The effects of mandatory ESG disclosure on price discovery efficiency around the world

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Abstract

We examine the effect of mandatory environmental, social and governance (ESG) disclosure on firms' price discovery efficiency around the world. Using data from 40 countries between 2000 and 2019 and a difference-in-difference method, we find that ESG mandatory disclosure increases firm-level stock price nonsynchronicity and timeliness of price discovery suggesting more firm-specific information is incorporated into stock price in a more timely manner. ESG mandatory disclosure improves price discovery efficiency more in countries with strong demands on ESG information and in firms with poor disclosure incentives. It also decreases the cost of equity capital, increases institutional ownership and firm valuation.

***JEL Classification*:** G14, G15, G18, G28, G30

Keywords: Mandatory ESG disclosure; Price efficiency; Governance

1. Introduction

In recent years growing social and environmental challenges (e.g., climate change, child labour and social inequality) have prompted companies to embrace a more systematic approach towards sustainability reporting, also known as corporate social responsibility (CSR) reporting or environmental, social and governance (ESG) reporting (Ioannou & Serafeim, 2019). Since the later 1990s a growing number of countries have implemented ESG disclosure mandates, either through laws and regulations or through stock exchange listing requirements. Furthermore, an increasing number of investors tend to make investment decisions based not only on expected returns but also on non-monetary criteria and social norms (Hong & Kostovetsky, 2012)[1]. Concurrent with this trend, the Global Reporting Initiative (GRI) was launched in 1997 with the goal of developing and establishing rigorous and credible reporting guidelines for the "triple bottom line" (accounting, environmental and social performance) of corporations. GRI aimed to gradually evolve sustainability reporting to a point that it would be on a par with financial reporting in terms of credibility and comparability. The Sustainability Accounting Standard Board (SASB), a non-profit organization, with a focus on investors demand of non-financial information, was founded in 2012 to develop and disseminate an industry-specific sustainability reporting standard and encourage companies to disclose financially material sustainability issues in compliance with the Security and Exchange Commission (SEC) requirement in the U.S.

Previous research suggests that better financial disclosure can lead to tangible capital market benefits, including improved liquidity and a lower cost of capital, as well as higher asset prices (or firm value) and better corporate decisions (e.g., Christensen et al., 2021). However, ESG disclosure may have fundamental differences from financial disclosure. Financial

[1] For example, socially responsible investors implement a "negative screening" approach that excludes firms operating in "sin" industries such as alcohol and tobacco, which creates additional demand for firms to disclose ESG information.

reporting informs equity investors on firms' operations and cash flows (Biddle et al., 2009), while ESG information not only informs shareholders in estimating future cash flows or when evaluating firms' potential risk (Grewal et al., 2019) but also stakeholders without a direct financial claim on the firm, such as customers or society at large (Christensen et al. 2017; Bénabou & Tirole, 2010). In addition, ESG reporting generally deals with strategic activities with a long-term horizon (Bénabou & Tirole, 2010) and is multi-dimensional in nature encompassing a diversity of topics, policies and activities (Amel-Zadeh & Serafeim, 2018). Given the fundamental differences between ESG and financial disclosure and the potential divergent effects on stock markets, there is high risk in relying on prior research in mandatory financial reporting to predict the consequence of mandated ESG reporting (Bénabou & Tirole, 2010; Christensen et al. 2017; Grewal et al., 2019).

Motivated by the fundamental difference between ESG disclosure and financial disclosure and their potentially divergent effects on stock markets, we focus on ESG mandatory disclosure and its economic consequence on share price discovery efficiency around the world. Mandated ESG disclosure is expected to address the selective disclosure issues related to ESG voluntary disclosure (Dhaliwal et al., 2011, 2012; Lins et al., 2017) and force firms to release previously unavailable information to the market, which in turn incentivizes market participants to actively incorporate newly available information into share price and this, ultimately, should improve share price discovery efficiency. However, there is limited evidence on the impacts of ESG mandatory disclosure policy on share price discovery efficiency. What's more, ESG reporting is more qualitative and less standardized in comparison to financial reporting, which relies on well-defined quantitative metrics, making it harder for investors to process (Park & Ravenel, 2013; Bingler et al., 2022), easier for managers to manipulate (Hermalin & Weisbach, 2012 for a literature review) and ultimately triggering higher agency costs or more agency problems (Hermalin & Weisbach, 2012). Therefore, whether ESG

mandatory disclosure regulations improve firm-level share price discovery efficiency is not ex ante obvious and thus the relative magnitudes of various benefits and costs that arise from a mandate are largely an empirical matter.

An efficient price discovery process, by incorporating all available public and/or private information in a timely manner, is crucial for a dynamic market efficiency which mitigates information asymmetries among investors, strengthens market discipline (Grossman & Stiglitz, 1980; Holmström & Tirole, 1993; Edmans, 2009; Zhang et al., 2017, 2022; Christensen et al., 2021) and thus reduces the cost of equity capital (Verrecchia, 2001; Brown et al., 2004; Easley & O'Hara, 2004). To capture the dynamic share price discovery process and its efficiency, we use two measures. Our first is stock price nonsynchronicity (*PSI*), capturing the proportion of variation in firm-level stock return that cannot be explained by market and industry-wide information but is driven by firm-specific information (Roll, 1988; Piotroski & Roulstone, 2004; Fernandes & Ferreira, 2008; Gul et al., 2011; Crawford et al., 2012). Greater values of *PSI* suggest more informative stock prices reflecting private information. Our second measure is the intra-year timeliness of price discovery (*TIMELINESS*), capturing the timely manner of forward-looking information being incorporated into stock price throughout a fiscal year (Ball & Brown, 1968; Alford et al., 1993; Beekes & Brown, 2006; Beekes et al., 2016; Zhang et al., 2022). Greater values of *TIMELINESS* suggest that the market is slower in incorporating forward-looking value-relevant information into current share price.

Using data collected from 40 countries between 2000 and 2019, we find that in countries where the mandatory ESG disclosure became effective, stock price nonsynchronicity increases, suggesting a higher price discovery efficiency outcome with more firm-specific information incorporated into stock price and improved timeliness of price discovery with forward-looking value-relevant information more quickly incorporated into stock prices. We further identify the potential channels through which ESG mandate could impact share price

discovery efficiency. Mandated ESG disclosure policy is expected to generate more capital market benefits when the demand on ESG information is stronger. We find that the net benefits of ESG mandate disclosure on price discovery efficiency is more pronounced in countries with strong demands on ESG information (countries with priority attitude to environmental protection, or with poor investor protection quality) and in firms with poorer disclosure incentives (firms with poorer ESG information disclosure records, or poorer corporate governance quality). Our difference-in-difference (DID) test strengthens the causal interference of our results. Our findings are robust when we use alternative mandate effective event window, exclude countries with other institutional reforms in the event window of ESG disclosure mandate, exclude observations from the U.S (representing more than 30% of the entire sample), conduct placebo tests using pseudo effective years of mandates, exclude ESG sensitive industries, and estimate pooled OLS regressions. Finally, we further reveal that ESG mandatory disclosure leads to real stock market changes in terms of reduced firm-level future stock returns, improved institutional investor participation and improved firm valuation outcome.

Our study makes important contributions to the ESG disclosure and corporate governance literature in a few ways. First, our study responds to the call by Christensen et al. (2021) for more research on whether mandated non-financial reporting generates market-wide benefits and costs. Our analysis extends previous research by focusing on ESG mandatory disclosure impacts and consequences.

Second, our study is the first to identify the capital market impacts of mandatary ESG disclosure on stock price discovery efficiency measured by price nonsynchronicity and timeliness. A concurrent study by Krueger et al. (2021) explores the effect of mandatory ESG disclosure on firms' information environment. They find that mandatory ESG disclosure increases the accuracy of analysts' earnings forecasts, lowers analyst forecast dispersion,

reduces negative ESG incidents and lowers the likelihood of stock price crashes. Our research question is fundamentally different from Krueger et al. (2021), in that we are interested in whether ESG mandates facilitate more forward-looking, value-relevant firm-level information to be incorporated into share price in a timely manner, bearing in mind, price discovery efficiency outcome is crucial to realize tangible capital market benefits (Brown et al., 2004; Easley & O'Hara, 2004; Christensen et al., 2021). With different levels or strictness of ESG mandatory disclosure, we also reveal potential spill-over effects (Admati & Pfleiderer, 2000; Baginski & Hinson, 2016; Shroff et al., 2017) of ESG mandatory disclosure in countries with more flexibility for firm to comply with these mandates. We find evidence suggesting market participants are able to infer information for non-complying or non-disclosing firms from those complying or disclosing peers, so that price discovery efficiency for these firms is slowed but the non-disclosed firm-information ultimately being incorporated into share prices. Our research also extends previous literature focusing on the economic consequences of voluntary ESG or CSR disclosure in terms of higher stock liquidity, lower cost of capital and better investment efficiency (see Christensen et al., 2021 for a comprehensive review).

Third, the empirical literature exhibits a heavy focus on disclosure regulation in the United States, while a global setting could provide opportunity for tighter research designs to strengthen the causal inferences of mandatory ESG disclosure policy that are not feasible in a U.S. setting (Leuz & Wysock, 2016). We respond to the call from Leuz and Wysock (2016) and focus on the country-level ESG mandatory disclosure policy in a global setting so that we can establish a control group from countries without ESG disclosure treatments where individual firms are less likely to be affected directly or indirectly by ESG mandatory disclosure policy from another country and thus provide a better benchmark to reveal the real impacts of ESG mandatory disclosure. What's more, our difference-in-difference approach, by mitigating identification issues, not only reveals the various impacts, via different channels

related to both internal and external demands for ESG disclosure, but also the real economic impacts of ESG mandatory disclosure regulation on stock markets. Our analysis should have powerful implications for regulators to evaluate the benefits and costs of ESG mandatory disclosure regulation.

Finally, a caveat of many of the prior studies is that they tend to concentrate on specific disclosure items (e.g., mine safety records or greenhouse gas emission) in a single country[2]. Our study looks at mandates for ESG disclosure, which comprehensively cover all ESG activities taking place within a firm around the world and thus likely add to literature with more powerful evidence on the benefits and costs trade-off related to ESG disclosure regulation.

The remainder of the paper is organized as follows. Section 2 reviews the literature and develops the main hypotheses. Sample and research design are described in Section 3. Section 4 presents the results of baseline models, robustness tests, heterogeneous treatment effects, and additional tests. The final section concludes.

