The nonlinear impact of firms' ESG disclosures on analysts' earnings forecast accuracy

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ABSTRACT

The disclosure of environmental, social, and governance (ESG) information by firms can signal to the capital markets the potential sustainable development capabilities of the company and provide oversight to curb opportunistic management practices. However, the continuous disclosure of ESG information not only leads to excessive investment and increased operational risks but also contributes to information overload in the capital markets. We examine the impact of firms' ESG disclosures on analyst earnings forecast accuracy (AEFA) using a nonlinear approach to capture both sides of ESG effects. Our nonlinear findings suggest that ESG disclosure has a U-shaped effect on AEFA. Specifically, a firm's ESG disclosure enhances AEFA but at a decreasing rate. The favorable effect becomes smaller as firms disclose more ESG, and eventually, increases in ESG disclosure led to worsening AEFA. The conclusion remains unchanged after an array of robustness checks. The mechanism test reveals that earnings management and media attention mediate the U-shaped relation between ESG disclosure and AEFA. Additional analysis shows that the U-shaped relation is more salient for SOEs and non-polluting firms. The findings not only broaden the research on the impact of ESG disclosure on AEFA, but also help investors make sound investment decisions.

1. Introduction

ESG refers to corporate environmental, social, and corporate governance initiatives. Many firms proactively disclose their ESG activities. Moreover, some stakeholders, such as investors, employees, customers, supply chain partners, governments, and other capital market participants, use ESG to assess corporate risks and corporate sustainability performance (Aguilera et al., 2007; Bai & Chang, 2015; Campbell, 2007; Garriga & Mele, 2004) and drive investors and banks to invest in firm with high ESG performance (Riedl & Smeets, 2017; Huang, Bui, et al., 2024). Previous studies examine the factors contributing to ESG disclosure including the role of government (Lin et al., 2021; Weber, 2014) and institutional ownership (Azar et al., 2018; Cheng et al., 2022), among others. Moreover, several studies examine the effect of ESG disclosure on various stakeholders' decisions and corporate performance (Jun et al., 2022; Yuan et al., 2022; Chai et al., 2023; Rau & Yu, 2024; Tang et al., 2024). Interestingly, Edmans (2023) articulates ESG to be irrelevant in guiding long-term investment decisions.

Analysts enhance the efficiency of information transfer (Huang et al., 2018) and improve the operational efficiency of the capital market (Loh

& Stulz, 2018). Although analysts primarily rely on publicly disclosed financial information in the earnings forecasting process (Jackson, 2022), their attention to non-financial information has gradually increased. ESG information disclosed by firms, as a form of non-financial information, provides incremental insights into corporate sustainability and future value, serving as an effective complement to financial information (Dhaliwal et al., 2012). Analysts' attention to ESG information has significantly increased (Baldini et al., 2018; Roger, 2024). Thus, ESG disclosure serves as a critical reference for analysts' earnings forecasting behavior, highlighting the need for further research on the relationship between ESG disclosure and analyst earnings forecast accuracy (AEFA).

The literature, however, underexplores the relation between ESG disclosure and analysts and pays even less attention to the effect of ESG disclosure on AEFA. The exceptions are Luo and Wu (2022), who find that a firm's having a high ESG rating leads to better AEFA in a sample of US firms, and Liu et al. (2024), who document that a large disagreement on ESG ratings from different rating agencies translates into worse AEFA in China. Given the important role of analysts in the capital market (Driskill et al., 2020; Schipper, 1991), there is room to further

investigate the relation between ESG disclosure and AEFA. We further motivate our study from the recent findings of a nonlinear effect of a corporate social network on corporate social responsibility (Zhao & Chan, 2023). In addition, we argue that ESG disclosure has a two-sided effect on the AEFA. In the short run, ESG information disclosed by firms force to strengthen internal governance (Cabaleiro-Cerviño & Mendi, 2024; Chubchuwong, 2019; Garavaglia et al., 2024; Park, 2024) and improve the quality of disclosure, which improves AEFA. However, in the long term, excessive ESG disclosure may lead to negative net present value (NPV) projects and elevate business risks (Bartkus et al., 2002). Furthermore, analysts' cognitive resources are inherently scarce and constrained (DellaVigna & Pollet, 2009) and thus excess ESG disclosure is a burden to analysts. Both scenarios suggest an increase in firm opacity and more difficulty for analysts in interpreting firm information when there are more ESG disclosure, leading to a decrease in AEFA.

The examination on the nonlinear relationship between ESG disclosure and AEFA in China is mainly based on the following considerations. First, compared to European and American countries, emerging market countries, such as China, started ESG development relatively late (Zhang et al., 2023), and do not have a strict regulatory system as well as a unified and systematic ESG disclosure standard. Hence, there is a lack of effective verification of the authenticity and credibility of ESG reports issued by companies (Zhou et al., 2021), as well as an imbalance between "quantitative coverage" and "quality assurance" of ESG disclosure. Consequently, analysts have limitations to screen information and analyze ESG data. Hence, it is informative to explore the non-linear impact of ESG disclosure on AEFA in an emerging market such as China. Second, compared to developed markets, the high participation of retail investors in the Chinese stock market suggests that information dissemination exhibit time lags (Wu et al., 2024), suggesting that analysts' reports have become a key source of information that influences investors' decision-making (Xu et al., 2025). Thus, AEFA is a core reference for investors' decision-making. Therefore, our findings offer valuable lessons for other markets with similar high participations of retail investors. Finally, China, as one of the economies with the largest number of listed companies in the world, provides large-scale sample data for this study. The data advantage is helpful to accurately portray the complex nonlinear relationship between ESG disclosure and AEFA.

