Can ESG Disclosure Mitigate Stock Price Bubbles?[1]

——Empirical Evidence from the Chinese Stock Markets

Abstract

ESG (Environmental, Social, and Governance) and other non-financial information reveals the sustainable development capability of a company and also helps investors to make a reasonable valuation of the company. Due to the strong speculative atmosphere and short-selling constraints in the Chinese Stock Markets, the potential for ESG disclosure to mitigate stock price bubbles deserves a comprehensive investigation. This empirical study examines the impact of ESG disclosure on stock price bubbles, employing daily data spanning from 2018 to 2022. Our findings demonstrate that ESG disclosure can mitigate the stock price bubble phenomenon. Furthermore, this mitigating effect is particularly pronounced among companies with high information uncertainty, such as those of smaller size, higher degree of information asymmetry and arbitrage complexities. Our mechanism analysis underscores that ESG disclosure primarily mitigates stock price bubbles by increasing the information content of stock prices (the information channel) and enhancing investor attention (the external monitoring channel). Furthermore, our research reveals a noteworthy correlation: the more exposed a firm is to climate transition risks, the stronger the mitigating effect of ESG disclosure on stock price bubbles. Consequently, it is necessary for companies to fortify their ESG construction and improve the quality of ESG disclosure. And policy makers should pay attention to the regulation of ESG disclosure, so as to increasing the stability of stock prices and fortify the companies' resilience against potential risks.

Keywords: ESG disclosure; Stock price bubbles; Information quality; Investor attention

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As the world's largest emerging capital market, the Chinese Stock Markets have experienced significant growth in recent years. However, it has also grappled with a more pronounced issue of mispricing and stock price bubbles. Specifically, in contrast to developed financial markets where institutional investors dominate trading activities, the Chinese Stock Markets are characterized by a dominance of retail investors who exhibit a greater appetite for risk (e.g., Nartea, Kong, and Wu 2017). The limited accessibility to information, high risk tolerance, and susceptibility to behavioral biases among retail investors (e.g., Berger and Turtle 2015; Pan 2020) have contributed to the prevalence of speculative behaviors and the subsequent occurrence of mispricing within the capital market. Concurrently, although the margin trading and securities lending systems have partially alleviated short-selling restrictions, China still grapples with stringent limitations. Particularly, investor behavioral biases stemming from these constraints tend to exacerbate speculative mispricing. In essence, the overvaluation induced by optimists under the constraint of short-selling on stocks remains uncorrected for extended periods. This not only results in persistent overvaluation of stock prices but also has the potential to generate stock price bubbles (e.g., Scheinkman and Xiong 2003). Consequently, under stronger short-selling restrictions, the mispricing attributed to speculative trading behaviors among retail investors is difficult to be corrected or eliminated in the short term (e.g., Jang and Kang 2019), thereby further exacerbating the prevalence of stock price bubbles. Hence, mitigating the expansion of stock price bubbles and their proliferation is an important research issue in finance.

In recent years, both industry practitioners and academia have advocated for enhanced transparency in information disclosure to reduce investors' behavioral biases and the phenomenon of mispricing, ultimately aimed at mitigating stock price bubbles (e.g., Caglayan et al. 2020; Liu and Liu 2021; Tian et al. 2022). Under the influence of the United Nations' sustainable development concepts and goals, nations worldwide have progressively established ESG disclosure systems. Specifically, with the frequent occurrence of climate-related disasters and the heightened governmental

attention to this issue, the development of ESG disclosure systems has gained momentum in recent years. According to the UN Sustainable Stock Exchange, 55 global exchanges have issued comprehensive guidelines intended to regulate the ESG disclosure practices of listed companies. Against this background, the China Securities Regulatory Commission (CSRC) also supplemented the basic framework of ESG information disclosure in its June 15th, 2018 revised Code of Governance for Listed Companies. China's ESG disclosure system, vital for realizing the strategic objectives of achieving "carbon peaking" by 2030 and "carbon neutrality" by 2060, has experienced rapid growth propelled by the combined efforts of the Chinese government and the market. According to the China Capital Research Institute and the 2021 China ESG Development White Paper, the number of companies in China's capital market issuing ESG-related reports has surged from 371 in 2009 to 1,121 in 2021. In the year 2020 alone, over 80% of companies listed in China's CSI 300 index had published ESG reports, and 27% of companies across the entire A-share market had similarly disclosed their ESG practices. This shows that ESG is becoming an important indicator of corporate sustainability and long-term value, with its disclosure increasingly impacting the dynamics of the capital market.

With the gradual improvement of the institutional framework, ESG disclosure has exerted a significant impact on the capital market. Specifically, companies that exhibit high-quality ESG disclosure practices tend to be less inclined to conceal adverse information, and their operational resilience remains comparatively robust even in times of crisis. Numerous studies have shown that, particularly during periods of low corporate trust such as crises, ESG-oriented firms consistently demonstrate superior operational performance and returns when relative to their counterparts, further highlighting the pivotal role of ESG disclosure (e.g., Lins, Servaes, and Tamayo 2017). Murata and Hamori (2021) have discerned a significant inverse relationship between ESG disclosure and crash risk. Beyond its impact on operational aspects and risk profiles of firms, ESG disclosure has evolved into an important factor affecting asset pricing. Some scholars have delved into the phenomenon of the ESG

premium, primarily from the perspective of investor behavioral biases (e.g., Briere and Ramelli 2021; Pastor, Stambaugh, and Taylor 2022b; Avramov et al. 2022). Pastor, Stambaugh, and Taylor (2022a), for instance, explicitly incorporate investor preferences for green and brown assets into utility functions and integrate ESG factors into the CAPM model, revealing that ESG ratings have weakly predictive power in predicting asset returns. Cao, Titman, and Zhan (2019) have identified a correlation between ESG performance and stock mispricing through an analysis of data from U.S. firms. In sum, there is a significant correlation between ESG disclosure and stock prices. Nevertheless, despite serving as a vital extension of asset pricing, few scholars have focused on the linkage between ESG disclosure and stock price bubbles.

Asset price bubbles occur when asset prices surpass their intrinsic value (e.g., Stiglitz 1990; Xiong and Yu 2011). Severe price bubbles not only impede a country's economic progress but also trigger a global financial crisis or worldwide recession, exacerbating existing inequality problems. Therefore, studying the relationship between ESG disclosure and stock price bubbles and the mechanism of its impact is crucial to mitigate extreme market volatility and protect the interests of investors. ESG disclosure plays an important role by supplying supplementary information, bridging the information asymmetry between corporations and investors, thereby preventing inflated stock prices and bubbles. Nevertheless, it is essential to acknowledge that ESG disclosure might sometimes deviate from actual practices, particularly when management views it as a mechanism to mask mismanagement and divert investor attention. Furthermore, external investors may be overly optimistic about the valuations of the company. Thus, it becomes imperative to explore the relationship between ESG disclosure and stock price bubbles in depth. This exploration should encompass diverse corporate characteristics, delineate the specific impact mechanisms, and ascertain whether the influence of ESG disclosure on stock price bubbles changes when faced with different climate-related risks magnitudes. A comprehensive inquiry into these issues can effectively improve the information environment of the capital market, enhance investors' comprehension of corporate

management, and stabilize corporate stock prices.

Based on the information asymmetry theory and stakeholder theory, this study focuses on a comprehensive analysis of the impact and underlying mechanisms of ESG disclosure on stock price bubbles. Subsequently, we empirically investigate the association between ESG disclosure and stock price bubbles. To achieve this, we measure stock price bubbles by using the GSADF method and ESG score data sourced from Wind database of A-share listed companies. Furthermore, this research delves into the specific mechanisms between ESG disclosure and stock price bubbles from dimensions such as the information content of stock price and the level of investor attention. Heterogeneity analysis shows that firm size, information asymmetry, and arbitrage feasibility all affect the relationship between ESG disclosure and stock price bubbles. Lastly, our study further examines the impact of climate risk exposure.

This paper makes several marginal contributions. Firstly, it investigates the influence of ESG disclosure on stock price bubbles, drawing from information asymmetry theory and stakeholder theory. This study significantly augments the body of literature concerning the economic consequences of ESG disclosure, while simultaneously addressing a gap in research on the relationship between ESG disclosure and stock price bubbles. Prior research predominantly focus on the impact of ESG disclosure on financial performance, capital costs, and the collapses risk of stock price (e.g., Martínez-Ferrero, Ruiz-Cano, and Garcia-Sanchez 2016). A limited number of scholars have explored the link between ESG performance and mispricing. However, few studies have extended their perspective to stock price bubble phenomenon, which may have a broader impact. Therefore, this paper delves into the impact of ESG disclosure on stock price bubbles, according to daily data sourced from the Wind database. This endeavor is of great significance for comprehending the influence of ESG disclosure on the capital market. Secondly, it introduces innovative tests that assess the influence of emerging ESG risks on the association between stock price bubbles and ESG disclosure. To achieve this, a firm-level climate risk indicator

is constructed. Existing literature primarily focuses on micro and macro factors like information asymmetry (e.g., Allen and Gorton 1993), noise trading (e.g., Tan, Jin, and Wu 2015), overconfidence (e.g., Michailova and Schmidt 2016), inflation (e.g., Casella 1989) and bank credit (e.g., Allen and Gale 2000) to examine the determinants of bubbles, and limited attention paid to emergent ESG risks such as climate change, environmental pollution, and transition risks (e.g., Busch, Bauer, and Orlitzky 2016). Consequently, the research within this paper contributes significantly to this particular facet of the literature.

