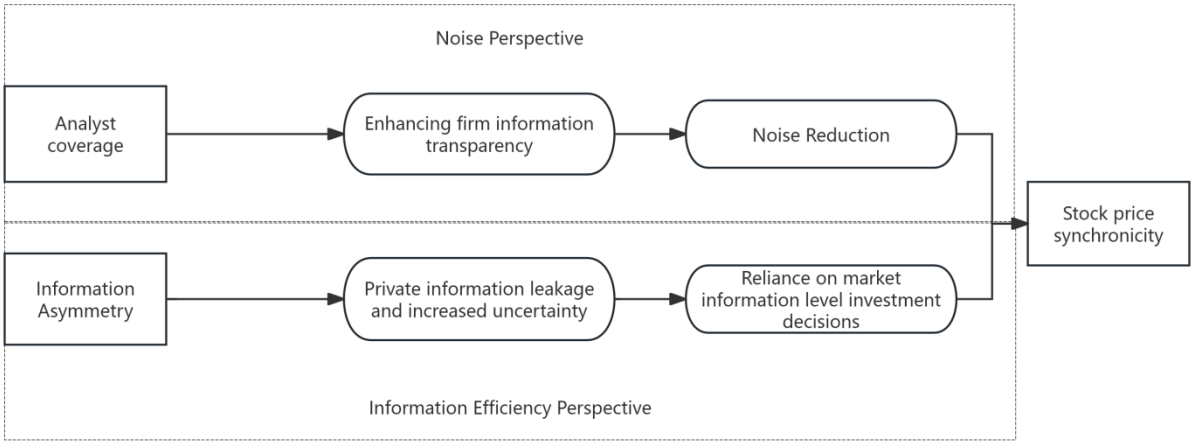

Fig. 3. Mechanistic analysis of the impact of analyst attention and information asymmetry on stock price synchronicity

Based on this, the following hypotheses are proposed:

Hypothesis 3a: ESG reduces stock price synchronicity by alleviating information asymmetry (the information efficiency channel).

Hypothesis 3b: ESG increases stock price synchronicity by enhancing analyst coverage (through increased coverage) (the noise channel).

3. Research Design

3.1 Data Sources

We selected panel data from Chinese A-share listed firms spanning the period 2009 to 2023 as the research sample. The data were primarily sourced from the WIND and CSMAR databases. Due to data availability constraints, the following processing steps were applied: exclusion of financial industry samples; removal of ST and *ST firms; elimination of samples with missing financial data; and winsorization of major variables at the 1% level. The final sample comprises 39,458 firm-year observations.

3.2 Variable Definitions

3.2.1 Dependent Variable: Stock Price Synchronicity

Stock price synchronicity (SYN) is measured following the approach of Chan and Hameed [20] and Gul *et al.,* [38]. We use the logarithm of the adjusted R^2 to quantify stock price synchronicity, resulting in the following dependent variable:

$$R_{i,w,t} = \beta_0 + \beta_1 R_{M,w,t} + \beta_0 R_{I,w,t} + \varepsilon_{i,t} \quad (1)$$

$$SYN = log(\frac{R_i^2}{1-R_i^2}) \quad (2)$$

In Eq (1), $R_{i,w,t}$ represents the weekly stock return of firm *i* in week *w* of year *t*, considering cash dividend reinvestment. $R_{M,w,t}$ represents the weekly market return of firm *i* in week *w* of year *t*, also considering cash dividend reinvestment. $R_{I,w,t}$ refers to the weekly market return of all stocks in the industry of firm *i*, excluding stock *i*, in week of year *t*, with cash dividend reinvestment considered. The industry classification used in this paper follows the 2012 classification by the China Securities Regulatory Commission (CSRC). The R^2 is calculated by performing an annual regression for Eq (1). To ensure that R^2 follows a normal distribution, we apply the logarithmic transformation in EQ (2) to obtain *SYN*.

3.2.2 Independent Variable: Measurement of ESG Performance

We utilize Hua Zheng's ESG ratings as the foundational data for measuring firms' ESG performance, with detailed evaluation metrics provided in Table 1. The independent variable *ESG* is constructed by assigning numerical values from 1 to 9 in ascending order based on the firms' ESG rating (categorized into nine tiers: C, CC, CCC, B, BB, BBB, A, AA, and AAA).