In light of this, using a sample of Chinese firms from 2007 to 2022, we find that ESG disclosure has a U-shaped association with AEFA. The findings remain intact after a battery of robustness checks. Specifically, when ESG disclosure increases, AEFA increases with a decreasing rate. Then, when the ESG disclosure level rises beyond approximately 82nd percentiles of the distribution, AEFA reaches a turning point from increased AEFA to decreased AEFA. Furthermore, the mechanism test reveals that earnings management and media attention mediate the U-shaped relation between ESG disclosure and AEFA, which corroborates the logic underlying the nonlinear relationship. Additional analysis suggests that the U-shaped relation is more salient for state-owned firms and for firms in non-polluting industries.

We make two contributions to the literature. First, this study enriches the research on the impact of non-financial information on AEFA by shifting the perspective to the "two-sidedness" of non-financial information using the lens of ESG. Several studies examine the impact of financial information (De Franco et al., 2011; Dhaliwal et al., 2012; Jackson, 2022) and non-financial information (e.g., forward-looking information, R&D and innovation information) (Beyhaghi et al., 2023; Gu & Wang, 2005; Vanstraelen et al., 2003) on analysts' forecasting behavior, mostly based on a single dimension, whereas this paper focuses on the "double-edged sword" of ESG disclosure. The U-shaped relation suggests that excessive ESG disclosure is not helpful to analysts in their earnings forecast. We argue that the nonlinear relation between ESG disclosure and AEFA partially explains why previous studies had mixed findings for the effect of ESG disclosure on corporate performance (Baker et al., 2021; Brammer et al., 2006; Rau & Yu, 2024; Yuan et al., 2022).

Second, this study not only extends the logical chain between ESG disclosure and AEFA but also provides new perspectives and insights for the effective operation of capital markets. On the one hand, while most of the previous studies focus on a single and linear internal governance perspective (e.g., information quality and operational risk) to analyze the relationship between the two (Luo & Wu, 2022; Wang & Xing, 2023), our study shows that ESG disclosure indirectly reduces AEFA in a nonlinear way through its effect on firms' internal earnings management as well as external media attention. This finding reveals a more complex and multidimensional interaction mechanism between ESG disclosure and firms' financial performance. On the other hand, in the context of complex capital market information, ESG disclosure should not be regarded as a purely ethical proposition. Instead, it is useful to improve the professionalism and information processing ability of media, analysts, and investors to help them identify the "halo effect traps" that may exist in ESG high scoring companies more prudently, and avoid making wrong investment decisions due to blind pursuit of high ESG score.

The remainder of this paper is organized as follows. The following section describes the literature review and research hypotheses. Section 3 describes the data sources and the model. In Section 4, the results of the empirical investigation are detailed, including the base results, quantile regression, endogeneity test, robustness check, mechanism analysis, and the results of heterogeneity tests. The conclusions and contributions of this study follow in Section 5.

2. Literature review and research hypotheses

There are two strands of literature that carry implications for the impact of ESG disclosure on AEFA. The first strand finds ESG disclosure has a positive effect on AEFA. ESG disclosure sends positive signals of a stable and healthy firm to stakeholders through multiple information channels, establishes a responsible and positive corporate image (Babiak & Trendafilova, 2011; Cho et al., 2013; Naqvi et al., 2021; Wong et al., 2021), and thus brings reputational capital to the firm (Cui et al., 2018; Goss & Roberts, 2011). Consequently, ESG disclosure reduces information asymmetry (Flammer, 2013; Ghoul et al., 2011; Naqvi et al., 2021; Yu et al., 2018; Zumente & Lāce, 2021), especially information related to a firm's business risk (Lisin et al., 2022). All else being the same, when firms disclose ESG information, analysts have a larger information set to conduct research that leads to an improved AEFA. From the perspective of firms' external monitoring, firm watchdogs, such as investors and the media, use ESG information disclosed by firms to improve the quality of disclosure (Cabaleiro-Cerviño & Mendi, 2024; Chubchuwong, 2019; Garavaglia et al., 2024; Park, 2024). If the disclosed information misrepresents the firm, the firm faces the risk of punishment from regulatory authorities. Therefore, for the sake of sustainable development, firms will try their best to disclose high-quality information. Hence, analysts have a reliable source of earnings forecasting information to reduce the analysts' errors in judgment about the firm's financial information (Shaw, 2003). Overall, with an expanded information set and an improved information environment, analysts produce better AEFA.

Second, ESG disclosure is costly (Jun et al., 2022). ESG investments take a long time to produce tangible benefits (Cai et al., 2016; Sun & Gunia, 2018). Such uncertainty in future returns results in a challenge for analysts to evaluate the net benefits of a firm's ESG investment. Consequently, AEFA worsens. Huang (2022, p. 1983) summarizes three possible relations between ESG disclosure and AEFA. He states:

> "First, from a valuation viewpoint, it is not clear how ESG factors are incorporated into earnings forecasts. Second, referencing agency and signaling theories, ESG may reduce information asymmetry between management-agents and shareholder-principals. Third, stakeholder and institutional theories situate ESG in a complex multi-actor and multi-interest environment."