2. Related literature and hypothesis development

Recent literature has moved away from a static market efficiency view and suggest that market efficiency is dynamic and an efficient price discovery process, by incorporating all available public and/or private information in a timely manner, is crucial to strengthen market

[2] For example, Christensen et al. (2017) examine the real effect of the mine-safety disclosure required by the Dodd-Frank Wall Street Reform and Consumer Protection Act of 2010 in the U.S, and find that the safety of coal mines improves but productivity declines. Chen et al. (2018) exploit the CSR disclosure mandate issued by Shanghai and Shenzhen Stock Exchanges in China which took effect for fiscal year ending on or after 31st December 2008. They find a decrease in overall industrial wastewater and CO_2 emissions in cities with more regulated firms. They further document that firms subject to the mandate experiences deterioration in profitability. Grewal et al. (2019) focus on short-window returns to events leading to the passage of EU directive mandating the disclosure of non-financial CSR information (EU Corporate Social Responsibility Directive: NFRD 2014/95/EU). They show on average a negative market reaction but positive returns for firms with more CSR disclosure and better CSR performance before the mandate came into force. Downar et al. (2021) investigate whether a mandate of Greenhouse gas (GHG) emissions introduced by the U.K government generates pressure for firms to decrease their emissions. They show that firms affected by the mandate reduce their emissions by about 8%, which is accompanied with a significant increase in production cost. Finally, Fiechter et al. (2022) also examine the EU Corporate Social Responsibility Directive (NFRD 2014/95/EU) that requires qualified firms to disclose non-financial information from fiscal year 2017. The report that firms increase their CSR activities and they do so even before the mandate took effect.

discipline (Grossman & Stiglitz, 1980; Holmström & Tirole, 1993; Edmans, 2009; Zhang et al., 2017, 2022; Christensen et al., 2021) and thus reduce the cost of equity capital (Verrecchia, 2001; Brown et al., 2004; Easley & O'Hara, 2004). How information is made available to market participants will impact upon the whole dynamic price discovery process by affecting the information asymmetries among investors who are differently informed about the fundamental investment value of a firm (Verrecchia, 2001; Easley & O'Hara, 2004). Under this dynamic market efficiency view, any information disclosure, including ESG disclosure, could reduce the overall information asymmetry between corporate insiders and external market participants but it is not clear yet how ESG mandatory disclosure could affect a price discovery process and its efficiency.

Some researchers suggest that ESG mandatory disclosure could improve price discovery efficiency because it increases the volume and quality of ESG information (Ioannou & Serafeim, 2019; Grewal & Serafeim, 2020), reduces the cost of information collection, processing and verification (Christensen et al., 2021), increases the participation of both informed and un-informed investors (Merton, 1987; Brown et al., 2004), and increases the competition among informed investors for a quick incorporation of information into share prices via informed trading (Bushman & Smith, 2001; Massa et al., 2015; Zhang et al., 2022). In the absence of mandatory ESG disclosure, firms might withhold important information. However, ESG mandatory disclosure, by directly disseminating a large quantity of information that otherwise would likely have been privately discovered and traded on at some later date, can preempt those future private information events and improve price discovery efficiency (Brown et al., 2004; Easley & O'Hara, 2004). For example, using ESG disclosure data disclosed in Bloomberg, Grewal and Serafeim (2020) report that on average U.S listed firms provide only 18% of the prescribed Sustainability Accounting Standard Board (SASB) disclosure items (which serve as benchmark for financially material ESG information).

Ioannou and Serafeim (2019), who compare firms from four countries with CSR disclosure mandates before 2011 (China, Denmark, Malaysia and South Africa), find that firms in countries with the mandates increase the volume and quality of CSR disclosure in the post-mandate period and are more likely to seek assurance for their disclosure. In addition, mandatory disclosure has regular disclosure frequency, transparency and comparability arising from standardization, which reduces the cost of obtaining, processing and comparing ESG information (Christensen et al., 2021). This ESG information attracts the attention of all investors, leading to more risk sharing and liquidity support from un-informed investors (Merton, 1987; Brown et al., 2004), better incentivized informed investors under increased competition (Bushman & Smith, 2001; Massa et al., 2015; Zhang et al., 2022), mitigating discreet informed trading which adds noise to the price discovery process (Grossman & Stiglitz, 1980; Ferreira et al., 2011; Zhang et al., 2017), and ultimately promote price discovery efficiency (Brown et al., 2004; Easley & O'Hara, 2004).

However, there are concerns on the effectiveness of ESG mandatory disclosure to promote price discovery efficiency because of its complex and qualitative nature (Christensen et al., 2021). Without clear guidance on the metrics for ESG information disclosure that firms have to provide, there are difficulties in disclosure standardization and regulation enforcement (Park & Ravenel, 2013; Bingler et al., 2022) plus a high risk of manipulation by management (Hermalin & Weisbach, 2012 for a review). Facing potentially more serious agency problems in ESG disclosure, ESG mandatory disclosure may fail to increase the high quality ESG information for market participants[3] and thus fail to reduce the cost of information collection, processing and verification (Park & Ravenel, 2013; Bingler et al., 2022). In addition, the high

[3] In addition, ESG mandatory disclosure may not change firm disclosure behavior rather, they may continue at the same level of ESG disclosure if the pre-existing ESG voluntary disclosure is adequate to satisfy the mandatory regulatory requirements. Fiechter et al. (2022) examine the EU Corporate Social Responsibility Directive (NFRD 2014/95/EU) that requires qualified firms to disclose non-financial information from fiscal year 2017. They report that firms increase their CSR activities and they do so even before the mandate took effect.

cost in establishing superior insights of fundamental investment value could stimulate more discreet informed trading by informed investors, adding more noise to the price discovery process and leading to a poor price discovery efficiency (Grossman & Stiglitz, 1980; Ferreira et al., 2011; Zhang et al., 2017).

Hence, it is ex ante unclear whether mandatory ESG disclosure regulation enhances the availability and quality of ESG information and thus improves price discovery efficiency. For empirical testing purposes, if the main impact of ESG mandatory disclosure on price discovery process is to improve information availability and quality, which reduce information asymmetries among differently informed investors and improve risk-sharing and participation by both un-informed and informed investors in the price discovery process, we predict that mandatory ESG disclosure should lead to an improved price discovery efficiency. Based on the above discussion, we propose H1 as follows:

H1: Mandatory ESG disclosure is associated with higher share price efficiency

3. Research methods

3.1. Sample and data

Our sample includes public firms from 40 countries for the period 2000-2019.[4] We include companies delisted during the sample period. We exclude firm-year observations with missing data in dependent or explanatory variables. We also exclude firms in financial sectors with the standard industrial classification (SIC) codes 6011-6799. Because mandatory ESG

[4] We select 40 developed and emerging countries from the constituent countries of the MSCI World Index and the MSCI Emerging Markets Index. The sample countries must have data/information for all country-level variables.

disclosure policy is likely to be simultaneous with other institutional reforms, we restrict our sample period of treatment group (i.e., countries with the implementation of mandatory ESG disclosure) to two years before the policy effective year, the policy effective year, and three years after the policy effective year.[5] This [-3, +3] sample results in a final sample of 76,000 firm-year observations for the price nonsynchronicity sample, and 76,952 firm-year observations for the price timeliness sample. Table 1 reports the sample distribution by country. As shown in the table, China has the largest number of observations in the treatment group with mandatory ESG disclosure reforms (3,129 and 3,150), and United States has the largest number of observations in the control group without mandatory ESG disclosure reforms (26,595 and 27,056). The United States also contribute more than 30% of observations for the full samples.

[Insert Table 1 about here]

We obtain share price and financial data of public firms from Refinitiv Datastream and Refinitiv Worldscope. The effective years of mandatory ESG disclosure reform are collected from the study of Krueger et al. (2021).[6] Major corporate governance reform years are collected from the study of Fauver et al. (2017). Firm-level corporate governance data is from Refinitiv Datastream. Institutional ownership data is from Refinitiv Ownership Database. The status of firm-level ESG reporting is collected from Refinitiv ESG Database. Data for legal institution quality and other country-level financial and macroeconomic variables is collected from the

[5] Fauver et al. (2017) restrict their sample period to five years before and after corporate governance reform to mitigate the impact of confounding events.

[6] Krueger et al. (2021) analyze ESG disclosure policies around the world and create a list of effective years of ESG disclosure mandate. For example, UK released the amendments of the Companies Act 2006 in 2013. According to the regulation, all public companies are required to produce reports on matters such as strategy and business model, levels of greenhouse gas emissions, human rights, and diversity in the company.

World Bank. Data with respect to the country-level attitudes on environment protection is collected from the World Values Survey.

3.2. Measuring price discovery efficiency

An efficient price discovery process, by incorporating all available public and/or private information in a timely manner, is crucial for a dynamic market efficiency (Grossman & Stiglitz, 1980; Verrecchia, 2001; Brown et al., 2004; Easley & O'Hara, 2004). We measure price discovery efficiency using two proxies, including stock price nonsynchronicity to capture to what extent the price discovery process incorporates firm-level information into the price and the timeliness of price discovery to capture how timely forward-looking information is incorporated into share price[7]. Following Morck et al. (2000) and Bennett et al. (2020), we construct the stock price nonsynchronicity measure based on the proportion of return variation that cannot be explained by the market and sector return where the firm resides. For each firm *i* and year *y* in our sample, we run following time-series regression:

$$r_{i,y,t} = \beta_{0,i,y} + \beta_{1,i,y}\, r_{m,y,t} + \beta_{2,i}\, r_{n,y,t} + \varepsilon_{i,y,t}, \quad (1)$$

where $r_{i,y,t}$ denotes the daily return time-series of firm *i* in year *y*, $r_{m,y,t}$ and $r_{n,y,t}$ are the day *t* value weighted return indices of the country and sector the firm *i* operates in. In the empirical analysis, the market index is constructed using value-weighted average return of all the constituent firms within a market. Similarly, we construct sector indices by value-weighted

[7] We do not use private-information risk measurement or PIN here as it only reflects the information asymmetries among differently informed investors while our focus is on the efficiency of price discovery process focusing on to what extend and how timely that share price incorporates all available public and/or private firm-level information.

average return of all firms in a sector specified by two-digit standard industry classification code (SIC).