The remainder of this paper is organized as follows. Section 2 provides a comprehensive review of relevant theories and outlines the research hypotheses. In Section 3, we present the data employed in our study and detail the regression model. Section 4 analyzes the impact of ESG disclosure on stock price bubbles, complemented by a series of robustness tests. Section 5 conducts heterogeneity analysis based on various firm characteristics. Section 6 delves into the specific mechanisms. In Section 7, we broaden our perspective to consider external risks in our further analysis. Finally, Section 8 provides a summary of the article's key findings and contributions.

I. Theoretical Analysis and Research Hypotheses

A. *ESG Disclosure and Stock Price Bubbles*

In traditional valuation theory, investors measure the intrinsic value of a stock by estimating its future cash flows and discount rate based on the company's public information and historical data (e.g., Gordon 1959). Similarly, the residual income model identifies firm-specific information as a key determinant of stock prices (e.g., Feltham and Ohlson 1995). In an efficient market, a firm's stock price should adequately reflect all fundamental information (e.g., FAMA 1965). In particular, the disagreement theory states that differences in investor perspectives on firm fundamentals can lead to mispricing. Importantly, greater disagreement among investors can heighten the likelihood of overvaluation, especially in the presence of

short-selling constraints (e.g., Miller 1977). Listed companies can bridge this gap by disseminating value-related information to the stock market, thereby enhancing investor perceptions and reducing disparities. This, in turn, reduces the phenomenon of stock prices deviating from their fundamental values (e.g., Berkman, Dimitrov, and Jain 2009). However, within China's capital market, characterized by a large number of retail investor and an imperfect disclosure system, information asymmetry among investors is more pronounced (e.g., Hou, Xue, and Zhang 2020). Information asymmetry may create a "lemon market", i.e., where investors, disadvantaged by a lack of information, struggle to form rational expectations about companies. Consequently, well-performing firms may find themselves undervalued, while the average market valuation is higher than that of poor-quality firms, potentially giving rise to a price bubble (e.g., Healy and Palepu 2001). It is evident that an inadequate information disclosure system plays an important role in generating stock price bubbles.

ESG disclosure plays a key role in enhancing the information disclosure system of the capital market. It serves to not only provide stakeholders with a comprehensive understanding of a company's environmental, social, and governance aspects, thereby improving the overall quality of corporate information, but also provides external investors with supplementary information related to investment decisions. This assists them in conducting more thorough assessments of a company's overall value and enhances the accuracy of cash flow forecasting (e.g., Clarkson et al. 2019). Consequently, in line with the information asymmetry theory, we propose the hypothesis that robust ESG disclosure can diminish information asymmetry within a company, improve the company's reputation, enhance investors' risk tolerance, and consequently mitigate the phenomenon of stock price bubbles.

Nevertheless, companies must allocate substantial resources to make ESG investments, prompting questions about whether ESG disclosure may adversely affect firms' economic interests. According to stakeholder theory, firms can enhance sustainability by recognizing and focusing the needs of their stakeholders (e.g.,

Mitchell, Agle, and Wood 1997). Specifically, when companies actively assume responsibility for environmental and social aspects, they send positive signals to stakeholders, improve their reputation, and facilitate external collaborations (e.g., Lo and Kwan 2017). In particular, with the growing attention of investors to climate-related matters, disclosing environmental information enables companies to obtain technical and service support from external entities. Simultaneously, the disclosure of social responsibility information helps companies establish a favorable public image, thereby improving their corporate reputation. Consequently, this translates to reduced stock price volatility in response to negative news or market turbulence (e.g., Godfrey 2005). Furthermore, sound corporate governance can alleviate information asymmetry between individual investors and companies, diminish management's surplus management, help investors form rational valuation expectations, and mitigate stock price bubbles resulting from mispricing.

Numerous studies have consistently highlighted issues plaguing Chinese listed companies, including issues like low information transparency and irregularities in information disclosure (e.g., Jin and Myers 2006; Gao Lei and Song Shunming 2007). These challenges have contributed to the persistence of long-term bubbles within the capital market. Consequently, ESG disclosure assumes a pivotal role in enhancing external investors' comprehension of a company's non-financial information, such as environmental, social, and governance aspects. On the one hand, this heightened transparency strengthens the external supervision of management. On the other hand, it mitigates information asymmetry among investors, reducing their information disadvantage and enabling them to make reasonable investment decisions. This, in turn, facilitates the return of stock prices to their intrinsic value, avoiding stock price exaggeration or bubbles. In particular, ESG disclosure furnishes shareholders with highly sensitive information, including details about litigation risks and potential social and environmental liabilities (e.g., Hong and Kostovetsky 2012). This helps investors to conduct comprehensive assessments of a company's value and risks, thereby avoiding issues like overvaluation and bubbles. Thus, we propose the

following hypothesis:

H1: ESG disclosure can mitigate stock price bubble phenomenon.

B. *ESG Disclosure, Information Quality and Stock Price Bubbles*

The degree of information content in stock prices directly correlates with the level of information heterogeneity related to the company, consequently influencing the likelihood of stock price bubbles and crashes (e.g., Hutton, Marcus, and Tehranian 2009). Stock prices typically contain both market-level and firm-specific information. The extent to which a firm's stock price incorporates firm-specific information can be quantified through stock price synchronization (e.g., Roll 1988). When a substantial portion of an individual stock's movement can be attributed to firm-specific information, stock price synchronization diminishes, and the information content of stock price rises. In cases where stock price information content is elevated, firm-specific information exerts a more profound impact on stock price fluctuations. Given that price movements mirror the market's assessment of a company's intrinsic value, managers tend to be cautious in their decision-making processes (e.g., Durnev, Morck, and Yeung 2004; Chen, Goldstein, and Jiang 2007). This, in turn, mitigates large fluctuations in a firm's stock price resulting from hasty investments. From the perspective of investors, heightened information content augments the credibility of a company's disclosed information, consequently influencing investor trading behavior (e.g., Albitar, Abdoush, and Hussainey 2022). With stock prices reflecting a more comprehensive set of fundamental information, investors can make more accurate investment decisions, thereby reducing the phenomena of mispricing, overvaluation, and stock price bubbles.

High stock price synchronization primarily arises from two main factors: low corporate information transparency and the elevated costs associated with information acquisition for investors. On the one hand, companies frequently withhold unfavorable news to conceal their self-serving behavior. On the other hand, investors may engage in adverse selection and tend to view each firm as mirroring the market average in an environment characterized by information asymmetry. This, in turn,

dilutes the impact of idiosyncratic information on stock prices (e.g., Atawnah, Balachandran, and Duong 2018). While some studies have demonstrated that an increase in institutional investors' shareholdings can accelerate the integration of new information into stock prices, thereby enhancing the pricing efficiency and information content of stock market (e.g., An and Zhang 2013). China's capital market features a significant retail investor presence, which often has limited information-gathering capabilities. Additionally, certain institutional investors may disregard their own private information and instead follow trading trends (e.g., DeVault, Sias, and Starks 2019), contributing to the overall reduced information content of stock price. Effectively addressing the challenge of enhancing the information content of stock prices is paramount in mitigating stock price bubbles.

ESG disclosure introduces fresh approaches to tackle this issue. Specifically, companies committed to socially responsible behavior view increased disclosure as an ethical obligation and consequently provide more comprehensive corporate information. Simultaneously, these companies proactively share additional information to meet the demands of their stakeholders. Socially responsible companies tend to furnish investors with enhanced transparency and more reliable financial information while reducing behaviors associated with surplus management. In essence, ethical considerations often motivate companies to disclose higher-quality financial reports (e.g., Kim, Park, and Wier 2012). This shows how ESG disclosure helps investors to gain a deeper understanding of a company's real financial, operational, as well as the sustainable development status. Numerous studies have shown that ESG disclosure can mitigate the issue of information asymmetry between firms and external investors (e.g., Yu, Guo, and Luu 2018). One plausible explanation lies in the information transmission theory. Companies that actively disclose ESG information send a signal to governmental agencies, investors, and other stakeholders, highlighting their dedication to environmental protection and sustainable development. Moreover, as ESG investments entail costs, companies also signal their strong operational status to investors by disclosing ESG information and

enhancing the quality of their financial reports. It becomes evident that ESG disclosure not only portrays a company's responsible image to investors but also implies its excellent operational capabilities while conveying additional valuable traits. Therefore, ESG disclosure can enhance the information content of stock price.

As previously mentioned, with the development of the concept of sustainability, companies that disclose ESG information are more likely to obtain a favorable reputation, attract increased attention from analysts, and concurrently enhance trust among employees and information transparency, thus reducing managerial surplus. Increased information content facilitates investors in making informed investment decisions, avoiding "follow the herd" and "herd" behavior. Moreover, because the stock price more accurately reflects real operational information, the likelihood of stock price bubbles diminishes. Conversely, companies with low ESG disclosure may pose challenges for investors in objectively assessing both the financial and non-financial performance of the firm, thereby increasing the likelihood of stock price bubbles. Thus, it is evident that ESG disclosure exerts an influence on investors' investment intentions and behaviors, even when investors prioritize the financial performance of firms. Therefore, we propose the following hypothesis:

H2: ESG disclosure can improve the information content of stock prices, thereby mitigating the stock price bubble phenomenon.

