Carbon Emissions Trading and Stock Price Informativeness: The International Evidence†

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Abstract

This paper shows that emissions trading systems (ETSs) globally enhance stock price informativeness at the firm level. ETS is particularly beneficial for firms where carbon-related information is financially material, earnings and returns are uncertain, and investors focus on carbon data. Our findings suggest that ETS reduces the cost of integrating carbon-related information by providing a transparent, market-based benchmark for carbon-related costs that are highly relevant for earnings forecasts. This leads to better-informed trading decisions and more accurate market prices. Correspondingly, analysts offer more precise and frequent earnings forecasts and are more likely to follow these firms after ETS implementation.

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Abstract

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Keywords: Emission Trading System (ETS); stock price informativeness; information processing cost; financial materiality

JEL Classifications: G14; G23; M14; M41

1. Introduction

Climate change is widely recognized not only as a severe environmental issue but also as a non-negligible threat to economic growth and financial stability. A 2022 report by the Deloitte Center for Sustainable Progress (DCSP) projects that insufficient action on climate change could cost the global economy $178 trillion over the next 50 years. Firms are also significantly exposed to climate-related risks, including reputation, regulatory, production, and physical risks (Painter, 2020), that directly affect operations, profitability, and valuation. For instance, in the 2021 S&P Global Corporate Sustainability Assessment, approximately 25% of surveyed companies identified climate change as a material business risk. In response, many countries have implemented policies to mitigate climate change, with the emissions trading system (ETS) being a key instrument among them. The European Union launched the first ETS in 2005, and by 2024, 41 countries had adopted similar systems at the regional, national, or sub-national level. These systems typically set a cap on carbon emissions and allocate tradable emission allowances, which generates a market price for carbon emissions. By internalizing the cost of carbon emissions, they incentivize firms to reduce their carbon footprint (Bai and Ru, 2024). Given the substantial importance of climate-related risks for firm fundamentals, a critical question is whether this market-based carbon pricing system influences how investors process carbon-related information and value firms. To address this question, we examine the effect of ETS implementation on stock price informativeness at the firm level.

The literature indicates that climate-related risks have significant implications for corporate cash flow and firm value. Both theoretical and empirical evidence suggest that environmental, social, and governance (ESG) performance conveys valuable information about firm fundamentals. Pedersen, Fitzgibbons, and Pomorski (2021) theorize that the ESG score predicts future fundamentals. Consistent with this view, Derrien, Krueger, Landier, and Yao (2024) show that negative ESG news primarily affects firm value by affecting the expected profitability. More specifically, firms' profitability is sensitive to climate-related risks. For example, exposures to climate shocks (e.g., extreme temperature, droughts) can adversely affect corporate earnings (Hong, Li, and Xu, 2019; Addoum, Ng, and Ortiz-Bobea, 2020; Pankratz, Bauer, and Derwall, 2023). Similarly, firms' carbon emissions are negatively associated with profitability and valuation (Matsumura, Prakash, and Vera-Munoz, 2014; Ferrat, 2021; Duan, Li, and Wen, 2025).[1] Taken together, these findings suggest that investors should incorporate climate-related risks when forming earnings expectations and valuing firms.

However, despite the financial materiality of climate-related risks, investors often underreact to them. A growing body of research shows that firms with stronger environmental performance or lower exposure to climate-related risks tend to outperform in both stock and bond markets (see, for example, Hong, Li, and Xu, 2019; Pedersen, Fitzgibbons, and Pomorski, 2021; Pástor, Stambaugh, and Taylor, 2021, 2022; Duan, Li, and Wen, 2025; Zhang, 2025).

One key explanation for this underreaction lies in the costs and difficulties investors face when processing and integrating nonfinancial information into valuation models. For instance, Hong, Li, and Xu (2019) show that firms more exposed to droughts have lower stock returns, and such underreaction is possibly because markets have little experience in assessing such risks and might not pay enough attention. Pedersen, Fitzgibbons, and Pomorski (2021) theorize that some investors remain unaware of firms' ESG scores that may predict firms' profits, leading to higher returns for firms with superior ESG scores. Pástor, Stambaugh, and Taylor (2021, 2022) and Zhang (2025) emphasize the roles of unexpected climate shocks and shifting investor preferences in explaining the outperformance of green stocks. In the same vein, Duan, Li, and Wen (2025) find that bonds issued by more carbon-intensive firms earn lower returns due to insufficient attention to carbon information and climate change issues. Those challenges, arising from

[1] In addition to influencing firms' expected cash flows, carbon emissions are also associated with their risk profiles (e.g., Bolton and Kacperczyk, 2021, 2023; Ilhan, Sautner, and Vilkov, 2021).

limited attention, information complexity, and difficulty of integrating nonfinancial data into earnings forecasts, could be interpreted as *information integration costs*, under the concept of Blankespoor, deHaan, Wertz, and Zhu (2019).[2]

The implementation of an ETS may help mitigate these information integration costs by enabling investors to better incorporate the carbon-related costs into earnings forecasts and firm valuation models. Integrating the climate-related risks into such forecasts requires investors to evaluate the financial impact of the associated costs. Among these, carbon-related costs, those arising directly or indirectly from firms' carbon emissions, constitute a major component and can significantly affect corporate cash flows. Explicit carbon-related costs include compliance expenditures and environmental abatement spending, which stem from regulatory requirements and firms' transition strategies.[3] In contrast, implicit carbon-related costs arise from carbon-related risks and are therefore highly uncertain and difficult to quantify. For example, carbon-intensive firms and their lenders may suffer from reputational damage (Chava, 2014; Jung, Herbohn, and Clarkson, 2018; Herbohn, Gao, and Clarkson, 2019) and face greater exposure to climate policy uncertainty, as these firms are most affected by regulatory efforts to curb emissions (Ilhan, Sautner, and Vilkov, 2021). Furthermore, they experience heightened transition pressure and are more likely to encounter production distortions during the shift toward low-carbon operations (Bolton and Kacperczyk, 2023).

Transforming carbon-related information into costs for income analysis is inherently challenging because these costs are difficult to measure. Firms differ

[2] According to Blankespoor, deHaan, Wertz, and Zhu (2019), information processing costs primarily include awareness, acquisition, and integration costs. Specifically, information awareness costs refer to the expenses incurred in monitoring the existence of a carbon emissions disclosure. Information acquisition costs involve obtaining the disclosure or specific details within it and converting them into a usable format. Lastly, information integration costs relate to the process of combining and incorporating the acquired information into trading decisions.

[3] Compliance costs refer to expenses incurred in meeting existing regulatory requirements, such as carbon taxes (Martin, de Preux, and Wagner 2014; Andersson, 2019), while environmental abatement costs represent expenditures related to the transition process or efforts to reduce carbon emissions (Xu and Kim, 2022).

substantially in their regulatory exposure and ability to manage carbon emissions, lending to considerable heterogeneity in explicit carbon-related costs such as compliance obligations and abatement expenditures. The lack of comparability of explicit carbon-related expenses, combined with inconsistent accounting and disclosure standards, imposes an additional processing burden on investors, making it difficult to estimate and integrate such costs into valuation models. In addition, firms face implicit carbon-related costs due to reputation, regulatory, and production risks, which are difficult to value because of climate policy uncertainty, shifting investor preferences, and firm-specific differences in transition capabilities. Collectively, these factors create significant information integration costs for investors seeking to incorporate carbon-related information into stock prices.

By establishing a market price for carbon emissions, an ETS provides a transparent, market-based benchmark for estimating carbon-related costs, thereby simplifying the projection of expected cash flows. ETS represents a realization of regulatory risks, as it imposes an explicit and economically significant price on firms' carbon emissions (Bai and Ru, 2024). In doing so, it transforms previously implicit and uncertain carbon costs into explicit, measurable, and dynamic price signals through a regulated carbon market and a transparent pricing mechanism. The carbon price not only captures the explicit compliance costs under the ETS but also embeds market expectations regarding future climate regulatory stringency and the marginal costs of the transition process, thereby reducing climate policy and transition uncertainty. Consequently, ETS facilitates the estimation of carbon-related costs and aligns investors' expectations, leading to more accurate and consistent assessments of firms' future earnings and better-informed trading decisions. Hence, stock price informativeness is likely to improve following the implementation of an ETS.

However, implementing an ETS may also introduce additional complexities to firms' operations, potentially making it more difficult for investors to assess firm value. For instance, ETS implementation raises concerns about "carbon leakage" that firms shift emissions-intensive activities to regions with less stringent regulations (Koch and Mama, 2019; Bartram, Hou, and Kim, 2022). Such strategic behaviour adds uncertainty and complicates the prediction of future earnings. Moreover, given investors' limited attention, this carbon pricing policy may distract them from traditional financial information into ESG information, including the non-material part, leading to underreaction to earnings news (Hirshleifer, Lim, and Teoh, 2009; Cao, Titman, Zhan, and Zhang, 2023). Such underreaction could hinder the incorporation of earnings information into stock prices. Therefore, whether ETS implementation ultimately enhances investors' ability to incorporate earnings information into stock prices remains an empirical question.

To examine the relationship between ETS implementation and firms' stock price informativeness, we analyze a global sample of firms from 78 countries over the period from 2002 to 2021. During our sample period, 37 countries ("treated countries") have introduced an ETS, while 41 countries have not done so ("control countries"). Following Bai, Philippon, and Savov (2016) and Kacperczyk, Sundaresan, and Wang (2021), we measure stock price informativeness by assessing the extent to which current market prices predict future cash flows. Specifically, we regress future earnings on current market capitalization, using the resulting coefficient as a proxy for stock price informativeness. We then test the impact of ETS implementation on this informativeness measure.

Because of the staggered adoption feature of ETS implementation, we use the stacked difference-in-differences (DID) approach (Cengiz, Dube, Lindner, and Zipperer, 2019; Baker, Larcker, and Wang, 2022).[4] This approach involves creating and stacking cohorts containing observations from treated and control countries based on each year of ETS implementation. It enables us to compare changes in stock price informativeness for firms in treated countries versus control countries over the same period. Applying this

[4] Our primary empirical approach employs the stacked DID methodology rather than the traditional staggered DID. The latter is biased due to the "bad comparisons" problem, which can occur when the research setting involves staggered treatment timing and heterogeneous treatment effects. For a more detailed explanation, please refer to Baker, Larcker, and Wang (2022).

regression framework with additional firm-level and country-level controls, we find that stock market prices have a higher level of predictability on future earnings for firms headquartered in countries that adopted an ETS, compared with firms in control countries. In other words, firms in treated countries experience a significant increase in stock price informativeness following ETS implementation. A parallel trend analysis supports our view that this improvement is attributable to ETS implementation rather than other events.

The causal relationship between ETS implementation and increased stock price informativeness is robust across several specifications. First, our results remain consistent if we use a standard staggered DID instead of a stacked DID. Second, our results are robust to a different matching analysis that identifies control firms based on common firm and country characteristics through a propensity score matching approach (PSM), rather than based on all firms headquartered in control countries. Third, instead of examining the impact of ETS implementation using panel regressions at a firm level, we calculate the informativeness measure for each country-year following Bai, Philippon, and Savov (2016), and find that ETS implementation still significantly improves country-level price informativeness.

We investigate the mechanisms driving the observed increase in stock price informativeness associated with ETS implementation. Carbon-related information is fundamentally relevant to firm valuation (e.g., Matsumura, Prakash, and Vera-Munoz, 2014; Duan, Li, and Wen, 2025), yet investors face significant costs when integrating such information into the valuation model because carbon-related costs are difficult to quantify for expected cash flow projections. Prior research suggests that lower integration costs can enhance stock price informativeness (e.g., Verrecchia, 1982a, b; Hirshleifer, Lim, and Teoh, 2009; You and Zhang, 2009; Ben-Rephael, Da, and Israelsen, 2017; Serafeim and Yoon, 2023).[5] We hypothesize that ETS implementation reduces these integration costs by providing a consensus and credible reference point for estimating firms' future carbon-related costs, thereby facilitating more accurate and consistent expectations about future cash flows. Our empirical findings provide strong evidence in support of this hypothesis.