The direct evidence on the relation by Liu et al. (2024) and Luo and Wu (2022) supports a positive effect for the impact of ESG disclosure on

AEFA. However, the depicted relation is a linear one. ESG has multiple actors and multiple interests among various stakeholders (Huang, 2022; Rau & Yu, 2024). The relation between ESG disclosure and AEFA is hardly a linear one.

We argue that analysts find information released in the early stage of ESG disclosure (up to a moderate level of ESG disclosure) to be particularly useful. At this stage, even if managers conduct ESG activities to seek private benefits (Buertey et al., 2020; Putra et al., 2021), they take a "wait and see" approach due to the monitoring effect of ESG. Such monitoring restrains managers' opportunistic activities (Eccles et al., 2014; Kim et al., 2012; Lopatta et al., 2016; Ng et al., 2021; Waddock & Graves, 1997), and the additional information provided by ESG disclosure suggests that analysts can fully take advantage of the governance benefits of ESG (Dhaliwal et al., 2012; Yu et al., 2018). All else being the same, when firms disclose from low to a moderate level of ESG information, AEFA improves.

When a firm's ESG disclosure continues to a high level, it is likely due to the firm's overinvestment in ESG (Barnea & Rubin, 2010; Becchetti et al., 2013). The high cost and uncertain nature of ESG become nontrivial. According to agency theory, overinvestment in ESG imposes additional costs on firms (Jensen & Meckling, 1976; Khanchel & Lassoued, 2022) and even generates negative net present value (Bartkus et al., 2002). Firms' investment in negative net present value projects increases operational risk (Godfrey, 2005) and uncertain future operating income. Thus, AEFA decreases when analysts consider a firm facing high operating risk (Becchetti et al., 2013; Jennings et al., 2017). Moreover, continuous, and extensive disclosure of ESG information overloads the market with information. According to the limited attention conceptual framework, analysts' cognitive resources are limited, and they, like average investors, will be constrained by their limited attention. Hence, analysts are unable to focus on all the information disclosed (DellaVigna & Pollet, 2009; Hirshleifer et al., 2009). Therefore, analysts focus on certain positive information about the firm and downplay negative information. Accordingly, they overestimate a firm's value, which triggers inaccurate earnings forecasts.

Based on the above analysis, we expect that ESG disclosure will affect AEFA; further, this effect is not linear, but rather, has a U-shaped relation. Accordingly, we propose the hypothesis:

H1. ESG disclosure has a U-shaped relation with analyst earnings forecast accuracy.

3. Data sources and modeling

3.1. Sample selection

We use A-share listed firms in China from 2007 to 2022 as the research sample. The Bloomberg database started to disclose ESG information of Chinese companies in 2006, and we lag the explanatory variables by one period, so this study starts from 2007. We exclude financially distressed firms (i.e., companies in "ST," "*ST," or "PT" status), firms belonging to financial industries, analysts' earnings forecast announcements whose release dates are later than the deadline of firms' annual reports, and firms with missing values in control variables. Typically, many analysts follow a firm. Thus, we only keep the most recent earnings forecast of each analyst per year. The final sample has 10,372 firm-year observations. The ESG disclosure data are obtained from the Bloomberg database, and the rest of the data are from the China Stock Market and Accounting Research (CSMAR) database. We winsorize all continuous variables at the 1 % and 99 % levels.

3.2. Dependent variable: analyst earnings forecast accuracy (FERROR1)

Following Hong and Kacperczyk (2010), Abernathy et al. (2013), and Haw et al. (2015), we construct the AEFA metric and denote it as *FERROR1*.

$$FERROR1_{i,t} = \frac{\left|FEPS_{i,t} - MEPS_{i,t}\right|}{Price_{i,t,t-1}} * 100 \tag{1}$$

where $FEPS_{i,t}$ represents the median of all analysts' forecasts for firm *i* in year *t*, $MEPS_{i,t}$ is the actual EPS of firm *i* in year *t*, and $Price_{i,t,t-1}$ is the opening price of firm *i*'s stock at the beginning of year *t*. A small value of *FERROR1* suggests a better AEFA.

3.3. Empirical models

To investigate whether there is a U-shaped link between ESG disclosure and analysts' earnings projection bias, we use the following econometric model:

$$\begin{aligned} FERROR1_{i,t} = &\alpha_0 + \alpha_1 ESG_{i,t-1}^2 + \alpha_2 ESG_{i,t-1} + \alpha_3 Controls_{i,t} \\ &+ Year + Industry + \varepsilon_{i,t} \end{aligned} \tag{2}$$

where *ESG* denotes ESG disclosure and *Controls* refer to a set of control variables. Following Berkan et al. (2021) and Christensen et al. (2022), we use firm size (*SIZE*), financial leverage (*LEV*), income growth of a firm (*GROWTH*), operating loss (*LOSS*), book-to-market ratio (*BM*), firm age (*LISTAGE*), board size (*BOARD*), board diligence (*MEETING*), top five shareholders' shareholding ratio (*TOP5*), analyst attention (*ANALYST*), analyst forecast ranges (*HORIZON*) and the number of analyst forecast revisions (*TIMES*). Table 1 presents detailed definitions of all variables. *Year* and *Industry* represent the year- and industry-fixed effects, respectively, and ε is the residual term. Furthermore, *ESG* is in year $t - 1$ because rating agencies typically release their reports at the end of year *t* and thus analysts use ESG disclosure at $t - 1$ to conduct their research.