Table 1
Hua zheng ESG (Environmental, Social, and Governance) Rating System (2021 Classification Standards)

Three pillars	Environmental responsibility	Social responsibility	Governance capability
14 themes	Environmental Management System (EMS) Green Business Goals Green Products External Environmental Certification Environmental Violation Incidents	System Framework Health and Safety Social Contribution Quality Management	System Framework Governance Structure Business Operations Business Risks External Sanctions
26 key indicators	Environmental Management System Low Carbon Plan or Goals Green Business Plan Carbon Footprint Sustainable Products or Services Product or firm Obtaining Environmental Certification Environmental Violations or Non-compliance Incidents	Quality of Social Responsibility Report Goals or Plans to Reduce Safety Incidents Negative Business Incidents Trend of Business Incident Occurrences Donations Related to Social Responsibility Employee Growth Rate Rural Revitalization Product or firm Obtaining Quality Certification	Firms' Self-ESG Supervision Related Party Transactions Board Independence Tax Transparency Asset Quality Overall Financial Credibility Short-term Debt Repayment Risk Equity Pledge Risk Quality of Information Disclosure Violations or Illegal Incidents in Listed Firms and Their Subsidiaries Violations or Illegal Incidents Involving Executives and Shareholders

3.2.3 Mediating Variables

Information disclosure quality, *DISC*, is constructed based on the assessment results of listed firms' information disclosure work published by the Shanghai Stock Exchange (SSE) and the Shenzhen Stock Exchange (SZSE). According to the four grades (A, B, C, D) assigned to information disclosure practices, we assign DISC values of 4, 3, 2, and 1, respectively.

We utilize analyst coverage (*ANALYST*) and research report coverage (*REPORT*) as proxy variables for analytical attention. Specifically, we adopt the quantity of analysts monitoring and analyzing the firm within a specific year to measure *ANALYST*. The frequency of research reports encompassing the firm is employed to assess *REPORT*.

3.2.4 Masking Variable

Information asymmetry (*ASY*). Drawing research of Amihud *et al.,* [39], Amihud [40], and Bharath *et al.,* [41], we develop the information asymmetry data grounded in individual stock trading data and pertinent literature on the microstructure of financial markets. Employing principal component analysis, we establish a proxy variable derived from the first principal component of three indicators: return reversal, illiquidity ratio, and liquidity ratio. This variable encapsulates their common variance, which mirrors asymmetric information, and is designated as the information asymmetry index (*ASY*).

3.2.5 Control Variables

Drawing existing research [17, 19, 22], we integrated multiple firm - specific control variables, as presented in Table 2. Moreover, we accounted for both firm fixed effects and time fixed effects.

Table 2
Control variables

	Variable Name	Measurement Method
Lev	Debt-to-Equity Ratio	Period-end liabilities divided by period-end assets
ROA	Return on Total Assets	Period-end Net Profit as a Ratio of Total Assets
ROE	Return on Equity	Period-End Net Profit Relative to Net Assets
BM	Book-to-Market Ratio	Total market capitalization over total assets at the end of the previous period
Ihold	Institutional Investor Ownership Percentage	Institutional Investor Shareholding Ratio
Dual	Duality of CEO and Chairman	General Manager and Chairman of the Board of Directors is one person take 1, otherwise 0 (dummy variable)
Bsize	Board Size	Natural Logarithm of Board Size
Big4	Big Four Auditing Firms	Auditor is from the "Big Four" (Dummy Variable: 1 if yes, otherwise 0)
Size	Firm Size	Natural Logarithm of Firm's Total Assets

3.3 Model

3.3.1 Benchmark model: ESG performance and stock price synchronicity.

Guided by the preceding theoretical framework, this study employs a two-way fixed effects model as its benchmark regression to examine the impact of firms' ESG on stock price synchronicity:

$$\mathrm{SYN}_{i.t} = \alpha_0 + \alpha_1 ESG_{i,t} + \sum_{j=2}^{n} \alpha_j \, Controls_{i,t} + v_i + u_t + \varepsilon_{i,t} \quad (3)$$

In Eq (3), *ESG* represents the independent variable; *SYN* denotes the dependent variable; *Controls* refer to a series of control variables. v_i represents the firm fixed effect, μ_t represents the year fixed effect, and $\varepsilon_{i,t}$ denotes the random error term.

3.3.2 The mechanism model: Mediation Effect and Masking Effect.

To explore the driving mechanism of ESG on stock price synchronicity, we set the following mediation effect model.

$$Med_{i,t} = \beta_0 + \beta_1 ESG_{i,t} + \sum_{j=2}^{n} \beta_j Controls_{i,t} + v_i + u_t + \varepsilon_{i,t} \quad (4)$$

$$SYN_{i,t} = \delta_0 + \delta_1 ESG_{i,t} + \delta_2 Med_{i,t} + \sum_{j=3}^{n} \delta_j Controls_{i,t} + v_i + u_t + \varepsilon_{i,t} \quad (5)$$

Med denotes the mediator variables, namely *DISC*, *ANALYST*, and *REPORT*. The definitions of all the remaining variables and symbols are consistent with those stipulated in Eq (3).

The masking mechanism is modeled as follows:

$$\mathrm{Med}^1{}_{i,t} = \beta_0 + \beta_1 ESG_{i,t} + \sum_{j=2}^{n} \beta_j Controls_{i,t} + v_i + u_t + \varepsilon_{i,t} \quad (6)$$

$$SYN_{i,t} = \delta_0 + \delta_1 ESG_{i,t} + \delta_2 Med^1{}_{i,t} + \sum_{j=3}^{n} \delta_j Controls_{i,t} + v_i + u_t + \varepsilon_{i,t} \quad (7)$$

Med[1] represents the masking variable, *ASY*. The definitions of all the remaining variables and symbols are consistent with those stipulated in Eq (3).