First, reducing the integration costs of carbon-related information results in more accurate pricing when this information is financially relevant (Khan, Serafeim, and Yoon, 2016; Serafeim and Yoon, 2022, 2023). Consequently, the effect of ETS implementation is expected to be more pronounced for firms where such information is integral to their fundamentals. For these firms, carbon-related costs constitute a significant portion of their cash flow and are thus critical to valuation. The financial materiality of carbon-related information varies across firms. Carbon-intensive firms, for example, face higher explicit carbon-related costs and elevated climate-related risks, making carbon-related information particularly relevant for their fundamentals. Consistent with this prediction, our results show that the positive relationship between ETS implementation and stock price informativeness is more pronounced for firms with higher carbon intensity.

Second, the literature indicates that investors tend to underreact to value-relevant information when firm transactions and reporting are more complex (Liu, Szewczyk, and Zantout, 2008; You and Zhang, 2009) or when the information itself is more uncertain (Serafeim and Yoon, 2023). The implementation of an ETS helps investors better predict firms' future cash flows by providing a transparent and market-based price benchmark, which reduces policy and transition uncertainty and thereby simplifies the valuation

[5] Different studies refer to information integration costs using various labels, but the underlying concept remains consistent: These costs represent the resources and efforts required to combine and refine acquired signals into a valuation estimate or investment decision (Blankespoor, deHaan, and Marinovic, 2020). For instance, Verrecchia (1982a) describes these costs as those incurred to obtain a more precise version of signals. Investor inattention, as highlighted by Hirshleifer, Lim, and Teoh (2009) and Ben-Rephael, Da, and Israelsen (2017), can also be considered a form of integration cost. Similarly, financial reporting complexity, as identified by You and Zhang (2009), represents another manifestation of these costs. Likewise, ESG rating disagreements, as discussed by Serafeim and Yoon (2023), illustrate the challenges of interpreting firms' ESG performance, which can also be regarded as a type of information integration cost.

process. These benefits are particularly significant for firms with higher ex-ante valuation complexity. Firms with greater uncertainty are inherently more challenging to value, and investor behavioral bias during trading is often exacerbated in such cases (Jiang, Lee, and Zhang, 2005; Kumar, 2009). To capture this complexity, we use two types of uncertainty, earnings uncertainty and return uncertainty, as proxies for valuation difficulty. Consistent with our expectations, we find that the impact of ETS implementation on stock price informativeness is more pronounced for firms with higher ex-ante earnings and return uncertainty.

Third, investors differ in the attention assigned to various information sources (Kahneman, 1973; Kacperczyk, Van Nieuwerburgh, and Veldkamp, 2016; Goldstein, Kopytov, Shen, and Xiang, 2024). This leads to some investors underreacting to some information (Hirshleifer, Lim, and Teoh, 2009; Ben-Rephael, Da, and Israelsen, 2017); carbon-related information is clearly more valuable to investors who recognize its importance. Consequently, reducing the integration costs of carbon-related information benefits investors who are more attentive to such information. Thus, we expect the impact of ETS implementation to be more pronounced for firms whose investors prioritize carbon-related information. Higher Google search index levels for carbon emissions indicate increased attention generally to carbon-related information in recent years (Da, Engelberg, and Gao, 2011, 2015). Consistent with our conjecture, we find that the increase in stock price informativeness is concentrated among firms headquartered in countries with higher Google search activity related to carbon emissions. This finding aligns with our central hypothesis.

Finally, investors play a critical role as information intermediaries, helping to interpret and disseminate information (Lang and Lundholm, 1996). A reduction in information integration costs motivates analysts to increase their coverage of firms (De Franco, Kothari, and Verdi, 2011; Harford, Jiang, Wang, and Xie, 2019) and improves the accuracy of their forecasts (De Franco, Kothari, and Verdi, 2011; Choi, Choi, Myers, and Ziebart, 2019). Consistent with this argument, we find that analysts are more likely to follow firms headquartered in treated countries than those in control countries after the implementation of an ETS. Furthermore, these analysts produce more accurate and less dispersed forecasts. This evidence suggests that both the quantity and quality of analyst forecasts increase following ETS implementation, supporting our hypothesis that ETS reduces information integration costs.

Alternatively, ETS implementation may increase the information supply of carbon-related information, improving the information environment and increasing stock price informativeness. Reichelstein (2024) highlights that current carbon disclosures lack global standardized accounting standards. To enhance the effectiveness of an ETS, governments are expected to monitor and verify reported carbon emissions by firms. This additional scrutiny may pressure firms to disclose more carbon-related information, reducing the costs of acquiring carbon-related information for investors. However, we find no evidence of an increase in the probability of carbon disclosure.

Our paper contributes to the literature on the impacts of ETS implementation. Previous studies primarily focus on the effectiveness of ETS in reducing carbon emissions and fostering innovation. For example, Zhu, Fan, Deng, and Xue (2019) find that China's ETS pilots increase low-carbon innovation among regulated firms without diminishing other technological innovations. Bai and Ru (2024) document that ETS implementation leads to greater carbon emissions reductions and an increase in the use of renewable energy. However, an ETS can also lead to carbon leakage. Bartram, Hou, and Kim (2022) show that firms subject to ETS regulation shift carbon emissions to regions with less stringent climate regulations. Similarly, Koch and Mama (2019) find that German multinational firms that are geographically mobile or less capital-intensive have increased foreign direct investment (FDI) in response to the EU ETS. While these studies explore various dimensions of ETS effectiveness, there is a growing interest in examining their impact on capital market quality. Ren, Zhong, Cheng, Yan, and Gozgor (2023) show that carbon price uncertainty can cause sudden falls in stock prices due to managers withholding bad news and heterogeneous investor beliefs. By investigating the effects of ETS implementation on stock price informativeness, our study provides new insights into the role of ETS in shaping the information environment and enhancing capital market quality. These findings have important policy implications for climate change mitigation and financial market stability.

Our study also contributes to the literature on the impact of information processing costs on the information environment. Greater disclosure and higher disclosure quality are shown to reduce information acquisition costs and improve the information environment. Lang and Lundholm (1996) demonstrate that firms' disclosures reduce information asymmetry and estimation risk. De Franco, Kothari, and Verdi (2011) find that financial statement comparability reduces information acquisition costs, increasing the quantity and quality of available information. Similarly, Chen, Collins, Kravet, and Mergenthaler (2018) show that financial statement comparability improves acquirers' investment decisions. Other studies find that enhanced disclosure is associated with higher stock price informativeness (Ettredge, Kwon, Smith, and Zarowin, 2005; Choi, Myers, Zang, and Ziebart, 2011; Dhaliwal, Radhakrishnan, Tsang, and Yang, 2012; Choi, Choi, Myers, and Ziebart, 2019).

For information integration costs, models developed by Verrecchia (1982a, 1982b) suggest that higher integration costs result in heterogeneous estimates of firm value, reducing price informativeness. Integration costs can arise from various sources, such as investor inattention (e.g., DellaVigna and Pollet, 2009; Hirshleifer, Lim, and Teoh, 2009; Ben-Rephael, Da, and Israelsen, 2017) and information complexity (e.g., Agrawal, Jaffe, and Mandelker, 1992; Liu, Szewczyk, and Zantout, 2008; You and Zhang, 2009; Serafeim and Yoon, 2023). Hirshleifer, Lim, and Teoh (2009) show that investors underreact to a firm's earnings news when distracted by other firms' concurrent earnings announcements. Ben-Rephael, Da, and Israelsen (2017) find that sufficient investor attention facilitates the incorporation of information into stock prices. Complexities in firms' transactions (Agrawal, Jaffe, and Mandelker, 1992; Liu, Szewczyk, and Zantout, 2008), financial reporting (You and Zhang, 2009), and ESG performance (Serafeim and Yoon, 2023) also hinder the financial market's ability to process information, leading to an underreaction to news. Our study contributes to this literature by demonstrating that ETS implementation significantly reduces information integration costs, resulting in higher stock price informativeness.

Furthermore, our study adds to the growing body of research on how trading activity in capital markets enhances the informational content of stock prices. For example, Drake, Myers, Myers, and Stuart (2015) find that short selling improves price informativeness, as short sellers often possess superior information. Brogaard and Pan (2022) show that increased dark-pool trading strengthens the relationship between stock prices and future earnings through enhanced information acquisition. Bai, Philippon, and Savov (2016) highlight the role of option trading in increasing price informativeness, and Cao, Goyal, Ke, and Zhan (2024) extend this by showing that option trading facilitates information production and improves price informativeness by making information acquisition more profitable. Our findings demonstrate that the introduction of a carbon trading market has a similar positive impact on stock price informativeness, akin to the effects of other capital market mechanisms.

2. Hypothesis Development

Extensive research documents that ESG performance, particularly its financially material part, offers valuable insights into firms' future fundamentals (e.g., Khan, Serafeim, and Yoon, 2016; Grewal, Riedl, and Serafeim, 2019; Pedersen, Fitzgibbons, and Pomorski, 2021; Serafeim and Yoon, 2022, 2023; Derrien, Krueger, Landier, and Yao, 2024). Within this literature, carbon-related information has attracted particular attention due to its direct financial relevance and the growing recognition of climate change as a material business risk. Matsumura, Prakash, and Vera-Munoz (2014) show that firms' carbon emissions influence investors' value expectations because of potential costs and liabilities associated with poor environmental performance. Ferrat (2021) finds that the financial burden of reducing carbon emissions can adversely affect firms' profitability. Similarly, Duan, Li, and Wen (2025) document that carbon intensity predicts firm-specific outcomes, such as cash-flow news, creditworthiness, and environmental incidents. Together, these studies underscore the critical role of carbon-related information in shaping expectations about firms' future fundamentals.

The efficient market hypothesis posits that stock prices should reflect all available information (Fama, 1969), including financially material carbon-related information. In practice, however, markets are not fully efficient because frictions hinder the transformation and incorporation of information into prices. One key friction arises from the costs associated with processing and integrating information into valuation models and investment decisions, which Blankespoor, deHaan, Wertz, and Zhu (2019) refer to as *information integration costs*. These costs make it difficult for investors to incorporate carbon-related information into firm valuations.

More specifically, quantifying carbon-related costs poses particular challenges. First, heterogeneity in firms' compliance and environmental abatement costs, together with the absence of standardized and comparable disclosure frameworks, complicates the estimation of how explicit carbon-related costs affect expected earnings.[6] Second, carbon-related risks impose significant implicit costs that are highly uncertain and difficult to value due to variation in firms' transition capabilities, climate policy uncertainty, and shifting investor preference (Pástor, Stambaugh, and Taylor, 2021, 2022; Zhang, 2025).[7] Consequently, investors face considerable integration costs when incorporating carbon-

[6] Explicit carbon-related costs include expenditures associated with environmental abatement efforts and compliance with climate regulations.

[7] Climate change-related risks generally fall into four categories: production risk, reputational risk, regulatory risk, and physical risk (Painter, 2020).

related information into expected cash flow projections. These costs can lead to noisy and divergent firm valuations, impeding the timely and accurate reflection of carbon-related information in stock prices (Verrecchia, 1982a, 1982b).

On the one hand, implementing an ETS can reduce information integration costs. ETS generally operate under a “cap and trade” mechanism, where the government sets a cap on total emissions for specific sectors and issues a corresponding number of emission allowances. Firms covered by the ETS must hold one allowance for each ton of carbon emissions. These allowances can be freely allocated, auctioned by the government, or purchased from other firms, creating a market-based carbon price through trading. The carbon price reflects the negative externalities of carbon emissions, firms’ transition challenges, and expectations about the stringency of future regulations. In other words, it captures not only compliance costs under current ETS requirements but also the marginal costs of emissions reduction and anticipated policy tightening (e.g., fewer free allowances). By providing a transparent and market-based carbon price, the ETS establishes a clear and consensus benchmark that reduces uncertainty surrounding climate policies and transition processes. This enables investors to better estimate carbon-related costs and their implications on expected earnings.[8] In turn, the ETS lowers the costs of integrating carbon-related information, allowing investors to form more accurate and consistent cash flow projections and make better-informed trading decisions. Consequently, stock prices may more effectively incorporate earnings information.

