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THE SIGNALING EFFECT OF ENVIRONMENTAL INFORMATION DISCLOSURE ON INSTITUTIONAL FUND INVESTMENT: EVIDENCE FROM CHINESE LISTED COMPANIES

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Abstract

Using China's corporate environmental disclosure policies and a dynamic incomplete information model, this study examines how listed companies' environmental disclosure signals fund investments. Results show that such disclosure positively signals fund investments, with the effect strengthening alongside rising market attention. Mechanism analyses indicate environmental disclosure signals corporate quality to consumers, enhancing sales and profits. Fund managers recognize this mechanism, directing investments that improve fund performance. This research confirms environmental disclosure as a positive market signal, offering insights for understanding disclosure motivations and mitigating information asymmetry.

Keywords

Environmental information disclosure, Social responsibility, Signaling, Fund investment

1. Introduction

Global emphasis on sustainability has prompted firms to disclose ESG information as competence signals (Cai & Hao, 2025). Environmental Information Disclosure (EID), a core ESG component, provides non-financial data critical for investment decisions (Miklosik & Evans, 2021; Meng & Zhang, 2022), establishing its indispensability in capital markets.

The rise of sustainable investment has intensified investor demands for environmental performance (Meng & Zhang, 2022), with institutional investors adopting EID scores as evaluation criteria (Garel & Petit-Romec, 2021). This ESG focus has reshaped financial practices globally (Matallín-Sáez et al., 2013). Empirical studies show EID enhances market liquidity (Roy et al., 2022; Blau, 2017), reduces capital costs (Clarkson et al., 2008), generates excess returns (Meng & Zhang, 2022; Wong & Zhang, 2022), and mitigates crash risks (Zhou et al., 2021; Kim et al., 2014). EID further attracts investors by lowering risk exposure, stimulating innovation, and improving corporate reputation (Albuquerque et al., 2019; Mayberry, 2020; Beji et al., 2021; Lončar et al., 2019; Hernández et al., 2020). Hoever, no study directly examines EID's impact on fund investments.

Publicly offered funds, as pivotal institutional investors, face growing pressure to align with corporate social responsibility (Eding & Scholtens, 2017; Lee, 2021; Fukuda & Ouchida, 2020). This raises key questions: Do profit-driven funds integrate environmental disclosure into investment decisions? What motivations underlie such behavior?

Information asymmetry persists in capital markets, undermining efficiency (Chan et al., 2008). While signal transmission theory (Spence, 1973) suggests environmental disclosure reduces asymmetry via

cost reduction in Western markets (Clarkson et al., 2008), China's context positions it as a strategic signal for product quality (Zhu et al., 2022), social accountability (Chen et al., 2020), and political alignment (Li, 2014). Critical gaps remain: Can market participants decode these signals to influence consumption? Do funds adjust strategies accordingly?

This study addresses two questions: (1) whether environmental disclosures are perceived by stakeholders, and (2) how they shape investor preferences. Theoretically, we build an incomplete-information dynamic game model showing investors rationally internalize disclosure signals. Empirically, using China's 2010 environmental policies and firm-level data, we analyze how environmental disclosures affect fund investments, examining mechanisms through consumer recognition and fund responses. Results indicate disclosures signal corporate responsibility, enabling consumers to identify firm types and generate profits. Funds recognizing this mechanism allocate investments that enhance performance and capital flows.

2. Theoretical Model and Research Hypotheses

Consumers, as highly sensitive stakeholders, link purchasing decisions to corporate social responsibility (CSR) performance (Sen & Bhattacharya, 2001). Information asymmetry (Akerlof, 1970) drives consumers to interpret environmental disclosure as signals of product quality and responsibility (Drempetic et al., 2020), contingent on effective signal reception and decoding (Du&Vieira, 2022). Environmental disclosures in annual reports primarily target consumers rather than governments:regulators access environmental data through policy channels, rendering annual report signals redundant, whereas consumers rely on standardized disclosures to assess corporate responsibility (Dhaliwal et al., 2020). This study thus focuses on market-driven consumer-investor dynamics rather than government-resource allocation.

We develop a dynamic incomplete-information model showing environmental disclosure functions as a strategic signal. The model demonstrates that precise disclosure conveys corporate responsibility, which aligns with consumers' long-term utility from products, incentivizing increased product purchases and stock investments.

2.1 Model Construction

2.1.1 Enterprise Production

Consider a two-period model with t = 0, 1. In period 0, the firm invests an initial cost of 1 to prepare for production. In period 1, the firm engages in production and sales to generate profits. The firm's production costs comprise both fixed costs and variable costs, where the unit variable cost is c > 0, and the fixed cost is a stochastic term ϵ following a normal distribution $N(\epsilon_0, \sigma^2)$. These fixed costs can be interpreted as market research expenses, sales expenses, administrative costs, etc., which are influenced by macroeconomic conditions or upstream raw material industry dynamics, hence their stochastic nature. Let p denote the product's selling price and q denote the sales quantity. The firm's operating profit from period 0 to period 1 is then given by:

$$r_0 = (p - c)q - \epsilon - 1 \quad (1)$$

2.1.2 Information Asymmetry

Assume firms are of two types: high-responsibility (H) (proportion μ) and low-responsibility (L) (proportion $1 - \mu$). A firm's responsibility level determines its product quality (denoted as Q). High-responsibility firms believe in providing high-quality products to consumers and therefore enhance quality control across production processes, ensuring a superior quality level (Q_H). Low-responsibility firms deem quality improvement unnecessary, consequently maintaining a lower quality level(Q_L). $Q_L < Q_H$

This study posits that product quality can only be observed through long-term post-consumption evaluation. Consequently, during the sales phase, external economic agents cannot assess product quality. Additionally, firms' responsibility levels remain unobservable. This information asymmetry creates challenges for consumers and investors. Absent supplementary signals, they rationally perceive the average product quality as $Q_m = \mu Q_H + (1 - \mu)Q_L$.