This bi-index model leads to a natural decomposition of the stock return variation, a systematic part that is synchronous to other firms, and a firm-specific part that is informative about the firm itself. We use the log transformed $R^2_{i,y}$ adjusted for degree of freedom to capture the informativeness of the stock for the firm:

$$PSI_{i,y} = ln\left(\frac{1 - R^2_{i,y}}{R^2_{i,y}}\right) \tag{2}$$

$$R^2_{i,y} = 1 - \frac{T_{i,y} - 1}{T_{i,y} - k_{i,y} - 1} \frac{s^2(\varepsilon_{i,y})}{s^2(r_{i,y})} \tag{3}$$

where $T_{i,y}$ and $k_{i,y}$ are the number of daily return observations and number of explanatory variables in the index model respectively and $s(x_{i,y})$ denote the sample standard deviation of x for firm i in year y. A firm has large *PSI* when its stock price moves less synchronously with the market and sector index, and therefore contains a larger idiosyncratic component and more firm-specific information.

To measure the timeliness of price discovery, we use the measure based on Beekes et al. (2016). The measure is based on the assumption that most of the contents in annual earnings reports are captured by the market before earnings release day (Ball & Brown, 1968). For each fiscal year, the measure traces the share price over 365 calendar days ending 14 days after the firm's annual earnings announcement day, which is an important event and is common to all firms in all countries. The measure captures the speed with which forward-looking information contained in forthcoming annual earnings report is reflected in stock price up to the day of the

annual earnings announcement. Specifically, the timeliness of price discovery (*TIMELINESS*) is calculated as:

$$TIMELINESS = \left(\left(\sum_{t=-365}^{t=-1} |ln(P_0) - ln(P_t)|\right) - 0.5\right)/365 \quad (4)$$

where P_t is the daily market-adjusted stock price of a firm from 365 calendar days before the annual earnings announcement day until 1 day before the annual earnings announcement day. P_0 is the price 14 days after the annual earnings announcement day, which reflects the intrinsic value of the year. In order to reduce the impact of volatility, we deflate the measure by one plus the absolute rate of return on the share over the time window used to calculate the timeliness metric. We forward-fill prices on days when there is trading. We set the ending date to be 14 days after the earnings release date, which allows the market to gradually absorb information (Beaver, 1968). The 0.5 adjustment is included to recognize that the flow of information is reflected in returns over the day (Beekes et al. 2016). The larger the value of *TIMELINESS*, the longer it takes a firm's share price to capture information and converge to P_0, suggesting slower price timeliness.

3.3. Control variables

According to the prior research, our regression models control for other country-level and firm-level variables to explain market efficiency (e.g., Bennett et al., 2020; Bolton and Kacperczyk, 2021; Kacperczyk et al., 2021). We control the following country-level variables: *CO2*, the natural logarithm of CO_2 emissions in metric tons per capita; *CGRF*, a dummy variable that equals to one if a country-year is after the year when a major corporate governance reform becomes effective, and zero otherwise. We obtain the information on corporate

governance reforms from the work of Fauver et al. (2017); *LIQ*, the sum of three World Governance Indicators (government effectiveness, regulatory quality, and the rule of law) and the anti-self-dealing index from Djankov et al. (2008). The WGI and anti-self-dealing indices are rescaled to be between 0 and 1; *MKTCAP*, market capitalization of listed domestic companies divided by GDP; *GDPG*, annual percentage growth rate of GDP. We control the following firm-level variables: *SIZE*, the natural logarithm of total assets of a firm in U.S. dollars; *IO*, number of shares held by institutional investors divided by total number of shares outstanding; *PROFIT*, earnings before interest, taxes and depreciation divided by total assets; LEV, Total debt divided by total assets; *BM*, book value of equity divided by market value of equity; *CASH*, cash and short-term investments divided by total assets; *CAPEX*, capital expenditures divided by total assets; *TURN*, share trading volume divided by adjusted shares outstanding; *NUMEST*, the natural logarithm of number of analysts following a firm in a year; *VOLTY*, the standard deviation of daily stock returns over the 365 calendar days prior to fiscal year end date. Detailed definitions of all variables and data resources are provided in Table A1 in Appendix A.

Table 2 provides descriptive statistics for variables used in main tests. All time varying variables are winsorized at the top and bottom 1% to control for outliers. We only report the statistics of variables used in our baseline models and the statistics of explanatory variables are based on the price nonsynchronicity (*PSI*) model. Price nonsynchronicity (*PSI*) ranges from -1.693 to 6.016, with a mean and median of 1.501 and 1.299, and a standard deviation of 1.452. Price timeliness (*TIMELINESS*) ranges from 0.029 to 0.402, with a mean and median of 0.133 and 0.115, and a standard deviation of 0.078. The main explanatory variable of interest, *ESGPOST*, is an indicator variable that is equal to one for all subsequent years after the mandatory ESG disclosure policy becomes effective in a country, and zero otherwise. *ESGPOST* has 9,759 observations with value of one, about 12.8% of all observations (76,000)

in the *PSI* model. *ESGPOST* has 10,097 observations with value of one, about 13.1% of all observations (76,952) in the *TIMELINESS* model. Table 3 provides the Pearson correlation coefficients of the main variables. The correlation between *PSI* and *ESGPOST* is 0.02, suggesting that price informativeness improves after the implementation of the mandatory ESG disclosure reform. The correlation between *TIMELINESS* and *ESGPOST* is -0.02, suggesting that price timeliness improves after the implementation of the ESG disclosure reform. In the following sections, we test our hypotheses using multivariate regressions controlling for other variables that could affect market efficiency.

[Insert Table 2 & Table 3 about here]

4. Regression results

We begin our regression analysis by estimating the baseline model that examines the effects of mandatory ESG disclosure on *PSI* and *TIMELINESS* respectively. Robustness of the main results is then checked by using alternative mandate effective window, exclusion of treatment countries with simultaneous reforms, exclusion of observations from the U.S (representing more than 30% of the entire sample), exclusion of ESG sensitive industries, placebo tests using pseudo effective years of mandates, and OLS estimation controlling for industry, country and year effects. In order to further strengthen causal inferences of mandatory ESG disclosure policy, we conduct two additional sets of tests. First, we investigate the potential channels through which ESG mandate could impact share price discovery efficiency by focusing on the heterogeneous treatment effects based on important country and firm characteristics which affect the demand on ESG disclosure. Second, we confirm the real stock

market changes due to ESG disclosure by looking at cross-sectional patterns of future stock returns, institutional ownership change and firm valuation.

4.1. The effects of mandatory ESG disclosure on price informativeness and timeliness

We first estimate the baseline regression models shown in Eq. (5). The dependent variables are price nonsynchronicity (*PSI*) and timeliness of price discovery (*TIMELINESS*) respectively. The main independent variable of interest is the implementation of mandatory ESG disclosure policy (*ESGPOST*). Among the 40 sample countries, 25 countries launched ESG disclosure reforms in different years during the sample period and 15 countries did not make such a change. This allows us to adopt a difference-in-difference design in multiple treatment groups and multiple time periods (Imbens & Wooldridge, 2009). Our DID approach compares changes in market efficiency after the ESG disclosure reforms with changes in market efficiency for countries without disclosure reforms during the sample years. The approach is commonly used in the literature to mitigate endogenous issues to strengthen causal inferences of the empirical investigation (Bertrand & Mullainathan, 2003; Fauver et al., 2017; Gao & Zhang, 2017). The baseline model specification is shown as follows:

$$PSI_{i,t} \text{ or } TIMELINESS_{i,t} = \alpha + \beta_1(ESGPOST) + \sum \beta_m \, CONTROLS + FIRM\ FE + YEAR\ FE + \varepsilon_{i,t} \quad (5)$$

where *i* and *t* stand for firm and year respectively. *ESGPOST* is an indicator variable equal to one starting the first year and subsequent years after the mandatory ESG disclosure policy became effective in the country and zero otherwise. *CONTROLS* includes firm- and country-level control variables. *FE* stands for firm and year fixed effects. Based on Hypothesis 1, we

expect ESG disclosure to be associated with more firm-specific information being incorporated into stock prices in a more timely manner and thus we expect β_1 to be positive in the *PSI* baseline model and negative in the *TIMELINESS* baseline model. In all regression estimations, we use robust standard errors clustered at the country level because the ESG disclosure policy is a country-level decision.

Columns 1 & 4 of Table 4 present the results of baseline models. The coefficient on *ESGPOST* is significantly positive in the *PSI* model (β_1=0.139, p<0.01) and significantly negative in the *TIMELINESS* model (β_1=-0.009, p<0.01). The results suggest that share price incorporates more firm-specific information in a more timely manner following the ESG disclosure reforms. Our hypotheses H1 is therefore supported. The effects are also economically significant. Column 1 shows that price informativeness increases by 9.3% relative to the mean following the reforms.[8] Column 4 shows that price timeliness increases by 6.8% relative to the mean following the reforms.[9] Columns 2 & 5 estimate the baseline models after including an interaction term between *ESGPOST* and comply-or-explain approach (*COE*). Columns 3 & 6 estimate the baseline models after including an interaction term between *ESGPOST* and all-at-once approach (*ATO*). ESG mandatory disclosure provides flexibility for firms in disclosing ESG information (i.e., explanation of no-comply, or not to disclose all ESG related information) and this is expected to provide incentives for some firms to withhold information, however, market participants could potentially infer this withheld information by comparison with ESG data from those firms which do comply or disclose (Admati & Pfleiderer, 2000; Baginski & Hinson, 2016; Shroff et al., 2017). If so, this potential spill-over effect of ESG mandatory disclosure should be evidenced with a partially compromised price discovery efficiency with unaffected price nonsynchronicity (*PSI*) but a reduced timeliness of price

[8] The magnitude of impact of *ESGPOST* on *PSI* is calculated as 0.139 (coefficient on *ESGPOST* in column 1 of Table 4) ÷ 1.501 (the sample mean of *PSI* in Table 2) = 9.3%.
[9] The magnitude of impact of ESG*POST* on *TIMELINESS* is calculated as 0.009 (absolute value of coefficient on *ESGPOST* in column 4 of Table 4) ÷ 0.133 (the sample mean of *TIMELINESS* in Table 2) = 6.8%.

discovery (*TIMELINESS*). This slower speed for share price to incorporate withheld information is due to the effort and time needed to be spent by market participants to infer the withheld information, derived from data supplied by those complying or disclosing firms. As predicted, columns 2 shows that the coefficient on *ESGPOST*×*COE* is insignificant, suggesting that the effect of reforms on *PSI* is similar across comply-or-explain disclosure approach and stricter ESG disclosure mandates. Columns 3 shows that the coefficient on *ESGPOST*×*ATO* is insignificant, suggesting that the effect of reforms on *PSI* is similar across the countries with the introduction of mandatory environmental, social and governance disclosure all at once and countries with gradual implementation of mandatory disclosure. As predicted, Columns 5 shows that the coefficient on *ESGPOST*×*COE* is significantly positive, suggesting that the effect of reforms on *TIMELINESS* is less pronounced for countries that adopt a comply-or-explain disclosure approach. Columns 6 shows that the coefficient on *ESGPOST*×*ATO* is significantly negative, suggesting that the effect of reforms on *TIMELINESS* is more pronounced for countries that introduce mandatory environmental, social and governance disclosure all at once.