On the other hand, the implementation of an ETS could exacerbate information integration costs. Compliance obligations may induce firms to engage in strategic behavior, such as carbon leakage, that is, relocating emissions-intensive operations to jurisdictions with weaker regulations (Bartram, Hou, and Kim, 2022; Koch and Mama, 2019). Such behaviors increase operational complexity and earnings uncertainty by exposing firms to

[8] For example, the authors could simply use the carbon price times the carbon emissions minus allocated free allowances as an estimate of the carbon-related costs.

greater regulatory and reputational risks, thereby complicating valuation. Prior research also shows that increased transaction complexity and information uncertainty can hinder investors' ability to accurately assess firm value, leading to market underreactions (e.g., Liu, Szewczyk, and Zantout, 2008; Serafeim and Yoon, 2023). Moreover, limited attention can further constrain information processing when market participants are distracted by other news (Hirshleifer, Lim, and Teoh, 2009; Cao, Titman, Zhan, and Zhang, 2023). Similarly, ETS implementation may divert investors' attention from traditional financial information toward ESG-related information, including potentially immaterial parts. Therefore, the additional complexity, uncertainty, and attention constraints induced by ETS implementation may heighten information integration costs, ultimately impeding the extent to which earnings information is reflected in stock prices.

Based on these competing predictions, we propose the following alternative hypotheses:

H1a: The ETS implementation is associated with a higher level of stock price informativeness.

H1b: The ETS implementation is associated with a lower level of stock price informativeness.

3. Research Design

3.1. Price informativeness (PI) measure

We adopt the approach of Bai, Philippon, and Savov (2016) and Kacperczyk, Sundaresan, and Wang (2021) to measure stock price informativeness (PI) as the prediction ability of current market prices for future cash flows. Specifically, we estimate PI using the following regression:

$$\frac{E_{i,t+1}}{A_{i,t}} = \gamma_0 + \gamma_1 Ln(\frac{M}{A})_{i,t} + \gamma_2 X_{i,t} + Year\ FE + Firm\ FE + \epsilon_{i,t+1}, \tag{1}$$

where $\frac{E_{i,t+1}}{A_{i,t}}$ is a firm's earnings before interest and taxes (EBIT) in fiscal year t+1, scaled by total assets in fiscal year t. $Ln(\frac{M}{A})_{i,t}$ is the natural logarithm of market capitalization (stock price times shares outstanding), scaled by total assets in fiscal year t. In Equation (1), γ_1 captures the extent to which future cash flows are incorporated into current stock prices, which is our measure of PI. $X_{i,t}$ is a vector of control variables, including firm characteristics and country characteristics. Firm characteristics include current scaled earnings ($\frac{E_{i,t}}{A_{i,t}}$), the natural logarithm of total assets ($Ln(AT)_{i,t}$), sales growth ($SALES\_GROWTH_{i,t}$), firm leverage ratio ($LEVERAGE_{i,t}$), the cash holdings ($CASH_{i,t}$), firm assets tangibility ($Tangibility_{i,t}$), and total institutional ownership ($IO_{i,t}$). Country characteristics include the natural logarithm of GDP ($Ln(GDP)_{i,t}$), GDP growth ($GDP\_GROWTH_{i,t}$), the natural logarithm of total population ($Ln(POP)_{i,t}$), and the natural logarithm of government consumption expenditure ($Ln(EXP)_{i,t}$). Detailed definitions of our control variables are provided in Appendix 1.

To evaluate the effect of ETS implementation on PI, we examine changes in γ_1 following the adoption of an ETS. A country is considered to have an ETS system if at least one sector is covered by the ETS. The countries that adopt an ETS within our sample period are designated as treated countries, and the rest are control countries. To analyze the impact of staggered ETS adoption at a country level on stock price informativeness, we employ a stacked difference-in-differences (DID) approach.[9] For each ETS implementation year, we create a cohort consisting of firm-year observations from treated countries (i.e., those that implement the ETS during the sample period) and control countries (i.e., those that do not implement an ETS during the sample period). Within each cohort, treated firms are those headquartered in countries that implement

[9] We do not use the standard staggered DID as our primary identification due to its potential bias arising from differential treatment timing and treatment effects (e.g., Baker, Larcker, and Wang, 2022). In addition, in the robustness check, we demonstrate that our results remain consistent when the standard staggered DID is applied.

an ETS during that cohort's specific year, and control firms are those headquartered in other countries. [10] For both treated and control firms, we include data for three years before and after the ETS implementation year (including the implementation year itself). These cohorts are then combined into a single dataset, which we analyze using the following panel regression:

$$
\begin{aligned}
\frac{E_{i,t+1}}{A_{i,t}} = b_0 + b_1 Ln\left(\frac{M}{A}\right)_{i,t} + b_2 Ln\left(\frac{M}{A}\right)_{i,t} \times TREAT_i + b_3 Ln\left(\frac{M}{A}\right)_{i,t} \times AFTER_{i,t} \\
+ b_4 Ln\left(\frac{M}{A}\right)_{i,t} \times TREAT_i \times AFTER_{i,t} + b_5 TREAT_i \times AFTER_{i,t} + b_6 X_{i,t} \\
+ \ b_7 Ln\left(\frac{M}{A}\right)_{i,t} \times X_{i,t} \ + Year - Cohort\ FE + Firm - Cohort\ FE \\
+ \varepsilon_{i,t+1}, \qquad (2)
\end{aligned}
$$

where $TREAT_i$ equals one for firms in treated countries and zero for those in control countries, and $AFTER_{i,t}$ equals one for periods during or after the implementation year and zero otherwise. b_4 is the coefficient of interest as it captures the effect of ETS implementation on PI. A positive value supports hypothesis H1a, while a negative value supports the alternative hypothesis H1b.

3.2. Data and sample

Our sample consists of publicly listed firms worldwide from the fiscal year 2002 to 2021. Firm-level accounting and ownership data are retrieved from the Compustat database and the FactSet Ownership database (LionShares). We obtain the country-level characteristics of the focal firm's headquarters from various sources. ETS-related information, including status and adoption time, is obtained from the International

[10] Therefore, a single firm may be used as a control in multiple cohorts.

Carbon Action Partnership (ICAP).[11] The macroeconomic data is sourced from the World Bank. After merging these datasets, we restrict the sample to country-year observations with at least five firms having complete data on accounting and macroeconomic variables. Firms headquartered in Australia are excluded due to the repeal of its carbon pricing mechanism in 2014.

The final dataset consists of 190,004 firm-year observations, representing 29,004 unique firms from 1,005 country-year observations across 78 countries. Of these, 47% (37 out of 78) implement an ETS between 2002 and 2021. Table A1 in Appendix 2 provides the ETS status and the number of observations for all countries in the sample.[12] Table A2 provides further details on the ETS implemented by each country.[13]

3.3. Summary statistics

Panel A of Table 1 reports the summary statistics for the key variables, all winsorized at the 1% and 99% levels. On average, current scaled earnings are 0.038, and future scaled earnings are 0.047. The natural logarithm of current scaled market capitalization has a mean value of -0.298. The summary statistics for all firm-level variables are consistent with those reported in earlier studies (e.g., Kacperczyk, Sundaresan, and Wang, 2021).

[Insert Table 1 about here]

[11] The ICAP is also the primary source used by Bai and Ru (2024) for obtaining ETS implementation information. Following their methodology, we further verify the accuracy of the data by cross-checking it with other online sources.
[12] Our sample includes countries with a small number of observations. In an untabulated analysis, we find that our results remain robust after excluding countries with fewer than 100, 300, 500, or 1000 observations.
[13] Table A2 shows that four countries, including China, Japan, Canada, and the United States, have subnational ETS. In an untabulated analysis, we find the impact of ETS remains unchanged after excluding these countries from our analysis.

Panel B of Table 1 presents the Pearson correlation coefficients for the variables. Consistent with prior studies, the current and future scaled earnings show a strong positive correlation (0.831). Moreover, both current and future scaled earnings are positively correlated with current scaled market capitalization (0.049 and 0.068, respectively), indicating that current market prices incorporate information about both current and future earnings. Notably, future earnings are not strongly correlated with other firm- or country-level characteristics.

4. Baseline Results

4.1. Stacked DID

To examine the impact of ETS implementation on PI, we run the stacked DID regression specified in Equation (2). The coefficient on the triple interaction term, $TREAT_i \times AFTER_{i,t} \times Ln(M/A)_{i,t}$, captures the effect of ETS implementation on the ability of current market prices to predict future earnings, that is, PI. Table 2 presents the regression results with and without control variables. The findings show that the coefficients of interest are consistently positive and statistically significant at the 1% level, regardless of whether firm-level and country-level control characteristics are included. These results indicate that, following ETS implementation, treated firms experience a significant increase in PI relative to control firms. Specifically, as shown in Column (3), the PI of treated firms increases by 22.8% ((0.009-0.001+0.005)/0.057), compared to control firms after ETS implementation.[14]

[Insert Table 2 about here]

[14] In the unreported analysis, our results remain robust when controlling for firms' carbon performance measured by the Scope12 carbon intensity (i.e., the sum of Scope1 and Scope2 carbon emissions scaled by total revenue, constructed using the data from Trucost) or when excluding financial firms.

To justify the validity of our stacked DID model, we show the parallel trend for results in Column (3) of Table 2. We construct a series of relative-time indicators for the years before and after the year of ETS implementation ($Relative\ Time =\ 0$), and replace the variable, *AFTER*, with these indicators in the regression specified in Equation (2). Point estimates and 90% confidence intervals for these coefficients are presented in Figure 1. The results indicate that the coefficient estimates for the relative-time indicators prior to ETS implementation are not statistically significant at the 10% level. In contrast, the coefficients become significant for the periods following ETS implementation. These findings confirm that our stacked DID model satisfies the parallel trends assumption, providing evidence that the positive relationship between ETS implementation and PI is causal rather than driven by pre-existing trends or other confounding events.

[Insert Figure 1 about here]

To further validate the causal impact of ETS implementation on PI, we perform tests using "placebo" ETS implementation years. Table A3 of Appendix 2 presents the results. In Column (1), we designate the third year before the ETS implementation year as the "placebo" implementation year and estimate the regression specified in Equation (2). The coefficient of interest is found to be insignificant. We repeat this process using the fifth year before the actual ETS implementation year as the "placebo" implementation year, and the coefficient of interest remains insignificant. These findings provide additional evidence that the causal impact of ETS implementation is not driven by confounding events in the pre-implementation period.

The above analysis considers all firms in countries with an ETS. Since ETS covers only specific sectors rather than all firms, we assess whether its effects hold for both covered and uncovered sectors. We classify firms in treated countries into "covered" and "uncovered" sectors based on whether their industries (determined by two-digit SIC codes) belong to sectors regulated by the ETS of their headquarters country.[15] For each group, we retain all firms from control countries and estimate the regression specified in Equation (2) using treated firms in "covered" or "uncovered" sectors alongside all control firms. The results are presented in Table 3.

[Insert Table 3 about here]

Table 3 shows that ETS implementation enhances stock price informativeness for firms in both covered and uncovered sectors. This finding aligns with the notion that ETS effects can spill over into unregulated sectors within treated countries. Uncovered firms may anticipate potential future inclusion in the ETS or face pressure from peers to reduce carbon emissions. Consequently, the price of carbon emissions serves as an indicator of anticipated costs related to emissions management. Additionally, reduced climate policy uncertainty and evolving investor preferences can further contribute to increased stock price informativeness for firms in uncovered sectors.

4.2. Robustness tests

4.2.1. Staggered DID

Our key findings are based on a stacked DID approach. To ensure our results are robust, we also conduct tests using a traditional staggered DID framework. For this analysis, we also keep a six-year window (i.e., [-3, 2]) relative to the implementation year for firms in the treated countries, and run the following regression:

[15] For example, we classify firms in industries with a code of "09 – Fishing, Hunting and Trapping" into the "Maritime" sector.

$$\frac{E_{i,t+1}}{A_{i,t}} = \delta_0 + \delta_1 Ln\left(\frac{M}{A}\right)_{i,t} + \delta_2 Ln\left(\frac{M}{A}\right)_{i,t} \times ETS_{i,t} + \ ETS_{i,t} + b_6 X_{i,t}$$
$$+ \ b_7 Ln\left(\frac{M}{A}\right)_{i,t} \times X_{i,t} + Year\ FE + Firm\ FE$$
$$+ \mu_{i,t+1}, \tag{3}$$

where $ETS_{i,t}$ is a dummy variable to indicate whether the focal firm i's headquarters country has an ETS in fiscal year t.

The regression results are reported in Table A4 of Appendix 2. The findings show that the coefficient on the interaction term, $ETS_{i,t} \times Ln(M/A)_{i,t}$, remains significantly positive. This indicates that our results are robust when using a standard staggered DID approach.