C. *ESG Disclosure, Investor Attention and Stock Price Bubbles*

Investor attention plays a key role in yielding positive returns for investors, improving stock market stability, and mitigating the impact of heterogeneous beliefs on stock market volatility (e.g., Engelberg and Parsons 2011). It also accelerates the integration of information into stock prices, diminishing the occurrence of stock price bubbles. According to the attention theory, attention shocks stimulate individual investors to engage in stock purchases. When a stock receives increased attention from investors, its demand and liquidity experience rapid short-term growth, consequently driving its stock price upwards (e.g., Baber and Odean 2008). In particular, investor attention can exclude the interference of external information and

improve the efficiency of information transmission between firms and investors. This, in turn, reduces information asymmetry between firms and individual investors, facilitating more accurate stock price valuations and diminishing the likelihood of stock price bubbles (e.g., Martellini and Menzio 2018). Conversely, the fragmentation of investor attention may lead to diminished external monitoring pressure on firms and heightened incentives for managers to conceal bad news (e.g., Ni et al. 2020). Thus heightens the likelihood of information asymmetry and stock price bubbles.

ESG disclosure provides a new way to address the issue of stock price bubbles, especially for companies with limited investor attention. Companies that engage in more extensive ESG disclosure typically exhibit greater social responsibility and serve as models in terms of both external environmental protection and internal corporate governance. Consequently, these companies tend to attract increased media exposure. According to the "investor perception effect", media coverage can improve the level of investor attention and mitigate the risk of information asymmetry (e.g., Dang, Huynh, and Nguyen 2020). In particular, ESG disclosure incorporates favorable information about individual companies into their stock prices, thereby capturing the attention of a broader investor base (e.g., Liu et al. 2022). This, in turn, diminishes the prevalence of heterogeneous beliefs concerning the future expectations of a stock stemming from information gaps (e.g., Yuan et al. 2022).

Furthermore, in the context of growing climate concerns and the pursuit of carbon neutrality, ESG disclosure has gradually become a hot issue in the capital market. Given the "salient feature" of the Chinese Stock Markets, information with a high level of attention can captivate investors (e.g., Kliger and Kudryavtsev 2008). Consequently, companies can take advantage of the irrationality and randomness characterizing individual investors' trading behaviors to speculate on hot stocks (e.g., Baker and Wurgler 2006; Bali, Cakici, and Whitelaw 2011). On the other hand, although institutional investors tend to exhibit more professionalism and rationality in their investment decisions compared to individual investors, they still favor information associated with market hotspots. This inclination arises from their

eagerness to invest in cutting-edge and innovative areas (e.g., Hendershott, Livdan, and Schurhoff 2015). Therefore, ESG disclosure can attract a diverse range of investors and increase their interest in the company.

Based on the analysis above, it is evident that ESG disclosure serves a dual purpose. On one hand, it enhances a company's reputation and increase investor attention through media coverage and other channels. On the other hand, in the context of sustainable development, ESG disclosure, being a hot topic, simultaneously attracts the attention of both individual and institutional investors, stimulating demand for stocks. Furthermore, it establishes an effective external monitoring mechanism, thereby reducing information asymmetry and alleviating the stock price bubble phenomenon. In particular, existing research predominantly focuses on the impact of environmental information disclosure, Internet information disclosure, etc. on investor attention. There is relatively less exploration into the attractiveness of comprehensive corporate disclosure encompassing environmental, social, and governance aspects to investors. Therefore, this paper concentrates on examining the impact of investor attention on the relationship between ESG disclosure and stock price bubbles. Based on the above analysis, we propose the following hypotheses:

H3: ESG disclosure increases the level of investor attention, thus mitigating the stock price bubble phenomenon.

II. Description of Data and Variables

A. *Data Source*

As ESG score data from Wind database became available after 2018, this study utilize daily data from A-share listed companies for the period spanning 2018 to 2022 to analyze the impact of ESG disclosure on stock price bubbles. The specific sample treatment process is as follows:(1) exclude ST, ST*, ST**, and listed companies in the financial industry; (2) exclude samples with a high number of missing data for variables; (3) to mitigate the impact of outliers on the results, continuous variables are shrink-tailed at the 1% and 99% deciles. And ultimately we derive a comprehensive

dataset comprising 17010046 sample observations for 2719 listed companies. The ESG score data have been sourced from the Wind database, while all other data used in this study are from the CSMAR database.

B. *Definition of Key Variables*

Stock Price Bubbles.—This study adopts the methodology outlined by Casella (1989) and Wei, Li, and Wang (2022) to estimate stock price bubbles. Initially, the GSADF method and BSADF test are applied to examine the daily mean stock price data of the A-share market. This analysis aims to ascertain the presence of a stock price bubble and determine the specific interval during which the bubble emerges. The specific steps are as follows:

(1) $$y_t = dT^{-\eta} + \theta y_{t-1} + \varepsilon_t, \varepsilon_t \sim N(0, \sigma^2)$$

(2) $$\Delta y_t = \alpha_{r1,r2} + \beta_{r1,r2} y_{t-1} + \sum_{i=1}^{k} \Psi_{r1,r2}^{i} \Delta y_{t-i} + \varepsilon_t, \varepsilon_t \sim (0, \sigma_{r1,r2}^2)$$

(3) $$\mathrm{SADF} = \sup \mathrm{ADF}_{0}^{\mathrm{r}_2}, \mathrm{r}_2 \in [\mathrm{r}_0, 1], \mathrm{r}_0 \in [0,1]$$

(4) $$\mathrm{GSADF} = \sup \mathrm{ADF}_{\mathrm{r}_1}^{\mathrm{r}_2}, \mathrm{r}_2 \in [\mathrm{r}_0, 1], \mathrm{r}_1 \in [0, \mathrm{r}_2 - \mathrm{r}_1], \mathrm{r}_0 = 0.01 + 1.8/\sqrt{\mathrm{T}}$$

Here, y_t is the price of asset, d is a constant, k is the hysteresis order, T is the size of sample, $\eta > 1/2$, ε_t is the random error. $\mathrm{ADF}_{\mathrm{r}_1}^{\mathrm{r}_2}$ is the ADF test value. SADF is the upper value of ADF. r_0 is the effective minimum smallest value of sub-sample window. r_1 is the starting point. $\mathrm{r}_2 = \mathrm{r}_0$ indicates that the number of samples in the optimal subsample window is equal to the number of samples in the subsample window that estimate a valid minimum value.

The GSADF and BSADF tests begin with the null hypothesis that the price series is smooth, while the alternative hypothesis posits the existence of bubble characteristics within the original series. Notably, the GSADF test differs from the SADF method in that it is not constrained to return a value of zero at the onset r_1 of the recursive test. Its value range spans from 0 to $r_2 - r_0$. The GSADF statistic is defined as the maximum value of right-tailed unit root test across all feasible ranges. It's worth noting that the SADF test is a specialized case of the GSADF test, and the

latter offers greater accuracy when assessing the presence of bubbles across the entire dataset. In contrast, the BSADF test is specifically designed to test bubble existence within a subset of the dataset.

Next, the value of stock price bubbles is estimated using the following method based on the calculated BSADF statistic: if the BSADF statistic exceeds the CV critical value, it signifies the existence of a bubble on that specific day and is denoted as 1. Once the bubble persists for a certain number of days, if the BSADF statistic falls below the CV critical value, it is regarded as a burst and is recorded as 0. If the marking sequence consistently exhibits consecutive values of 1, the value of bubble on day t is determined as the average stock price on day t minus the average stock price on day t-1.

ESG Disclosure.—In assessing ESG disclosure, this paper utilizes the ESG score data from Wind database as an indicator. Wind database has been evaluating the ESG performance of A-share listed companies since 2018 and expanded its coverage to encompass all A-share listed companies in 2022. The comprehensive score is derived by combining the scores for management practices and controversial events using a 7:3 weighting ratio, and the scores ranging from 0 to 10. The management practice component includes three dimensions: environmental, social, and governance. Specifically, the ESG score data from the Wind Database are based on daily frequency, allowing for a more accurate and rapid reflection of the impact of new information, in comparison to the quarterly data provided by CSI ESG Ratings and SynTao Green Finance ESG Ratings.