[Insert Table 4 about here]

With respect to control variables, stock price informativeness and timeliness are significantly related to legal institution quality (*LIQ*), GDP growth (*GDPG*), firm size (*SIZE*), profitability (*PROFIT*), financial leverage (*LEV*), boot-to-market ratio (*BM*), cash holding (*CASH*) and capital expenditure (*CAPEX*). The findings are consistent with previously documented evidence (Beekes et al., 2016; Bennett et al., 2020) and indicate that economic conditions and firm fundamentals can affect price discovery efficiency.

4.2. Robustness checks

Table 5 presents robustness checks of the findings from the baseline regression models. Panel A of Table 5 shows the results using a [-1, +1] sample, which restricts sample period to one year before and including the policy effective year, and one year after the policy effective year. The narrower event window can further reduce the impact of other simultaneous reforms implemented in the sample countries. Moreover, we create a restricted [-3, +3] sample that requires a firm to appear at least one year in the pre-reform period and one year in the post-reform period. The results of using the two alternative samples are similar to those reported in columns 1 & 4 of Table 4.

Columns 1 & 2 of Panel B of Table 5 present the results excluding treatment countries with simultaneous reforms and excluding US firms. Columns 3 & 4 of Panel B present the results excluding US firms. Australia, Canada and France launched major corporate governance reforms in 2004, 2004 and 2003 respectively. The governance reforms took place within the event windows of ESG disclosure mandate in the countries. To rule out the impact of confounding events, we exclude firms from the three countries as a robust check.[10] It is likely that our results are driven by the US firms which are over 30% percent of our sample. We therefore re-estimate the baseline models without US firms. The results of Panel B show that the effects of *ESGPOST* remain unchanged.

Panel C of Table 5 presents a policy timing analysis and results excluding ESG sensitive industries. In columns 1 & 2 of Panel C, *ESGPOST* is replaced by three reform timing indicator variables: *Pre-ESG disclosure years*, which equals to one for the two years before the policy effective year; *First effective year*, which is equal to one for the first year after the policy

[10] In unreported tests, we also exclude countries from the control group with corporate governance reforms that took place within the event window of ESG disclosure mandate. Our results remain robust.

effective year; and *Year 2+*, which is equal to one for the second and third years after the reform becomes effective and zero otherwise. To confirm the impact of ESG disclosure reform, we expect insignificant effects of *Pre-ESG disclosure years* and significant effects of post-reform indicator variables. For both *PSI* and *TIMELINESS* models, the results show insignificant coefficients on the *Pre-ESG disclosure years* indicator variable and significant coefficients on the *First effective year* indicator variable. The coefficient on *Year 2+* indicator variable is significantly positive in the *PSI* model. These results suggest that the improvement in price efficiency materializes after the ESG disclosure reform becomes effective.

Bolton and Kacperczyk (2021) indicate that only a few salient industries produce the most fraction of carbon emissions. There might be designated regulations or by-laws in place for the salient industries before the ESG disclosure policy is implemented. It is therefore likely that the existence of salient industries in our samples prevents us from analyzing marginal effects of the new policy on an average firm. Columns 3 & 4 of Panel C of Table 5 present the analysis excluding salient industries. The salient industries we define are mining (SIC>=1000 and SIC<=1499), oil & gas (SIC>=1311 and SIC<=1389), chemicals (SIC>=2800 and SIC<=2890) and utilities and transportation (SIC>= 4000 and SIC<= 4999). Regarding the effects of the ESG disclosure reform on informativeness and timeliness, our previous conclusions are unchanged.

Panel D of Table 5 presents the results of placebo tests, which verify the parallel trend assumption underlying our DID estimation. Specifically, we aim to show that, in the absence of the ESG disclosure reforms, the average change in price informativeness and timeliness would have been the same for the treatment and benchmark groups. In the first placebo test, we set the pseudo effective year as three years before the actual reform effective year. In the second placebo test, we set the pseudo effective year as three years after the actual reform effective year. Panel C shows that the coefficients on *ESGPOST* are not significant for all

models, suggesting that in the absence of treatment, our treatment and benchmark samples exhibit a similar trend in price efficiency.

Panel E of Table 5 presents the results of pooled OLS estimation controlling for industry, country and year effects. Our baseline model estimation with firm fixed effects (i.e., within firm estimation) does not allow for the inclusion of industry or country fixed effects due to multicollinearity. The concern is that uncontrolled industry and country fixed effects may cause biased coefficient estimation. Bolton and Kacperczyk (2021) find that including industry effects changes both significance and magnitude of the effects of carbon emissions on stock returns. We construct industry, country and year dummy variables and include them in the baseline regression models.[11] As shown in columns 1 & 2 of Panel E, the results remain unchanged after controlling for industry, country and year effects.

[Insert Table 5 about here]

4.3. Heterogeneous treatment effects

To provide further evidence that the mandatory ESG disclosure reforms indeed cause the change in market efficiency, we create interaction terms to examine the heterogeneous treatment effects. Examining heterogeneous treatment effects using interaction terms can help to alleviate the endogeneity concerns due to omitted explanatory variables. It is less likely to have an omitted control variable correlated with the interaction term than with linear terms (Claessens & Laeven, 2003; Raddatz, 2006; Gao & Zhang, 2017). Moreover, tests of heterogeneous effects provide further managerial and policy implications. We design four sets

[11] The industry dummy variables are based on the Fama-French 48 industry groups.

of tests to explore the cross-sectional patterns in market efficiency with a potential causal effect of the ESG disclosure policies.

First, if the improved efficiency after the reforms is indeed due to increased disclosure of ESG information, the treatment effect should be stronger in countries in which priority is given to environmental protection over economic growth. Moreover, it is more likely to see the introduction of ESG disclosure reforms in a country that prioritizes environmental issues. We obtain the information on attitudes on environment protection from the World Value Survey (WVS) database. We select four waves of the WVS covering the period from 1999 to 2020. We create an indicator variable, *Environment first*, that takes the value of one for the countries where more of the population agree that environment protection should be given priority over economic growth and zero otherwise. *Environment first* is estimated based on responses to the WVS questions: "Which of them comes closer to your own point of view? 1. Protecting the environment should be given priority, even if it causes slower economic growth and some loss of jobs. 2. Economic growth and creating jobs should be the top priority, even if the environment suffers to some extent." We recode the response to this question to one if a survey participant chose statement 1 and zero otherwise. We then calculate the mean score of responses for each country-wave. Within a wave, the score is calculated once and applies to all country-years covered by the wave. An average score is finally calculated for each country across the waves of WVS. Higher scores suggest that more people put environment protection ahead of economic growth. We create an indicator variable, *Environment first*, that takes the value of one if the attitude score is above the sample median and zero otherwise. We re-estimate Eq. (5) by replacing the *ESGPOST* indicator with *ESGPOST* × *Environment first* and *ESGPOST* × *Not environment first*. The *Not environment first* indicator is defined as (1 – *Environment first*). Panel A of Table 6 presents the results. The coefficients on *ESGPOST* × *Environment first* are significant at the 1% or 5% level, whereas the coefficients on *ESGPOST*

× *Not environment first* are insignificant. The result indicates that the effect of ESG disclosure reform is more pronounced in countries where the value of environment first prevails.

[Insert Table 6 about here]

Second, the effects of ESG disclosure reform may depend on firms' status of ESG reporting. If it is the first time for a firm to produce and/or submit ESG-related reports due to ESG mandatory disclosure regulations, the impact of mandatory ESG disclosure should lead to a complete new set of information available to market participants and thus its impacts on price discovery should be more pronounced for the firm. We create an indicator variable, *ESG reporting firms* (*ESGRPT*), that takes the value of one if a firm has ESG reports uploaded in the Refinitiv ESG database (formerly known as ASSET4) in a year and zero otherwise. In regression estimation, we replace the *ESGPOST* indicator with *ESGPOST* × *ESG reporting firms* and *ESGPOST* × *NonESG reporting firms*. The *NonESG reporting firms* indicator is defined as (1 – *ESG reporting firms*). Panel B of Table 6 presents the results. The coefficients on *ESGPOST* × *NonESG reporting firms* are significant at the 1% level for both *PSI* and *TIMELINESS* models. The coefficient on *ESGPOST* × *ESG reporting firms* is only significant at the 10% level for the *PSI* model. The result indicates that the effect of ESG disclosure reform is more pronounced for firms without previous ESG information disclosure practice.

Third, prior research documents that good corporate governance improves disclosure and price efficiency (Beekes & Brown, 2006; Beekes et al., 2016; Kacperczyk et al., 2021). The mandatory ESG disclosure reforms are likely to play a governance role if firms lack sound internal governance. To test the conjecture, we create an indicator variable, *High corporate governance quality*, that takes the value of one for the firms whose average corporate governance score is above the sample median, and zero otherwise. We adopt the approach of

Chung et al. (2010) and construct a firm-level index of corporate governance quality (*CGQ*) with 22 underlying governance characteristics. Appendix B gives details of governance items and criteria. If a firm meets a characteristic successfully in a given year, it will score one point and zero otherwise. We weight all characteristics equally to obtain total *CGQ* index for a year. Average CGQ index is then calculated to represent the overall corporate governance quality of a firm during the sample period. In regression estimation, we replace the *ESGPOST* indicator with *ESGPOST* × *High corporate governance quality* and *ESGPOST* × *Low corporate governance quality*. The *Low corporate governance quality* indicator is defined as (1 – *High corporate governance quality*). Panel A of Table 7 presents the results. The coefficients on *ESGPOST* × *Low corporate governance quality* are significant at the 1% level for both *PSI* and *TIMELINESS* models. The coefficient on *ESGPOST* × *High corporate governance quality* is significant at the 10% level for the *TIMELINESS* model. The result shows that the effect of ESG disclosure reform is more pronounced for firms with poorer corporate governance, suggesting that external mandatory ESG reform substitutes for internal corporate governance in enhancing price efficiency.