2.1.3 Environmental Information Disclosure by Firms

Firms may voluntarily disclose environmental information (period 0) motivated by social responsibility. Disclosure in period 1 incurs cost $F > 0$; non-disclosers bear zero cost. We differentiate firm

types:(1)High-responsibility (H) firms derive non-pecuniary utility $e > 0$ from disclosure as social obligation.(2)Low-responsibility (L) firms gain no utility beyond monetary returns

Both types face identical F but asymmetric benefits: H-types obtain monetary + non-pecuniary gains, while L-types consider only profits. This payoff asymmetry enables H-types to credibly signal type through disclosure.

External attention evolves with policy implementation. Pre-mandatory regimes had low stakeholder attention probability $\lambda \in (0,1)$. As disclosure policies strengthen (e.g., mandatory reporting requirements), attention λ increases over time, critically shaping equilibrium outcomes.

2.1.4 Consumers

In Period 1, the representative consumer's utility maximization problem is formulated as follows:

$$\max_{m\geq 0, q\geq 0} v(m) + Qu(q)$$
$$s.t. \quad m + pq \leq I \tag{2}$$

In this context, q represents the quantity of goods purchased by consumers, generating utility $Qu(q)$. The direct utility function $u(q)$ satisfies $u'(q) > 0, u''(q) < 0$, while consumer utility increases with product quality Q. Within this framework, m denotes expenditures on other goods, with the indirect utility function $v(m)$ satisfying $v'(m) > 0$ and $v''(m) \leq 0$. Given product price p and consumer income I, the budget constraint is defined as $m + pq \leq I$.For analytical simplicity, this study adopts the functional forms$u(q) = \ln(a + q)$ and $v(m) = m$, where $a > 0$. Therefore, when consumers observe product quality Q, their optimal consumption quantity is derived as:

$$q = \frac{Q}{p} - a \tag{3}$$

This consequently indicates that the pricing function faced by the firm is:

$$p = \frac{Q}{a + q} \tag{4}$$

2.1.5 Profit Maximization of Enterprise Operations.

The firm's operating profit r_0 is given by equation (1). Given that consumers perceive the firm's product quality as Q, the price function is determined by equation (4). Substituting this into equation (1), the firm's expected operating profit maximization problem is:

$$\max_{q\geq 0} \left(\frac{Q}{a + q} - c\right) q - \epsilon_0 - 1 \tag{5}$$

Therefore, we obtain:

$$q = \sqrt{\frac{aQ}{c}} - a \tag{6}$$

and the maximized expected operational profit rate is:

$$r_0^*(Q) = \left(\sqrt{Q} - \sqrt{ac}\right)^2 - \epsilon_0 - 1 \tag{7}$$

Clearly, the firm's operating profit $r_0^*(Q)$ increases with consumers' perceived product quality Q.

2.1.6 Investors

Investors purchase corporate shares at period 0 and obtain returns at period 1. The stock return rate, denoted as r, equals the firm's net profit margin. If a firm discloses little or no environmental information, its net profit equals operating profit margin ($r = r_0$). When a firm engages in substantial environmental disclosure, it incurs additional monetary cost F, resulting in a net profit margin equal to operating profit margin minus this incremental cost ($r = r_0 - F$). Notably, for highly responsible firms, the non-monetary utility derived from enhanced environmental disclosure stems from corporate responsibility and is not incorporated in accounting profits, hence no addition of parameter e. As evident from equation (1)'s expression of r_0, since ϵ is stochastic, the stock return rate becomes a random variable following a normal distribution with mean $E(r)$ and variance σ^2.

Assume the investor's utility function follows a mean-variance specification. Specifically, denoting the wealth increment as w, the investor's expected utility is expressed as:

$$U = E(w) - \frac{1}{2}\rho Var(w) \tag{8}$$

where $\rho > 0$ represents the investor's risk aversion coefficient.

Let d denote the quantity of corporate shares purchased by the investor, and let r_f represent the risk-free rate. The wealth increment at period 1 is then given by $w = d\ (r - r_f)$. Consequently, the optimal share quantity selected by the investor is determined as:

$$d = \frac{E(r) - r_f}{\rho\sigma^2} \tag{9}$$

2.2 Equilibrium Analysis

In the dynamic game with incomplete information(Fudenberg & Tirole, 1991), firms and consumers sequentially make strategic choices:

(1)Period 0: Firms choose environmental disclosure levels

(2)Period 1: Consumers form type beliefs from disclosures, determining consumption that affects profits.

Information asymmetry (Healy & Palepu, 2001) prevents consumers from observing product quality Q. Firms thus signal through environmental disclosure to reduce friction and build trust (Healy & Palepu, 2001). As per Equation (3), perceived quality drives demand: when consumers undervalue high-responsibility firms' attributes (due to unrecognized quality), these firms strategically use disclosure levels as responsibility signals to boost recognition and sales.