Given that the findings from fixed-effects regression (model (2)) are limited to the sample's average effect, as a robustness check, we also use a quantile regression (QR) model to investigate the potential impact of ESG disclosure on the bias of analysts' earnings estimates in various quartiles. We use quantile regression (QR) model (Koenker & Bassett Jr, 1978) to analyze the effects of each explanatory variable on AEFA in different quantiles. It benefits in investigating, accurately, the determinants of AEFA. QR model assists in understanding the effects of each variable by looking at the sign of the coefficient, size and level of significance across the distribution (Wu & Chang, 2022). The QR model is:

Table 1
Variable definitions.
This table presents definitions of all variables.

Symbol	Definition
FERROR1	The absolute value of the difference between the median EPS forecasts by analysts and the actual EPS for the year in a firm, divided by the firm's stock price at the beginning of the period. We multiply it by 100 for easy interpretation.
ESG	Bloomberg ESG Score/100
SIZE	The natural logarithm of total assets
LEV	The ratio of total liabilities to total assets
GROWTH	(Current year's operating income/previous year's operating income) − 1
LOSS	Dummy variable that takes a value equal to one if the firm reports a loss during the quarter
BM	The ratio of market value to book value
LISTAGE	The natural logarithm of the difference of current year and year of listing plus 1
BOARD	The natural logarithm of the number of board members plus 1
MEETING	The natural logarithm of the number of board meetings
TOP5	Shareholding of top five shareholders to total outstanding shares
ANALYST	The natural logarithm of the number of analysts following plus 1
HORIZON	The natural logarithm of the average number of days between the date of release of analysts' forecasts and the date of disclosure of the company's financial report
TIMES	The number of times an analyst's earnings forecast for a company is revised in the current year and averaged out

Table 3

Fixed effect and quantile regression results.

This table presents the results for the impact of ESG on analyst earnings forecast accuracy (*FERROR1*). Column (1) is the fixed effect regression. Columns (2) to (6) present the results of quantile regressions at various percentiles of *FERROR1* (10th, 25th, 50th, 75th, and 90th). The last row presents the point estimates for the combined impact of ESG on *FERROR1* valuated at various percentiles of *FERROR1*. *t*-statistics are in parentheses. Table 1 presents definitions of all variables. ***, **, and * indicate 1 %, 5 %, and 10 % significance, respectively.