4.2.2. DID with matching

The stacked DID approach identifies all firms in control countries as control firms. To further validate our analysis, we conduct a DID analysis using the alternative PSM method to identify control firms. Treated firms include those headquartered in treated countries that implemented an ETS during our sample period, while non-treated firms are those headquartered in control countries that do not implement an ETS during the same period. For each treated firm, we identify one control firm from the pool of non-treated firms in the same year, based on common firm and country characteristics from the year prior to ETS implementation. Our matching variables include *Ln(M/A)*, *Ln(AT)*, *SALES_ GROWTH*, *LEVERAGE*, *CASH*, *TANGIBILITY*, *IO*, *GDP_ GROWTH*, and *Ln(EXP)*. Panel A of Table A5 shows that the matching characteristics are not significantly different between treated and control firms, confirming the quality of our DID matching analysis.

We also restrict the sample to a window of three years before and after ETS implementation (including the implementation year) and estimate the following regression model in Equation (4):

$$
\begin{aligned}
\frac{E_{i,t+1}}{A_{i,t}} = {} & \alpha_0 + \alpha_1 Ln\left(\frac{M}{A}\right)_{i,t} + \alpha_2 Ln\left(\frac{M}{A}\right)_{i,t} \times TREAT_i + \alpha_3 Ln\left(\frac{M}{A}\right)_{i,t} \times AFTER_{i,t} \\
& + \alpha_4 Ln\left(\frac{M}{A}\right)_{i,t} \times TREAT_i \times AFTER_{i,t} + \alpha_5 TREAT_i \times AFTER_{i,t} + \alpha_6 X_{i,t} \\
& + \alpha_7 Ln\left(\frac{M}{A}\right)_{i,t} \times X_{i,t} + Year\ FE + Firm\ FE \\
& + \tau_{i,t}, \qquad (4)
\end{aligned}
$$

where $TREAT_i$ equals one for treated firms and zero for control firms. $AFTER_{i,t}$ equals one for periods during or after the ETS implementation and zero otherwise. $X_{i,t}$ is a vector of control variables, including those used in Column (3) of Table 2. Panel B of Table A5 reports the regression results. Our coefficient of interest, α_4, is significantly positive. These findings indicate that our results are robust to this DID matching analysis.

4.2.3. Country-level stock price informativeness

To examine the impact of ETS implementation on PI, we primarily employ firm-level analysis, following Kacperczyk, Sundaresan, and Wang (2021). Additionally, we conduct country-level analysis, based on the methodology of Bai, Philippon, and Savov (2016), by estimating the following cross-sectional regression for each country-year:

$$
\frac{E_{i,t+1}}{A_{i,t}} = \partial_{0,c,t} + \partial_{1,c,t} Ln(\frac{M}{A})_{i,t} + \partial_{2,c,t} \frac{E_{i,t}}{A_{i,t}} + Industry\ FE + \theta_{i,t+1}, \qquad (5)
$$

where industries are classified using one-digit SIC codes. We calculate country-level PI (CPI) as the predicted variation of future cash flows from market prices using the following formula:

$$CPI_{c,t} = \partial_{1,c,t} \times \sigma_{c,t}\left(Ln(\tfrac{M}{A})\right), \tag{6}$$

where $\sigma_{c,t}(Ln(\frac{M}{A}))$ is the standard deviation of $Ln(\frac{M}{A})$ in each country-year. After calculating the country-year PI, we run the following regression:

$$\begin{aligned} CPI_{c,t} = \varphi_0 + \varphi_1 TREAT_c \times AFTER_{c,t} + \varphi_2 Y_{c,t-1} \ + Year - cohort\ FE + Country \\ - cohort\ FE + \ \theta_{c,t}, \end{aligned} \tag{7}$$

where $TREAT_c$ equals one for treated countries and zero for control countries, and $AFTER_{c,t}$ equals one for the period during or after the ETS implementation. $Y_{c,t-1}$ is a vector of country characteristics in fiscal year $t-1$, including Ln(GDP), GDP_GROWTH, Ln(POP), and Ln(EXP).

The regression results are reported in Table A6 of Appendix 2. The coefficient of interest, φ_1, is significantly positive. These results further support the robustness of the relationship between ETS implementation and PI.

4.2.4. The impact of carbon tax policies

Another major form of carbon pricing is the carbon tax policy (CTP), which requires covered entities to pay a fixed charge for each ton of greenhouse gas emissions. Prior research shows that CTPs can effectively reduce carbon emissions (Martin, de Preux, and Wagner 2014; Andersson, 2019). Given that both CTPs and ETSs have an explicit price on carbon emissions, we examine whether CTPs have similar effects on stock price informativeness. Specifically, we replicate the baseline analysis in Section 4.1, substituting the policy shock from ETS with that from CTP. The regression results, reported in Table

A7, show that the implementation of CTPs does not have a statistically significant impact on stock price informativeness.

This finding supports the view that CTPs do not provide an effective benchmark for valuing carbon-related costs. First, CTPs generally impose relatively low carbon prices, offering weaker incentives for firms to adjust their carbon management strategies. Bai and Ru (2024) show that the effective carbon price under CTPs is substantially lower than under ETSs, resulting in limited motivation for firms to alter their emissions behavior. Because these compliance costs are small, they do not meaningfully reflect the realization of regulatory risks associated with carbon emissions. Investors may therefore continue to anticipate additional climate policies, such as ETSs, to be implemented. Second, the carbon price under a CTP is set by the government rather than determined by market trading. Hence, it does not convey information about market expectations regarding future regulatory stringency or transition challenges. Unlike ETS, which generates market-based signals that reduce regulatory and transition uncertainty, CTPs merely impose additional compliance costs without lowering the costs of integrating carbon-related information.

5. Mechanism

5.1. Information integration cost hypothesis

In this section, we investigate the mechanism through which the implementation of an ETS enhances stock price informativeness. Carbon-related information provides important insights into firm fundamentals, yet investors face substantial challenges in incorporating such information into valuation models and trading decisions. These challenges can be interpreted as *information integration costs* (Blankespoor, deHaan, Wertz, and Zhu, 2019). Specifically, the integration costs arise from significant variation in explicit carbon-related costs across firms and the lack of standardized methods for disclosing or estimating these costs. Moreover, valuing carbon-related risks is complicated by firms' heterogeneous transition capabilities, uncertainties surrounding climate policy, and evolving investor preferences. Overall, the absence of standardized metrics, combined with the inherent uncertainty and complexity of carbon-related information, makes it costly for investors to interpret and integrate such information into firm valuations.

An ETS is expected to mitigate these information integration costs. The transparent, market-based carbon price established under an ETS provides a credible and widely recognized benchmark for quantifying carbon-related costs. This price captures not only firms' explicit compliance costs but also market expectations about future implicit carbon-related costs arising from regulatory and operational risks. Therefore, the ETS simplifies the estimation of carbon-related costs, aligns investor expectations, and facilitates the incorporation of such costs into expected cash flow projections. We refer to this mechanism as the *information integration cost hypothesis* and proceed to test it empirically.

5.1.1. Financial materiality

A reduction in the integration costs of carbon-related information is more valuable to investors when such information is critical for forecasting future cash flows. If the documented effects are indeed driven by decreased integration costs, this relationship should be more pronounced among firms for which carbon-related information is more financially relevant.

Carbon-related information is inherently more material for carbon-intensive firms. These firms typically incur higher abatement and compliance costs, which constitute a substantial share of their operating expenses. A transparent carbon price under an ETS provides investors with a clear benchmark for assessing these costs. Moreover, they are more exposed to carbon-related risks, such as regulatory penalties, reputational losses, and production distortions during the transition to low-carbon operations, which increase cash flow uncertainty (Safiullah, Kabir, and Miah, 2021). Because an ETS represents the realization of regulatory risk and its price reflects the expected future stringency of carbon regulation and the marginal cost of the transition process, it significantly reduces policy and transition uncertainty for these firms. Consequently, the benefits of ETS implementation should be stronger for such firms. We therefore examine whether the observed increase in stock price informativeness following ETS implementation is more pronounced for these firms.

We obtain carbon emissions data from Trucost. Trucost provides greenhouse gas (GHG) emissions in tons of carbon dioxide (CO_2), and classifies these carbon emissions into three categories: Scope 1, Scope 2, and Scope 3. Scope 1 carbon emissions represent direct GHG emissions from sources owned and controlled by the firm, such as emissions from fossil fuels used in production. Scope 2 carbon emissions are indirect GHG emissions from the consumption of purchased heat, steam, or electricity. Scope 3 carbon emissions are other indirect GHG emissions that occur in the value chain and are not directly controlled by the firm.

We use firms' carbon intensity to identify carbon-intensive firms following Azar, Duro, Kadach, and Ormazabal (2021) and Ilhan, Sautner, and Vilkov (2021). This is calculated as the sum of a firm's Scope 1 and Scope 2 carbon emissions scaled by its total revenue (U.S. dollars, in millions), as the firm directly controls these emissions. We classify firms into high- and low-carbon-emission groups based on the median carbon intensity for each country year and then estimate Equation (2) using these sub-samples. Table 4 presents the regression results, showing that the positive impact of ETS implementation is more pronounced among firms with higher carbon intensity.[16]

[Insert Table 4 about here]

In summary, the results confirm that the impact of ETS implementation is more pronounced among firms for which carbon-related information is more financially relevant.

[16] Our results remain consistent when we measure firms' carbon emissions using Scope 1 carbon emissions scaled by total revenue.

This analysis provides evidence that ETS implementation reduces the integration costs associated with financially material carbon-related information.

5.1.2. Firm uncertainty

Investors often underreact to information when it is complex and uncertain (Liu, Szewczyk, and Zantout, 2008; You and Zhang, 2009; Serafeim and Yoon, 2023). By lowering the integration costs of carbon-related information, ETS implementation is expected to significantly reduce the difficulty of valuing firms. If this hypothesis is correct, we anticipate that the impact of ETS implementation on PI will be more pronounced for firms with higher ex-ante valuation complexity.

Firms with higher uncertainty are inherently more difficult to value. For instance, investors' behavioral biases in decision-making are often amplified for firms with greater uncertainty and complexity around their valuation (Jiang, Lee, and Zhang, 2005; Kumar, 2009). To measure valuation complexity, we follow Choi, Choi, Myers, and Ziebart (2019) and utilize both return uncertainty and earnings uncertainty as proxies. Earnings uncertainty is calculated as the standard deviation of E/A over the previous 10 years, while return uncertainty is measured as the standard deviation of monthly stock returns for each fiscal year. Firms are divided into two groups based on the median level of their earnings uncertainty or return uncertainty, and Equation (2) is estimated for each sub-sample. Panels A and B of Table 5 present the results.

[Insert Table 5 about here]

The results show that our findings are stronger for firms with higher earnings volatility and return volatility. This provides additional evidence that ETS implementation reduces the integration costs of carbon-related information, thereby lowering the difficulty of predicting a firm's future earnings.

5.1.3. Investor attention

Investors have limited information-processing capacity and must allocate their attention across the business cycle, different assets, and various risks and information sources (Kahneman, 1973; Kacperczyk, Nieuwerburgh, and Veldkamp, 2016). Thus, investors who prioritize carbon-related information are more likely to benefit from reduced integration costs associated with it. If the observed improvement in PI is indeed driven by lower integration costs for carbon-related information, we expect our results to be more pronounced among firms whose investors prioritize carbon-related information.

The Google Search Index is a widely used proxy for investors' attention (Da, Engelberg, and Gao, 2011, 2015). Investors who focus on specific types of information are more likely to search for it online. Accordingly, we use the Google Search Index for carbon emissions in each country to measure general investors' attention to carbon-related information for firms headquartered in that country. Specifically, we extract the monthly search index for the topic "Greenhouse Gas Emissions" from Google Trends and calculate the annual average for each country. We then compute the annual change in the natural logarithm of the search index as a proxy for attention to carbon-related information. Using the median value of this change, we classify the sample into high- and low-search-index groups. We estimate Equation (2) for these two groups. Table 6 presents the results, which show that our findings are more pronounced for firms headquartered in countries with higher Google search indexes for carbon emissions.

[Insert Table 6 about here]

The improvement in PI is more pronounced for firms whose investors assign greater importance to carbon-related information, supporting our hypothesis that ETS implementation significantly reduces the integration costs of such information.