4. Results

4.1 Descriptive Statistics

Table 3 reports the descriptive statistics of the main variables. SPN spans from -4.222 at the bottom end to 1.318 on the high side, averaging out at -0.676, with a standard deviation of 1.055. This indicates significant differences in stock price synchronization across firms. ESG ranges from 1 to 6, averaging 4.155 with a standard deviation of 0.985, which underscores substantial variation in

firms' sustainability practices. This reveals a wide spectrum of ESG commitment among the firms studied.

Table 3
Descriptive Statistics

Variables	N	Mean	Std	Min	Max
SYN	39458	-0.678	1.051	-4.092	1.320
ESG	39458	4.158	0.983	1	6
Lev	39458	0.421	0.204	0.0530	0.887
ROA	39458	0.0500	0.0650	-0.220	0.233
ROE	39458	0.0500	0.145	-0.837	0.309
BM	39458	0.622	0.247	0.127	1.194
Ihold	39458	38.54	25.05	0.226	90
Dual	39458	0.294	0.456	0	1
Bsize	39458	8.507	1.672	5	15
Big4	39458	0.940	0.238	0	1
Size	39458	22.22	1.282	19.96	26.22

4.2 Baseline Results

Table 4 reports the regression results of Equation (3). Column (1) controls for firm fixed effects, Column (2) further controls for time fixed effects, and Column (3) adds a series of control variables. The results indicate that the coefficients of *ESG* are significantly positive at the 1% level. Column (3) presents the main findings, with an *ESG* coefficient of 0.022, suggesting that a one-unit improvement in ESG rating leads to a 2.2% increase in stock price synchronicity.

These results reflect the fact that firms' ESG performance enhances stock price synchronicity. While increased information disclosure intensity improves investors' understanding of the firm, it does not necessarily provide them with more firm-specific information. Moreover, in ESG reports, managers' information masking behavior may further complicate investors' ability to identify firm-specific information. However, the market and industry information contained in ESG reports can mitigate noise interference caused by investors. As a result, stock prices incorporate more comprehensive market and industry information, leading to higher synchronicity. Here, we confirm Hypothesis 1.

Table 4
The Impact of ESG Performance on Stock Price Synchronicity

	(1) *SYN*	(2) *SYN*	(3) *SYN*
ESG	0.0374***	0.0397***	0.0220***
	(0.00730)	(0.00610)	(0.00607)
Lev			-0.307***
			(0.0511)
ROA			-0.259
			(0.170)
ROE			0.0161
			(0.0690)
BM			0.841***
			(0.0392)
Ihold			-0.00130***
			(0.000391)

Table 4
Continued

	(1) *SYN*	(2) *SYN*	(3) *SYN*
Dual			-0.0176
			(0.0157)
Bsize			-0.00554
			(0.00542)
Big4			-0.0444
			(0.0453)
Size			0.132***
			(0.0152)
Firm Fixed Effects	YES	YES	YES
Year Fixed Effects	NO	YES	YES
_cons	-0.833***	-0.843***	-3.902***
	(0.0304)	(0.0254)	(0.334)
N	39458	39458	39458
R-squared	0.280	0.497	0.513
Adjusted R-squared	0.185	0.430	0.449

Note: The numbers in parentheses represent the robust standard errors clustered at the firm level. *, **, *** indicate significance at the 10%, 5%, and 1% levels, respectively. Unless otherwise specified, the same applies below.

4.3 Heterogeneity Analysis

In China, state-owned enterprises (SOEs) and non-state-owned enterprises (non-SOEs) exhibit significant differences in ESG performance. On one hand, SOEs bear more government-mandated missions and tend to be more proactive in developing ESG practices. In contrast, non-SOEs primarily focus on profitability, which may lead to less enthusiasm in promoting ESG initiatives. On the other hand, SOEs often enjoy easier access to government special funds and lower loan thresholds [42], giving them certain advantages in building ESG capabilities. These differences in ESG performance may lead to varying impacts on stock price synchronicity.

We categorize listed firms into SOEs and non-SOEs for heterogeneity analysis. Table 5 reports the results: Column (1) presents the SOE sample, while Column (2) shows the non-SOE sample. The results indicate that the coefficients of ESG are significantly positive at the 5% level for both groups, suggesting that ESG performance enhances stock price synchronicity regardless of ownership type. However, the regression coefficient for the SOEs sample is larger (0.0324 > 0.026), indicating that the promoting effect of ESG performance on stock price synchronicity is more pronounced in SOEs.

SOEs are typically more deeply integrated into national strategies, and their ESG practices are often closely aligned with macro-level policies such as the dual-carbon goals. Their ESG performance is more likely to be interpreted by the market as a signal of policy compliance and long-term sustainability. This policy endorsement effect effectively reduces uncertainty in the eyes of investors. Furthermore, SOEs generally exhibit more standardized corporate governance structures and stricter information disclosure systems, making their ESG data more comparable and credible. High-quality, high-transparency ESG information can significantly reduce information asymmetry between firms and investors, thereby minimizing noise trading driven by misjudgments or speculation. Consequently, the impact of ESG performance on stock price synchronicity is stronger in SOEs than in non-SOEs.