Model Setting.—To examine the relationship between ESG disclosure and stock price bubbles, this paper formulates the following model:

$$\text{Bubble}_{i,t} = \beta_0 + \beta_1 \text{ESG}_{i,t} + \beta_2 \text{Controls}_{i,t} + \epsilon_{i,t} \quad (5)$$

Here, $\text{Bubble}_{i,t}$ represents the stock price bubble of stock i on day t, $\text{ESG}_{i,t}$ is the ESG score of stock i on day t, and $\text{Controls}_{i,t}$ accounts for a series of control

TABLE 1—SUMMARY STATISTICS

Variable	Observations	Mean	Standard deviation	Min	Max
Panel A					
Bubbles	1,701,046	0.0030	0.0535	-0.0313	3.6265
ESG score	1,701,046	5.9619	0.8328	1.7800	9.8400
SPI	1,701,046	0.6079	1.3656	-36.0437	11.7745
Illiquidity ratio	1,701,046	0.0362	0.1578	0.0000	97.1361
Comment	1,701,046	60.4041	182.8278	0.0000	21729.0000
IVOL	1,701,046	0.0100	2.1632	0.0000	1735.0600
Volatility	1,701,046	0.0031	0.0028	0.0000	0.0545
Log(size)	1,701,046	3.1436	0.0521	3.0198	3.3534
Book-to-market ratio	1,701,046	-0.5160	0.5099	-3.5344	0.5018
Turnover	1,701,046	0.1598	1.0315	-6.0933	4.2812
Price-earning ratio	1,701,046	3.4780	789.0207	0.3018	90578.2700
Return of equity	1,701,046	0.0653	0.1021	-0.1412	11.0410
Log(age)	1,701,046	2.4748	0.6028	0.0000	3.4965
Bubble(Absolute)	1,701,046	-0.1133	0.8452	-25.1582	19.5675
Bubble(Relative)	1,701,046	-0.0492	0.6245	-21.9493	76.0492
Transrisk	1,701,046	150.5452	179.0642	0.0000	2399.0000
Panel B					
	Test Statistic	Critical values			
		90%	95%	99%	
GSADF	2.52**	2.10	2.37	2.91	

Notes: Panel A reports the summary statistics of related variables. Panel B reports the test statistic and critical values of GSADF test. The sample period ranges from January 1st, 2018 to December 31th, 2022, with a total sample size of 1701046, and includes the 2719 common stocks in the Chinese A-share Markets.

variables influencing the stock price bubbles. Following the existing literature, this study includes company size, years of listing (Age), book-to-market ratio, price-earnings ratio, return on equity, volatility of weekly returns, and turnover rate as control variables. Specifically, company size and years of listing are both subjected to logarithmic transformations. Regarding the research methodology, this paper adopts the approach outlined by Fama and French (1993). This involves calculating the mean series of the variables for all stocks throughout the sample period and subsequently conducting time series regression analysis using the least squares method or other methods.

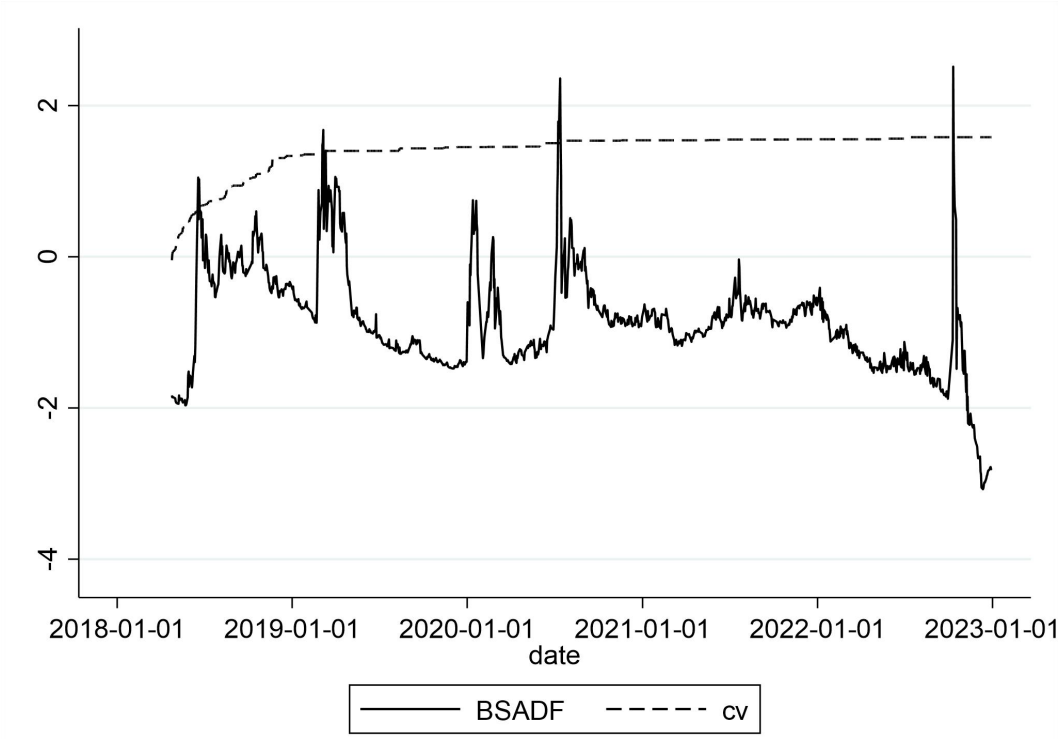

FIGURE 1. STOCK PRICE BUBBLES TEST

Notes: Figure shows the results of GSADF test compute by RStudio. The solid line is the BSADF statistic and the dashed line refers to the critical value of 5% significance level. When the BSADF statistic exceeds the critical value, it implies the existence of stock price bubbles. The sample period ranges from January 1st, 2018 to December 31th, 2022, with a total sample size of 1701046, and includes the 2719 common stocks in the Chinese A-share Markets.

Descriptive Statistics.—Panel A of Table 1 presents the descriptive statistics of the primary variables employed in this paper. As observed in Table 1, the mean value of stock price bubbles is 0.0030, indicating that bubbles occur relatively infrequently in the time series. This is also verified in Figure 1, which shows that the BSADF statistic exceeds critical value infrequently. Despite the low frequency of stock price bubbles, Panel B of Table 1 shows that the GSADF statistic is significant at the 5% level. Thus it is still necessary to pay attention to the occurrence of stock price bubbles. Additionally, the mean value of the ESG score is 5.9619, suggesting that the ESG performance of A-share listed companies falls within the mid-range.

TABLE 2—BASELINE REGRESSION

	Bubble	Bubble(Dummy)
	(1)	(2)
ESG score	-0.0662**	-4.709***
	(0.0277)	(1.405)
Book-to-market ratio	0.131	-0.947
	(0.0818)	(4.299)
Turnover rate	0.0153	2.284***
	(0.0127)	(0.767)
Price-earning ratio	0.000137	0.00507
	(0.0002)	(0.0082)
Return of equity	0.320	13.59**
	(0.208)	(5.489)
Log(size)	1.499	65.04
	(1.358)	(44.89)
Volatility	-5.849	-862.4**
	(11.87)	(436.9)
Log(age)	0.0574	1.126
	(0.0574)	(0.880)
Constant	-4.405	-182.2
	(4.112)	(137.8)
Observations	1,215	1,215
R-squared	0.013	-

Notes: This table reports the baseline regression. The standard error of the regression coefficients are reported in parentheses. On day t, the mean values of variables of A share stocks in the Chinese Stock Markets are calculated. Column 1's dependent variable is the value of stock price bubbles and regress using least square method. Column 2's dependent variable is a binary variable and regress using probit model. If there is a bubble on day t, then the value of stock price bubble equals 1, else the value is 0. Both of column 1 and 2 control for the company's book-to-market ratio, turnover rate, price-earning ratio, return of equity, size, volatility, and age. The sample period ranges from January 1st, 2018 to December 31th, 2022, with a total sample size of 1701046, and includes the 2719 common stocks in the Chinese A-share Markets. Here, ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively.

III. Benchmark regression results and robustness tests

A. *Baseline regression results*

Table 2 reports the results of the baseline regression examining the impact of ESG disclosure on stock price bubbles. In column 1, the explanatory variable is the magnitude of stock price bubbles, assessed through OLS regression. The regression coefficient for ESG score on stock price bubbles is -0.0662, and is significant at the

5% level. In column 2, the explanatory variable is a binary indicator for the presence of stock price bubbles, estimated using the probit model. The regression coefficient is -4.709, also implying statistical significance at the 1% level. These regression results affirm the validity of hypothesis 1, indicating that an increase in the level of ESG disclosure can mitigate the stock price bubble phenomenon.

B. *Robustness test*

Instrumental Variable Method.—To address potential endogeneity issues, such as reverse causation, this section attempts to construct instrumental variables. Previous studies have often employed the ESG mean values of listed companies in the same industry or region as instrumental variables (e.g., Breuer et al 2018). However, to a certain extent, this method may not satisfy the exclusion requirement (e.g., Gormley and Matas 2014). Specifically, stock price bubbles tend to exhibit a high degree of industry heterogeneity. For instance, industries like high-tech are more susceptible to inflated prices. On the one hand, ESG mean values of industry can impact firms' ESG disclosure, on the other hand, there may also be other industry-related confounding influences.

Hence, according to existing literature, we use ESG fund shareholding as an instrumental variable for ESG disclosure. In terms of relevance, ESG funds, being institutional investors, possess the ability to influence a company's operations through their "voting with their feet" approach (e.g., He, Huang, and Zhao 2019) and can transfer their investment philosophy to management, consequently affecting the ESG disclosure practices of firms (e.g., Dimson, Karakas, and Li 2015). Concerning exclusivity, it is improbable that information regarding ESG fund holdings directly impacts firms' stock price bubbles. One plausible explanation is that the establishment and size of ESG funds are determined by fund companies, and changes in their holdings are decided by fund managers, factors that do not exhibit a direct correlation with firms. Therefore, we employ ESG funds data in the Wind database as exogenous events, utilizing both the number of ESG funds holding the firm and the market value of their holdings as instrumental variables for ESG disclosure.