Variables	*FERROR1*					
	(1)	Quantile				
		(2)	(3)	(4)	(5)	(6)
	Fixed effect	10	25	50	75	90
ESG_{t-1}^2	6.4716** (2.29)	0.5781 (1.38)	1.4494** (2.39)	3.9721*** (3.73)	9.8688*** (4.16)	20.5323*** (3.74)
ESG_{t-1}	−6.0058*** (−3.25)	−0.5153* (−1.72)	−1.3739*** (−3.52)	−3.2680*** (−5.17)	−7.0997*** (−5.39)	−13.7008*** (−4.15)
SIZE	−0.0043 (−0.09)	−0.0093 (−1.10)	−0.0136 (−1.19)	−0.0220 (−1.26)	0.0613 (1.49)	0.2732*** (3.04)
LEV	1.1928*** (5.07)	0.0391 (1.12)	0.1788*** (3.36)	0.5380*** (5.15)	0.9201*** (5.53)	0.9683** (2.52)
GROWTH	−0.5001*** (−5.22)	−0.1150*** (−5.47)	−0.2199*** (−8.60)	−0.3700*** (−6.36)	−0.4367*** (−7.35)	−0.5049*** (−4.99)
LOSS	7.8435*** (25.00)	2.1919*** (10.12)	3.8470*** (18.02)	7.0333*** (13.78)	11.4653*** (19.03)	17.2643 *** (26.12)
BM	2.3753*** (12.51)	0.2475*** (7.50)	0.6394*** (15.45)	1.3901*** (19.15)	2.2833*** (17.66)	3.3503*** (10.59)
LISTAGE	−0.1848*** (−3.66)	−0.0227** (−2.59)	−0.0790*** (−5.64)	−0.1555*** (−6.41)	−0.2499*** (−6.53)	−0.2708** (−3.05)
BOARD	−0.5729*** (−3.47)	−0.0159 (−0.59)	−0.1347*** (−2.96)	−0.3302*** (−4.81)	−0.5923*** (−4.46)	−0.9262*** (−3.36)
MEETING	0.3793*** (4.21)	0.0527*** (3.34)	0.0575*** (2.73)	0.0905** (2.60)	0.0826 (1.25)	0.4083** (2.41)
TOP5	−0.8200*** (−3.59)	−0.1437*** (−3.57)	−0.3329*** (−6.16)	−0.5911*** (−6.08)	−0.9332*** (−4.55)	−1.3756*** (−3.14)
ANALYST	−0.2930*** (−6.79)	−0.0266*** (−3.03)	−0.0652*** (−6.58)	−0.1690*** (−8.62)	−0.4612*** (−12.13)	−0.8279*** (−10.50)
HORIZON	2.9740*** (23.29)	0.3875*** (10.93)	0.8756*** (21.78)	1.6986*** (34.86)	2.7106*** (31.12)	3.6684*** (21.86)
TIMES	−0.0986* (−1.88)	−0.0168** (−1.97)	−0.0283** (−2.33)	−0.0422* (−1.69)	−0.0232 (−0.49)	−0.1637** (−1.99)
Constant	−15.4033*** (−12.58)	−1.9449*** (−8.12)	−4.1165*** (−13.82)	−7.7207*** (−18.20)	−13.2304*** (−14.92)	−20.7570*** (−11.15)
Industry	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
N	10,372	10,372	10,372	10,372	10,372	10,372
Adj. R^2/Pseudo R^2	0.4420	0.0486	0.1044	0.1815	0.2857	0.3769
F	140.57					
ESG value at the given percentile		0.1529	0.1938	0.2630	0.3145	0.3861
The aggregated effect of ESG and ESG^2 on FERROR1		−0.3385	−0.8121	−1.1787	−0.8922	2.1542
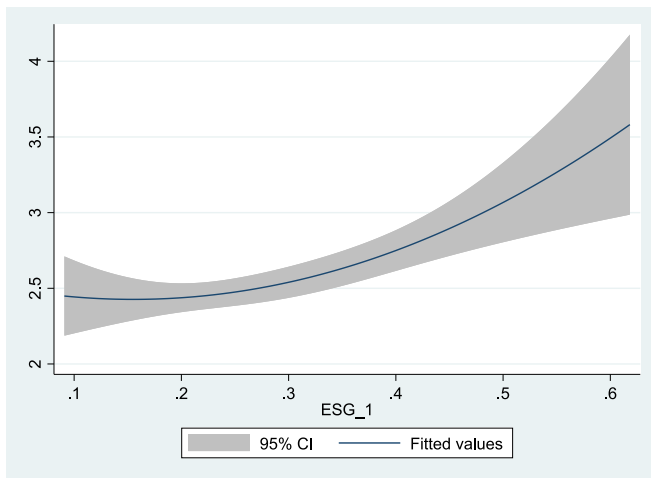
Fig. 1. The impact of ESG disclosure on analyst earnings forecast accuracy.

4.4. Robustness tests

4.4.1. Alternative metric of analyst earnings forecast accuracy

For robustness, we use an alternative metric of AEFA. We use the mean of all analysts' most recent EPS forecasts for the year instead of median EPS forecasts to measure AEFA (denoted as *FERROR2*) (Duru & Reeb, 2002). The regression results, as shown in column (1) of Table 6,

Table 4

Instrumental variables approach regression results.

This table presents the results for the impact of ESG on analyst earnings forecast accuracy (*FERROR1*) using an instrumental variable (IV) approach. We use ESG_{t-2} as an IV for ESG_{t-1}. Columns (1) and (2) generate predicted values of ESG_{t-1}^2 and ESG_{t-1}. For brevity, we do not present the coefficients of control variables. *t*-statistics are in parentheses. Table 1 presents definitions of all variables. ***, **, and * indicate 1 %, 5 %, and 10 % significance, respectively.

Variables	First stage		Second stage
	(1)	(2)	(3)
	ESG_{t-1}	ESG_{t-1}^2	*FERROR1*
ESG_{t-1}^2 (predicted)			10.4653** (2.57)
ESG_{t-1} (predicted)			−9.2088*** (−3.27)
ESG_{t-2}^2	0.4291*** (11.85)	1.1075*** (44.61)	
ESG_{t-2}	0.5776*** (24.21)	−0.1138*** (−8.11)	
Control var.	Yes	Yes	Yes
Constant	−0.0035 (−0.23)	−0.0167* (−1.72)	−19.7675*** (−13.42)
Industry	Yes	Yes	Yes
Year	Yes	Yes	Yes
N	8653	8653	8653
Adj. R^2/Pseudo R^2	0.8835	0.8820	0.4554
F	1075.84	652.85	

Table 5

Heckman two-stage regression results.

This table presents the results for the impact of ESG on analyst earnings forecast accuracy (*FERROR1*) using Heckman two-stage regression. *SALE_EXP* is the ratio of sales expenses to revenue. *ESG_DUM* is a dummy variable with a value of 1 if a firm has ESG score and 0 no such score. *IMR* is the inverse Mills ratio recovered from column (1). For brevity, we do not present the coefficients of control variables. *t*-statistics are in parentheses. Table 1 presents definitions of all variables. ***, **, and * indicate 1 %, 5 %, and 10 % significance, respectively.

Variables	First stage	Second stage
	(1)	(2)
	ESG_DUM	*FERROR1*
$SALE\_EXP_{t-1}$	0.9840*** (6.73)	
ESG_{t-1}^2		4.4198* (1.65)
ESG_{t-1}		−4.4613** (−2.28)
IMR		−0.0989 (−0.51)
Control var.	Yes	Yes
Constant	−23.8174*** (−44.81)	−14.7389*** (−6.42)
Industry	Yes	Yes
Year	Yes	Yes
N	24,426	10,812
Adj. R^2/Pseudo R^2	0.3830	0.3291
F		94.32

show that the coefficient of ESG^2 remains positively significant at the 10 % level while the coefficient of *ESG* continues to be negatively significant at the 1 % level. Hence, the U–shaped relation between ESG disclosure and AEFA remains.