Significant differences exist between large and small firms in terms of resources, capabilities, regulatory pressures, and market expectations. These disparities may lead to variations in how firms adopt ESG principles, thereby influencing the effect of ESG on stock price synchronicity. We categorize firms into large and small firms based on the median firm size to examine the

heterogeneous impact of firm size on the relationship between ESG development and stock price synchronicity. Table 6 reports the results. Column (1) presents the large firm sample, while Column (2) shows the small firm sample. The results indicate that the coefficient of *ESG* is significantly positive only in Column (1), suggesting that the ESG performance of small firms does not exhibit a significant promoting effect on stock price synchronicity.

Table 5
Heterogeneity Analysis of Firm Ownership

	(1) SOEs *SYN*	(2) Non-SOEs *SYN*
ESG	0.0324**	0.0260**
	(0.0102)	(0.00828)
Control Variables	YES	YES
Firm Fixed Effects	YES	YES
Year Fixed Effects	YES	YES
_cons	-1.657**	-4.206***
	(0.585)	(0.488)
N	12140	20949
R-squared	0.490	0.535
Adjusted R-squared	0.429	0.458

The resource advantages of large firms enable greater investment in ESG initiatives, leading to more comprehensive and reliable ESG information disclosure. Additionally, large firms often face stricter regulatory pressures and higher market expectations, which motivate them to more actively improve ESG performance and provide high-quality disclosures. These factors collectively contribute to higher-quality ESG information and stronger signaling effects from large firms, which more effectively reduce noise-driven trading. As a result, the stock prices of large firms integrate more stably into overall market trends.

Table 6
Analysis of Firm Size Heterogeneity

	(1) Large Firms *SYN*	(2) Small Firms *SYN*
ES*G*	0.034***	0.004
	(4.00)	(0.45)
Control Variables	YES	YES
Firm Fixed Effects	YES	YES
Year Fixed Effects	YES	YES
_cons	-5.206***	-3.559***
	(-9.39)	(-5.82)
N	21822	19,469
R-squared	0.556	0.551
Adjusted R-squared	0.443	0.458

Based on agency theory, firms with varying levels of risk exhibit differences in their motivation to disclose public information. For high-risk firms, management's use of social responsibility disclosures often serves as a form of masking behavior. As risk increases, management may become more proactive in leveraging social responsibility information to obscure the firms' true condition. To examine this, we employ Altman's method to construct the Zeta Score (referred to as Z-Score) to measure firms' bankruptcy risk, where a higher Z-value indicates lower bankruptcy risk. We

categorize firms into low-risk and high-risk groups based on the median bankruptcy risk for heterogeneity testing. The results are presented in Table 7. Column (1) shows the low bankruptcy risk sample, while Column (2) presents the high bankruptcy risk sample. The results indicate that the coefficient of ESG is significantly positive only in Column (2), suggesting that ESG performance significantly promotes stock price synchronicity in high-risk firms, whereas no such effect is observed in low-risk firms.

This phenomenon transpires as management within high-risk firms exhibits greater concern regarding the scrutiny from investors and the market. In order to evade external inquiries regarding their operational circumstances and safeguard their self-interests, they proactively disclose ESG reports to conceal opportunistic and unethical conduct, consequently misleading investors and other stakeholders. Nevertheless, these ESG reports are prone to obscuring the genuine situation of the firms, predominantly encompassing industry and market - level information rather than firm - specific particulars. Under this masking effect, stock price synchronicity is augmented.

Table 7
Heterogeneity Analysis of Firm Risk

	(1) Low Risk Firms *SYN*	(2) High Risk Firms *SYN*
ESG	0.0181	0.0277**
	(0.00933)	(0.00853)
Control Variables	YES	YES
Firm Fixed Effects	YES	YES
Year Fixed Effects	YES	YES
_cons	-4.932***	-3.298***
	(0.559)	(0.477)
N	19307	19321
R-squared	0.543	0.532
Adjusted R-squared	0.452	0.450

4.4 Robustness Tests

4.4.1 One-Period Lagged Treatment

To mitigate potential biases or misleading conclusions arising from reverse causality, we utilize the one-period lagged *ESG*. Column (1) of Table 8 reports the results, indicating that the coefficient of ESG_{t-1} is significantly positive at the 5% level.

4.4.2 Alternative Dependent Variable

Following the approach of Gul *et al.,* [38], we replace the outcome of Eq (1) with Eq (8):

$$R_{i,w,t} = \beta_0 + \beta_1 R_{M,w,t} + \beta_2 R_{I,w,t} + \beta_3 R_{M,w,t-1} + \beta_4 R_{I,w,t-1} + \varepsilon_{i,t} \quad (8)$$

Eq (8) introduces first-order lag terms of market and industry returns on the basis of Eq (1). We employ the newly derived dependent variable SYN_1 to conduct regression analysis. The results of this analysis are presented in Column (2) of Table 8, showing that the coefficient of *ESG* is positive at the 1% significance level.