TABLE 3—REGRESSION OF INSTRUMENTAL VARIABLES

	ESG score	Bubble	ESG score	Bubble
	(1)	(2)	(3)	(4)
Number of ESG funds holding the firm	2.482***			
	(0.0943)			
Fit value of number of funds holding the firm		-0.140***		
		(0.0448)		
Log(market value of holdings)			0.660***	
			(0.0249)	
Fit value of market value of holdings				-0.140***
				(0.0446)
Book-to-market ratio	1.083***	0.0917	1.159***	0.0917
	(0.0743)	(0.0710)	(0.0757)	(0.0710)
Turnover rate	0.00385	0.0189	0.00993	0.0189
	(0.0107)	(0.0127)	(0.0107)	(0.0127)
Price-earning ratio	1.56e-05	-3.29e-06	4.30e-06	-3.29e-06
	(1.36e-05)	(1.61e-05)	(1.36e-05)	(1.61e-05)
Return of equity	2.986***	0.348**	3.077***	0.349**
	(0.115)	(0.150)	(0.116)	(0.149)
Log(size)	31.04***	2.953*	33.13***	2.955*
	(1.109)	(1.517)	(1.136)	(1.514)
Volatility	-68.82***	-20.28	-73.95***	-20.31
	(10.04)	(13.58)	(9.916)	(13.55)
Log(age)	-0.197***	0.0984	-0.231***	0.0985*
	(0.0547)	(0.0599)	(0.0552)	(0.0598)
Constant	-91.15***	-8.607*	-97.65***	-8.614*
	(3.371)	(4.546)	(3.455)	(4.539)
Observations	1,215	1,215	1,215	1,215
R-squared	0.815	0.016	0.816	0.017

Notes: This table reports the regression of instrumental variables. The standard error of the regression coefficients are reported in parentheses. Column 1 and 2 are the results of the first stage and second stage when the instrumental variable is the number of ESG funds holding the firm. Column 3 and 4 are the results of the first stage and second stage when the instrumental variable is the market value of holdings. On day t, the mean values of variables of A share stocks in the Chinese Stock Markets are calculated and regress using least square method. Column 1-4 control for the company's book to market ratio, turnover rate, earning of per share, return of equity, size, volatility, and age. The sample period ranges from January 1st, 2018 to December 31th, 2022, with a total sample size of 1701046, and includes the 2719 common stocks in the Chinese A-share Markets. Here, ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively.

Table 3 presents the results of the instrumental variables. Columns 1 and 3 show the outcomes of the first-stage regressions, where the regression coefficients for ESG are 0.156 and 0.601, respectively. These coefficients are significant at the 1% level, confirming the correlation of the instrumental variables. Columns 2 and 4 show the results of the second-stage regression. The coefficients of the fitted values are -0.425 and -0.110, respectively, and are significant at the 1% level. Importantly, the sign of these coefficients aligns with the results of the baseline regression, underscoring the robustness of the study's findings. Additionally, the Cragg-Donald Wald F-statistic and Sargan statistic indicate the absence of weak instrumental variables and over-identification issues. Thus, it is evident that ESG disclosure can mitigate the stock price bubble phenomenon.

Alternative Stock Price Bubbles Indicator.—In the baseline regression, this paper employs the GSADF methods and BSADF statistic to measure stock price bubbles. However, since the value of stock price bubbles remain at zero for extended periods, this may introduce some bias into the estimation results. To address this, the section refers to Cheng et al's (2021) methodology. And utilizes Tobin's Q-value-based calculations of the absolute stock price bubbles ($Abs\_bubbles_{i,t}$) and relative stock price bubbles ($Rela\_bubbles_{i,t}$) indicators as the explanatory variables for the test. The specific calculations are as follows:

$$q_{i,t} = \beta_0 + \beta_1 MNI_{i,t} + \beta_2 TOA_{i,t} + \beta_3 LEV_{i,t} + \beta_4 GR_{i,t} + \mu_{i,t} \tag{6}$$

$$q_{i,t}^{f} = \hat{q}_{i,t} \tag{7}$$

$$Abs\_bubbles_{i,t} = q_{i,t} - \hat{q}_{i,t} \tag{8}$$

$$Rela\_bubbles_{i,t} = (q_{i,t} - \hat{q}_{i,t})/q_{i,t}^{f} \tag{9}$$

Here, $q_{i,t}$ is the Tobin-Q of company i on day t, $MNI_{i,t}$ is the net profit margin on sales, $TOA_{i,t}$ is the total asset turnover rate, $LEV_{i,t}$ is the asset-liability ratio, $GR_{i,t}$ is the growth rate of operating revenue, $q_{i,t}^{f}$ is the Tobin-Q value fitted

TABLE 4—ALTERNATIVE INDICATORS OF BUBBLES AND ESG DISCLOSURE

	Bubble(Absolute)	Bubble(Relative)	Bubble
	(1)	(2)	(3)
ESG score	-0.118***	-0.0950***	
	(0.0144)	(0.00511)	
ESG rating of CSI			-0.00377***
			(0.00137)
Book-to-market ratio	-1.358***	-0.462***	-0.0471
	(0.0425)	(0.0151)	(0.101)
Turnover rate	-0.00554	0.0159***	0.0149
	(0.00660)	(0.00234)	(0.0127)
Price-earning ratio	0.000452***	0.000235***	-9.55e-05
	(0.000108)	(3.84e-05)	(0.000209)
Return of equity	0.802***	0.407***	-0.0127
	(0.108)	(0.0383)	(0.194)
Log(size)	17.11***	8.905***	-0.705
	(0.705)	(0.250)	(1.259)
Volatility	-17.10***	-16.67***	5.061
	(6.165)	(2.186)	(10.40)
Log(age)	-0.366***	-0.143***	0.0996
	(0.0298)	(0.0106)	(0.0631)
Constant	-53.02***	-27.36***	1.975
	(2.136)	(0.757)	(3.825)
Observations	1,215	1,215	1,215
R-squared	0.854	0.898	0.014

Notes: This table reports the regression using alternative indicators of stock price bubbles and ESG disclosure. The standard error of the regression coefficients are reported in parentheses. The dependent variables of column 1 and 2 are the absolute values and the relative values of stock price bubbles according to the method of Cheng et al (2021). And the independent variable is the ESG score of Wind.The dependent variable of column 3 is the stock price bubbles according to the method of GSADF. And the independent is the ESG rating of CSI. On day t, the mean values of variables of A share stocks in the Chinese Stock Markets are calculated and regress using least square method. Column 1-3 control for the company's book to market ratio, turnover rate, earning of per share, return of equity, size, volatility, and age. The sample period ranges from January 1st, 2018 to December 31th, 2022, with a total sample size of 1701046, and includes the 2719 common stocks in the Chinese A-share Markets. Here, ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively.

according to regression coefficients, $Abs\_bubbles_{i,t}$ is the difference between true and fitted value, $Rela\_bubbles_{i,t}$ is the ratio of $Abs\_bubbles_{i,t}$ and $q_{i,t}^{f}$. The regression results are reported in Column 1 and 2 of Table 4, revealing that the sign of

TABLE 5—HECKMAN TWO-STAGE REGRESSION

	ESG(Dummy)	Bubble
	(1)	(2)
ESG score		-0.296***
		(0.0376)
Inverse mills ratio		-4.16e-05**
		(1.84e-05)
Book-to-market ratio		0.852***
		(0.120)
Turnover rate		0.0205
		(0.0129)
Log(size)		8.775***
		(1.584)
Price-earning ratio	0.0230***	0.00118***
	(0.00284)	(0.000238)
Return of equity	37.90***	2.030***
	(3.055)	(0.289)
Volatility	1,069***	-15.50
	(119.2)	(11.77)
Log(age)	10.53***	0.379***
	(0.622)	(0.0671)
Constant	-33.81***	-26.50***
	(1.766)	(4.798)
Observations	1,215	1,215
R-squared	-	0.077

*Note*s: This table reports the Heckman two-stage regression. The standard error of the regression coefficients are reported in parentheses. The dependent variable of column 1 is a dummy variable. If the ESG score exceed the median value, it equals 1, else it equals 0. The dependent variable of column 2 is the stock price bubbles. Column 1 controls for the company's earning of per share, return of equity, volatility, and age. Column 2 controls for the company's book to market ratio, turnover rate, earning of per share, return of equity, size, volatility, and age. On day t, the mean values of variables of A share stocks in the Chinese Stock Markets are calculated and regress using least square method or others. The sample period ranges from January 1st, 2018 to December 31th, 2022, with a total sample size of 1701046, and includes the 2719 common stocks in the Chinese A-share Markets. Here, ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively.

the ESG coefficients are significantly negative, consistent with the findings of the baseline regression. Hence, ESG disclosure can effectively mitigate the stock price bubble phenomenon.

Alternative ESG Disclosure Indicator. — Since the existing literature mostly

adopts the ESG rating data of CSI in examining the economic implications of ESG disclosure (e.g., Lin, Fu, and Fu 2021), this section takes a step further by substituting the score indicators from the Wind ESG score data with CSI rating data. Each of the nine grades of CCC, CC, C, BBB, BB, B, A, AA, AAA is assigned a score of 1-9. The baseline regression equation is then re-estimated, and the results are reported in Column 3 of Table 4. The coefficient for ESG rating of CSI is -0.00377, significant at the 1% level, aligning with the findings of the baseline regression.

Sample Selection Problem.—Due to the potential issue of sample self-selection in the baseline regression, this section refers to the approach of Mansouri and Momtaz (2022) to conduct the Heckman two-stage regression test. In the first-stage probit regression, the explanatory variables consist of ESG disclosure dummy variables, taking the value of 1 when ESG disclosure exceeds the median, and 0 otherwise. Additionally, some control variables are chosen as exogenous instrumental variables for the regression. Subsequently, the inverse mills ratio (IMR) is computed based on the first-stage regression results. Moving to the second stage of regression, the inverse mills ratio is introduced into the baseline regression equation as a control variable. The results are shown in Table 5, where the coefficient of ESG in the second-stage regression is significantly negative at the 1% level. This suggests the absence of a sample selection problem.