5.1.4. Analysts' forecast precision

Analysts play a critical role in interpreting information (Lang and Lundholm, 1996). As information intermediaries, they are expected to benefit from reduced information processing costs, delivering more accurate earnings forecasts (De Franco, Kothari, and Verdi, 2011; Choi, Choi, Myers, and Ziebart, 2019). Similarly, if ETS implementation reduces information integration costs, analysts, whose primary role is to interpret information, are expected to make more precise earnings estimates.

To examine this expectation, we follow Mattei and Platikanova (2017) to use both analysts' earnings forecast error and dispersion as measures of forecast precision. First, we retain only the latest earnings forecasts made by each analyst each year. We exclude firm-year observations with fewer than three earnings forecasts, following Cheong and Thomas (2011) and Mattei and Platikanova (2017). Forecast accuracy is calculated as the negative of the absolute difference between the mean earnings per share (EPS) forecast and actual EPS. Forecast dispersion is measured as the standard deviation of EPS forecasts. Using both forecast accuracy and forecast dispersion, we estimate the following regression:

$$Precision_{i,t} = \lambda_0 + \lambda_1 TREAT_i \times AFTER_{i,t} + \lambda_2 X_{i,t-1} + Year-cohort\ FE + Firm - cohort\ FE + \varrho_{i,t}, \quad (8)$$

where $TREAT_i$ equals one for firms in treated countries and zero for firms in control countries, and $AFTER_{i,t}$ equals to one for the period during or after the ETS implementation. $X_{i,t-1}$ is a vector of firm and country characteristics in fiscal year t-1, including those used in Column (3) of Table 2.

Table 7 reports the regression results. The findings indicate that ETS implementation increases earnings forecast accuracy and reduces dispersion. In other words, analysts make more accurate and less dispersed earnings forecasts following ETS implementation. This provides evidence that ETS implementation reduces the costs associated with analyzing information, enabling analysts to make more accurate and consistent earnings predictions.

[Insert Table 7 about here]

5.1.5. Analysts' coverage

Financial analysts are likely to primarily focus on firms that are more critical to their careers and firms with disclosures that can be processed at a lower cost (e.g., De Franco, Kothari, and Verdi, 2011; Harford, Jiang, Wang, and Xie, 2019; Driskill, Kirk, and Tucker, 2020). The ETS implementation is expected to reduce the integration costs of carbon-related information, enabling analysts to interpret such information more efficiently. These benefits are anticipated to attract analysts, as they can make more accurate estimates at a lower cost.

To test this argument, we examine whether analysts are more likely to follow and make more estimates for firms in treated countries after ETS implementation than in control countries. Specifically, we follow the methodology of Harford, Jiang, Wang, and Xie (2019) and Cao, Goyal, Ke, and Zhan (2024) to analyze analyst coverage and forecast frequency. Analyst coverage is measured as the natural logarithm of the number of analysts following a firm, and forecast frequency is defined as the natural logarithm of the average number of estimates made by each analyst for the focal firm. We then estimate the regression in Equation (8), replacing the dependent variable with these two measures. Table 8 presents the results.

[Insert Table 8 about here]

Consistent with our expectations, the results show a significant increase in analyst coverage and forecast frequency for firms in treated countries relative to those in control countries after ETS implementation. These findings are consistent with our hypothesis that ETS implementation reduces information processing costs, attracting more analysts and increasing the efforts spent on covered firms.

5.2. Alternative story - Information supply hypothesis

To ensure the effectiveness of ETS implementation, governments often establish compliance procedures to guarantee the transparency and accuracy of reported carbon emissions.[17] This reporting pressure can lead to an increase in the supply of carbon-related information. First, since firms are already required to report to the government and incur no additional preparation costs for public disclosure, they may disclose more and higher-quality carbon-related information. Second, investors can access additional carbon-related information, such as verified and reported emissions, through government websites. This increased supply of carbon-related information lowers the cost of acquiring such information. As a result, investors can access more information at a lower cost, enabling them to incorporate it more effectively into stock prices. In this way, the improvement in PI resulting from ETS implementation may stem from reduced information acquisition costs. We refer to this as the *information supply hypothesis*.

We then test whether there is an increase in the supply of carbon-related information. Trucost provides data on whether carbon emissions are disclosed. Using this disclosure status, we examine whether there is an increase in the probability of carbon disclosure. We focus on the disclosure of Scope 1 and Scope 2 carbon emissions, as these are directly controlled by the firm. Specifically, we construct two dummy variables to indicate whether Scope 1 and Scope 2 carbon emissions data are disclosed by the firm in each fiscal year. We then estimate the regression in Equation (8), replacing the dependent variables with these two disclosure indicators. Table 9 presents the results.

[17] For instance, the EU ETS requires covered installations and operators to have an approved monitoring plan for tracking and reporting annual emissions, and the data in the emissions report must be verified by an accredited verifier.

[Insert Table 9 about here]

The findings indicate no significant change in the probability of Scope 1 or Scope 2 disclosure, which is not consistent with the "information acquisition cost" hypothesis.

6. Conclusion

The implementation of ETS has been widely documented to influence firm policies, such as carbon emissions and innovation. Our study provides new evidence of an unintended benefit of ETS implementation: its positive impact on market quality. Using a global sample of firms, we exploit the staggered introduction of ETS across regions. A stacked difference-in-differences analysis reveals that ETS implementation significantly increases stock price informativeness. Parallel trend analysis further confirms that this effect is not due to other events in the pre-treatment period.

In the mechanism analysis, we find that the impact of ETS implementation is more pronounced among firms where carbon-related information has greater financial relevance. Firms with higher earnings and return uncertainty show a larger increase in stock price informativeness. The effect is also stronger when investors prioritize carbon-related information. However, we find no significant differences in the impact of ETS implementation among firms with varying levels of information asymmetry, nor do we observe evidence that ETS implementation increases firms' disclosure of carbon emissions data. These findings support the hypothesis that ETS implementation reduces information integration costs for investors rather than increasing the supply of carbon-related information. Consistent with this hypothesis, we also find that analysts provide more frequent and accurate, and less dispersed earnings forecasts following ETS implementation.

In summary, our study contributes to the literature on the economic impacts of ETS and extends our understanding of how information processing costs influence market efficiency. Additionally, our findings offer valuable insights into the relationship between

ESG factors and financial performance, highlighting the broader implications of environmental policies for market dynamics.

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Table 1. Summary Statistics

This table provides descriptive statistics for firm-level accounting variables and country-level macroeconomic indicators. The sample comprises 190,004 firm-year observations from 30,913 unique firms across 78 countries from 2002 to 2021. Panel A presents summary statistics for firm-year accounting variables and country-year macro variables. Firm-level variables include the earnings scaled by total assets (E/A), the natural logarithm of market capitalization scaled by total assets (Ln(M/A)), sales growth rate (SALES_GROWTH), leverage ratio (LEVERAGE), cash holdings as a proportion of total assets (CASH), asset tangibility (TANGIBILITY), and total institutional ownership (IO). Country-level variables include the natural logarithm of GDP (Ln(GDP)), the annual GDP growth rate of GDP (GDP_GROWTH), the natural logarithm of total population (Ln(POP)), and the natural logarithm of government consumption (Ln(EXP)). All the variables are winsorized at the 1% level. Panel B reports the Pearson correlations among all the variables.

Panel A. Descriptive statistics of key variables

2002-2021	Obs	Mean	Std	10-Pctl	Q1	Med	Q3	90-Pctl
Firm-level								
$E_{i,t}/A_{i,t}$	190,004	0.038	0.144	-0.053	0.016	0.052	0.097	0.155
$E_{i,t+1}/A_{i,t}$	190,004	0.047	0.147	-0.055	0.015	0.054	0.106	0.176
$Ln(M_{i,t}/A_{i,t})$	190,004	-0.298	1.147	-1.777	-1.013	-0.282	0.449	1.143
$Ln(AT)_{i,t}$	190,004	6.218	1.898	3.840	5.019	6.169	7.410	8.681
$SALES\_GROWTH_{i,t}$	190,004	0.123	0.427	-0.177	-0.040	0.057	0.184	0.412
$LEVERAGE_{i,t}$	190,004	0.213	0.196	0.000	0.042	0.175	0.331	0.480
$CASH_{i,t}$	190,004	0.179	0.178	0.018	0.050	0.121	0.245	0.430
$TANGIBILITY_{i,t}$	190,004	0.270	0.227	0.020	0.077	0.219	0.408	0.616
$IO_{i,t}$	190,004	0.208	0.309	0.001	0.009	0.056	0.243	0.832
Country-level								
$Ln(GDP)_{c,t}$	1,005	26.132	0.667	25.212	25.570	26.121	26.635	27.007
$GDP\_GROWTH_{c,t}$ (%)	1,005	2.584	3.608	-2.503	1.064	2.801	4.832	6.788
$Ln(POP)_{c,t}$	1,005	17.078	1.482	15.275	15.775	17.165	18.058	19.019
$Ln(EXP)_{c,t}$	1,005	24.797	1.243	23.194	23.740	24.601	25.675	26.640

Panel B. Correlation of key variables

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
(1) $E_{i,t}/A_{i,t}$	1.000												
(2) $E_{i,t+1}/A_{i,t}$	0.831	1.000											
(3) $Ln(M_{i,t}/A_{i,t})$	0.049	0.068	1.000										
(4) $Ln(AT_{i,t})$	0.275	0.236	-0.323	1.000									
(5) $SALES\_GROWTH_{i,t}$	0.023	-0.014	0.149	-0.048	1.000								
(6) $LEVERAGE_{i,t}$	-0.110	-0.084	-0.281	0.206	-0.015	1.000							
(7) $CASH_{i,t}$	-0.178	-0.176	0.412	-0.287	0.084	-0.361	1.000						
(8) $TANGIBILITY_{i,t}$	0.074	0.078	-0.095	0.135	-0.027	0.295	-0.352	1.000					
(9) $IO_{i,t}$	0.060	0.060	0.068	0.307	0.002	0.050	-0.007	-0.094	1.000				
(10) $Ln(GDP)_{c,t}$	0.092	0.077	-0.022	0.017	-0.029	-0.042	0.006	0.053	-0.321	1.000			
(11) $GDP\_GROWTH_{c,t}$	0.075	0.050	0.168	-0.007	0.138	-0.021	0.015	0.047	-0.129	-0.058	1.000		
(12) $Ln(POP)_{c,t}$	-0.013	-0.004	0.121	0.094	0.021	-0.023	0.075	-0.068	0.214	-0.230	0.321	1.000	
(13) $Ln(EXP)_{c,t}$	-0.062	-0.065	0.012	0.083	0.003	-0.028	0.039	-0.113	0.121	0.082	-0.080	0.407	1.000

Table 2. Effects of Emissions Trading System on Stock Price Informativeness: Firm Level

This table presents a stacked difference-in-differences (DID) analysis of firm-level stock price informativeness around the implementation of a country-level emissions trading system (ETS). The analysis uses the specification in Equation (2) to evaluate the impact of ETS implementation. Specifically, the first year of ETS adoption is designated as the implementation year. Treated countries are defined as those implementing an ETS between 2002 and 2021, while control countries are those that did not adopt an ETS during the sample period. For each implementation year, a cohort is created by combining observations from treated and control countries. Furthermore, the analysis isolates three years before and after the implementation year (including the implementation year) for each cohort. The dependent variable, E_{t+1}/A_t, is calculated as the earnings before interest and taxes (*EBIT*) in fiscal year $t+1$ divided by total assets in fiscal year t. The independent variable, $Ln(M/A)_t$, is the natural logarithm of market capitalization scaled by total assets in fiscal year t. We interact $Ln(M/A)_t$ with the time-matching variables and a set of control variables in fiscal year t. $AFTER_{i,t}$ equals one during or after the ETS implementation year and zero otherwise. $TREAT_i$ equals one for firms in the treated countries and zero otherwise. In Column (2), control variables include a set of firm-level variables, including *E/A*, *SIZE*, *SALES_ GROWTH*, *LEVERAGE*, *CASH*, *TANGIBILITY*, and *IO*. In Column (3), country-level controls are added to the firm-level controls, including *Ln(GDP)*, *GDP_ GROWTH*, *Ln(POP)*, and *Ln(EXP)*. For brevity, the table only reports the interaction terms of $Ln(M/A)_t$ with the matching variables. All regressions control for year-cohort fixed effects and firm-cohort fixed effects. The t-statistics in the brackets are calculated from standard errors clustered by firm-cohort. ***, **, and * denote significance at the 0.01, 0.05, and 0.10 levels based on a two-sided test.