4.4.3 Alternative Independent Variable

We adopt a broader categorization approach for ESG by grouping them into major tiers. Specifically, ratings between C and CCC are assigned a value of $ESG_1 = 1$; ratings between B and BBB are assigned $ESG_1 = 2$; and ratings between A and AAA are assigned $ESG_1 = 3$. Column (3) of Table 8

reports the regression results using this new independent variable. The coefficient of ESG_1 remains significantly positive at the 5% level.

4.4.4 Adjusted Sample

To mitigate the potential impact of the 2015 stock market crash and the COVID-19 pandemic, we exclude data from the years 2015 and 2020–2023. Column (4) of Table 8 presents the regression results based on this adjusted sample period. The coefficient of *ESG* remains significantly positive at the 1% level, demonstrating that the promoting effect of ESG on stock price synchronicity persists even when excluding the influence of these exceptional events.

Table 8
Alternative Variables and Adjusted Sample

	(1)	(2)	(3)	(4)
	SYN	*SYN1*	*SYN*	*SYN*
ESG		0.0185***		0.0265***
		(0.00540)		(0.00717)
ESG1			0.030**	
			(2.30)	
ESG_{t-1}	0.0164**			
	(0.00565)			
Control Variables	YES	YES	YES	YES
Firm Fixed Effects	YES	YES	YES	YES
Year Fixed Effects	YES	YES	YES	YES
_cons	-3.924***	-3.338***	-3.913***	-1.889***
	(0.335)	(0.294)	(-11.70)	(0.388)
N	38529	39458	39,458	24540
R-squared	0.506	0.513	0.513	0.438
Adjusted R-squared	0.446	0.449	0.448	0.348

4.4.5 Altering Clustering Method

In the baseline regression analysis, we employed a common statistical approach by clustering standard errors at the firm-year level. However, in practice, peer effects may exist among firms, particularly within the same industry or region. Specifically, if one firm in an industry (or region) begins adopting ESG standards, other firms in the same industry (or region) may follow suit to remain competitive. This phenomenon could lead to within-group correlation in the error terms of firms within the same industry (or region). To address this potential issue, this study adopts a more robust analytical approach by altering the clustering method to ensure the reliability of the statistical results. Table 9 reports the results after changing the clustering of standard errors. Column (1) clusters standard errors at the city level, Column (2) at the province level, and Column (3) at the industry level. The results show that the coefficients of ESG remain significantly positive at the 5% level across all specifications.

4.5 Endogeneity Tests

To address potential endogeneity concerns between firms' ESG performance and stock price synchronicity, we employ instrumental variables for validation. We use the one-period lagged ESG development indicator and the average ESG value of firms in the same year, industry, and province as instrumental variables, denoted as IV_1 and IV_2. Table 10 reports the results of the instrumental variable regression. Columns (1) and (2) present the results for instrumental variable IV_1, while Columns (3) and (4) show the results for instrumental variable IV_2. The results indicate that in the

first-stage regression, the coefficients of both instrumental variables are significantly positive at the 1% level. In the second-stage regression, the coefficients of *ESG* are significantly positive at the 5% and 1% levels, respectively. Additionally, the instrumental variables pass both the under identification test and the weak instrument test. This confirms that the selection of instrumental variables is valid and appropriate, thereby enhancing the reliability of the baseline regression results.

Table 9
Altering Clustering Method

	(1)	(2)	(3)
	SYN	*SYN*	*SYN*
ESG	0.0220**	0.0220**	0.0220**
	(0.00778)	(0.00701)	(0.00677)
Control Variables	YES	YES	YES
Firm Fixed Effects	YES	YES	YES
Year Fixed Effects	YES	YES	YES
_cons	-3.902***	-3.902***	-3.902***
	(0.341)	(0.363)	(0.570)
N	39458	39458	39458
R-squared	0.513	0.513	0.513
Adjusted R-squared	0.449	0.449	0.449

To further mitigate endogeneity concerns between firms' ESG performance and stock price synchronicity, thereby enhancing the reliability of our conclusions, we adopt the double machine learning (DML) method proposed by Bodory *et al.,* [43] for re-estimation. Compared to traditional causal inference models, DML offers significant advantages in variable selection and model construction, particularly in addressing issues such as the "curse of dimensionality" and multicollinearity.

On one hand, DML combines multiple algorithms and regularization techniques to automatically identify effective factors from high-dimensional control variables, thereby improving estimation accuracy. On the other hand, given that stock price fluctuations are influenced by numerous factors, it is essential to control for other potential confounders when assessing the impact of ESG on synchronicity. DML effectively avoids the "curse of dimensionality" caused by redundant control variables while reducing estimation bias due to omitted variables.