Specifically, in the signaling game equilibrium, highly responsible firms choose to disclose more environmental information, while low-responsibility firms opt for non-disclosure or minimal disclosure. Both strategies are observable to consumers, enabling them to discern firm types and product quality. Achieving this separating equilibrium requires two conditions. First, highly responsible firms view extensive environmental disclosure as a social responsibility obligation, believing this conduct will ultimately gain consumer recognition and yield higher returns, as expressed by:

$$\lambda r_0^*(Q_H) + (1-\lambda) r_0^*(Q_m) - F + e \geq \lambda r_0^*(Q_L) + (1-\lambda) r_0^*(Q_m) \tag{10}$$

The left-hand side represents the return for high-responsibility firms engaging in environmental disclosure. Specifically, increased disclosure incurs monetary cost F while generating non-monetary utility e from responsibility fulfillment. With probability λ, consumers notice the disclosure behavior, perceive the firm as highly responsible with product quality Q_H, thereby granting high profit $r_0^*(Q_H)$. With probability$(1-\lambda)$, consumers do not observe the level of environmental disclosure, assign the firm quality Q_m, resulting in average profit $r_0^*(Q_m)$.The right side of the equation denotes the return for non-disclosure or limited disclosure: With probability λ, consumers detect low disclosure levels, infer low responsibility (quality Q_L), leading to low profit $r_0^*(Q_L)$.With probability $(1-\lambda)$, consumers remain unaware of disclosure levels, assign the firm quality Q_m, yielding average profit $r_0^*(Q_m)$.

Second, low-responsibility firms perceive environmental disclosure as a burden, where non-disclosure or limited disclosure yields higher returns. Analogous to Equation (10), the condition can be formalized as an inequality:

$$\lambda r_0^*(Q_H) + (1-\lambda) r_0^*(Q_m) - F \leq \lambda r_0^*(Q_L) + (1-\lambda) r_0^*(Q_m) \tag{11}$$

A separating equilibrium is an equilibrium in which two types of incumbents will choose to acquire a signal to distinguish themselves from the rest of the swarm (Kreps et al., 1982). Based on the two equations above, the conditions for the existence of a separating equilibrium can be obtained:

Condition 1: $F > \lambda\left(\sqrt{Q_H} - \sqrt{Q_L}\right)\left(\sqrt{Q_H} + \sqrt{Q_L} - 2\sqrt{ac}\right) > F - e$

Proposition 1: If Condition 1 holds, there exists a unique separating equilibrium. In equilibrium: (1) Highly responsible firms choose extensive environmental disclosure. (2) Low-responsibility firms opt for minimal disclosure.

Healy & Palepu's (2001) cost-benefit theory posits separating equilibrium sustainability requires high-type firms' net benefits (non-monetary utility + sales returns) from signaling exceed disclosure costs, while low-type firms cannot offset costs lacking such utility. Our model's Condition 1 relies on e: socially

responsible firms gain additional utility from environmental disclosure unavailable to low-type firms. This ensures when monetary returns fall short, they enhance disclosures without low-type imitation, validating the signaling mechanism.

2.3 Research Hypotheses

Our theoretical framework (via separating equilibrium analysis) shows highly responsible firms disclose more environmental information, while less responsible ones choose minimal/no disclosure. This signaling resolves enterprise-stakeholder information asymmetry: increased disclosure enables consumers/investors to distinguish corporate types (high vs. low responsibility), refining product quality assessments. Updated beliefs directly shape purchasing decisions and capital allocation.

Investors prefer environmentally transparent, socially responsible firms, recognizing these firms' reliable product quality and long-term sustainability potential. We therefore posit fund investors systematically prioritize enterprises with superior environmental disclosure

Building upon this analysis, we formulate Hypothesis 1:

H1: Firms with higher environmental information disclosure levels attract greater investment from fund investors.

Within the separating equilibrium derived from Proposition 1, a firm's environmental disclosure intensity serves as a positive signal distinguishing its type and product quality. Firms with elevated disclosure levels are perceived by consumers as offering higher-quality products, leading to increased sales volume and revenue. According to Equation (7), operating profit margins rise with quality level (Q), granting superior profitability to high-disclosure firms. Equation (10) further demonstrates their net profit margins exceed those of low-disclosure counterparts. For investor behavior, since investor returns equate to firms' net profit margins (as per our theoretical derivation), investing in high-disclosure firms generates higher returns. Additionally, Equation (9) establishes that return rates positively correlate with investment amounts. This yields our second hypothesis:

H2: In separating equilibrium, firms' sales revenue and profits serve a mediating role between environmental information disclosure levels and fund investments.

It is critical to note that Condition 1 does not universally hold—its validity depends on the magnitude of λ (the probability that consumers/investors monitor corporate disclosure behavior). Separation equilibrium emerges only when λ falls within a moderate range. Two boundary scenarios disrupt the signaling mechanism: (1)Low λ regime ($\lambda \to 0$): Environmental disclosures receive negligible attention, nullifying their signaling value. (2)High λ regime ($\lambda \to 1$): Stakeholders possess full awareness of disclosure patterns. The excessive monetary gains from signaling incentivize even low-responsibility firms to mimic high-disclosure strategies despite lacking non-pecuniary utility, resulting in pooling equilibrium.

China's EID policy evolution—from the 2010 Guidelines (mandating annual reports in polluting industries) to the 2022 Reform Plan (enhancing verification mechanisms)—exhibits three characteristics: expanded disclosure scope, intensified enforcement, and deepened content from compliance to materiality. This progression creates institutional dynamics for analyzing external scrutiny effects. From an evolutionary perspective, China's EID framework remains in developmental stages. The study posits that during initial phases, when public attention (λ) to corporate EID was minimal, signaling effects remained non-existent. As policy implementation intensified, standardized disclosure modules enabled clearer differentiation of corporate environmental performance, leading to rising λ and the emergence of separating equilibrium. However, with further increases in λ, low-responsibility enterprises increasingly mimic high-responsibility counterparts through strategic disclosures, gradually eroding the separating equilibrium and diminishing the signaling value of EID for fund investment decisions.