IV. Heterogeneity analysis

A. *Firm size*

Firm size plays an important role in assessing a company's capacity to access resources (e.g., Schiffer and Weder 2019). Larger firms typically have more stable investor relationships and greater resilience to risks. Moreover, they often have superior reputation, capital, and resource availability. Consequently, larger enterprises tend to be less reliant on ESG disclosure as a means to acquire additional resources. Conversely, smaller firms face notable challenges and constraints regarding resources. For these companies, disclosing non-financial information related to environmental,

TABLE 6—REGRESSION SORTED BY COMPANY SIZE

	Smallest	Next 20%	Next 20%	Next 20%	Largest
	(1)	(2)	(3)	(4)	(5)
ESG score	-0.0208*	-0.0273**	-0.0344	-0.0300	-0.0183
	(0.0121)	(0.0109)	(0.0279)	(0.0208)	(0.0191)
Book-to-market ratio	0.0318	-0.0618	-0.413	0.120	-0.114
	(0.0673)	(0.175)	(0.309)	(0.0908)	(0.0872)
Turnover rate	0.0190***	0.0172***	0.00585	0.0188	0.0243***
	(0.0056)	(0.00521)	(0.0121)	(0.0116)	(0.00571)
Price-earning ratio	-0.0001**	-4.80e-05	-5.02e-05	1.09e-05	-6.70e-06
	(5.47e-05)	(4.13e-05)	(0.0002)	(5.93e-05)	(5.21e-05)
Return of equity	-0.165	0.0684	0.476	-0.0878	0.177
	(0.128)	(0.224)	(0.421)	(0.230)	(0.115)
Log(size)	1.170	-0.598	-9.563	3.625*	-2.353
	(1.634)	(3.846)	(7.160)	(2.083)	(1.650)
Volatility	3.129	-7.370	-4.196	-13.20	-8.483
	(5.081)	(4.907)	(14.36)	(13.46)	(5.444)
Log(age)	-0.0252	-0.000617	0.213**	0.0195	0.0436
	(0.0195)	(0.0286)	(0.0950)	(0.0414)	(0.0863)
Constant	-3.396	2.012	29.45	-11.25*	7.558
	(4.956)	(11.85)	(22.19)	(6.532)	(5.188)
Observations	1,215	1,215	1,215	1,215	1,215
R-squared	0.018	0.018	0.010	0.018	0.021

Notes: This table reports the regression sorted by company size. The standard error of the regression coefficients are reported in parentheses. On day t, all A share stocks in the Chinese Stock Markets are sorted into 5 quantile portfolios by preranking company size. And the mean values of variables in the market are calculated and regress using least square method. Column 1 - 5 control for the company's book to market ratio, turnover rate, earning of per share, return of equity, size, volatility, and age. The sample period ranges from January 1st, 2018 to December 31th, 2022, with a total sample size of 1701046, and includes the 2719 common stocks in the Chinese A-share Markets. Here, ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively.

social and governance can fulfill investor demands (e.g., Bizoumi, Lazaridis, and Stamou 2019), obtain social recognition and enhance access to resources from government, financial institutions, and other sectors (e.g., Zeidan, Boechat, and Fleury 2015), ultimately enhancing their operational management. Additionally, an improved corporate reputation can bring higher marginal utility to smaller firms.

In this section, firms are evenly divided into five groups based on their size, ranging from small to large. Mean values of the variables are calculated for all stocks

within each daily group, followed by regression analysis using the baseline regression model. The results of Table 6 reveal that the ESG coefficient for the smallest firms is -0.0208, and it is significant at the 10% level. Conversely, the ESG coefficient for the largest firms stands at -0.0183 but lacks significance at the 10% level. Therefore, we can infer that the mitigating effect of ESG disclosure on the stock price bubble phenomenon is more pronounced among smaller firms.

B. *Information asymmetry*

Enterprises characterized by a low level of information asymmetry typically convey more valuable information to investors, enabling investors to systematically and comprehensively assess the enterprise's value. Consequently, stock prices can promptly reflect relevant information (e.g., Chen, Cho, and Patten 2014). Moreover, there is a reduced likelihood of management concealing unfavorable news (e.g., Kim, Wang, and Zhang 2019). Thus, the stock prices of these firms are less susceptible to inflate or experience high volatility, resulting in a less obvious mitigating effect of ESG disclosure on stock price bubbles. Conversely, when information asymmetry is high, investors are more prone to being influenced by sentiment and other factors, leading to irrational investment decisions. This, in turn, increases the likelihood of stock price bubbles. ESG disclosure enhances information transparency in environmental, social, and corporate governance aspects for companies (e.g., Loof, Sahamkhadam, and Stephan 2022). Thus the disclosure of ESG information of firms with high information asymmetry is more likely to mitigate the phenomenon of stock price bubbles.

In this section, we assess the degree of information asymmetry using the illiquidity ratio, as proposed by Amihud (2002). A larger illiquidity ratio indicates a stronger degree of information asymmetry. Specifically, we categorize the sample into five groups based on the stock's information asymmetry indicator, ranging from the smallest to the largest. Mean values of the variables are computed for all stocks in each daily group, and regression analysis is conducted using the baseline regression model. The results reported in Table 7 reveal that the ESG coefficient for firms

TABLE 7—REGRESSION SORTED BY INFORMATION ASYMMETRY

	Smallest	Next 20%	Next 20%	Next 20%	Largest
	(1)	(2)	(3)	(4)	(5)
ESG score	-0.0103	-0.0228**	-0.0483*	-0.0158	-0.0295***
	(0.0185)	(0.00886)	(0.0265)	(0.0112)	(0.0110)
Book-to-market ratio	-0.0319	-0.00315	0.171***	0.00128	0.0207
	(0.0392)	(0.0249)	(0.0652)	(0.0344)	(0.0344)
Turnover rate	0.0153	0.0198***	0.0281**	0.0243***	0.0185***
	(0.0104)	(0.00582)	(0.0117)	(0.00540)	(0.00516)
Price-earning ratio	-7.01e-05	3.88e-05	-1.66e-05	-2.40e-05	-2.58e-05
	(7.33e-05)	(2.89e-05)	(9.04e-05)	(3.30e-05)	(4.02e-05)
Return of equity	0.0680	0.0626	0.338*	0.00642	0.0163
	(0.117)	(0.0653)	(0.175)	(0.0912)	(0.0997)
Log(size)	-1.527***	0.280	1.884***	-0.753**	-1.002**
	(0.369)	(0.309)	(0.620)	(0.377)	(0.441)
Volatility	3.069	-6.839*	11.22	-1.357	-0.227
	(6.619)	(3.956)	(9.769)	(4.409)	(4.270)
Log(age)	0.121**	-0.00668	-0.0370	-0.00727	0.0208
	(0.0478)	(0.0197)	(0.0647)	(0.0102)	(0.0179)
Constant	4.582***	-0.722	-5.514***	2.471**	3.256**
	(1.145)	(0.941)	(1.921)	(1.141)	(1.340)
Observations	1,215	1,215	1,215	1,215	1,215
R-squared	0.026	0.019	0.049	0.024	0.019

Notes: This table reports the regression sorted by information asymmetry. The standard error of the regression coefficients are reported in parentheses. On day t, all A share stocks in the Chinese Stock Markets are sorted into 5 quantile portfolios by preranking information asymmetry. And the mean values of variables of A share stocks in the Chinese Stock Markets are calculated, then regress using least square method. Column 1 - 5 control for the company's book to market ratio, turnover rate, earning of per share, return of equity, size, volatility, and age. The sample period ranges from January 1st, 2018 to December 31th, 2022, with a total sample size of 1701046, and includes the 2719 common stocks in the Chinese A-share Markets. Here, ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively.

characterized by the highest degree of information asymmetry is -0.0295, significant at the 1% level. Conversely, the ESG coefficient for firms with the lowest degree of information asymmetry is -0.0103 but not significant at the 1% level. This supports the inference made in this paper, suggesting that the mitigating effect of ESG disclosure on the stock price bubble phenomenon is more pronounced in firms with a greater degree of information asymmetry.

TABLE 8—REGRESSION SORTED BY HETEROGENEOUS VOLATILITY

	Smallest	Next 20%	Next 20%	Next 20%	Largest
	(1)	(2)	(3)	(4)	(5)
ESG score	0.00263	-0.0243*	-0.0210	-0.0194	-0.0311**
	(0.0428)	(0.0130)	(0.0280)	(0.0128)	(0.0130)
Book-to-market ratio	0.0154	-0.0104	-0.0529	-0.0426	0.00620
	(0.107)	(0.0448)	(0.0766)	(0.0461)	(0.0511)
Turnover rate	0.0203*	0.0228***	0.00710	0.0192***	0.0201***
	(0.0113)	(0.00598)	(0.0113)	(0.00563)	(0.00573)
Price-earning ratio	-9.97e-05	2.00e-05	-5.73e-05	-4.18e-05	2.10e-05
	(0.0003)	(5.60e-05)	(0.0001)	(3.37e-05)	(2.57e-05)
Return of equity	0.00896	0.0739	-0.118	0.00798	0.0792
	(0.205)	(0.0789)	(0.162)	(0.0833)	(0.108)
Log(size)	0.421	0.0151	-2.773**	-0.251	-0.406
	(1.080)	(0.777)	(1.244)	(0.633)	(0.684)
Volatility	4.804	-5.693	-1.944	-4.544	-0.483
	(9.685)	(5.536)	(12.03)	(4.262)	(4.135)
Log(age)	-0.0816	-0.00219	0.168*	-0.00574	0.0129
	(0.135)	(0.0118)	(0.0895)	(0.0325)	(0.0234)
Constant	-1.121	0.108	8.411**	0.905	1.405
	(3.327)	(2.380)	(3.774)	(1.911)	(2.039)
Observations	1,215	1,215	1,215	1,215	1,215
R-squared	0.014	0.018	0.015	0.016	0.017

Notes: This table reports the regression sorted by heterogeneous volatility. The standard error of the regression coefficients are reported in parentheses. On day t, all A share stocks in the Chinese Stock Markets are sorted into 5 quantile portfolios by preranking arbitrage difficulty. And the mean values of variables of A share stocks in the Chinese Stock Markets are calculated, then regress using least square method. Column 1 - 5 control for the company's book to market ratio, turnover rate, earning of per share, return of equity, size, volatility, and age. The sample period ranges from January 1st, 2018 to December 31th, 2022, with a total sample size of 1701046, and includes the 2719 common stocks in the Chinese A-share Markets. Here, ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively.