Based on Chernozhukov *et al.,* [44], we construct a partially linear instrumental variable (PLIV) model using DML, with the following specification:

$$Y_{i,t} = \theta_0 Event_{i,t} + g(X_{i,t}) + \varepsilon_{i,t} \tag{9}$$

$$Instrument_{i,t} = m(X_{i,t}) + V_{i,t} \tag{10}$$

Where *i* represents the city and t represents the year; $Y_{i,t}$ represents stock price synchronicity; $Event_{i,t}$ represents the treatment variable, which is the firm's ESG score in this study; ϑ_0 represents the treatment coefficient; $X_{i,t}$ represents the set of high-dimensional control variables; $\boldsymbol{\varepsilon_{i,t}}$ is the random error term, which satisfies the condition of having a mean of zero. In this model, $Instrument_{i,t}$ is the instrument variable for $Event_{i,t}$ where the instrument is the average ESG score of firms in the same industry and province in the same year. ($X_{i,t}$) represents the regression relationship between the estimated variable and the high-dimensional control variables, and machine learning methods are used to determine its specific form. $\hat{m}(X_{i,t})$ (specifically using Lasso regression, Gradient Boosting, and Neural Networks for prediction and solving). The specific method is as follows. First, a machine learning model is used to estimate $m(X_{i,t})$, obtaining the estimate $\hat{m}(X_{i,t})$. Then,

$Instrument_{i,t}$ is used as the instrument for $Event_{i,t}$ to estimate the model. Finally, machine learning algorithms are used again to estimate the function $g(X_{i,t})$ and obtain the unbiased estimate $\hat{g}(X_{i,t})$.

$$\hat{\theta}_0 = \left(\frac{1}{n}\sum_{i\in I,t\in T} Instrument_{i,t}Event_{i,t}\right)^{-1}\frac{1}{n}\sum_{i\in I,t\in T} Instrument_{i,t}(Y_{i,t} - \hat{g}(X_{i,t})) \quad (11)$$

According to column (5) of Table 10, at the 1% significance level, the firms' ESG performance significantly enhances stock price synchronicity. Therefore, after addressing the endogeneity issue using double machine learning, the conclusions of this study remain robust.

Table 10
Endogeneity Tests

	(1) Stage One	(2) Stage Two	(3) Stage One	(4) Stage Two	(5)
	Instrumental Variables Method				Double Machine Learning Model
	ESG	*SYN*	*ESG*	*SYN*	*SYN*
IV_1	0.388***				
	(0.00518)				
ESG		0.0423**		0.0227**	
		(0.0145)		(0.00788)	
IV_2			0.936***		
			(0.00493)		
IV_M					0.395***
					(0.00000772)
Control Variables	YES	YES	YES	YES	YES
Firm Fixed Effects	YES	YES	YES	YES	YES
Year Fixed Effects	YES	YES	YES	YES	YES
_cons	-0.265		-1.638***		
	(0.285)		(0.247)		
N	38529	38529	39458	39458	11676
R-squared	0.568	0.033	0.785	0.034	
Adjusted R-squared	0.516	0.033	0.757	0.033	
Kleibergen-Paaprk LM	1418.33 ***			1612.53 ***	
Cragg-Donald Wald F Stock-Yogo	5607.30>16.38			36093.64>16.38	

5. Further Analysis

Following the rigorous mediating effect testing procedure proposed by Baron and Kenny [45], we empirically examine the mediating and masking effects.

5.1 Mediating Effects

Table 11 reports empirical results testing the mediating effect of information disclosure quality. Column (1) replicates Column (3) of Table 4 (baseline regression results). Column (2) presents the regression results based on Equation (4), showing that the coefficient of *ESG* is 0.0854 and statistically significant at the 1% level. This indicates that firms' ESG performance significantly enhances information disclosure quality. Column (3) displays the regression results based on Equation (5), where the coefficient of *DISC* is 0.0599 and significant at the 1% level, while the coefficient of *ESG* is insignificant. This suggests that improved information disclosure quality significantly promotes stock price synchronicity, confirming the mediating role of information disclosure quality and validating Hypothesis 2.

We use the Bootstrap approach to test the statistical significance of the mediating effect. Table 12 reports the results, showing that the confidence interval for the Bootstrap-mediated effect does not include zero, indicating that the mediating effect is statistically significant.

Table 11
The Mechanism of ESG on Stock Price Synchronicity: The Mediating Role of Information Disclosure

	(1) *SYN*	(2) *DISC*	(3) *SYN*
ESG	0.0220***	0.0854***	0.0117
	(0.00607)	(0.00475)	(0.00702)
DISC			0.0599***
			(0.0110)
Control Variables	YES	YES	YES
Firm Fixed Effects	YES	YES	YES
Year Fixed Effects	YES	YES	YES
_cons	-3.902***	0.752**	-3.770***
	(0.334)	(0.286)	(0.423)
N	39458	28494	28494
R-squared	0.513	0.513	0.529
Adjusted R-squared	0.449	0.436	0.455

Table 12
Mediation Mechanism Test of Information Disclosure: Bootstrap Mediation Test