4.4.2. Alternative metric of ESG disclosure

To control for the potential bias of the measurement error of the explanatory variable, we use ESG data from Hexun.com as an alternative metric for ESG disclosure. The website uses a professional evaluation system that covers the majority of Shanghai and Shenzhen A-share listed firms. The regression results, as shown in column (2) of Table 6, show that the coefficient of ESG^2 continues to be positively significant at the 1 % level, and the coefficient of *ESG* remains negatively significant at the 1 % level, which indicates that the U–shaped relation between ESG disclosure and AEFA remains intact.

Table 6

Robustness test results.

This table presents various robustness results for the impact of ESG on analyst earnings forecast accuracy. In column (1), *FERROR2* = the absolute value of the difference between the average EPS forecasts by analysts and the actual EPS for the year in a firm, divided by the firm's stock price at the beginning of the period multiplied by 100. In column (2), we use ESG data from Hexun.com. In column (3), we use a Tobit estimation method. In column (4), we excluded samples with *ANALYST* = 0. For brevity, we do not present the coefficients of control variables. *t*-statistics are in parentheses. Table 1 presents definitions of all variables. ***, **, and * indicate 1 %, 5 %, and 10 % significance, respectively.

Variables	(1)	(2)	(3)	(4)
	FERROR2	*FERROR1* (Hexun.com ESG data)	*FERROR1* (Tobit method)	*FERROR1* (Removal of outliers)
ESG_{t-1}^2	4.5635* (1.65)	0.0003*** (2.84)	6.7581* (2.38)	6.9513** (2.47)
ESG_{t-1}	−5.1147*** (−2.84)	−0.0245*** (−2.87)	−6.1684*** (−3.32)	−5.8756*** (−3.14)
Control var.	Yes	Yes	Yes	Yes
Constant	−15.9733*** (−13.46)	−15.9084*** (−19.36)	−16.7306*** (−13.17)	0.8372** (0.91)
Industry	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
N	10,372	16,968	10,372	9481
Adj. R^2/Pseudo R^2	0.4490	0.4564	0.1053	0.3936

4.4.3. Alternative estimation method

Given that some firms may choose not to disclose ESG information, we use a Tobit model to account for the possible censored sample bias in the sample. Column (3) of Table 6 shows the regression results. The results are qualitatively similar to those in column (1) of Table 3. Support for H1 remains strong.

4.4.4. Removal of outliers

Given the lack of analyst coverage for some firms, we exclude these samples to address possible sample selection bias due to analysts' behavior. Column (4) of Table 6 shows the regression results. The results are qualitatively similar to those in column (1) of Table 3, which support H1.

4.5. Mechanism analysis

4.5.1. ESG disclosure, earnings management, and analysts' earnings forecast accuracy

The monitoring effect of ESG disclosure improves information transparency and increases the possibility of detecting earnings management. Thus, ESG disclosure generally restrains earnings management (Almahrog et al., 2018; Kim et al., 2012; Sun et al., 2024). However, excessive ESG disclosure suggests a firm is concerned about its public image. The firm uses earnings management to paint a positive image of the firm, which lowers AEFA (Bénabou & Tirole, 2010). Taken together, earnings management mediates the U-shaped relation between ESG disclosure and AEFA. That is, when ESG disclosure increases from a low to moderately high level, it restrains earnings management. Accordingly, ESG disclosure has an overall positive effect on AEFA. However, when ESG disclosure is high, the firm uses more earnings management to paint a good image, which makes it challenging for analysts to assess a firm's actual performance (Chaney et al., 2011). In that case, high ESG disclosure contributes to an overall negative effect on AEFA via earnings management. Thus, we argue that earnings management mediates the nonlinear effect of ESG disclosure on AEFA.

In line with Baron and Kenny (1986), we construct a nonlinear mediation effect model. Through a regression analysis, we assess the mediating role of earnings management in H1. The model is specified as follows:

$$AbsREM_{i,t} = \alpha_0 + \alpha_1 ESG_{i,t-1}^2 + \alpha_2 ESG_{i,t-1} + \alpha_3 Controls + Year + Industry + \varepsilon_{i,t} \quad (4)$$

$$FERROR1_{i,t} = \alpha_0 + \alpha_1 ESG_{i,t-1}^2 + \alpha_2 ESG_{i,t-1} + \alpha_3 AbsDEM_{i,t} + \alpha_4 Controls + Year + Industry + \varepsilon_{i,t} \quad (5)$$

where $AbsREM_{i,t}$ as the mediating variable, denotes the degree of earnings management for firm *i* in year *t*. Specifically, we construct real activity earnings management indexes from three dimensions of abnormal production cost, abnormal cash flow, and abnormal manipulative expenses, and takes its absolute value (*AbsREM*) to measure the level of real earnings management of enterprises (Cohen et al., 2008; Roychowdhury, 2006). A large value of *AbsREM* suggests a great degree of earnings management. Other variables are the same as those in Eq. (2).