	$E_{i,t+1}/A_{i,t}$		
	(1)	(2)	(3)
$Ln(M/A)_{i,t}$	0.025***	0.017***	0.057***
	(26.04)	(5.92)	(2.79)
$TREAT_i \times Ln(M/A)_{i,t}$	0.002	0.008***	0.009***
	(0.94)	(4.29)	(4.53)
$AFTER_{i,t} \times Ln(M/A)_{i,t}$	-0.004***	-0.001**	-0.001**
	(-6.98)	(-2.23)	(-2.26)
$TREAT_i \times AFTER_{i,t} \times Ln(M/A)_{i,t}$	**0.005*** **	**0.005*** **	**0.005*** **
	(5.20)	**(5.79)**	**(4.91)**
Firm Controls	No	Yes	Yes
Country Controls	No	No	Yes
Year-cohort FE	Yes	Yes	Yes
Firm-cohort FE	Yes	Yes	Yes
Observations	111,812	111,812	111,812
Adjusted R^2	0.73	0.75	0.75

Table 3. Covered vs. Uncovered Sectors

This table presents a robustness check for the relationship between the implementation of a country-level emissions trading system (ETS) and firm-level stock price informativeness by separating treated firms into two groups: covered and uncovered sectors. The analysis employs the same specification as Table 2. In Column (1), we keep treated firms in sectors covered by an ETS and all the control firms. In Column (2), we keep treated firms in sectors NOT covered by an ETS and all the control firms. We identify the sectors covered by an ETS based on the descriptions of industries (identified using the SIC 2-digit code). The control variables are the same as those used in Column (3) of Table 2. For brevity, the table only reports the interaction terms of $Ln(M/A)_t$ with the matching variables. All regressions control for year-cohort fixed effects and firm-cohort fixed effects. The t-statistics in the brackets are calculated from standard errors clustered by firm-cohort. ***, **, and * denote significance at the 0.01, 0.05, and 0.10 levels based on a two-sided test.

	$E_{i,t+1}/A_{i,t}$	
	Covered Sectors	Uncovered Sectors
	(1)	(2)
$Ln(M/A)_{i,t}$	0.078^{***}	0.068^{***}
	(2.79)	(2.75)
$TREAT_i \times Ln(M/A)_{i,t}$	0.015^{***}	0.006^{**}
	(4.68)	(2.51)
$AFTER_{i,t} \times Ln(M/A)_{i,t}$	-0.001^{**}	-0.002^{***}
	(-2.18)	(-2.64)
$TREAT_i \times AFTER_{i,t} \times Ln(M/A)_{i,t}$	**0.006****	**0.005*****
	(2.54)	**(4.76)**
Controls	Yes	Yes
Year-cohort FE	Yes	Yes
Firm-cohort FE	Yes	Yes
Observations	80,170	101,274
Adjusted R^2	0.73	0.75

Table 4. The Impact of Financial Materiality

This table presents a stacked difference-in-differences (DID) analysis of firm-level stock price informativeness around the implementation of a country-level emissions trading system (ETS), using different groups of sample firms based on the financial materiality of carbon-related information. The analysis employs the same specification as Table 2. Firms in each country and year are divided into high- and low-carbon intensity groups based on the median carbon intensity. Carbon intensity is calculated as the natural logarithm of the sum of Scope 1 and Scope 2 carbon emissions, scaled by total assets (in USD millions). Observed differences are the coefficient differences of $TREAT_i \times AFTER_{i,t} \times Ln(M/A)_{i,t}$ between the two groups, and p-values reported in the last row are estimated through 1000 bootstrap draws. Control variables (omitted for brevity) are the same as those used in Column (3) of Table 2. For brevity, the table only reports the interaction terms of $Ln(M/A)_t$ with the matching variables. All regressions control for year-cohort fixed effects and firm-cohort fixed effects. The t-statistics in the brackets are calculated from standard errors clustered by firm-cohort. ***, **, and * denote significance at the 0.01, 0.05, and 0.10 levels based on a two-sided test.

	$E_{i,t+1}/A_{i,t}$	
	High Carbon Intensity	Low Carbon Intensity
	(1)	(2)
$Ln(M/A)_{i,t}$	0.036	0.118**
	(0.55)	(2.24)
$TREAT_i \times Ln(M/A)_{i,t}$	0.013*	0.014***
	(1.85)	(3.29)
$AFTER_{i,t} \times Ln(M/A)_{i,t}$	-0.003*	-0.001
	(-1.88)	(-1.02)
$TREAT_i \times AFTER_{i,t} \times Ln(M/A)_{i,t}$	**0.007****	0.002
	(2.28)	(0.96)
Controls	Yes	Yes
Year-cohort FE	Yes	Yes
Firm-cohort FE	Yes	Yes
Observations	13,938	13,360
Adjusted R^2	0.71	0.84
Observed Differences	**0.005***	
p-values	**0.056**	

Table 5. The Impact of Firm Uncertainty

This table presents a stacked difference-in-differences (DID) analysis of firm-level stock price informativeness around the implementation of a country-level emissions trading system (ETS) using different groups of sample firms based on firm uncertainty. The analysis employs the same specification as Table 2. In Panel A, firms in each country and year are divided into high- and low-earnings volatility groups based on the median earnings volatility. Earnings volatility is measured as the standard deviation of E/A over the previous 10 years (including fiscal year t), following Suk, Lee, and Kross (2021). In Panel B, firms in each country and year are divided into high- and low-return volatility groups, based on the median return volatility. Return volatility is calculated as the standard deviation of monthly stock returns over the fiscal year, following Choi, Choi, Myers, and Ziebart (2019). Observed differences are the coefficient differences of $TREAT_i \times AFTER_{i,t} \times Ln(M/A)_{i,t}$ between the two groups, and p-values reported in the last row are estimated through 1000 bootstrap draws. Control variables (omitted for brevity) are the same as those used in Column (3) of Table 2. For brevity, the table only reports the interaction terms of $Ln(M/A)_t$ with the matching variables. All regressions control for year-cohort fixed effects and firm-cohort fixed effects. The t-statistics in the brackets are calculated from standard errors clustered by firm-cohort. ***, **, and * denote significance at the 0.01, 0.05, and 0.10 levels based on a two-sided test.

Panel A. The impact of earnings volatility

	$E_{i,t+1}/A_{i,t}$	
	High Earnings Volatility	Low Earnings Volatility
	(1)	(2)
$Ln(M/A)_{i,t}$	0.056	0.058***
	(1.54)	(2.85)
$TREAT_i \times Ln(M/A)_{i,t}$	0.010***	0.008***
	(3.11)	(4.82)
$AFTER_{i,t} \times Ln(M/A)_{i,t}$	-0.002**	0.000
	(-2.30)	(0.25)
$TREAT_i \times AFTER_{i,t} \times Ln(M/A)_{i,t}$	**0.007*** **	0.001
	(3.44)	(1.27)
Controls	Yes	Yes
Year-cohort FE	Yes	Yes
Firm-cohort FE	Yes	Yes
Observations	52,915	53,413
Adjusted R^2	0.75	0.77
Observed Differences	**0.006*** **	
p-values	**0.000**	

Panel B. The impact of return volatility

	$E_{i,t+1}/A_{i,t}$	
	High Return Volatility	Low Return Volatility
	(1)	(2)
$Ln(M/A)_{i,t}$	-0.077**	0.174***
	(-2.12)	(6.37)
$TREAT_i \times Ln(M/A)_{i,t}$	0.005	0.012***
	(1.58)	(4.55)
$AFTER_{i,t} \times Ln(M/A)_{i,t}$	-0.000	-0.002***
	(-0.43)	(-2.72)
$TREAT_i \times AFTER_{i,t} \times Ln(M/A)_{i,t}$	**0.007*** **	**0.003*** **
	(3.56)	**(2.79)**
Controls	Yes	Yes
Year-cohort FE	Yes	Yes
Firm-cohort FE	Yes	Yes
Observations	46,735	48,400
Adjusted R^2	0.70	0.81
Observed Differences	**0.004***	
p-values	**0.052**	

Table 6. The Impact of Investor Attention to Carbon-related Information

This table presents a stacked difference-in-differences (DID) analysis of firm-level stock price informativeness around the implementation of a country-level emissions trading system (ETS), using different groups of sample firms based on investor attention to carbon-related Information. The analysis employs the same specification as Table 2. Investor attention to carbon-related information is proxied by changes in the Google Search Index on the topic of "Greenhouse gas emissions". Specifically, we calculate the annual change in the natural logarithm of the monthly average Google Search Index for each country. Firms are divided each year into high- and low-search index groups based on whether they are located in countries with above- or below-median annual changes in the search index. Observed differences are the coefficient differences of $TREAT_i \times AFTER_{i,t} \times Ln(M/A)_{i,t}$ between the two groups, and p-values reported in the last row are estimated through 1000 bootstrap draws. Control variables (omitted for brevity) are the same as those used in Column (3) of Table 2. For brevity, the table only reports the interaction terms of $Ln(M/A)_t$ with the matching variables. All regressions control for year-cohort fixed effects and firm-cohort fixed effects. The t-statistics in the brackets are calculated from standard errors clustered by firm-cohort. ***, **, and * denote significance at the 0.01, 0.05, and 0.10 levels based on a two-sided test.

	$E_{i,t+1}/A_{i,t}$	
	High Search Index on Carbon	Low Search Index on Carbon
	(1)	(2)
$Ln(M/A)_{i,t}$	-0.106	0.245***
	(-0.90)	(3.32)
$TREAT_i \times Ln(M/A)_{i,t}$	0.006	-0.004
	(1.00)	(-0.98)
$AFTER_{i,t} \times Ln(M/A)_{i,t}$	-0.004**	-0.002*
	(-2.41)	(-1.88)
$TREAT_i \times AFTER_{i,t} \times Ln(M/A)_{i,t}$	**0.010*** **	**0.006*** **
	(3.96)	**(3.84)**
Controls	Yes	Yes
Year-cohort FE	Yes	Yes
Firm-cohort FE	Yes	Yes
Observations	22,725	40,165
Adjusted R^2	0.72	0.78
Observed Differences	**0.004** **	
p-values	**0.012**	

Table 7. Effects of Emissions Trading System on Analysts' Forecast Precision

This table presents a stacked difference-in-differences (DID) analysis of the analysts' forecast precision around the implementation of a country-level emissions trading system (ETS). The analysis uses the specification in Equation (8) to evaluate the impact of ETS implementation. This analysis focuses on the most recent annual earnings per share (EPS) forecast for each analyst. Observations with less than three earnings forecasts are excluded, following Cheong and Thomas (2011) and Mattei and Platikanova (2017). The dependent variable is the proxy for analysts' forecast precision, including analysts' forecast accuracy in Column (1), and analysts' forecast dispersion in Column (2). $ACCURACY_{i,t}$ is defined as the negative absolute difference between the mean EPS and the actual EPS in year t, scaled by the stock price at the previous reporting year-end. And $DISPERSION_{i,t}$ is the standard deviation of EPS forecasts in year t, divided by the stock price at the end of the previous reporting year. $AFTER_{i,t}$ equals one during or after the ETS implementation year and zero otherwise. $TREAT_i$ equals one for firms in the treated countries and zero otherwise. Control variables (omitted for brevity) are the same as those used in Column (3) of Table 2 in the previous year. All regressions control for year-cohort fixed effects and firm-cohort fixed effects. The t-statistics in the brackets are calculated from standard errors clustered by firm-cohort. ***, **, and * denote significance at the 0.01, 0.05, and 0.10 levels based on a two-sided test.