	Observed Coef.	Bootstrap std. err.	z	P>|z|	Normal-based[95%Conf.Interval]	
ind_eff	0.0177229	0.0015836	11.19	0.000	0.0146191	0.0208267
dir_eff	0.0238325	0.0015836	3.99	0.000	0.0121164	0.0355486

Table 13 reports the regression results testing the mediating effects of analyst coverage and the number of research reports. Columns (1) and (2) present the results for analyst coverage. In Column (1), the coefficient of *ESG* is 0.0703 and statistically significant at the 1% level, indicating that ESG performance increases analyst attention. In Column (2), the coefficient of *ANALYST* is 0.019 and significant at the 5% level, suggesting that increased analyst coverage enhances stock price synchronicity. Additionally, the coefficient of *ESG* is 0.0206, which is smaller than the baseline regression coefficient of 0.022. This implies the presence of a mediating effect through analyst coverage.

Columns (3) and (4) present the results for the number of research reports. In Column (3), the coefficient of *ESG* is 0.0836 and significant at the 1% level, indicating that ESG performance increases research report coverage. In Column (4), the coefficient of *REPORT* is 0.0123 and significant at the 10% level, suggesting that a higher number of research reports enhances stock price synchronicity. Additionally, the coefficient of *ESG* is 0.0209, which is smaller than the baseline regression coefficient of 0.022. This demonstrates the mediating effect of research report coverage.

The increase in analyst coverage and research report coverage reduces information asymmetry between investors and firms, ultimately leading to higher stock price synchronicity. This further confirms that the impact of ESG performance on stock price synchronicity aligns with noise theory. Columns (2) and (4) report the combined effects of ESG capabilities, analyst coverage, and research report coverage on stock price synchronicity. The positive coefficients of *ESG*, analyst coverage, and research report coverage indicate that, for the full sample, analyst coverage and research report coverage support the noise perspective conclusion. This validates Hypothesis 3b.

We use the Bootstrap approach to test the statistical significance of the mediating effects. Tables 14 and 15 report the statistical test results for analyst coverage and research report coverage as mediating variables, respectively. The confidence intervals for the Bootstrap-mediated effects do not include zero, confirming that both mediating effects are statistically significant.

Table 13
The Mechanism of ESG on Stock Price Synchronicity: The Concealment Effect of Analyst Attention

	(1)	(2)	(3)	(4)
	Analyst Attention		Number of Research Reports	
	ANALYST	*SYN*	*REPORT*	*SYN*
ESG	0.0703***	0.0206***	0.0836***	0.0209***
	(0.00591)	(0.00609)	(0.00733)	(0.00609)
ANALYST		0.0190**		
		(0.00725)		
REPORT				0.0123*
				(0.00593)
Control Variables	YES	YES	YES	YES
Firm Fixed Effects	YES	YES	YES	YES
Year Fixed Effects	YES	YES	YES	YES
_cons	-13.09***	-3.653***	-16.38***	-3.700***
	(0.388)	(0.351)	(0.470)	(0.351)
N	39458	39458	39458	39458
R-squared	0.749	0.513	0.749	0.513
Adjusted R-squared	0.716	0.449	0.716	0.449

Table 14
Mediation Mechanism Test of Analyst Attention: Bootstrap Mediation Test

	Observed Coef.	Bootstrap std. err.	z	P>|z|	Normal-based[95%Conf.Interval]	
ind_eff	0.0197168	0.0010294	19.15	0.000	0.0176993	0.0217344
dir_eff	0.0186024	0.0052909	3.52	0.000	0.0082325	0.0289723

Table 15
Mediation Mechanism Test of Research Report Attention: Bootstrap Mediation Test

	Observed Coef.	Bootstrap std. err.	z	P>|z|	Normal-based[95%Conf.Interval]	
ind_eff	0.0187193	0.0010164	18.42	0.000	0.0167273	0.0207114
dir_eff	0.0195999	0.0054045	3.63	0.000	0.0090073	0.0301925

5.2 Masking Effect

Table 16 reports the empirical results testing the masking effect of information asymmetry. Column (1) replicates the regression results of Column (3) in Table 4. Column (2) presents the regression results based on Equation (6), showing that the coefficient of ESG is -0.00841 and statistically significant at the 1% level. This indicates that firms' ESG performance significantly alleviates information asymmetry. Column (3) displays the regression results based on Equation (7), where the coefficient of ASY is 0.104 and significant at the 1% level, while the coefficient of ESG is 0.0228 (greater than 0.022) and also significant at the 1% level. This suggests the presence of a masking effect of information asymmetry, confirming Hypothesis 3a.