C. *Difficulty of Arbitrage*

According to behavioral finance theory, when a stock price deviates from its fundamental value, arbitrage activities can drive the stock price towards its true value. Therefore, for enterprises with lower arbitrage costs, it is easier for arbitrageurs to construct portfolios that reduce mispricing of the stock, subsequently reducing the

stock price bubble phenomenon. However, when firms face high arbitrage costs, stock prices are more susceptible to sharp volatility and mispricing due to reduced arbitrage activity and decreased liquidity. This, in turn, results in higher transaction costs for investors (e.g., Guidolin and Ricci 2020). In particular, the short-selling constraints in the Chinese Stock Markets limit arbitrageurs' ability to engage in short-selling (e.g., Stambaugh 2015; Zhang 2020). Thus, stock price inflation and bubbles are more likely to occur when arbitrage costs are high. Therefore, firms with higher arbitrage costs rely more on enhancing information transparency through ESG disclosure. This, in turn, reduces noise trader risk and fundamental risk faced by arbitrageurs (e.g., Shleifer and Vishney 1990, 1997), ultimately mitigating stock price bubbles when compared to firms with lower arbitrage costs.

Referring to Lee et al. (2019), this paper adopts the heterogeneous volatility indicator (IVOL), constructed by the GARCH model to measure the degree of arbitrage difficulty of stocks. A larger heterogeneous volatility indicator suggests greater challenges in arbitraging firms' stocks. Based on this indicator, the sample is categorized into five groups, ranked from smallest to largest. The mean values of the variables for all stocks within each daily group are then calculated and the regression analysis is conducted by using the baseline regression model. The results in Table 8, reveal that the ESG coefficient for firms with the highest heterogeneous volatility is -0.0311 and is significant at the 1% level. Conversely, for firms with the lowest heterogeneous volatility, the ESG coefficient is 0.0026 and is not significant at the 1% level. Hence, it can be asserted that the mitigating effect of ESG disclosure on the stock price bubbles is more pronounced in firms characterized by higher heterogeneous volatility, which implies a greater level of arbitrage difficulty.

V. Mechanism test

A. *Information quality*

To investigate the influence of ESG disclosure on stock price bubbles through informational effects, this paper employs a methodology of Baker, Bloom, and Davis

TABLE 9—MECHANISM EXAMINATION

	SPI	Bubble	Comment	Bubble
	(1)	(2)	(3)	(4)
ESG score	0.727***	-0.0541*	0.169***	-0.0553**
	(0.116)	(0.0281)	(0.0441)	(0.0278)
SPI		-0.0167**		
		(0.00687)		
Comment				-0.0645***
				(0.0180)
Book-to-market ratio	-3.728***	0.0686	-0.287**	0.113
	(0.342)	(0.0855)	(0.130)	(0.0815)
Turnover rate	-0.339***	0.00966	0.198***	0.0281**
	(0.0531)	(0.0129)	(0.0202)	(0.0131)
Price-earning ratio	-0.00126	0.000116	-0.00174***	2.52e-05
	(0.000871)	(0.000208)	(0.000331)	(0.000210)
Return of equity	5.036***	0.404*	-1.168***	0.244
	(0.870)	(0.211)	(0.331)	(0.208)
Log(size)	5.569	1.592	14.06***	2.406*
	(5.677)	(1.356)	(2.160)	(1.375)
Volatility	330.9***	-0.308	82.32***	-0.539
	(49.62)	(12.06)	(18.88)	(11.90)
Log(age)	-0.396*	0.0508	0.735***	0.105*
	(0.240)	(0.0574)	(0.0914)	(0.0587)
Constant	-23.33	-4.796	-46.63***	-7.413*
	(17.19)	(4.107)	(6.540)	(4.177)
Sobel-Goodman	-0.0123**		-0.0109**	
Mediation Tests	(0.0054)		(0.0042)	
Observations	1,215	1,215	1,215	1,215
R-squared	0.489	0.018	0.745	0.023

Notes: This table reports the mechanism examination. The standard error of the regression coefficients are reported in parentheses. Column 1 and 2 show the results when the mechanism variable is information content of stock price. Column 3 and 4 show the results when the mechanism variable is investor attention. On day t, the mean values of variables of A share stocks in the Chinese Stock Markets are calculated, then regress using least square method. Column 1- 4 control for the company's book to market ratio, turnover rate, earning of per share, return of equity, size, volatility, and age. The sample period ranges from January 1st, 2018 to December 31th, 2022, with a total sample size of 1701046, and includes the 2719 common stocks in the Chinese A-share Markets. Here, ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively.

(2016). It conducts monthly regressions using daily return data, equation (10) and (11) show the specific calculations:

(10) $$R_d = \beta_0 + \beta_1 R_{MKT,d} + \beta_2 R_{IND_i,d} + \varepsilon_d$$

(11) $$SPI_{i,t} = ln(\frac{1-R_{i,t}^2}{R_{i,t}^2})$$

(12) $$\text{Intermediary}_{\text{i,t}} = \beta_0 + \beta_1 \text{ESG}_{\text{i,t}} + \beta_2 \text{Controls}_{\text{i,t}} + \epsilon_{\text{i,t}}$$

(13) $$\text{Bubbles}_{\text{i,t}} = \beta_0 + \beta_1 \text{ESG}_{\text{i,t}} + \beta_2 \text{Intermediary}_{\text{i,t}} + \beta_3 \text{Controls}_{\text{i,t}} + \epsilon_{\text{i,t}}$$

where R_d represents the daily return accounting for the reinvestment of cash dividends of stock i on day t. $R_{MKT,d}$ is the market capitalization-weighted return on outstanding shares in the A-share market on day t. $R_{IND_i,d}$ represents the return of industry i on day t. ε_d is the regression residual, $R_{i,t}^2$ captures the goodness-of-fit of the regression, and $1 - R_{i,t}^2$ captures the idiosyncratic information in the stock price. A larger value of $SPI_{i,t}$ signifies a higher information content in the stock price. Equation (12) and (13) show the method of the mechanism test. Where $\text{Intermediary}_{\text{i,t}}$ is the value of information content of stock prices or investor attention of company i on day t.

Table 9 reports the results of the mediation effect test. In column 1, the coefficient of ESG is 0.727, signifying that ESG disclosure significantly enhances the information content of stock prices. In column 2, both the coefficients of ESG and SPI are significantly negative, implying a negative influence of stock price information content on stock price bubbles. Importantly, the mitigating effect of ESG on stock price bubbles remains significant. These results suggest that stock price information content partially mediates the relationship between ESG disclosure and stock price bubbles. In other words, ESG disclosure mitigates the stock price bubble phenomenon by enhancing stock price information content, thus confirming the information channel proposed in hypothesis 2.

B. *Investor attention*

To investigate whether ESG disclosure affects stock price bubbles through external monitoring channels, this section employs the number of comments on the

Oriental Fortune stock bar as a proxy for investor attention in the mediation effect test (e.g., Antweiler and Frank 2004; Gao et al. 2019). According to the results in column 3 of Table 9, the regression coefficient of ESG is 0.169 and is significant at the 1% level. This suggests that ESG disclosure significantly enhances the level of investor attention, as evidenced by increased discussions about the company on the posting board. In column 4, the results indicate a significant negative effect of investor attention on stock price bubbles, while ESG disclosure continues to play a significant negative impact on stock price bubbles. These findings imply that investor attention plays a partial mediating role between ESG and stock price bubbles. In other words, ESG disclosure mitigates the stock price bubble phenomenon by enhancing investor attention, thus confirming the external monitoring channel proposed in hypothesis 3.

VI. Further analysis

In the context of global warming, the climate system has become increasingly unstable, leading to a rise in the frequency of extreme weather events that result in substantial damage to both human lives and property. According to the European Union's Environment Agency (EEA), European countries incurred losses ranging from € 450 billion to € 520 billion due to weather and climate-related events over a 40-year period from 1980 to 2020. Specifically, in May 2022, northeastern Brazil experienced the same amount of rainfall in just 24 hours as it typically received in the entire 22-day period for previous years. This week-long deluge resulted in devastating floods and landslides, leading to the tragic loss of at least 133 lives and the displacement of tens of thousands of people. Climate risks also pose significant challenges to businesses, negatively impacting their production and operations. In particular, Pankratz, Bauer, and Derwall (2019) demonstrated that coping with hot weather conditions leads to increased costs in terms of goods sold and various expense categories, subsequently reducing profitability and operating income. Furthermore, Kruttli, Tran, and Watugala (2019) found that extreme weather events are also reflected in stock and option market prices.