Hypothesis 3: External attention (λ) exerts a nonlinear moderating effect on the relationship between environmental information disclosure and fund investment.

When λ remains at lower levels, the positive impact of environmental information disclosure on fund investment strengthens progressively with rising λ; however, once λ surpasses a critical threshold,

this positive impact gradually weakens as λ continues to increase, collectively forming an inverted U-shaped curve.

3 Research Design

3.1 Data Sources

Following China's 2010 environmental disclosure standardization, we analyze 2010-2020 Shanghai/Shenzhen A-share listed companies (excluding financial firms, ST/*ST/PT stocks, and observations with excessive missing values). Continuous variables are winsorized at 99%, yielding 25,839 firm-year observations from 3,971 companies. Environmental disclosure data, governance metrics, and financial indicators originate from CSMAR Database, with CSR scores from Hexun CSR Reports. Fund shareholding ratios (fund shares as percentage of tradable A-shares) are measured using equity/hybrid funds' semi-annual and annual reports. Holdings are matched with corporate samples and categorized by investee firms' EID levels and fund attributes, incorporating ownership proportions and performance metrics.

3.2 Variable Selection

3.2.1 Dependent Variable

This study measures fund shareholdings using the shareholding ratio, defined as the proportion of shares held by funds relative to the total number of tradable A-shares or share capital of the company during the corresponding period. The analysis focuses exclusively on actively managed equity funds and hybrid funds. Chinese equity funds fully disclose portfolio holdings in semi-annual and annual reports. To enhance the robustness of conclusions, we calculate year-end and semi-annual fund shareholding ratios based on fund reporting timelines.

3.2.2 Independent Variable

Following Flammer and Luo (2017) and Wang et al. (2022), we measure corporate environmental information disclosure (EID) through disclosure quantity using a structured 30-indicator framework (see Appendix A). Each indicator across five categories is scored 0 (no disclosure), 1 (qualitative), or 2 (quantitative), with lower scores indicating greater information omission. These indicators collectively serve as EID proxy variables in Model (12). Data are sourced from CSMAR's Environmental Data Research Database.

$$EID_i = \sum_{j=1}^{n} I_{i,j} \tag{12}$$

3.2.3 Mediating Variables

We employ three mediating variables: next-period asset turnover ratio (AT, sales revenue/total assets), operating return on assets (OROA, operating profit/total assets), and return on assets (ROA, net profit/total assets). AT captures asset utilization efficiency in sales activities. OROA measures operational profit generation capability, while ROA evaluates overall asset profitability through net profit assessment.

3.3 Model

This paper employs the following baseline model to examine the impact of corporate environmental information disclosure on fund investment:

$$Hold_{i,i+1} = \beta_0 + \beta_1 EID_{i,t} + \beta_2 X_{i,t} + \gamma_y + \gamma_{ind} + \varepsilon_{i,t} \tag{13}$$

Where $Hold_{i,i+1}$ represents two fund ownership variables for firm i at the fiscal year-end disclosure date: the proportion of fund-held shares to total outstanding A-shares and total share capital respectively. To mitigate sampling bias effects, we additionally construct semi-annual fund ownership measures(HoldT_sem and HoldA_sem) for robustness checks. The core explanatory variable $EID_{i,t}$ captures firm i's environmental information disclosure status in year t. $X_{i,t}$ represents the control variables, including corporate social responsibility (CSR) score, firm age, size, return on equity (ROE), leverage ratio, and state ownership, with individual and time fixed effects incorporated in the econometric model. Detailed definitions of these variables are provided in Table 1.

Table 1. Description of variables.

Variable	Definition
Dependent variable	
HoldT	Fund-held shares as a percentage of total share capital (%)
HoldA	Fund-held shares as a percentage of outstanding A-shares (%)
Independent variables	
EID	Corporate environmental information disclosure level
Mediating Variables	
AT	sales revenue as a percentage of total assets
OROA	operating profit as a percentage of total assets
ROA	net profit as a percentage of total assets
Control variables	
CSR	Hexun corporate social responsibility (CSR) score
Age	Firm age:natural logarithm of the difference between the current year and the establishment year
Size	Firm size: natural logarithm of total assets
ROE	Return on equity, Net profit divided by shareholders' equity.
Lev	Leverage ratio, Debt-to-asset ratio.
SOE	Dummy variable,1 for state-controlled enterprises, 0 otherwise.
FEID	Dummy variable,1 for firms with first-time environmental disclosure in the current year, 0 for those with no disclosure history.
Target	Investment opportunities, Growth rate of year-end total assets compared to the prior year.
Top1	Largest shareholder ownership, Proportion of shares held by the largest shareholder to total outstanding shares.
Commit	Independent director ratio, Number of independent directors divided by total board members.

3.4 Descriptive Statistics

Descriptive statistics in Table 2 show that the dependent variable HoldT has a mean of 3.089, a maximum value of 23.61, a minimum value of approximately 0, and a standard deviation of 4.918, indicating significant variation in fund ownership across firms. The dependent variable HoldA exhibits similar characteristics. The explanatory variable EID level has a mean of 6.729, ranging from 1 to 27, suggesting a relatively low overall environmental information disclosure (EID) practice among Chinese listed companies. These results are broadly consistent with comparable data (Yang et al., 2022).