	$ACCURACY_{i,t}$	$DISPERSION_{i,t}$
	(1)	(2)
$TREAT_i \times AFTER_{i,t}$	**0.026****	**-0.017****
	(2.29)	**(-2.48)**
Firm Controls	Yes	Yes
Country Controls	No	Yes
Year-cohort FE	Yes	Yes
Firm-cohort FE	Yes	Yes
Observations	26,055	26,449
Adjusted R^2	0.72	0.70

Table 8. Effects of Emissions Trading System on Analyst Coverage

This table presents a stacked difference-in-differences (DID) analysis of the analysts' coverage around the implementation of a country-level emissions trading system (ETS). The analysis uses the specification in Equation (8) to evaluate the impact of ETS implementation. In Column (1), the dependent variable is the natural logarithm of the number of analysts issuing at least one forecast of annual earnings per share (EPS) in year t, denoted by $LN(ANA)_{i,t}$. In Column (2), the dependent variable is the natural logarithm of the average number of estimates made by each analyst in year t, denoted by $Ln(ESTIMATES)_{i,t}$. $AFTER_{i,t}$ equals one during or after the ETS implementation year and zero otherwise. $TREAT_i$ equals one for firms in the treated countries and zero otherwise. Control variables (omitted for brevity) are the same as those used in Column (3) of Table 2 in the previous year. All regressions control for year-cohort fixed effects and firm-cohort fixed effects. The t-statistics in the brackets are calculated from standard errors clustered by firm-cohort. ***, **, and * denote significance at the 0.01, 0.05, and 0.10 levels based on a two-sided test.

	$Ln(ANA)_{i,t}$	*Ln* (ESTIMATES)
	(1)	(2)
$TREAT_i \times AFTER_{i,t}$	**0.098***** **(4.97)**	**0.033***** **(2.61)**
Firm Controls	Yes	Yes
Country Controls	Yes	Yes
Year-cohort FE	Yes	Yes
Firm-cohort FE	Yes	Yes
Observations	41,221	41,221
Adjusted R^2	0.81	0.60

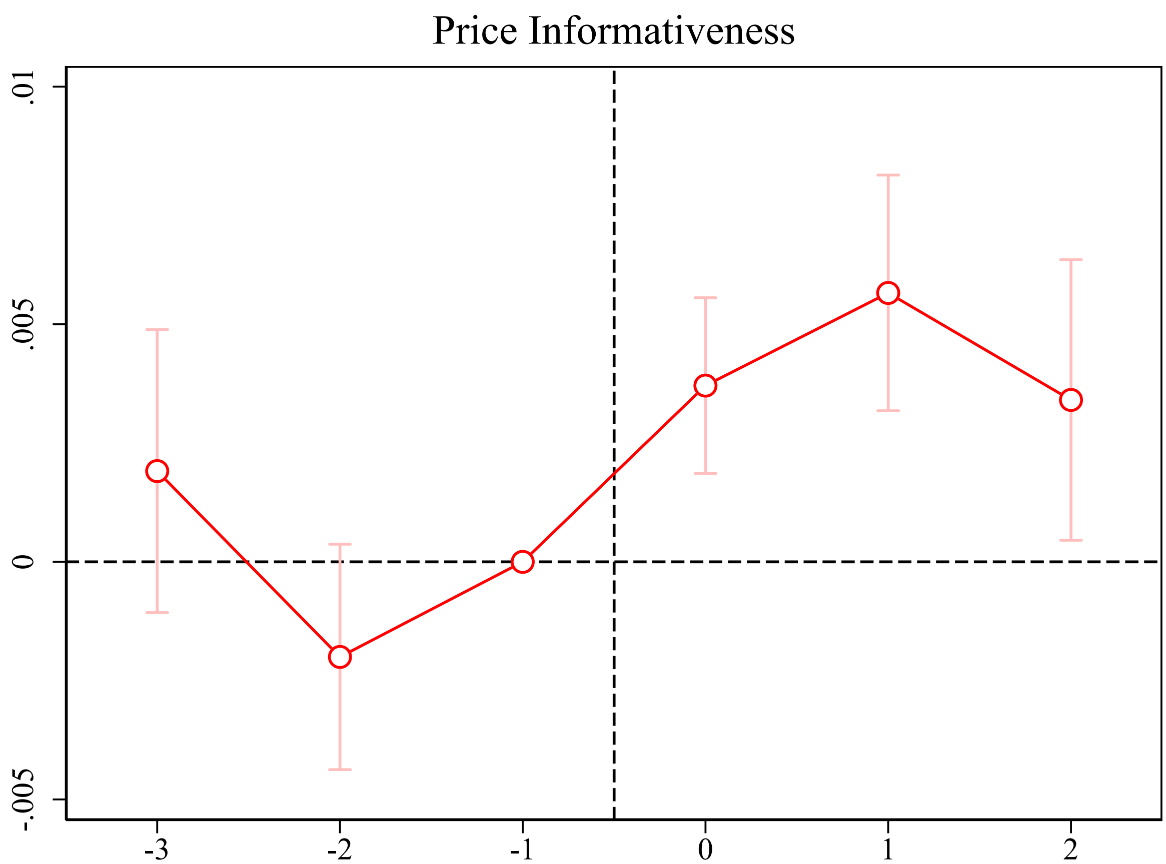
Table 9. Effects of Emissions Trading System on Carbon Disclosure

This table presents a stacked difference-in-differences (DID) analysis of the probabilities of carbon disclosure around a country-level emissions trading system (ETS). The analysis uses the specification in Equation (8) to evaluate the impact of ETS implementation. The dependent variables include dummy variables for whether a firm discloses Scope 1 carbon emissions ($Scope1\_DIS_{i,t}$), and Scope 2 carbon emissions ($Scope2\_DIS_{i,t}$). $AFTER_{i,t}$ equals one during or after the ETS implementation year and zero otherwise. $TREAT_i$ equals one for firms in the treated countries and zero otherwise. Control variables (omitted for brevity) are the same as those used in Column (3) of Table 2 in the previous year. All regressions control for year-cohort fixed effects and firm-cohort fixed effects. The t-statistics in the brackets are calculated from standard errors clustered by firm-cohort. ***, **, and * denote significance at the 0.01, 0.05, and 0.10 levels based on a two-sided test.

	$SCOPE1\_DIS_{i,t}$	$SCOPE2\_DIS_{i,t}$
	(1)	(2)
$TREAT_i \times AFTER_{i,t}$	-0.014	-0.011
	(-1.03)	(-0.83)
Controls	Yes	Yes
Year-cohort FE	Yes	Yes
Firm-cohort FE	Yes	Yes
Observations	19,674	19,674
Adjusted R^2	0.79	0.77

Figure 1. Dynamic Effects of ETS Implementation on Stock Price Informativeness

This figure presents regression coefficient estimates illustrating the dynamic impact of ETS implementation on stock price informativeness, based on the results reported in Column (3) of Table 2. The x-axis represents relative-time indicators spanning three years before to two years after the ETS implementation year (including the implementation year) in the firm's headquarters country. The relative time indicator for the year immediately preceding ETS implementation ($Relative\ Time = -1$) is excluded and serves as the benchmark year. The control variables are those used in Column (3) of Table 2. All regressions control for year-cohort and firm-cohort fixed effects. For each relative-time period from – 3 to 2, we plot the point estimate (the hollow circle) and the 90% confidence interval (the vertical lines intersecting the hollow circles) clustered at firm-cohort level.



Appendix 1:

- $Ln(AT)_{i,t}$: The natural logarithm of total assets in USD (millions). Source: Compustat.
- $SALES\_GROWTH_{i,t}$: The growth rate of firm sales. Source: Compustat.
- $LEVERAGE_{i,t}$: The sum of long-term debt and current liabilities scaled by total assets. Source: Compustat.
- $CASH_{i,t}$: The ratio of cash and short-term investments to total assets. Source: Compustat.
- $TANGIBILITY_{i,t}$: The net property, plant, and equipment scaled by total assets. Source: Compustat.
- $IO_{i,t}$: The total market value of shares held by all the institutions scaled by firms' market capitalization. Source: Factset.
- $Ln(GDP)_{i,t}$: The natural logarithm of total GDP (in USD). Source: Databank.
- $GDP\_GROWTH\ (\%)_{i,t}$: The annual percentage growth of GDP. Source: Databank.
- $Ln(POP)_{i,t}$: The natural logarithm of the total population. Source: Databank.
- $Ln(EXP)_{i,t}$: The natural logarithm of general government final consumption expenditure (in USD). Source: Databank.

Table A1: Sample Distribution by Each Country

This table presents the distribution of observations across countries, along with the ETS implementation status and adoption year for each country.

Country	Obs	ETS	Country	Obs	ETS
United States	54,577	2009	Egypt	380	N/A
Japan	27,290	2010	Austria	377	2005
China	22,248	2013	Croatia	301	2013
South Korea	8,729	2015	Morocco	235	N/A
United Kingdom	8,575	2005	Bangladesh	218	N/A
India	7,682	N/A	Nigeria	213	N/A
Canada	7,475	2013	Peru	189	N/A
France	5,109	2005	Ireland	180	2005
Hong Kong	4,799	N/A	Qatar	180	N/A
Malaysia	3,350	N/A	Slovenia	161	2005
Germany	3,304	2005	Kuwait	158	N/A
Poland	2,605	2005	United Arab Emirates	154	N/A
Sweden	2,309	2005	Sri Lanka	144	N/A
Singapore	2,053	N/A	Lithuania	141	2005
South Africa	1,725	N/A	Hungary	133	2005
Italy	1,704	2005	Oman	127	N/A
Thailand	1,670	N/A	Colombia	123	N/A
Israel	1,660	N/A	Kenya	123	N/A
Indonesia	1,459	N/A	Estonia	115	2005
Brazil	1,367	N/A	Bulgaria	106	2007
Pakistan	1,347	N/A	Tunisia	96	N/A
Turkey	1,339	N/A	Mauritius	85	N/A
Switzerland	1,251	2008	Jordan	71	N/A
Viet Nam	1,045	N/A	Argentina	67	N/A
Spain	1,038	2005	Czechia	61	2005
Norway	986	2008	Luxembourg	57	2005
Finland	898	2005	Serbia	57	N/A
Belgium	844	2005	Cayman Islands	55	N/A
Greece	827	2005	Latvia	48	2005
Russia	782	N/A	Iceland	47	2008
Denmark	714	2005	Ukraine	45	N/A
Netherlands	699	2005	Malta	39	2005
Saudi Arabia	674	N/A	Zimbabwe	32	N/A
Mexico	665	2020	Ghana	19	N/A
New Zealand	653	2008	Botswana	15	N/A
Philippines	586	N/A	Kazakhstan	15	2013
Romania	492	2007	Côte d'Ivoire	10	N/A
Chile	489	N/A	Bahrain	5	N/A
Portugal	398	2005	Bermuda	5	N/A

Table A2: Details of ETS

This table presents the characteristics (including the level and sector coverage) of the ETS for each country.

Country	Level	Sector Coverage
Austria	Regional	Maritime, Domestic Aviation, Industry, Power
Belgium	Regional	Maritime, Domestic Aviation, Industry, Power
Bulgaria	Regional	Maritime, Domestic Aviation, Industry, Power
Canada	Subnational	Transport, Buildings, Industry, Power
China	Subnational	Maritime, Domestic Aviation, Transport, Buildings, Industry, Power
Croatia	Regional	Maritime, Domestic Aviation, Industry, Power
Czechia	Regional	Maritime, Domestic Aviation, Industry, Power
Denmark	Regional	Maritime, Domestic Aviation, Industry, Power
Estonia	Regional	Maritime, Domestic Aviation, Industry, Power
Finland	Regional	Maritime, Domestic Aviation, Industry, Power
France	Regional	Maritime, Domestic Aviation, Industry, Power
Germany	Regional	Maritime, Domestic Aviation, Industry, Power
Greece	Regional	Maritime, Domestic Aviation, Industry, Power
Hungary	Regional	Maritime, Domestic Aviation, Industry, Power
Iceland	Regional	Maritime, Domestic Aviation, Industry, Power
Ireland	Regional	Maritime, Domestic Aviation, Industry, Power
Italy	Regional	Maritime, Domestic Aviation, Industry, Power
Japan	Subnational	Buildings, Industry
Kazakhstan	National	Industry, Power
Latvia	Regional	Maritime, Domestic Aviation, Industry, Power
Lithuania	Regional	Maritime, Domestic Aviation, Industry, Power
Luxembourg	Regional	Maritime, Domestic Aviation, Industry, Power
Malta	Regional	Maritime, Domestic Aviation, Industry, Power
Mexico	National	Industry, Power
Netherlands	Regional	Maritime, Domestic Aviation, Industry, Power
New Zealand	National	Forestry, Maritime, Waste, Domestic Aviation, Transport, Buildings, Industry, Power
Norway	Regional	Maritime, Domestic Aviation, Industry, Power
Poland	Regional	Maritime, Domestic Aviation, Industry, Power
Portugal	Regional	Maritime, Domestic Aviation, Industry, Power
Romania	Regional	Maritime, Domestic Aviation, Industry, Power
Slovenia	Regional	Maritime, Domestic Aviation, Industry, Power
South Korea	National	Maritime, Waste, Domestic Aviation, Transport, Buildings, Industry, Power
Spain	Regional	Maritime, Domestic Aviation, Industry, Power
Sweden	Regional	Maritime, Domestic Aviation, Industry, Power
Switzerland	National	Domestic Aviation, Industry, Power
United Kingdom	Regional	Maritime, Domestic Aviation, Industry, Power
United States	Subnational	Power

Table A3. Effects of Emissions Trading System on Stock Price Informativeness: Placebo Tests

This table presents placebo tests for the stacked difference-in-differences (DID) analysis of firm-level stock price informativeness around the implementation of a country-level emissions trading system (ETS). The analysis employs the same specification as Table 2, except that placebo implementation years are used. In Column (1), the placebo implementation year is set to the third year before each country's actual ETS implementation year. In Column (2), the placebo implementation year is set to the fifth year before the actual ETS implementation. For each placebo implementation year, three years before and after (including the placebo year) are isolated to create a cohort. Control variables are the same as those used in Column (3) of Table 2. For brevity, the table only reports the interaction terms of $Ln(M/A)_t$ with the matching variables. All regressions control for year-cohort fixed effects and firm-cohort fixed effects. The t-statistics in the brackets are calculated from standard errors clustered by firm-cohort. ***, **, and * denote significance at the 0.01, 0.05, and 0.10 levels based on a two-sided test.