[Insert Table 7 about here]

Lastly, considering that country-level legal institutions influence investor protection, corporate governance and firm value (La Porta et al., 1997, 1998, 2000, 2002), the treatment effects are likely to be different across countries with different legal institution quality. On one hand, better legal institutions may help ESG disclosure reform to take effect via stronger enforcement of rules and regulations, and therefore the treatment effect is likely to be more pronounced in countries with better institutional quality. On the other hand, mandatory ESG disclosure reform may substitute for legal institutions in affecting price efficiency because the

reforms can be implemented through other channels instead of completely through legal institutions. To explore the empirical question, we create an indicator variable, *High legal institution quality*, that takes the value of one if the legal institution quality index of a country (*LIQ*) is above the sample median, and zero otherwise. We re-estimate the baseline models by replacing the *ESGPOST* indicator with *ESGPOST* × *High legal institution quality* and *ESGPOST* × *Low legal institution quality*. The *Low legal institution quality* indicator is defined as (1 – *High legal institution quality*). Panel B of Table 7 presents the results. The coefficients on *ESGPOST* × *Low legal institution quality* are significant at the 1% level for both *PSI* and *TIMELINESS* models, whereas the coefficients on *ESGPOST* × *High institutional quality* are insignificant. The result indicates that the effect of ESG disclosure reform is more pronounced in countries where the value of environment first prevails.

4.4. Do ESG mandatory disclosure lead to real stock market changes?

Our results of main tests shed some light on the contemporaneous impact of the ESG disclosure policy on market efficiency. We continue to confirm if investors care about the changes due to the new policy and whether ESG mandatory disclosure indeed leads to real stock market change in a longer term. Relevant theories suggest that if the ESG disclosure reforms help to reduce private information asymmetry, a lower cost of equity capital can be expected (Brown et al., 2004; Easley and O'Hara, 2004). Hence, we test the return predictability of the ESG disclosure reform. In addition to stock returns, we also examine the change in institutional ownership after the ESG disclosure reform. Previous studies have integrated relevant ESG factors into the analysis of pattern of stock returns. For example, Chava (2014) finds that firms that derive substantial revenues from the sale of coal or oil are associated with a higher implied cost of capital. Bolton and Kacperczyk (2021) find that carbon

emissions of US firms are significantly positively related to the cross-sectional stock returns, suggesting that investors have demanded compensation for their exposure to carbon emission risk. The authors also find that institutional investors indeed divest from firms associated with high carbon emissions. Pedersen et al. (2021) sort stocks into quintiles based on individual ESG proxies and then form portfolios that goes long on the best ESG stocks and short on the worst ESG stocks. The authors find that the portfolio based on G (i.e., governance) has earned significant abnormal returns. They also find that the ESG proxies are positively associated with institutional holdings in favor of greener firms.

We calculate annual market-adjusted stock returns using the same estimation window as that defined in the estimation of *TIMELINESS*. The change in institutional ownership is calculated as the absolute value of institutional ownership in year *t*+1 minus institutional ownership in year *t*. We estimate the following fixed-effects regression model:

$$RET_{i,t+1} \; or \; \Delta IO_{i,t+1} = \alpha + \beta_1(ESGPOST) + \sum \beta_m \, CONTROLS_{i,c,t} + FIRM \; FE + YEAR \; FE + \varepsilon_{i,t} \quad (7)$$

where $RET_{i,t+1}$ refers to annual stock return of company *i* in year *t*+1. $\Delta IO_{i,t+1}$ is the absolute value of institutional ownership in year *t*+1 minus institutional ownership in year *t*. *ESGPOST* is defined in the way as in Eq. (5). The vector of controls includes all the firm- and country-specific variables controlled in the *PSI* and *TIMELINESS* models. We include firm age (*AGE*) and stock price momentum (*MM1*) as additional control variables (e.g., Fauver et al., 2017; Kacperczyk et al., 2021). Firm fixed effects and year fixed effects are also included. We cluster standard errors at the country level. The coefficient of interest is β_1. For the return model, the expected sign of β_1 is negative because the ESG disclosure is likely to reduce the risk premium of information asymmetry and ultimately reduce investors' expected return and cost of equity

capital. For the institutional ownership model, the expected sign of β_1 is positive meaning that investors may either increase investments in firms associated with good ESG performance or divest from firms associate with poor ESG performance after the ESG disclosure reforms become effective.

We are also interested to test if the ESG reforms will ultimately influence firm value, given the alleged effects on price efficiency and returns. Firm value is measured by Tobin's q, which is calculated as total assets minus book value of equity plus market value of equity divided by total assets. We estimate the following fixed-effects regression model:

$$TQ_{i,t} = \alpha + \beta_1(ESGPOST) + \sum \beta_m CONTROLS_{i,c,t} + FIRM\ FE + YEAR\ FE + \varepsilon_{i,t} \quad (8)$$

where $TQ_{i,t}$ refers to the Tobin's q of company *i* in year *t*, calculated as total assets minus book value of equity plus market value of equity divided by total assets. The explanatory variables and fixed effects used are the same as defined in Eq. (7). We cluster standard errors at the country level. The coefficient of interest is β_1. The expected sign of β_1 is positive because the ESG disclosure reform is likely to increase firm value if the reform reduces the cost of equity capital all other things being equal.

We report the regression results of the additional tests in Table 8. Columns 1 & 2 show the results for regression models as shown in Eq. (7). Column 3 presents the results for regression model shown in Eq. (8). We find a negative and statistically significant effect of *ESGPOST* on future stock returns (*RET*) (β_1=-0.041, p<0.05) in column 1. The result suggests that mandatory ESG disclosure contributes to the information set so that risk premiums on ESG factors are reduced after the implementation of new policies. The ESG disclosure reform decreases stock returns by 4.1% annualized. Our finding echoes that of Bolton and Kacperczyk

(2021) and Pedersen et al. (2021). For example, Bolton and Kacperczyk (2021) document that a one-standard-deviation increase in firms' carbon emission can increase stock returns by up to 3.6% per annum. In column 2, the change in institutional ownership (ΔIO) shows a significant increase after the ESG reform (β_1=0.005, p<0.05), suggesting that institutional investors integrate ESG factors and adjust their portfolios accordingly. The result in column 3 shows that firm value (TQ) increases in the post-reform period (β_1=0.157, p<0.01). With respective to magnitude of effects, the mandatory ESG disclosure reforms are associated with an 11.9% increase in the change of institutional ownership, and an 8.5% increase in firm value relative to their means respectively.[12]

[Insert Table 8 about here]

5. Conclusion

Both scholars such as Nobel Laureate in Economics Oliver Hart and practitioners such as CEO and chairman of BlackRock, the largest asset management firm in the world, Larry Fink argue that the purpose of incorporation goes beyond shareholder value maximization to providing products and solving social problems such as climate change and social inequality. ESG disclosure mandates enable a wide audience to understand the implication of firms' activities and policies on social welfare. How though, does the stock market respond to the changes in relation to ESG developments and what are the real impacts of ESG mandatory disclosure on price discovery efficiency? These are fundamental questions for the emerging field of ESG and accounting/finance.

[12] The magnitude of impact of ESG*POST* on ΔIO is calculated as 0.005 (coefficient on *ESGPOST* in column 2 of Table 8) ÷ 0.042 (the unreported sample mean of ΔIO) = 11.9%. The magnitude of impact of ESG*POST* on *TQ* is calculated as 0.157 (coefficient on *ESGPOST* in column 3 of Table 8) ÷ 1.845 (the unreported sample mean of *TQ*) = 8.5%.

This paper examines the impact of mandatory ESG disclosure reforms launched around the world since early 2000s on price discovery efficiency in a sample of 40 countries. We undertake a difference-in-difference analysis and find robust evidence that the ESG disclosure reform has significantly improved price discovery efficiency. Heterogeneous treatment tests reveal the conditions and channels by which the reforms take effect. The effects of the ESG reforms are stronger for firms in countries that value the priority of environmental protection, for firms in countries of low institutional quality, for firms that do not release ESG related documents and for firms that lack complete corporate governance mechanisms. We find that institutional investors care about the reforms so that the real impacts of ESG mandatory disclosure lead to reduced future stock return (cost of equity capital), improved institutional ownership and firm valuation in the post-reform period.

Our research has implications to policy makers in a couple of ways. First, stock exchanges now face global competition to attract high quality companies to list and raise equity capital from investors. In order to strengthen their competition in the global financial market, it is crucial to prioritize ESG disclosure mandatory regulations, which can improve price discovery efficiency and reduce cost of equity capital. Second, flexibility in ESG mandatory regulation such as COE or step-by-step style in ESG mandatory disclosure is not as effective as strictly mandatory without such flexibility in promoting price discovery efficiency. However, it is better than no mandatory disclosure regulation because it could still generate spill-over benefits and improve the overall information environment and price discovery efficiency. Finally, despite mandatory disclosure having net benefits in promoting price discovery efficiency, the challenges remain in creating standardized reporting standards for ESG disclosure (Christensen, Hail, and Leuz 2021), which could further reduce the cost of information collection, processing and verification and maximize its benefits in promoting stock market development. Our analysis also has valuable implications for corporate managers,

board directors, and investors. For management and board directors, ESG disclosure practice could be perceived as a quality signal by investors to differentiate themselves from their competitors. Although institutional investors may be able to establish their insights out of ESG disclosure, retailing investors may need to be mindful to trade those shares with low level of ESG disclosure compliance.

Further studies can extend our analysis in a couple of ways. We focus on market level ESG disclosure regulation on overall price discovery efficiency in incorporating both financial and non-financial information. Further studies can extend to investigate how firm-level financial disclosure quality and ESG disclosure quality are affected by ESG disclosure regulation and via which channels that price discovery efficiency is promoted more. Second, we find some evidence of spill-over effects of ESG mandatory disclosure with compliance flexibilities. Further research could extend via which channels such spill-over effects are realized.

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Table 1

Number of firm-year observations by country and effective years of mandatory ESG disclosure policies.

Columns 1 & 2 show the number of firm-year observations by country based on the regression models as shown in Eq. (5) using the [-3, +3] sample. The effective years of mandatory ESG disclosure policies by country are outlined in column 3. Columns 4 & 5 indicate the reform approaches. The data on effective years of mandatory ESG disclosure reform and reform approaches are collected from Krueger et al. (2021).