Table 2. Decriptive statistics

VARIABLES	(1) N	(2) mean	(3) sd	(4) min	(5) max
HoldT	25,841	3.089	4.918	0	23.61
HoldA	25,841	4.687	7.858	0	39.36
EID	25,841	6.729	6.155	1	27
CSR	25,841	25.11	15.18	-2.680	74.38
Age	25,839	1.202	0.166	0.602	1.491
Size	25,841	22.19	1.315	19.86	26.23
ROE	25,841	0.0729	0.101	-0.378	0.359
Lev	25,841	0.412	0.204	0.0486	0.865
SOE	25,841	0.360	0.480	0	1
Fecofriendly	25,841	0.0830	0.276	0	1
Target	25,841	0.181	0.361	-0.239	2.488
Top1	25,841	35.18	15.01	8.947	75.10
Commit	25,841	37.50	5.356	33.33	57.14

Note: This table reports the summary statistics of the major variables in our regressions.

4 Empirical Analysis

4.1 Baseline Regression Results

Table 3 columns (1)-(4) present regression results for environmental disclosure (EID) effects on fund ownership using four measurement approaches. All coefficients show 1% significance. EID maintains positive significance across year-end/semi-annual metrics (HoldT/HoldA vs. HoldT_sem/HoldA_sem), confirming environmental disclosure's robust impact on fund holdings. Aligning with theoretical predictions, EID sends positive signals to fund investments, validating Hypothesis 1.

Table 3. Baseline regression results.

VARIABLES	(1) HoldT	(2) HoldA	(3) HoldT_sem	(4) HoldA_sem
EID	0.040***	0.056***	0.025***	0.024*
	(5.19)	(4.62)	(3.28)	(1.87)
Constant	15.522***	56.876***	12.262***	46.983***
	(9.03)	(21.08)	(7.12)	(16.57)
Control	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Observations	25,839	25,839	25,753	25,753
R-squared	0.077	0.098	0.078	0.100
Number of firms	3,971	3,971	3,957	3,957

Note: Baseline regression results for corporate environmental disclosure (EID) effects on fund investment. Standard errors in parentheses. // denote significance at 1%/5%/10% levels.

4.2 Robustness Checks

The aforementioned regressions do not account for potential biases stemming from individual heterogeneity, reverse causality, and omitted variables. We address these concerns through robustness checks by controlling for fund-firm heterogeneity and employing instrumental variables (IV).

1. <u>Mitigating Fund Heterogeneity</u>

This study asserts that fund investments in firms disclosing environmental information reflect the signaling effects of environmental information disclosure (EID). To ensure baseline results are not confounded by funds' endogenous preferences or policy mandates, we examine two dimensions of fund heterogeneity.

Following Wang et al. (2022), we compare Socially Responsible Investment (SRI) and Non-SRI (NSRI) funds to address concerns that funds' inherent social responsibility drives investments in EID firms. Table 5 Columns (1)-(2) show significantly positive EID effects on both fund types ($p<0.05$), indicating signal assimilation irrespective of social responsibility orientations.

We further test policy mandate confounders by distinguishing green funds (prioritizing environmental objectives per Flammer, 2021; Ng & Zheng, 2018; Sangiorgi & Schopohl, 2021) and policy-mandated funds (state-owned or green-labeled). Table 4 Columns (3)-(6) reveal positive EID effects across state-owned/non-state-owned and green/non-green funds ($p<0.05$), excluding policy-driven alternatives.

Table 4. Controlling for Fund Heterogeneity

	(1) SRI HoldT	(2) NSRI HoldT	(3) State-owned funds HoldT	(4) Non-state-owned funds HoldT	(5) Green funds HoldT	(6) Non-green funds HoldT
EID	0.007**	0.012***	0.021***	0.018***	0.002***	0.038***
	(2.06)	(4.00)	(4.50)	(3.96)	(4.10)	(4.97)
Constant	7.590***	4.657***	10.557***	5.160***	-0.484***	15.978***
	(10.78)	(7.03)	(10.28)	(5.16)	(-4.27)	(9.55)
Control	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES

Year FE	YES	YES	YES	YES	YES	YES
Observations	22,468	22,468	25,839	25,839	25,839	25,839
R-squared	0.055	0.037	0.072	0.050	0.029	0.079
Number of firms	3,512	3,512	3,971	3,971	3,971	3,971

2. Instrumental Variable Estimation Results

Drawing on Yang et al. (2023), our first instrumental variable (IV) uses chief executive compensation (Pay).As key disclosure decision-makers, executives' compensation incentives align with environmental disclosure quality through two mechanisms: compensation contracts mitigate agency problems by reducing self-serving motives (Benlemlih et al., 2022), while reputation concerns motivate regulatory compliance to protect professional standing (Khenissi et al., 2022). Being an internal profit allocation metric, Pay remains exogenous to fund investment decisions.

Our second IV employs contemporary industry-average environmental disclosure within the same province (CIED), following established methodologies (Ye et al., 2015; Ge & Chen, 2023). Peer effects in environmental disclosure ensure the relevance condition, while its industry-regional aggregation satisfies exclusion restrictions as fund investors typically make firm-specific evaluations.