Columns (1) and (2) in Table 6 report the regression results with *AbsREM* as the mediating variable. In column (1) of Table 7, the coefficient of ESG^2 (*ESG*) is positively (negatively) significant at the 5 % (1 %) level. Thus, ESG disclosure and earnings management exhibit a U-shaped relation. That is, ESG disclosure generally restrains earnings management but at a decreasing rate. In column (2) of Table 7, the coefficient of *AbsREM* is positively significant at the 1 % level, while the coefficients of ESG^2 and *ESG* remain significant with the expected signs. These results imply that earnings management plays a mediating role in the relation between ESG disclosure and AEFA.

Table 7

Results of the mediation effect test.

This table presents the results for the mediation effect for the impact of ESG on analyst earnings forecast accuracy. In column (1), we attempted to demonstrate the nonlinear relationship between ESG disclosure and AbsREM. In column (2), we demonstrate that the mediating effect of AbsREM. In column (3), We focus on whether there is a nonlinear relationship between ESG disclosure and MEDIA. In column (4), we demonstrate that the mediating effect of MEDIA. Table 1 presents definitions of all variables. ***, **, and * indicate 1 %, 5 %, and 10 % significance, respectively.

Variables	(1)	(2)	(3)	(4)
	AbsREM	*FERROR1*	*MEDIA*	*FERROR1*
ESG_{t-1}^2	0.2019**	5.6319* (1.94)	3.2197***	5.9928**
	(2.28)		(5.40)	(2.11)
ESG_{t-1}	−0.1893***	−5.3662***	−0.8454**	−5.9748***
	(−2.59)	(−2.77)	(−2.14)	(−3.22)
AbsREM		1.4684***		
		(5.59)		
MEDIA				0.1650***
				(3.89)
Control var.	Yes	Yes	Yes	Yes
Constant	0.1475***	−15.8491***	−5.5519***	−14.6241***
	(4.10)	(−11.92)	(−19.94)	(−11.66)
Industry	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
N	9520	9520	10,254	10,254
Adj. R^2/ Pseudo R^2	0.1642	0.4382	0.5470	0.4443

4.5.2. ESG disclosure, media attention, and analysts' earnings forecast accuracy

We argue that as ESG disclosure is a relatively recent phenomenon, and in most cases, firms are not required to disclose their ESG information (Sun et al., 2024).[3] These disclosures, if made, lack uniform standards and lead to different ratings (Berg et al., 2022; Christensen et al., 2022). Hence, it is challenging for media to validate the ESG disclosure of a firm due to information clutter and poor comparability, which in turn leads to a decline in media attention. However, as the public's recognition of the ESG concept grows (Sun et al., 2024) and China's regulatory requirements for corporate ESG disclosure improves, disclosures about shareholder governance, risk management, and internal control have received increased media attention (Hahn & Kühnen, 2013). Then, there is a U-shaped relation between ESG disclosure and media attention (*MEDIA*). When ESG disclosure is low (high), media attention shrinks (increases to disproportionately high attention).

However, as media attention increases, at some point, it moves to information overload. An excess of information leads analysts to become distracted and unable to timely react to all public information in the market (DellaVigna & Pollet, 2009; Hirshleifer et al., 2009), resulting in lowered AEFA. To summarize, we propose that media attention mediates the U–shaped relation between ESG disclosure and AEFA in a nonlinear way. That is, ESG disclosure influences media attention via the U–curve effect, which then influences AEFA in a U–shaped relation.

To examine the mediating role of media attention for the effect of ESG disclosure on AEFA, we use Eqs. (4) and (5) but replace *AbsREM* with *MEDIA*, which is the number of media reports of a firm. Following Guo et al. (2018) and Huang, Huang, and Ho (2024), we use the natural logarithm of one plus the number of annual media reports for a firm to measure media attention (*MEDIA*). The data of media reports are obtained from the CNRDS database. A large value of *MEDIA* suggests high media attention. Columns (3) and (4) in Table 7 report the regression results with media attention as the mediating variable. They are qualitatively similar to those in columns (1) and (2). That is, ESG disclosure and media attention

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[3] https://www.forbes.com/sites/jimdeloach/2023/09/13/esg-reporting-is-already-required-heres-what-you-need-to-know/.

exhibit a U-shaped relation: A low ESG disclosure level contributes to less media attention. As ESG disclosure increases, media attention increases disproportionately. In column (4), the coefficient of *MEDIA* is positively significant at the 1 % level, while the coefficients of ESG^2 and *ESG* remain significant with the expected signs. These results imply that media attention plays a mediating role in the relation between ESG disclosure and AEFA in a nonlinear framework.

4.6. Heterogeneity tests

4.6.1. State ownership

Many firms in China are state-owned. State-owned firms (SOEs) face higher political pressures than non-SOEs, and in addition to economic objectives, they must also bear the duty of achieving job growth and other social objectives (Zhang & You, 2024). We expect that SOEs proactively leverage ESG disclosure in the spirit of serving the societal good. However, SOEs also make ESG disclosure to convey a positive image to their supervising authorities and the public. At the margin, SOEs are more likely than non-SOEs to behave in a way predicted by H1. Accordingly, the nonlinear effect of ESG disclosure on AEFA remains salient. In contrast, non-SOEs consider survival and wealth maximization as their primary objectives (Luo et al., 2024; Zhang & You, 2024). ESG disclosure is not necessarily a priority. Such disclosure from non-SOEs may or may not mean anything to analysts. Accordingly, the nonlinear effect of ESG disclosure on AEFA is weak.