	Number of Observations		Mandatory ESG disclosure policy year	Comply-or-explain regulation?	All-at-once disclosure?
	PSI sample	*TIMELINESS* sample			
Country	(1)	(2)	(3)	(4)	(5)
Argentina	47	47	2008	No	Yes
Australia	569	662	2003	No	No
Austria	162	163	2016	No	No
Belgium	797	804	-	-	-
Brazil	1,155	1,136	-	-	-
Canada	814	889	2004	No	Yes
Chile	139	143	2015	Yes	No
China	3,129	3,150	2008	No	Yes
Colombia	80	80	-	-	-
Czech	71	65	-	-	-
Denmark	737	740	-	-	-
Egypt	245	223	-	-	-
Finland	1,274	1,324	-	-	-
France	661	548	2001	No	Yes
Germany	1,409	1,450	2016	Yes	Yes
Greece	191	186	2006	No	Yes
Hungary	27	27	2016	Yes	Yes
India	2,562	2,554	2015	No	No
Indonesia	487	479	2012	No	No
Israel	259	242	-	-	-
Italy	646	653	2016	Yes	Yes
Japan	17,350	17,540	-	-	-
Korea	3,972	3,686	-	-	-
Malaysia	913	950	2007	Yes	No
Mexico	725	757	-	-	-
Netherlands	287	285	2016	Yes	No
Norway	380	401	2013	No	No
Pakistan	67	67	2009	No	Yes
Peru	41	42	2016	No	Yes
Philippines	423	398	2011	No	Yes
Poland	454	491	2016	No	Yes
Portugal	124	126	2010	No	No
Singapore	367	376	2016	Yes	No
Spain	350	356	2012	Yes	No
Sweden	2,166	2,195	-	-	-
Switzerland	1,602	1,622	-	-	-
Thailand	2,057	2,075	-	-	-
Turkey	310	310	2014	No	No
United Kingdom	2,356	2,654	2013	No	No
United States	26,595	27,056	-	-	-
Total	**76,000**	**76,952**			

Table 2

Summary Statistics.

PSI is the price nonsynchronicity, which is estimated by Eqs. (2) & (3). *TIMELINESS* is the price timeliness, which is calculated by Eq. (4). *ESGPOST* is an indicator variable that is equal to one for all subsequent years after the mandatory ESG disclosure policy becomes effective in a country, and zero otherwise. *CO2* is the natural logarithm of CO_2 emissions in metric tons per capita. *CGRF* is an indicator variable equal to one for all subsequent years after a major corporate governance reform became effective in the country, and zero otherwise. *LIQ* is the legal institution quality of a country, which is measured based on rule of law, regulatory quality, government effectiveness, and protection against self-dealing. *MKTCAP* is annual market capitalization of listed domestic companies divided by GDP. *GDPG* is GDP growth (annual %). *SIZE* is the natural logarithm of total assets of a firm in US dollars. *IO* is number of shares held by all types of institutions divided by total number of shares outstanding. *PROFIT* is earnings before interest, taxes and depreciation divided by total assets. *LEV* is total debt divided by total assets. *BM* is book value of equity divided by market capitalization. *CASH* is cash and short-term investments divided by total assets. *CAPEX* is capital expenditures divided by total assets. *TURN* is annual share trading volume divided by adjusted shares outstanding. *NUMEST* is the natural logarithm of number of analysts following a firm in a fiscal year. *VOLTY* is the standard deviation of daily stock returns over the 365 days prior to fiscal year end dates. All continuous variables are winsorized at the top and bottom 1%. Table A1 provides details on data and variables.

Variables	Mean	Median	SD	Min	Max	p10	p25	p75	p90
PSI	1.501	1.299	1.452	-1.693	6.016	-0.116	0.514	2.286	3.459
TIMELINESS	0.133	0.115	0.078	0.029	0.402	0.051	0.074	0.171	0.240
ESGPOST	0.128	0.000	0.335	0.000	1.000	0.000	0.000	0.000	1.000
CO2	2.230	2.251	0.634	0.432	3.019	1.342	1.934	2.759	2.942
CGRF	0.882	1.000	0.323	0.000	1.000	0.000	1.000	1.000	1.000
LIQ	2.537	2.720	0.592	0.292	3.841	1.471	2.362	2.921	2.982
MKTCAP	1.011	1.006	0.403	0.231	2.162	0.478	0.665	1.337	1.489
GDPG (%)	2.534	2.244	2.607	-5.693	10.636	0.042	1.458	3.160	6.149
SIZE	13.845	13.788	1.824	9.756	18.269	11.526	12.558	15.059	16.319
IO	0.405	0.295	0.325	0.003	1.123	0.052	0.132	0.690	0.921
PROFIT	0.096	0.108	0.143	-0.655	0.402	0.004	0.066	0.159	0.221
LEV	0.224	0.209	0.179	0.000	0.701	0.000	0.059	0.347	0.474
BM	0.682	0.522	0.572	0.042	3.188	0.165	0.293	0.883	1.390
CASH	0.175	0.116	0.180	0.002	0.889	0.019	0.050	0.231	0.413
CAPEX	0.049	0.035	0.048	0.001	0.259	0.007	0.017	0.065	0.107
TURN	1.495	0.953	1.650	0.010	9.063	0.155	0.403	1.958	3.497
NUMEST	3.988	4.060	1.062	1.386	5.951	2.485	3.178	4.828	5.352
VOLTY	0.021	0.019	0.010	0.008	0.059	0.011	0.014	0.025	0.033

Table 3

Correlation Matrix.

This table reports the Pearson correlations among variables. All continuous variables are winsorized at the top and bottom 1%. * indicates that the correlation is significant at least at the 5% level (two-tailed test).

		[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]	[17]	[18]
PSI	[1]	0.20*	0.02*	0.04*	-0.16*	0.13*	0.15*	-0.02*	-0.54*	-0.12*	-0.21*	-0.07*	0.08*	0.14*	-0.06*	-0.17*	-0.37*	0.18*
TIMELINESS	[2]		-0.02*	0.04*	-0.07*	-0.01*	0.01*	0.05*	-0.28*	-0.02*	-0.27*	0.01*	0.08*	0.18*	0.03*	0.20*	-0.15*	0.55*
ESGPOST	[3]			-0.33*	0.10*	-0.27*	-0.20*	0.39*	-0.07*	-0.19*	0.06*	0.01	-0.07*	-0.04*	0.07*	-0.06*	-0.03*	-0.06*
CO2	[4]				-0.16*	0.71*	0.43*	-0.32*	0.06*	0.52*	-0.13*	-0.05*	-0.06*	0.10*	-0.04*	0.28*	0.10*	0.15*
CGRF	[5]					-0.10*	0.06*	0.06*	0.05*	0.05*	0.01*	-0.04*	-0.07*	0.04*	-0.02*	0.10*	0.02*	-0.17*
LIQ	[6]						0.60*	-0.44*	0.02*	0.49*	-0.11*	-0.08*	-0.07*	0.07*	-0.10*	0.06*	0.12*	0.04*
MKTCAP	[7]							-0.03*	0.02*	0.51*	-0.08*	-0.04*	-0.23*	0.09*	-0.05*	0.17*	0.15*	-0.03*
GDPG	[8]								-0.10*	-0.16*	0.08*	0.03*	-0.17*	-0.02*	0.14*	0.11*	-0.03*	-0.06*
SIZE	[9]									0.23*	0.21*	0.33*	0.03*	-0.36*	0.04*	0.03*	0.63*	-0.39*
IO	[10]										0.01	0.02*	-0.24*	0.01*	-0.05*	0.33*	0.39*	-0.01*
PROFIT	[11]											-0.02*	-0.16*	-0.35*	0.19*	-0.09*	0.17*	-0.43*
LEV	[12]												0.06*	-0.42*	0.12*	0.03*	0.08*	-0.04*
BM	[13]													-0.19*	-0.06*	-0.14*	-0.27*	0.11*
CASH	[14]														-0.20*	0.15*	-0.08*	0.30*
CAPEX	[15]															0.05*	0.07*	-0.01
TURN	[16]																0.16*	0.34*
NUMEST	[17]																	-0.21*
VOLTY	[18]																	

Table 4

The effects of mandatory ESG disclosure on price informativeness and timeliness: Baseline results.

This table presents the regression results of the impact of mandatory ESG disclosure on price informativeness and timeliness using the [-3, +3] sample. The dependent variables are price nonsynchronicity (*PSI*) in columns 1-3, and price timeliness (*TIMELINESS*) in columns 4-6. *ESGPOST* is an indicator variable that is equal to one for all subsequent years after the mandatory ESG disclosure policy becomes effective in a country, and zero otherwise. *COE* is an indicator variable that is equal to one for all subsequent years after the mandatory ESG disclosure policy becomes effective in a country if comply-or-explain ESG disclosure approach is adopted, and zero otherwise. *ATO* is an indicator variable that is equal to one for all subsequent years after the mandatory ESG disclosure policy becomes effective in a country if mandatory environmental, social, and governance disclosure are introduced all at once, or zero if the country implements mandatory disclosure gradually. *CO2* is the natural logarithm of CO_2 emissions in metric tons per capita. *CGRF* is an indicator variable equal to one for all subsequent years after a major corporate governance reform became effective in the country, and zero otherwise. *LIQ* is legal institution quality of a country, which is measured based on rule of law, regulatory quality, government effectiveness, and protection against self-dealing. *MKTCAP* is annual market capitalization of listed domestic companies divided by GDP. *GDPG* is GDP growth (annual %). *SIZE* is the natural logarithm of market capitalization of a firm in US dollars. *IO* is number of shares held by all types of institutions divided by total number of shares outstanding. *PROFIT* is earnings before interest, taxes and depreciation divided by total sales. *LEV* is total debt divided by total assets. *BM* is book value of equity divided by market capitalization. *CASH* is cash and short-term investments divided by total assets. *CAPEX* is capital expenditures divided by total assets. *TURN* is share trading volume divided by adjusted shares outstanding. *NUMEST* is the natural logarithm of number of analysts following a firm in a fiscal year. *VOLTY* is the standard deviation of daily stock returns over the 365 days prior to fiscal year end dates. All continuous variables are winsorized at the top and bottom 1%. Standard errors are clustered at the country level. The t-statistics are reported in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively (two-tailed tests).