Table 5 presents two-stage IV results. First-stage estimates (Column 1) show Pay and CIED significantly predict disclosure levels (1% significance), with F-statistic 1271.50 confirming strong instruments. Second-stage results (Column 2) reveal maintained disclosure-fundholdings relationship, supported by Cragg-Donald Wald F (4265.912 > 19.93 critical value) and valid Hansen J-test. Results confirm baseline findings' robustness.

Table 5. Estimation Results

VARIABLES	EID First （1）	HoldT Second （2）
Pay	0.0005*** (0.0001)	
CIED	0.7814*** （0.0155）	
EID		0.0546*** （0.0198）
Control	YES	YES
Firm FE	YES	YES
Year FE	YES	YES
Observations	25299	25349
The F-statistic of the first stage	1271.50	
Kleibergen-Paap rk LM		544.366
P-value		（0.0000）
Cragg-Donald Wald F statistic		4265.912
Hansen J statistic		1.299
P-value		（0.2544）

Notes: Standard errors are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

3. Heckman Sample Selection Model

Data screening (Section 3.1) may introduce sample selection bias. The Heckman model corrects this bias through a two-step procedure. Using control variables and two instruments (compensation and average age) in the selection equation addresses unobservable characteristics. We estimate the inverse Mills ratio via probit and include it in the second-stage regression. Table 6 shows Heckman results, confirming environmental disclosure significantly increases stock price synchronicity (1% level), demonstrating robustness.

Table 6. Heckman Sample Selection Model Estimates

	HoldT	
	MLE	Twostep
VARIABLES	(1)	(2)
EID	0.0117***	0.2278**
	（0.0026）	（0.0096）
Imr		-3.2325***
		（0.4251）
Constant	1.4159***	3.0564***
	（0.0910）	（1.0034）
Control	YES	YES
Firm FE	YES	YES
Year FE	YES	YES
Observations	29613	25299

Note: Column (1) reports MLE estimates with robust standard errors; (2) second-stage results. All specifications include individual and time fixed effects (standard errors in parentheses). // indicate significance at 1%/5%/10% levels.

5. Mechanism Analysis

Our findings confirm environmental disclosure (EID) positively affects fund investment. We now investigate the underlying mechanisms.

First, we analyze how EID enhances sales and profits. By signaling product quality through differentiation strategies, EID strengthens consumer purchase intentions, improving commercial performance that attracts fund investments. We test this mechanism using sales revenue and profit as dependent variables:

$$Performance_{i,i+1} = c_0 + C_1 \times EID_{i,t} + c_2 \times X_{i,t} + \gamma_y + \gamma_{ind} + \varepsilon_{i,t} \quad (14)$$

Where $\text{Performance}_{i,i+1}$ represents the mechanism variables measuring corporate sales revenue and profits normalized by total assets, operationalized as next-period asset turnover (AT: sales revenue divided by total assets), operating return on assets (OROA: operating profit divided by total assets), and return on assets (ROA: net profit divided by total assets). $X_{i,t}$ denotes control variables, including corporate social responsibility (CSR) scores, firm age, firm size (logarithm of total assets), leverage ratio (total liabilities to total assets), investment opportunities (Tobin's Q), largest shareholder ownership, proportion of independent directors, along with entity/industry and time fixed effects. We implement mediation effect analysis to test three potential channels through which EID influences fund investment.

Table 7 Panel A reports hypothesis testing results. We first estimate OLS models linking environmental information disclosure (EID) to the three mediators. Columns (1)-(3) show significantly positive coefficients on EID for asset turnover (AT), operating ROA, and ROA. Extending the baseline specification from Table 4 by including these mediators (Columns 4-6), we observe reduced EID coefficients compared to original estimates while maintaining statistical significance, with all mediators displaying significant coefficients.

To test the initial disclosure effect - where first-time EID conveys strategic signals about corporate responsibility commitments and provides incremental investor information - Columns (7)-(9) analyze financial performance impacts. The results validate the sales channel mechanism: EID transmits quality signals that strengthen consumer demand, thereby increasing sales revenue and profits to attract fund investments, consistent with Hypothesis 2.

Table 7. Regression Results of Mediation Effect Tests

	（1）	（2）	（3）	（4）	（5）	（6）	（7）	（8）	（9）
	Environmental Information Disclosure						First-Time Environmental Disclosure		
	AT	OROA	ROA	HoldT	HoldT	HoldT	AT	OROA	ROA
EID	0.359***	0.025**	0.034***	0.039***	0.037***	0.036***			
	(6.14)	(2.31)	(3.19)	(4.93)	(4.78)	(4.67)			
AT				0.010***					
				(6.97)					
OROA					0.121***				
					(23.27)				
ROA						0.129***			
						(22.87)			
FEID							1.926**	1.057***	0.903***
							(2.30)	(2.30)	(5.93)
Constant	55.088***	45.945***	43.978***	10.593***	6.127***	6.195***	43.063***	43.083***	41.476***
	(7.88)	(20.21)	(19.93)	(6.14)	(3.57)	(3.61)	(8.26)	(18.68)	(18.52)
Control	YES	YES	YES	YES	YES	YES	YES	YES	YES
Firm FE	NO	YES	YES	YES	YES	YES	NO	YES	YES
Industry FE	YES	NO	NO	NO	NO	NO	YES	NO	NO
Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	29596	29627	29627	25,828	25,832	25,832	29596	29627	29627
R-squared	0.173	0.058	0.064	0.064	0.085	0.084	0.215	0.060	0.065

Notes: Continuous variables have been winsorized at the 1% and 99% levels to mitigate the effects of outliers. Robust standard errors are reported in parentheses.