Climate risk consists of physical risk and transition risk, both affecting stock

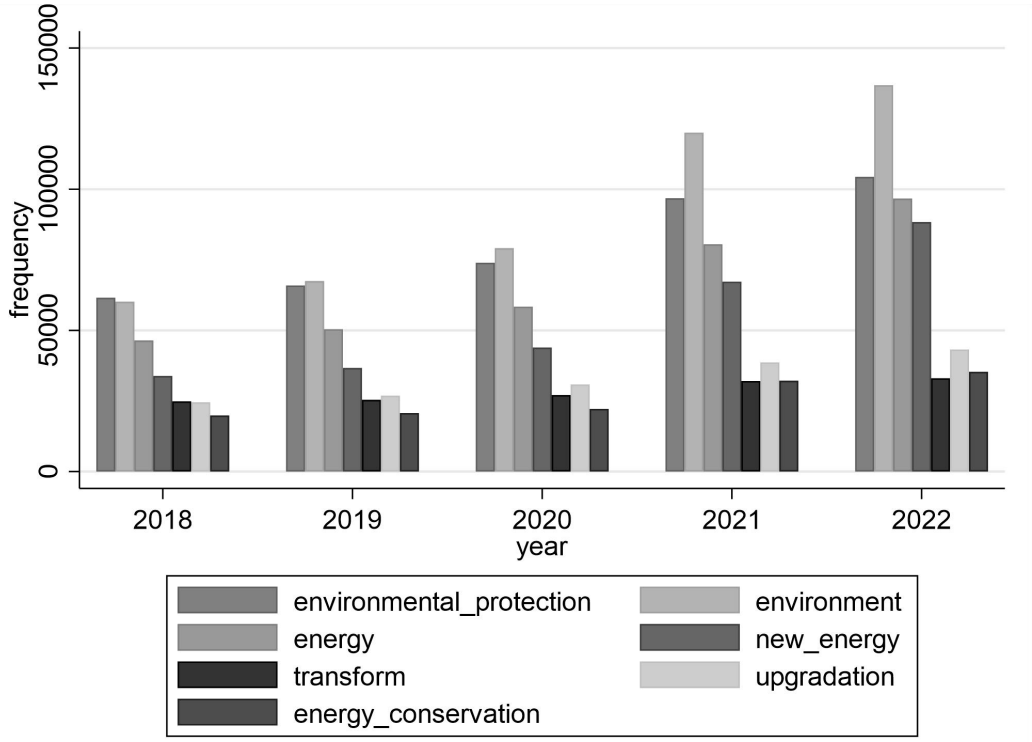

FIGURE 2. RESULTS OF TEXT ANALYST

Notes: Figure shows the frequency of some vocabularies selected in the study about climate transition risk in firms' annual reports between 2018 and 2022. Only the 7 most frequently occurring words are shown here.

prices by impacting a company's future cash flows but originating from distinct sources. Physical risk primarily impacts a firm's operating conditions through extreme temperatures and climate-related disasters, subsequently exerting an influence on stock prices. In contrast, transition risk primarily alters a firm's operating conditions through climate-related financial policies, including monetary and fiscal policy. Given that the effects of physical risk on firms may be long-term and lagged, this section centers on the influence of transition risk on the relationship between ESG disclosure and stock price bubbles. In the face of heightened transition risk, corporate managers exhibit stronger motivations to engage in environmentally responsible practices, enhance the quality of ESG disclosure, and diminish the risk of regulatory penalties (e.g., Jiang et al. 2023). Simultaneously, companies adopt more effective strategies to manage ESG risks and promptly adjust their business models, thereby improving

TABLE 10—THE IMPACT OF TRANSITION RISK

	Small	Large
ESG score	-0.000254	-0.0387**
	(0.0349)	(0.0175)
Book-to-market ratio	0.184	0.0681
	(0.130)	(0.0786)
Turnover rate	0.00795	0.0197*
	(0.0118)	(0.0119)
Price-earning ratio	1.33e-05	2.00e-06
	(0.000115)	(0.000169)
Return of equity	0.00182	0.110
	(0.218)	(0.172)
Log(size)	2.192	1.080
	(1.994)	(0.997)
Volatility	8.088	-5.395
	(9.307)	(12.19)
Log(age)	-0.0112	0.0406
	(0.0639)	(0.0417)
Constant	-6.745	-3.238
	(6.093)	(3.114)
Observations	1,215	1,215
R-squared	0.009	0.017

Notes: This table reports the impact of transition risk. The standard error of the regression coefficients are reported in parentheses. On day t, all A share stocks in the Chinese Stock Markets are sorted into 2 quantile portfolios by preranking transition risk. And the mean values of variables of A share stocks in the Chinese Stock Markets are calculated, then regress using least square method. Column 1 - 2 control for the company's book to market ratio, turnover rate, earning of per share, return of equity, size, volatility, and age. The sample period ranges from January 1st, 2018 to December 31th, 2022, with a total sample size of 1701046, and includes the 2719 common stocks in the Chinese A-share Markets. Here, ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively.

operational performance and reputation (e.g., Eccles et al. 2012). Therefore, increased information transparency and enhanced reputation contribute to a reduced likelihood of management concealing adverse news or misrepresenting their intentions and actions, ultimately mitigating the stock price bubble phenomenon.

Referring to Li, Shan, and Tang (2020) and Wu, Xiao, and Liu (2022) for the terminology of "climate transition risk"[2], this section employs a text analysis

[2] The specific terms of climate transition risk used of this study are shown in Appendix.

approach to create a firm-specific climate transition risk indicator. The indicator is established by analyzing the frequency of climate transition risk-related terms within firms' annual reports. According to Figure 2, the 7 most frequently occurring words are environmental protection, environment, energy, new energy, transform, upgradation, and energy conservation. In terms of trends, the frequency of terms related to climate transition risks in annual reports has increased year after year. Table 10 reports the impact of ESG disclosure on stock price bubbles under varying degrees of climate transition risk. The results indicate that, when faced with high transition risk, the regression coefficient stands at -0.0387 and is significant at the 1% level. This implies that firms' disclosure of ESG information effectively mitigates the stock price bubble phenomenon.

VII. Conclusion

This study conducts an empirical analysis to investigate the influence of ESG disclosure on stock price bubbles, employing unbalanced panel data spanning from January 1st, 2018, to December 31th, 2022, including 2719 listed companies in China. The results show that: Firstly, ESG disclosure can mitigate the stock price bubble phenomenon. Specifically, the regression results remain statistically significant even when altering the calculation method of stock price bubbles. Additionally, heterogeneity analysis reveals that ESG disclosure exerts a more potent mitigating effect on stock price bubbles among listed companies characterized by a high degree of information uncertainty, such as small size, high degree of information asymmetry, and high arbitrage difficulty. Secondly, the mediation effect examination unveils that ESG disclosure predominantly impacts stock price bubbles via the channels of information content and external monitoring. In other words, ESG disclosure diminishes stock price bubbles by increasing the information content of stock prices and investor attention. Lastly, the study reveals that the effect of ESG disclosure in mitigating the stock price bubble phenomenon becomes particularly pronounced when firms confront higher exposure to climate transition risks.

The conclusions of this study provide useful policy insights for standardizing the

ESG disclosure among listed companies and promoting high-quality economic development. Firstly, government agencies should further establish a comprehensive framework for ESG disclosure. This involves standardizing and improving the institutional framework of ESG disclosure content, especially the disclosure of climate risk-related information. This effort is crucial for boosting the enthusiasm of listed companies to engage in ESG disclosure and the quality of information. Additionally, such measures can prevent the manager from using information disclosure to conceal self-interested behavior. Secondly, listed companies ought to place greater emphasis on long-term sustainable development. They should make development strategies according to their unique circumstances, allocate resources and capital towards environmental preservation, social responsibility, and corporate governance, and improve the quality of ESG information disclosure. By forming a responsible external image, companies can improve their reputation, attract investor attention, expand external collaboration opportunities, and enhance their market competitiveness. Thirdly, regulators should provide increased support for companies grappling with information uncertainty, including small size, high information asymmetry and arbitrage difficulty. These firms should be encouraged to establish the concept of sustainable development, improve information transparency through ESG information disclosure, and strengthen communication and information sharing with investors. These actions can improve the accuracy of investor valuations and help mitigate the risk of inflated stock prices and bubbles. In sum, ESG disclosure can promote the long-term and high-quality development of companies. It offers fresh developmental perspectives for resource-constrained enterprises and improves market stability. Therefore, government agencies, listed companies, and regulators should actively participate in and promote the healthy development of ESG disclosure.

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APPENDIX

THESAURUS OF CLIMATE TRANSITION RISK INDICATORS

Risk	Anthology of words	
Climate transition risk	Carbon emission	Wind power
	Energy efficiency	Photovoltaic
	Utilization rate	Energy conservation
	Oil consumption	Ecology
	Power consumption	Wind power generation
	Energy consumption	Energy technology
	Energy	Synergy
	Fuel oil	Reduce emission
	Fuel	Environmental protection
	Renewable energy	Green
	New energy	Low carbon
	Clean energy	Reduce consumption
	Alternative oil	Intensive
	Solar energy	Upgradation
	Natural gas	Transformation
	Nuclear power	Circulate
	Transform	Efficient
	Environment	Water conservation