Table 16
The Mechanism of ESG on Stock Price Synchronicity: The Masking Effect of Information Asymmetry

	(1)	(2)	(3)
	SYN	*ASY*	*SYN*
ESG	0.0220***	-0.00841***	0.0228***
	(0.00607)	(0.00174)	(0.00607)
ASY			0.104***
			(0.0272)
Control Variables	YES	YES	YES
Firm Fixed Effects	YES	YES	YES
Year Fixed Effects	YES	YES	YES
_cons	-3.902***	6.692***	-4.595***
	(0.334)	(0.130)	(0.372)
N	39458	39458	39458
R-squared	0.513	0.827	0.513
Adjusted R-squared	0.449	0.804	0.449

6. Conclusions

Employing Chinese A - share listed firms spanning from 2009 to 2023 as the research sample, we investigate the influence of ESG performance on stock price synchronicity. The empirical findings suggest that ESG performance improves stock price synchronicity, and this positive effect is more prominent in the subsamples of SOEs, large firms, and firms with relatively high bankruptcy risk. Information disclosure quality and analyst attention act as positive mediating mechanisms through which ESG exerts an impact on synchronicity. In contrast, information asymmetry plays a concealing role in the relationship between firms' ESG performance and stock price synchronicity.

Our research findings are in line with studies such as those by Chan and Hameed [20] and Hu *et al.,* [21], jointly validating the significant positive impact of the ESG performance of listed firms on stock price synchronicity. Nevertheless, there are remarkable disparities in theoretical mechanisms and measurement methods.

These disparities are initially manifested in the deepening of theoretical perspectives. The existing literature predominantly conducts analyses from a single theoretical vantage - point. For example, it solely employs either information efficiency theory or noise theory. In contrast, based on the reality of China's under - developed market, we integrate both information efficiency theory and noise theory within a unified analytical framework. This adjustment of the framework enables a more lucid comprehension of the theoretical basis for how ESG performance promotes stock price synchronicity.

Secondly, in our mechanism analysis, we do not merely test the mediating effects of information disclosure quality and analyst attention. We also investigate the masking effect of information asymmetry. This approach not only facilitates the observation of the intricate mechanism through which ESG affects stock price synchronicity but also enhances the reliability of causal relationship testing. The exploration of the masking effect offers valuable methodological insights for researching pricing efficiency in under - developed capital markets.

Moreover, our conclusions present new evidence and perspectives for both information efficiency theory and noise theory in the context of under - developed markets. Conventionally, price fluctuations in under - developed markets are often mainly explained by noise theory. Our research reveals that the information masking effect derived from information efficiency theory and the irrational effects from noise jointly influence stock price synchronicity. This forms a distinctive influence path: ESG → Noise and Information Efficiency → Stock Price Synchronicity. This discovery not only enriches the connotations of relevant theories in under - developed markets but also

provides new theoretical support and practical guidance for understanding and promoting capital markets in developing countries.

Nevertheless, this study has certain limitations. The most notable one pertains to the construction of the ESG indicator. There are discrepancies in ESG ratings provided by different institutions owing to variations in rating criteria [46]. The Hua Zheng ESG rating system was selected because it comprehensively integrates international ESG core concepts, encompasses all A - share listed firms and some Hong Kong - listed firms, and provides a long - term time series commencing as early as 2009, enabling the observation of a larger sample. To draw more robust conclusions, future research could utilize different ESG rating systems.

Based on these conclusions, we propose the following implications:

Firstly, regulatory authorities ought to enhance supervision, emphasizing the quality rather than the quantity of ESG information. Specifically, regulators should give priority to reviewing the materiality, balance, and forward - looking nature of firms' ESG reports. This guarantees that the ESG reports issued by listed firms are in line with their own operational characteristics, rather than simply mirroring industry or market - level information. Meanwhile, the quality of ESG information disclosure should be incorporated into the annual assessment and rating of listed firms' information disclosure work, and the results should be made public to the market. This measure will contribute to ensuring the quality of information disclosed by listed firms.

Secondly, regulators must promote the integration of ESG principles from mere promotional catchphrases into the core of corporate management and innovate financial instruments to accurately price ESG risks and values. Firms should be guided to deeply integrate ESG development into corporate governance and risk management processes. For example, clarifying the responsibilities of ESG or sustainability committees under the board of directors and linking their supervision performance to executive compensation. Firms should be encouraged to engage third - party institutions for ESG audits and provide assurance reports to investors, thereby enhancing the credibility of the information.

Thirdly, regulatory authorities should guide investors and market intermediaries to improve their capabilities in interpreting and applying ESG information. Analyst attention is a significant channel influencing stock price synchronicity, yet they need to be guided to shift their focus from the existence of ESG information to analyzing the quality of ESG performance. For instance, providing specialized ESG training for analysts and institutional investors to enhance their capabilities in identifying and assessing the transmission mechanisms between ESG risks and firms' financial performance.

Author Contributions

Conceptualization, Y.Y. and Z.L.; methodology, Y.Y.; software, Y.Y.; validation, Y.Y., Z.L. and K.L.; formal analysis, Z.L.; investigation, T.W.; resources, K.L.; data curation, Y.Y.; writing–original draft preparation, Y.Y.; writing–review and editing, Y.Y. and Z.L.; visualization, K.L.; supervision, S.C.; project administration, S.C. and T.W.; funding acquisition, S.C. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

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