6.Further Discussion

The further discussion comprises three components: attention and signaling efficacy, heterogeneity analysis based on enterprise ownership types, and an investigation into the economic effects and underlying motivations of fund investments in environmentally disclosing enterprises.

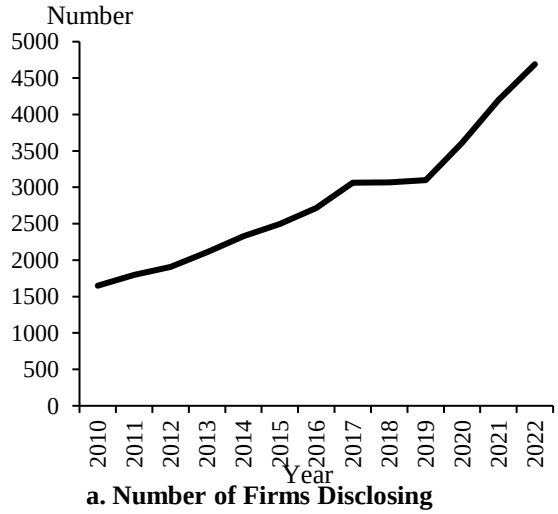
6.1 Attention Level and Signaling Efficacy

Our theoretical framework hypothesizes that high public attention and substantial economic returns from environmental disclosure (EID) incentivize low-responsibility firms to mimic high-responsibility peers through false signals, potentially diminishing the signaling effect. We test this proposition by extending the sample through 2022. Figure 1 charts EID trends following 2010 policy implementation, showing temporary COVID-19-related declines in 2020 but sustained growth in public attention alongside growing participation and disclosure quality. To analyze attention-level dynamics, we introduce time dummies constructed as:

$$
\begin{aligned}
Hold_{i,i+1} = {} & \beta_0 + \beta_1 TPA_{i,t} + \beta_2 t_{2010} + \beta_3 t_{2011} + \beta_4 t_{2012} + \beta_5 t_{2013} + \beta_6 t_{2014} \\
& + \beta_7 t_{2015} + \beta_8 t_{2016} + \beta_9 t_{2017} + \beta_{10} t_{2018} + \beta_{11} t_{2019} + \beta_{12} t_{2020} \\
& + \beta_{13} t_{2021} + \beta_{14} t_{2022} + \beta_{14} TPA_{i,t} \times t_{2010} + \beta_{15} TPA_{i,t} \times t_{2011} \\
& + \beta_{16} TPA_{i,t} \times t_{2012} + \beta_{17} TPA_{i,t} \times t_{2013} + \beta_{18} TPA_{i,t} \times t_{2014} \\
& + \beta_{19} TPA_{i,t} \times t_{2015} + \beta_{20} TPA_{i,t} \times t_{2016} + \beta_{21} TPA_{i,t} \times t_{2017} \\
& + \beta_{22} TPA_{i,t} \times t_{2018} + \beta_{23} TPA_{i,t} \times t_{2019} + \beta_{24} TPA_{i,t} \times t_{2020} \\
& + \beta_{25} TPA_{i,t} \times t_{2021} + \beta_{26} TPA_{i,t} \times t_{2022} + \beta_{27} X_{i,t} + \gamma_{ind} + \varepsilon_{i,t} \qquad (14)
\end{aligned}
$$

In the model, TPA represents a dummy variable indicating whether a firm's environmental information disclosure level in the current year exceeds the sample-period average. Time dummy variables $t_{2010}, t_{2011}, t_{2012}, t_{2013}, t_{2014}, t_{2015}, t_{2016}, t_{2017}, t_{2018}, t_{2019}, t_{2020}, t_{2021}$ and t_{2022} correspond to the years 2010–2022. Taking 2010 as an example, the fund ownership proportions for firms with above-average and below-average environmental disclosure levels are expressed as $\beta_0 + \beta_1 + \beta_2 + \beta_{14}$ and $\beta_0 + \beta_2$, respectively. The dynamic marginal effect is thus quantified as $\beta_1 + \beta_{14}$. By extrapolating this method, the dynamic marginal effects for each year can be decomposed, all of which notably share a common coefficient $\beta_{14}, \beta_{15}, \beta_{16}, \beta_{17}, \beta_{18}, \beta_{19}, \beta_{20}, \beta_{21}, \beta_{22}, \beta_{23}, \beta_{24}, \beta_{25}$ and β_{26} to examine the time-varying marginal impacts of environmental disclosure on fund ownership proportions.

Table 8 documents dynamic signaling effects of environmental disclosure. Coefficient patterns show insignificant impacts during 2010-2015, reflecting ineffective economic influence during policy infancy with unstandardized practices and low public



a. Number of Firms Disclosing Environmental Information by Year

b. Annual Mean Score of Corporate Environmental Disclosure

attention (λ). Post-2016 analysis in Table 9 reveals sustained coefficient growth, indicating strengthening effects on fund investments as policies matured, disclosure transparency improved, and environmental scrutiny intensified.

While Table 8 confirms progressive signaling enhancement, no attenuation emerges - likely because public attention remains below critical thresholds for effect reversal. Hypothesis 3 thus receives partial support: environmental disclosure exhibits the ascending phase of an inverted U-curve, though full validation requires future threshold-crossing observations.