Dependent variable	*PSI*			*TIMELINESS*		
	(1)	(2)	(3)	(4)	(5)	(6)
ESGPOST	0.139***	0.115**	0.056	-0.009***	-0.011***	-0.005**
	(3.02)	(1.99)	(0.68)	(-2.89)	(-2.85)	(-2.47)
ESGPOST × *COE*		0.087			0.007*	
		(0.70)			(1.88)	
ESGPOST × *ATO*			0.191			-0.010*
			(1.51)			(-1.91)
Country-level controls						
CO2	0.601	0.605	0.559	0.006	0.006	0.008*
	(1.48)	(1.48)	(1.43)	(0.92)	(1.00)	(1.72)
CGRF	-0.300	-0.298	-0.310	0.004	0.004*	0.005*
	(-1.39)	(-1.39)	(-1.43)	(1.64)	(1.77)	(1.94)
LIQ	-1.354***	-1.342***	-1.328***	-0.019***	-0.018***	-0.020***
	(-2.95)	(-2.83)	(-2.82)	(-4.78)	(-4.09)	(-5.54)
MKTCAP	0.678***	0.673***	0.667***	0.002	0.001	0.002
	(3.26)	(3.29)	(3.22)	(0.16)	(0.12)	(0.22)
GDPG	-0.056***	-0.056***	-0.056***	0.001*	0.001*	0.001*
	(-3.42)	(-3.41)	(-3.42)	(1.84)	(1.84)	(1.84)
Firm-level Controls						
SIZE	-0.333***	-0.332***	-0.335***	-0.005***	-0.005***	-0.005***
	(-18.72)	(-19.18)	(-19.11)	(-5.43)	(-5.70)	(-5.77)
IO	-0.403	-0.406	-0.400	0.015***	0.014***	0.014***
	(-1.58)	(-1.59)	(-1.57)	(5.37)	(5.24)	(5.20)
PROFIT	-0.302**	-0.303**	-0313**	-0.020***	-0.020***	-0.020***

	(-2.42)	(-2.42)	(-2.40)	(-6.14)	(-6.17)	(-6.28)
LEV	0.819***	0.819***	0.817***	0.034***	0.034***	0.034***
	(11.37)	(11.41)	(11.24)	(11.20)	(11.09)	(11.11)
BM	0.328***	0.328***	0.328***	0.009***	0.009***	0.009***
	(4.57)	(4.56)	(4.58)	(2.78)	(2.78)	(2.77)
CASH	-0.390***	-0.390***	-0.392***	-0.013***	-0.013***	-0.013***
	(-5.73)	(-5.71)	(-5.76)	(-4.76)	(-4.79)	(-4.77)
CAPEX	-0.747***	-0.750***	-0.764***	0.020**	0.019**	0.020**
	(-4.24)	(-4.22)	(-4.36)	(2.11)	(2.08)	(2.27)
TURN	-0.058**	-0.057**	-0.058**	-0.001	-0.001	-0.001
	(-2.56)	(-2.57)	(-2.58)	(-0.78)	(-0.77)	(-0.75)
NUMEST	-0.061*	-0.061*	-0.063*	-0.001	-0.001	-0.001
	(-1.73)	(-1.72)	(-1.75)	(-0.94)	(-0.90)	(-0.87)
VOLTY	0.153	0.136	0.211	3.316***	3.314***	3.310***
	(0.03)	(0.03)	(0.04)	(38.82)	(39.64)	(39.60)
Number of observations	76,000	76,000	76,000	76,952	76,952	76,952
Adjusted R-squared	0.309	0.308	0.309	0.170	0.170	0.170
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes

Table 5.
The effects of mandatory ESG disclosure on price informativeness and timeliness: Robustness checks.

Panel A reports the robustness checks using two alternative samples: a [-1, +1] sample and a restrictive [-3, +3] sample that requires a firm to appear at least one year before the first effective year and one year after the effective year. Panel B presents the results excluding treatment countries with simultaneous reforms and excluding US firms. Panel C presents results of policy timing analysis and excluding ESG sensitive industries. Panel D reports results of placebo tests using pseudo effective years. Continuous variables are winsorized at the top and bottom 1% to control for outliers. Panel E presents results using pooled OLS estimation with industry, country, and year effects. All the control variables used in Table 4 are included. All continuous variables are winsorized at the top and bottom 1%. The results of control variables and fixed effects are not reported for brevity. Standard errors are clustered at the country level. The t-statistics are reported in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively (two-tailed tests).

Panel A: Alternative event window and restricted sample				
	[-1, +1] sample		Restricted sample	
Dependent variable	*PSI*	*TIMELINESS*	*PSI*	*TIMELINESS*
	(1)	(2)	(3)	(4)
ESGPOST	0.136**	-0.007**	0.139***	-0.008***
	(2.25)	(-2.15)	(2.98)	(-3.00)
Number of observations	72,580	65,614	72,810	73,639
Adjusted R-squared	0.316	0.177	0.312	0.173
Control variables	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Panel B: Alternative samples				
	Excluding treatment countries with simultaneous reforms		Excluding the U.S. firms	
Dependent variable	*PSI*	*TIMELINESS*	*PSI*	*TIMELINESS*
	(1)	(2)	(3)	(4)
ESGPOST	0.148***	-0.010***	0.157***	-0.007**
	(2.96)	(-2.82)	(3.83)	(-2.18)
Number of observations	73,956	74,853	49,405	47,861
Adjusted R-squared	0.315	0.170	0.273	0.141
Control variables	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Panel C: Policy timing analysis and ESG sensitive industries				
	Pre- and post-ESG disclosure		Excluding ESG sensitive industries	
Dependent variable	*PSI*	*TIMELINESS*	*PSI*	*TIMELINESS*
	(1)	(2)	(3)	(4)
ESGPOST			0.147***	-0.009***
			(3.11)	(-3.45)
Pre-ESG disclosure years	0.092	0.006		
	(0.94)	(1.49)		
First effective year	0.168**	-0.006**		
	(2.21)	(-2.32)		
Year 2+	0.203**	-0.004		

	(2.20)	(-1.12)		
Number of observations	76,000	76,952	64,387	65,306
Adjusted R-squared	0.308	0.170	0.308	0.165
Control variables	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes

Panel D: Placebo tests

Dependent variable	3 years pre-reform		3 years post-reform	
	PSI	*TIMELINESS*	*PSI*	*TIMELINESS*
	(1)	(2)	(3)	(4)
ESGPOST	-0.002	0.002	-0.056	-0.003
	(-0.02)	(0.68)	(-0.54)	(-1.20)
Number of observations	71,769	72,469	76,984	78,209
Adjusted R-squared	0.318	0.170	0.304	0.166
Control variables	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes

Panel E: Pooled OLS estimation with industry, country, and year effects

Dependent variable	*PSI*	*TIMELINESS*
	(1)	(2)
ESGPOST	0.140**	-0.008***
	(2.34)	(-2.94)
Number of observations	76,000	76,952
Adjusted R-squared	0.538	0.343
Control variables	Yes	Yes
Industry fixed effects	Yes	Yes
Country fixed effects	Yes	Yes
Year fixed effects	Yes	Yes

Table 6.

Heterogeneous treatment effects based on attitudes on environment protection and status of ESG reporting.

Panel A reports the results of examining the relative effects of ESG disclosure reform on market efficiency in different countries based on the attitude on the priority of environment protection. *Environment first* is an indicator variable that takes the value of one for the countries where people agree that environment protection should be given priority over economic growth, and zero otherwise. *Not environment first* is (1 – *Environment first*). Panel B reports the results of examining the relative effects of ESG disclosure reform on market efficiency for different firms based on the status of ESG reporting. *ESG reporting firms* is an indicator variable that takes the value of one if a firm has ESG reports uploaded in the Refinitiv ESG database in a year, and zero otherwise. *NonESG reporting firms* is (1 – *ESG reporting firms*). All the control variables used in Table 4 are also included. All continuous variables are winsorized at the top and bottom 1%. The results of control variables and fixed effects are not reported for brevity. Standard errors are clustered at the country level. The t-statistics are reported in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively (two-tailed tests).

Panel A: Heterogeneous effects based on the attitudes on environment protection		
Dependent variable	*PSI*	*TIMELINESS*
	(1)	(2)
ESGPOST × *Environment first*	0.141**	-0.010***
	(2.38)	(-2.97)
ESGPOST × *Not environment first*	0.132	-0.004
	(1.53)	(-1.51)
Number of observations	74,109	75,054
Adjusted R-squared	0.311	0.170
Control variables	Yes	Yes
Firm fixed effects	Yes	Yes
Year fixed effects	Yes	Yes
Panel B: Heterogeneous effects based on the status of ESG reporting		
Dependent variable	*PSI*	*TIMELINESS*
	(1)	(2)
ESGPOST × *ESG reporting firms*	0.130*	-0.003
	(1.84)	(-1.31)
ESGPOST × *NonESG reporting firms*	0.142***	-0.011***
	(2.73)	(-3.38)
Number of observations	76,000	76,952
Adjusted R-squared	0.308	0.170
Control variables	Yes	Yes
Firm fixed effects	Yes	Yes
Year fixed effects	Yes	Yes

Table 7.

Heterogeneous effects based on corporate governance and institutional quality.

Panel A reports the results of examining the relative effects of ESG disclosure reform on market efficiency for different firms based on corporate governance quality. *High corporate governance quality* is an indicator variable that takes the value of one for the firms whose average corporate governance score is above the sample median, and zero otherwise. *Low corporate governance quality* is (1 – *High corporate governance quality*). Panel B reports the results of examining the relative effects of ESG disclosure reform on market efficiency in different countries based on institutional quality. *High legal institution quality* is an indicator variable that takes the value of one for the countries whose legal institution quality index (*LIQ*) is above the sample median, and zero otherwise. *Low legal institution quality* is (1 – *High legal institution quality*). All the control variables used in Table 4 are also included. All continuous variables are winsorized at the top and bottom 1%. The results of control variables and fixed effects are not reported for brevity. Standard errors are clustered at the country level. The t-statistics are reported in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively (two-tailed tests).

Panel A: Heterogeneous effects based on corporate governance quality		
Dependent variable	*PSI*	*TIMELINESS*
	(1)	(2)
ESGPOST × *High corporate governance quality*	0.037	-0.006*
	(0.48)	(-1.94)
ESGPOST × *Low corporate governance quality*	0.204***	-0.011***
	(3.18)	(-3.44)
Number of observations	76,000	76,952
Adjusted R-squared	0.309	0.170
Control variables	Yes	Yes
Firm fixed effects	Yes	Yes
Year fixed effects	Yes	Yes
Panel B: Heterogeneous effects based on legal institution quality		
Dependent variable	*PSI*	*TIMELINESS*
	(1)	(2)
ESGPOST × *High legal institution quality*	0.038	-0.005
	(0.41)	(-1.51)
ESGPOST × *Low legal institution quality*	0.180***	-0.010***
	(2.82)	(-3.00)
Number of observations	76,000	76,952
Adjusted R-squared	0.308	0.170
Control variables	Yes	Yes
Firm fixed effects	Yes	Yes
Year fixed effects	Yes	Yes

Table 8.
The impact of mandatory ESG disclosure on stock returns.