We present the findings in columns (1) and (2) of Table 8. The coefficients of ESG^2 and *ESG* continue to be positively and negatively significant as those in Table 3 in column (1), while the same coefficients are insignificant in column (2).

4.6.2. Industry heterogeneity test

As a developing country, China has many high-pollution industries. Firms in these industries produce heavy pollutants and consume a lot of energy. They naturally face greater legitimacy pressure and public scrutiny. As a strategy response, heavy-polluting firms are motivated to disclose more higher-quality environmental information to minimize fines (Bayoud et al., 2012; Gamerschlag et al., 2011; Patten, 2002; Reverte, 2009). In contrast, firms in non-heavy–polluting industries have less ecological impact, and the intensity of external attention and

Table 8

Results of heterogeneity analysis.

This table presents the results of moderating variables for the impact of ESG on analyst earnings forecast accuracy. In columns (1) and (2), we form subsamples of state-owned (SOEs) and non-state-owned firms (non-SOEs). In columns (3) and (4), we decompose the full samples into subsamples of heavy- and non-heavy–polluting firms. For brevity, we do not present the coefficients of control variables. *t*-statistics are in parentheses. Table 1 presents definitions of all variables. ***, **, and * indicate 1 %, 5 %, and 10 % significance, respectively.

Variables	Property rights		Industry	
	(1)	(2)	(3)	(4)
	SOE	Non-SOE	Heavy polluting	Non-heavy polluting
ESG_{t-1}^2	8.9944**	3.0808 (0.77)	3.5320 (0.76)	7.2897**
	(2.24)			(1.93)
ESG_{t-1}	−7.2927***	−3.7673	−3.0574	−7.1824***
	(−2.81)	(−1.46)	(−0.93)	(−3.13)
Control var.	Yes	Yes	Yes	Yes
Constant	−18.8869***	−16.8305***	−13.4778***	−16.5286***
	(−10.19)	(−8.66)	(−5.98)	(−11.39)
Industry	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
N	5599	4549	3576	6796
Adj. R^2/ Pseudo R^2	0.4642	0.4323	0.4491	0.4328

environmental supervision on them is relatively low (Wang et al., 2023). Therefore, non-heavy–polluting firms face little or no environmental scrutiny.

We reexamine Eq. (2) by subsamples of firms in heavy-polluting industries and non-heavy–polluting industries. We classify the full sample into heavily polluting industries and non-heavily polluting industries based on the Guidelines on Industry Classification of Listed Companies revised by the China Securities Regulatory Commission in 2012, the Management List of Industry Classification for Environmental Verification of Listed Companies formulated by the Ministry of Environmental Protection in 2008 (Letter of Environmental Affairs [2008] No. 373), and the Guidelines on Environmental Information Disclosure of Listed Companies (Letter of Environmental Affairs [2010] No. 78). The sample was then divided into two groups for regression analysis. The results in columns (3) and (4) of Table 8 show that the nonlinear relation between ESG disclosure and AEFA remains intact for firms in non-heavy–polluting industries while that for heavy-polluting industries is insignificant.

5. Conclusions and implications

ESG disclosure is a relatively new concept in China through which firms comprehensively consider environmental concerns, social responsibility, and corporate governance in their operations and development strategies. Analysts, who act as important participants in the capital market, play a dual role in researching and disseminating information about covered firms to the public.

We investigate the effects of ESG disclosure on AEFA using a nonlinear framework. Using a sample of A-share Chinese firms from 2007 to 2022, we document that firm ESG disclosure has a U–shaped relation with AEFA. The results remain valid to an array of robustness checks. Additional analysis suggests that earnings management and media attention mediate the nonlinear impact of ESG disclosure on AEFA. Cross-sectional tests reveal the effects are more salient for SOEs and those in non-heavy polluting industries.

Our findings carry several implications. First, it would be beneficial for the government to provide guidance to regulators for formulating ESG disclosure policies. Up to a moderate level of ESG disclosure helps analysts provide accurate earnings forecasts, thereby enhancing capital market development. However, when firms have high ESG disclosure levels, analyst forecast accuracy drops, which harms capital market development. Thus, it would be useful for regulators to develop a complete set of mandatory ESG disclosure policies to encourage ESG disclosure but restrain excessive ESG disclosure.

Second, we demonstrate that analysts need to realize the implications of excessive ESG disclosure. Analysts should remain objective and make reasonable use of ESG information disclosed by firms during the earnings forecasting process to avoid increased earnings forecast bias.

Finally, it would be helpful for investors to evaluate a firms' ESG disclosure and analyst earnings forecasts with an understanding of the various levels of ESG disclosure. Specifically, when investors evaluate firms with low level of ESG, analysts' earnings forecasts are useful because of low AEFA. However, when investors examine firms with high level of ESG, analysts' earnings forecasts are not useful because of high AEFA.

Acknowledgments

Data availability

No

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