Plate 1. Trends in the Number of Firms Disclosing Environmental Information and Their Mean Scores Since 2010

Table 8. Dynamic Effects of Attention and Signaling Mechanisms

Year	HoldT		HoldA	
	Attention Coefficient	T-value	Attention Coefficient	T-value
2010	-0.347	-1.04	-0.430	-0.82
2011	0.359	1.07	0.786	1.48
2012	0.012	0.04	0.355	0.69
2013	-0.367	-1.15	0.081	0.16
2014	-0.712**	-2.27	-0.362	-0.74
2015	0.290	0.94	0.797*	1.64
2016	1.033***	3.37	2.004***	4.16
2017	0.685**	2.33	1.722***	3.73
2018	0.764***	2.64	1.864***	4.10
2019	1.003***	3.48	2.074***	4.56
2020	1.393***	4.94	2.590***	5.84
2021	1.150***	4.15	2.508***	5.76
2022	1.247***	5.08	2.135***	5.53

Note: *,** and * denote statistical significance at the 0.01, 0.05, and 0.1 levels, respectively.**

6.2 Heterogeneity Analysis Based on Enterprise Ownership Types

To assess ownership-based heterogeneity, we conduct subsample analyses comparing state-owned (SOEs) and non-state-owned enterprises (non-SOEs). Subsample regressions (Table 9) reveal positive disclosure effects in both groups, with stronger impacts for non-SOEs. This aligns with non-SOEs' greater dependence on external financing, which strengthens their disclosure incentives to attract capital, while SOEs' stable government backing and market positions reduce disclosure pressures. These patterns confirm funds' economically-driven integration of environmental disclosure into investment decisions.

Table 9. Heterogeneity Tests Based on Enterprise Ownership Types

	HoldT		HoldA	
	SOEs	non-SOEs	SOEs	non-SOEs
EID	0.028***	0.043***	0.040***	0.059***
	(3.01)	(3.67)	(3.29)	(3.03)
Constant	14.391***	15.677***	26.028***	65.319***
	(5.01)	(6.74)	(7.02)	(16.83)
Control	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Observations	9299	16540	9299	16540

Note: ***, , and * denote statistical significance at the 0.01, 0.05, and 0.1 levels, respectively.

6.3 Fund Return Implications

We evaluate funds' economic rationale for investing in environmentally transparent firms through two dimensions: (1) recognition of consumer-oriented disclosure signals and (2) realized financial returns. Investment intensity is measured via shareholding proportion ($Holdlevel$) and its market-value-weighted counterpart ($Holdlevel\_w$), with fund performance quantified as t+1 raw returns. Controls include fund size, age, prior performance, return volatility, and star fund status (Table 10-Panel B).

Results show significant performance gains for funds investing in high-disclosure firms, confirming their effective recognition of environmental signals and successful capital allocation to enhance financial returns.

Table 10. Fund Holdings in High Environmental Disclosure Firms and Fund Performance

	Return	
Holdlevel	0.005*** （0.0010）	
Holdlevel_w		0.002*** （0.0001）
Constant	-234.826*** （10.7282）	-218.269*** (10.3975)
Control	YES	YES
Observations	12430	12430
R-squared	0.1473	0.1626

Note: ***, , and * denote statistical significance at the 0.01, 0.05, and 0.1 levels, respectively.

7 Conclusion

This study integrates theoretical and empirical analyses to reveal that corporate environmental disclosure serves as a critical information bridge between firms and investors, with its positive signaling effect significantly facilitating fund investment decisions. The findings demonstrate that environmental disclosure transmits quality signals enabling consumers to identify corporate types, which generates sales profits through a distinctive "first-mover effect." Fund investments in environmentally disclosing companies are primarily driven by economic returns rather than altruistic motives. Additionally, the signaling effect is stronger in private enterprises and gains momentum alongside improvements in policy systems.

These results validate the economic value of environmental disclosure while offering actionable insights. Enterprises should strategically leverage environmental reporting to build organizational capabilities and competitive advantages, shifting from cost-focused approaches to emphasizing the long-term benefits of transparency. Policymakers, in turn, need to establish science-based disclosure frameworks with elevated standards and transparency requirements to incentivize corporate responsibility fulfillment.

Future research should address three key limitations. Expanding sample coverage beyond listed companies could reduce selection bias, while examining differential responses across fund types would enhance the scope of current findings. Longitudinal tracking is also critical to assess whether the observed signaling effects sustain or diminish over time. Such extensions would deepen the understanding of environmental disclosure’s economic implications across market ecosystems.

Appendix A. EID index system

First-level indicators	Second-level indicators	Third-level indicators	Maximum score
Soft disclosures	the EID carrier	Annual report of listed companies	1
		Social Responsibility Report	1
		Environmental Report	1
	Environmental management disclosure	Environmental protection concept	1
		Environmental goals	1
		Environmental protection management system	1
		Environmental education and training	1
		Environmental protection special action	1
		Emergency mechanism for environmental incidents	1
		Environmental honors or awards	1
		"Three Simultaneities" system	1
Hard disclosures	Environmental regulation and certification disclosure	Pollutant discharges up to standard	1
		Key pollution monitoring units	1
		Sudden environmental accident	1
		Environmental violations	1
		Environmental petition cases	1
		Have you passed ISO14001 certification	1
		Have you passed ISO9001 certification	1
	Disclosure of environmental liabilities	Wastewater discharge	2
		COD emission	2
		CO2 emissions	2
		Smoke and dust emissions	2
		SO2 emission	2
		Production of industrial solid waste	2
	Environmental performance and governance disclosure	Emission reduction and treatment	2
		Wastewater emission reduction and treatment	2
		Dust and smoke control	2
		Utilization and disposal of solid waste	2
		Noise, light pollution and radiation control	2
		Implementation of cleaner production	2

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