This table presents the regression results of the impact of mandatory ESG disclosure on stock return, change in institutional ownership, and firm valuation using the [-3, +3] sample. In column 1, the dependent variable is stock return (*RET*), measured as market-adjusted annual returns of a share in year *t*+1. In column 2, the dependent variable is the change in institutional ownership (Δ*IO*), measured as the absolute value of institutional ownership in year *t*+1 minus institutional ownership in year *t*. In column 3, the dependent variable is Tobin's q (*TQ*), measured as total assets minus book value of equity plus market value of equity divided by total assets in year *t*. *RET* and Δ*IO* lead explanatory variables by one year, and *TQ* is contemporaneous with explanatory variables. *ESGPOST* is an indicator variable that is equal to one for all subsequent years after the mandatory ESG disclosure policy becomes effective in a country, and zero otherwise. *AGE* is the natural logarithm of firm age. *MM1* stands for price momentum measured as the compounded returns over the previous 12 months. Other control variables are the same as those used in Table 4. Continuous variables are winsorized at the top and bottom 1% to control for outliers. The results of control variables and fixed effects are not reported for brevity. Standard errors are clustered at the country level. The t-statistics are reported in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively (two-tailed tests).

Dependent variable	*RET*	Δ*IO*	*TQ*
	(1)	(2)	(3)
ESGPOST	-0.041**	0.005**	0.157***
	(-2.38)	(2.39)	(3.46)
Country-level controls			
CO2	-0.032	0.017	-0.290
	(-0.70)	(1.63)	(-1.33)
CGRF	-0.021	-0.010**	-0.066
	(-0.99)	(-2.53)	(-1.19)
LIQ	-0.058	0.008	-0.461**
	(-1.27)	(1.07)	(-2.38)
MKTCAP	0.090*	0.006*	0.495***
	(1.71)	(1.70)	(2.78)
GDPG	0.006	0.001**	-0.013*
	(1.44)	(2.56)	(-1.83)
Firm-level Controls			
AGE	0.037***	-0.006**	-0.064
	(3.28)	(-2.11)	(-1.59)
MM1	-0.053***	0.002***	0.329***
	(-9.69)	(3.36)	(11.05)
SIZE	-0.142***	-0.006***	-0.253***
	(-12.95)	(-3.37)	(-6.51)
IO	-0.045**	0.014	0.280***
	(-2.56)	(0.85)	(6.14)
PROFIT	-0.077*	-0.008***	0.880***
	(-1.66)	(-3.47)	(3.93)
LEV	0.222***	0.018**	-0.639***
	(7.98)	(2.55)	(-6.33)
BM	0.175***	0.004	-0.594***
	(8.14)	(1.32)	(-6.06)
CASH	-0.038	-0.003*	0.788***
	(-0.78)	(-1.85)	(7.11)

CAPEX	-0.341***	-0.006	1.398***
	(-3.54)	(-0.92)	(3.69)
TURN	-0.018***	0.001***	-0.001
	(-3.76)	(4.83)	(-0.06)
NUMEST	-0.045***	-0.002*	0.137***
	(-11.78)	(-1.69)	(3.92)
VOLTY	3.272**	0.240***	3.103
	(2.05)	(6.05)	(1.21)
Number of observations	71,163	74,197	74,452
Adjusted R-squared	0.115	0.047	0.262
Firm fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes

Appendix A. Variable definitions

Table A1

Variable	Acronym	Description	Data source
Stock price nonsynchronicity	*PSI*	PSI is a measure of stock price informativeness based on the R^2 from asset pricing regressions, as shown in Eqs. (1) – (3).	Refinitiv Datastream Authors' own calculation
Stock price timeliness	*TIMELINESS*	The price timeliness of value-relevant news, based on daily market-adjusted share prices, as estimated in Eq. (4). The measure is deflated by one plus the absolute rate of return on the share over the period.	Refinitiv Datastream & Worldscope Authors' own calculation
Mandatory ESG disclosure	*ESGPOST*	An indicator variable that is equal to one for all subsequent years after the mandatory ESG disclosure policy becomes effective in a country, and zero otherwise.	Krueger et al. (2021)
Comply-or-explain	*COE*	An indicator variable that is equal to one for all subsequent years after the mandatory ESG disclosure policy becomes effective in a country if comply-or-explain ESG disclosure approach is adopted, and zero otherwise.	Krueger et al. (2021)
All-at-once	*ATO*	An indicator variable that is equal to one for all subsequent years after the mandatory ESG disclosure policy becomes effective in a country if mandatory environmental, social, and governance disclosure are introduced all at once, or zero if the country implements mandatory disclosure gradually.	Krueger et al. (2021)
Carbon emissions	*CO2*	*CO2* is the natural logarithm of CO_2 emissions in metric tons per capita.	World Development Indicators
Corporate governance reform	*CGRF*	An indicator variable equal to one for all subsequent years after a major corporate governance reform became effective in the country, and zero otherwise.	Fauver et al. (2017) Local stock exchanges
Legal institution quality	*LIQ*	Sum of three World Governance Indicators (government effectiveness, regulatory quality, and the rule of law), and the anti-self-dealing index from Djankov et al. (2008). The WGI and anti-self-dealing indices are rescaled to be between 0 and 1.	World Governance Indicators Djankov et al. (2008)
Stock market capitalization	*MKTCAP*	Market capitalization of listed domestic companies divided by GDP.	World Development Indicators
GDP growth	*GDPG*	Annual percentage growth rate of GDP.	World Development Indicators
Environment first	*ATTUD*	Environment first score of a country is estimated based on responses to the WVS questions: "Which of them comes closer to your own point of view? 1. Protecting the environment should be given priority, even if it causes slower economic growth and some loss of jobs. 2. Economic growth and creating jobs should be the top priority, even	Four waves of the World Value Survey (WVS) in 1999-2004, 2005-2009, 2010-2014, and 2017-2020.

		if the environment suffers to some extent." We recode the response to this question to one if a survey participant chose statement 1, and zero otherwise. We then calculate the mean of the response for each country-wave. The score is calculated for each wave of the WVS. Within a wave, the score is calculated once and applies to all country-years covered by the wave. An average score is calculated for each country. Higher scores suggest that people put environment protection in the first place.	
ESG reporting firms	*ESGRPT*	An indicator variable that takes the value of one if a firm has ESG reports uploaded in the Refinitiv ESG database in a year, and zero otherwise.	Refinitiv ESG Database
Corporate governance quality	*CGQ*	Refer to the Appendix B for our corporate governance standards relating to financial and operating, following Chung et al. (2010). CGQ is the ratio of their CG scores according to these 22 CG standards, divided by the full score of 22.	Refinitiv Eikon
Firm size	*SIZE*	The natural logarithm of total assets of a firm in U.S. dollars (Worldscope item 02999)	Refinitiv Worldscope
Institutional ownership	*IO*	Number of shares held by all types of institutions divided by total number of shares outstanding.	Refinitiv Ownership Database
Profitability	*PROFIT*	Earnings before interest, taxes and depreciation (Worldscope item 18198) divided by total assets (Worldscope item 02999).	Refinitiv Worldscope
Leverage	*LEV*	Total debt (Worldscope item 03255) divided by total assets (Worldscope item 02999).	Refinitiv Worldscope
Book to market ratio	*BM*	Book value of equity (Worldscope item 03501) divided by market value of equity (Worldscope item 08001).	Refinitiv Worldscope
Cash holding	*CASH*	Cash and short-term investments (Worldscope item 02001) divided by total assets (Worldscope item 02999).	Refinitiv Worldscope
Capital expenditure	*CAPEX*	Capital expenditures (Worldscope item 04601) divided by total assets (Worldscope item 02999).	Refinitiv Worldscope
Stock trading volume	*TURN*	Share trading volume (Datastream item VO) divided by adjusted shares outstanding (Datastream items NOSH/AF).	Refinitiv Datastream
Analyst following	*NUMEST*	The natural logarithm of number of analysts following a firm in a fiscal year.	I/B/E/S
Stock return volatility	*VOLTY*	The standard deviation of daily stock returns over the 365 calendar days prior to fiscal year end date.	Refinitiv Datastream Authors' own calculation
Firm age	*AGE*	The natural logarithm of number of years since the firm was incorporated.	Refinitiv Worldscope

Stock price momentum	*MM1*	Compounded stock returns over the previous 12 months.	Refinitiv Datastream Authors' own calculation
Stock return	*RET*	Market-adjusted annual returns of a share in year t+1	Refinitiv Datastream Authors' own calculation
Change in institutional ownership	ΔIO	The absolute value of institutional ownership in year t+1 minus institutional ownership in year t.	Refinitiv Ownership Database
Tobin's q	*TQ*	Total assets (Worldscope item 02999) minus book value of equity (Worldscope item 03501) plus market value of equity (Worldscope item 08001) divided by total assets.	Refinitiv Worldscope

Appendix B. Construction of corporate governance index.

Table B1
This table shows the construction method for the corporate governance quality index. Following Chung et al. (2010), we adopt 22 CG standards relating to financial and operating transparency. The CG standards are taken from data compiled by Refinitiv Eikon.

Corporate Governance Categories and Standards	
Audit	
1	Audit committee independence is true.
Board	
2	Strictly independent board members are more than 50% of the board directors.
3	Nomination committee independence is true.
4	Compensation committee is compromised solely of independent outside directors.
5	Committee meeting attendance average is greater than zero (i.e., meets at least once during the year).
6	Staggered Board Structure is false.
7	Size of board of directors is at least 6 but not more than 15 members.
8	Shareholders have cumulative voting rights to elect directors.
9	CEO serves on no more than two additional boards of other public companies.
10	Chairman is not ex-CEO.
11	CEO and Chairman is separated.
12	Any of the following policies is available publicly. • Board Independence • Board Diversity • Board Experience • Executive Compensation Performance • Executive Compensation ESG Performance • Executive Retention
Charter	
13	There is no poison pill provision.
14	Supermajority Vote Requirement is false.
15	Shareholder Approval Significant Transactions is true.
16	Written Consent Requirements is true.
17	Limited Shareholder Rights to Call Meetings is false.
18	Unlimited Authorized Capital or Blank Check is false.
Compensation	
19	Board Member Long Term Compensation Incentives is greater than zero.
Ownership	
20	Executive Compensation Long Term Objectives is true.
21	Shareholders Approval Stock Compensation Plan is true.
Anti-Takeover Devices	
22	There is no anti-takeover device.