	$E_{i,t+1}/A_{i,t}$	
	t-3	t-5
	(1)	(2)
$Ln(M/A)_{i,t}$	0.028	-0.065**
	(1.19)	(-2.04)
$TREAT_i \times Ln(M/A)_{i,t}$	0.004	0.001
	(1.51)	(0.23)
$AFTER_{i,t} \times Ln(M/A)_{i,t}$	-0.003***	-0.003***
	(-4.32)	(-3.92)
$TREAT_i \times AFTER_{i,t} \times Ln(M/A)_{i,t}$	0.002	0.002
	(1.23)	(1.11)
Firm Controls	Yes	Yes
Country Controls	Yes	Yes
Year-cohort FE	Yes	Yes
Firm-cohort FE	89,169	66,069
Observations	0.77	0.80

Table A4. Effects of Emissions Trading System on Stock Price Informativeness: Staggered DID

This table presents a staggered difference-in-differences (DID) analysis of the firm-level stock price informativeness around the implementation of a country-level emissions trading system (ETS). The analysis uses the specification outlined in Equation (3) to evaluate the impact of ETS implementation. The first year when each country adopts an ETS is designated as the implementation year. For firms in countries that implemented an ETS between 2002 and 2021, the analysis isolates three years before and after implementation (including the implementation year). The dependent variable, E_{t+1}/A_t, is calculated as the earnings before interest and taxes (EBIT) in fiscal year $t+1$ divided by total assets in fiscal year t. The independent variable, $Ln(M/A)_t$, is the natural logarithm of market capitalization scaled by total assets in fiscal year t. $Ln(M/A)_t$ is interacted with $ETS_{i,t}$ and a set of control variables measured in fiscal year t. $ETS_{i,t}$ is a dummy variable indicating whether firm i's country has an ETS in year t. Control variables are the same as those used in Column (3) of Table 2. For brevity, this table only reports the interaction terms between $Ln(M/A)_t$ and the ETS implementation indicator. All regressions control for year fixed effects and firm fixed effects. The t-statistics in the brackets are calculated from standard errors clustered by firm. ***, **, and * denote significance at the 0.01, 0.05, and 0.10 levels based on a two-sided test.

	$E_{i,t+1}/A_{i,t}$
	(1)
$Ln(M/A)_{i,t}$	0.009***
	(6.82)
$ETS_{i,t} \times Ln(M/A)_{i,t}$	**0.003*** **
	(3.41)
Firm Controls	Yes
Country Controls	Yes
Year FE	Yes
Firm FE	74,834
Observations	0.75

Table A5. Effects of Emissions Trading System on Stock Price Informativeness: DID with Matching

This table presents a difference-in-differences (DID) matching analysis of the firm-level stock price informativeness around the implementation of a country-level emissions trading system (ETS). The analysis uses the specification outlined in Equation (4) to evaluate the impact of ETS implementation. We use the first year when each country has an ETS as the implementation year. The first year when each country adopts an ETS is designated as the implementation year. For each implementation year, the analysis isolates three years before and after implementation (including the implementation year). The treatment group consists of 698 firms domiciled in countries that implemented an ETS between 2002 and 2021. The control group consists of one firm (matched without replacement) from countries that never implemented an ETS during the sample period. Matching is performed using the propensity score matching method to identify control firms that best match each treated firm. Panel A compares the average values of the matching variables between the treatment and control groups one year before the ETS implementation (time t = -1). Panel B reports the regression results for the DID model. The dependent variable, E_{t+1}/A_t, is calculated as the earnings before interest and taxes (EBIT) in fiscal year $t+1$ divided by total assets in fiscal year t. The independent variable, $Ln(M/A)_t$, is the natural logarithm of market capitalization scaled by total assets in fiscal year t. We interact $Ln(M/A)_t$ with the time-matching variables and a set of control variables in fiscal year t. $AFTER_{i,t}$ equals one during or after the ETS implementation year and zero otherwise. $TREAT_i$ equals one for firms in the treated countries and zero otherwise. The control variables are the same as those used in Column (3) of Table 2. For brevity, the table only reports the interaction terms of $Ln(M/A)_t$ with the matching variables. All regressions control for year fixed effects and firm fixed effects. The t-statistics in the brackets are calculated from standard errors clustered by firm. ***, **, and * denote significance at the 0.01, 0.05, and 0.10 levels based on a two-sided test.

Panel A. Pre-treatment comparison

	Treatment Group	Control Group	Difference	p-value
Ln(M/A)	-0.435	-0.414	-0.021	0.438
Ln(AT)	6.374	6.317	0.058	0.168
SALES_GROWTH	0.078	0.086	-0.008	0.400
LEVERAGE	0.213	0.215	-0.002	0.623
CASH	0.169	0.169	0.000	0.891
TANGIBILITY	0.337	0.341	-0.004	0.524
IO	0.040	0.040	0.000	0.762
GDP_GROWTH	0.985	1.123	-0.137	0.591
Ln(EXP)	25.952	25.952	0.000	0.995

Panel B. ETS and stock price informativeness

	$E_{i,t+1}/A_{i,t}$
	(1)
$Ln(M/A)_{i,t}$	-0.035
	(-0.46)
$TREAT_i \times Ln(M/A)_{i,t}$	0.007
	(1.39)
$AFTER_{i,t} \times Ln(M/A)_{i,t}$	-0.004***
	(-2.90)
$TREAT_i \times AFTER_{i,t} \times Ln(M/A)_{i,t}$	**0.005****
	(2.11)
Controls	Yes
Year FE	Yes
Firm FE	Yes
Observations	5,743
Adjusted R^2	0.69

Table A6. Effects of Emissions Trading System on Climate Policy Uncertainty and Stock Price Informativeness: Country Level

This table presents a stacked difference-in-differences (DID) analysis of country-level stock price informativeness around the implementation of a country-level emissions trading system (ETS). The analysis uses the specification outlined in Equation (7) to evaluate the impact of ETS implementation. The first year a country adopts an ETS is designated as the implementation year. For each implementation year, a cohort is created by combining country-year observations from treated countries and control countries. Furthermore, the analysis isolates three years before and after the implementation year (including the implementation year) for each cohort. Treated countries are defined as those implementing an ETS between 2002 and 2021, while control countries are those that did not adopt an ETS during the sample period. The dependent variable is the country-level stock price informativeness, $CPI_{c,t}$, constructed following Bai, Philippon, and Savov (2016). For each country and fiscal year, we run the cross-sectional forecasting regression specified in Equation (5) and obtain the coefficient of $Ln(M/A)_{i,t}$, denoted as $\partial_{1,c,t}$. Only coefficients from regressions with more than five degrees of freedom are retained. $PI_{c,t}$ is then calculated as $\partial_{1,c,t} \times \sigma_{c,t}(Ln(M/A))$ as specified in Equation (6), where $\sigma_{c,t}(Ln(M/A))$ is the cross-sectional standard deviation of Ln(M/A) in country c and fiscal year t. $AFTER_{c,t}$ equals one during or after the ETS implementation year and zero otherwise. $TREAT_c$ equals one for the treated countries and zero otherwise. Control variables (omitted for brevity) are country-level characteristics in the previous year, including Ln(GDP), GDP_GROWTH, Ln(POP), and Ln(EXP). All regressions control for year-cohort fixed effects and country-cohort fixed effects. The t-statistics in the brackets are calculated from standard errors clustered by country-cohort. ***, **, and * denote significance at the 0.01, 0.05, and 0.10 levels based on a two-sided test.

	$PI_{c,t}$
	(1)
$TREAT_c \times AFTER_{c,t}$	**0.011****
	(2.05)
Country Controls	Yes
Year-cohort FE	Yes
Country-cohort FE	Yes
Observations	857
Adjusted R^2	0.04

Table A7. Effects of Carbon Tax Policies on Stock Price Informativeness: Firm Level

This table presents a stacked difference-in-differences (DID) analysis of firm-level stock price informativeness around the implementation of a country-level carbon tax policy (CTP). The analysis uses the specification in Equation (2) to evaluate the impact of CTP implementation. Specifically, the first year of CTP adoption is designated as the CTP implementation year. Treated countries are defined as those implementing a CTP between 2002 and 2021, while control countries are those that did not adopt a CTP during the sample period. For each implementation year, a cohort is created by combining observations from treated and control countries. Furthermore, the analysis isolates three years before and after the implementation year (including the implementation year) for each cohort. The dependent variable, E_{t+1}/A_t, is calculated as the earnings before interest and taxes (*EBIT*) in fiscal year $t+1$ divided by total assets in fiscal year t. The independent variable, $Ln(M/A)_t$, is the natural logarithm of market capitalization scaled by total assets in fiscal year t. We interact $Ln(M/A)_t$ with the time-matching variables and a set of control variables in fiscal year t. $AFTER_{i,t}$ equals one during or after the CTP implementation year and zero otherwise. $TREAT_i$ equals one for firms in the treated countries and zero otherwise. In Column (2), control variables include a set of firm-level variables, including *E/A*, *SIZE*, *SALES_ GROWTH*, *LEVERAGE*, *CASH*, *TANGIBILITY*, and *IO*. In Column (3), country-level controls are added to the firm-level controls, including *Ln(GDP)*, *GDP_ GROWTH*, *Ln(POP)*, and *Ln(EXP)*. For brevity, the table only reports the interaction terms of $Ln(M/A)_t$ with the matching variables. All regressions control for year-cohort fixed effects and firm-cohort fixed effects. The t-statistics in the brackets are calculated from standard errors clustered by firm-cohort. ***, **, and * denote significance at the 0.01, 0.05, and 0.10 levels based on a two-sided test.

	$E_{i,t+1}/A_{i,t}$		
	(1)	(2)	(3)
$Ln(M/A)_{i,t}$	0.024***	0.006***	0.057***
	(44.30)	(3.19)	(5.02)
$TREAT_i \times Ln(M/A)_{i,t}$	0.004	0.005**	0.008***
	(1.10)	(1.97)	(2.77)
$AFTER_{i,t} \times Ln(M/A)_{i,t}$	-0.002***	-0.001***	-0.001***
	(-8.49)	(-5.26)	(-5.68)
$TREAT_i \times AFTER_{i,t} \times Ln(M/A)_{i,t}$	-0.002	-0.002	-0.002
	(-1.14)	(-0.97)	(-0.97)
Firm Controls	No	Yes	Yes
Country Controls	No	No	Yes
Year-cohort FE	Yes	Yes	Yes
Firm-cohort FE	Yes	Yes	Yes
Observations	458,772	458,772	458,772
Adjusted R^2	0.78	0.80	0.80