

Carbon Tax Policy, Environmental Accounting Disclosure, and Corporate Financial Performance: Evidence from Listed Energy and Manufacturing Firms

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ABSTRACT

Purpose – Carbon pricing is transforming environmental externalities into measurable corporate costs, yet its financial consequences may differ substantially across carbon-intensive industries. This study examines the association of carbon-tax policy exposure and environmental accounting disclosure with corporate financial performance, focusing on sectoral differences between listed energy and manufacturing firms in Indonesia.

Design/methodology/approach – Using an unbalanced panel of 132 firms and up to 812 firm-year observations from 2018–2025, the study applies two-way fixed-effects regression with firm-clustered robust standard errors and sectoral interaction terms. The main return-on-assets regressions use 799 complete firm-year observations because sales-growth data are unavailable for 13 observations; robustness-test sample sizes vary with the availability of Tobin's Q, return on equity, and lagged disclosure data.

Finding/Results – Carbon-tax policy exposure is negatively associated with financial performance, whereas environmental accounting disclosure is positively associated with profitability. Sectoral estimates reveal a pronounced asymmetry: the adverse financial effect of carbon-policy exposure is substantially stronger among energy firms, while the positive marginal effect of environmental accounting disclosure is also larger in the energy sector. These findings remain stable across alternative performance measures, lagged disclosure specifications, and Driscoll–Kraay standard errors.

Originality/Value – The study integrates carbon-policy exposure, environmental accounting disclosure, and sectoral heterogeneity in an Indonesian firm-level setting. It highlights uneven financial associations with the carbon transition and the potential relevance of environmental disclosure for managing transition-related risks.

ARTICLE INFO

Keywords:

Carbon Tax Policy; Corporate Financial Performance; Energy Sector; Environmental Accounting Disclosure; Manufacturing Sector

Article Information:

Received: 29/05/2026

Revise: 08/06/2026

Accepted: 02/08/2026

ISSN:

2985-3168 (Online)

2985-3222 (Print)

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1. Introduction

Decarbonization is fundamentally changing the way firms perceive and manage carbon emissions. Emissions that were once treated primarily as environmental externalities are increasingly being translated into explicit economic costs through carbon taxes, emissions trading schemes, internal carbon pricing, and climate-related reporting requirements (Bento & Gianfrate, 2020; Tang & Demeritt, 2018; Trinks et al., 2022). This transition is particularly consequential for publicly listed firms because its effects extend beyond environmental compliance to capital budgeting, operating costs, projected cash flows, asset valuation, and investor risk assessment (Ganda & Milondzo, 2018; Miah et al., 2021). In Indonesia, the development of carbon-pricing instruments reinforces the need to understand how firms respond financially to the transition toward a low-carbon economy. Rokhmawati et al. (2024) demonstrate that alternative carbon-tax scenarios can materially affect Indonesia's emissions trajectory, suggesting that the effectiveness and economic consequences of carbon policy depend not only on the tax rate itself but also on how emission-intensive sectors adjust their production, investment, and technology choices. Accordingly, carbon tax policy should be viewed not merely as an environmental instrument, but as an institutional and economic shock capable of reshaping corporate financial outcomes.

The financial consequences of such policies are likely to be especially pronounced in the energy and manufacturing sectors. Energy firms face relatively direct exposure because their business models are closely connected to the production, conversion, and consumption of carbon-intensive energy. Manufacturing firms, by contrast, encounter a more dispersed form of exposure through electricity and fuel consumption, raw-material use, process efficiency, waste generation, supply-chain requirements, and growing market demand for low-carbon products. These differences in asset structure, production technology, and carbon intensity imply that an identical carbon-policy signal may generate heterogeneous financial responses across sectors (Siddique et al., 2021; Tzouvanas et al., 2020). Liu et al. (2023) show that carbon-emission policy can affect the financial performance of targeted firms, indicating that environmental regulation can be transmitted into profitability and firm value through changes in operating costs, investment needs, financing conditions, and competitive positioning. Treating energy and manufacturing firms as a homogeneous population may therefore obscure economically meaningful differences in policy sensitivity.

A synthesis of the literature reveals at least three research gaps. First, studies on carbon pricing, environmental taxation, and emission regulation frequently examine policy effects on environmental behavior or firm performance without explicitly integrating environmental accounting disclosure as part of the corporate response mechanism (Liu et al., 2023; Zhao et al., 2022, 2024). Second, research on environmental accounting often focuses on environmental performance, innovation, disclosure quality, or firm performance in isolation, leaving limited integrated evidence on how policy pressure and environmental disclosure jointly relate to financial outcomes (Deb et al., 2023; Gerged et al., 2024; Qian et al., 2018). Third, many empirical studies rely on broad multi-industry samples in which structural differences in carbon exposure are absorbed by industry controls rather than examined as an economically meaningful source of heterogeneity (Siddique et al., 2021; Velte et al., 2020). Consequently, the literature still provides an incomplete explanation of how carbon tax policy, corporate environmental information, and financial performance interact across sectors with fundamentally different carbon-risk profiles.

These gaps create room for a more integrated explanation of corporate responses to the low-carbon transition. This study conceptualizes carbon tax policy as an institutional-economic pressure that raises the relative cost of emission-intensive activities; environmental accounting disclosure as an information and accountability mechanism that reflects how firms identify, quantify, manage, and communicate environmental consequences; and corporate financial performance as the economic outcome through which the costs and benefits of adaptation become observable (Qian et al., 2018; Scarpellini et al., 2020). This framing links institutional pressure with signalling and environmental-management capabilities (Gerged et al., 2024; Gunaratne et al., 2021). It also recognizes that disclosure can play a dual role: it may reduce information asymmetry for external stakeholders while simultaneously indicating whether environmental information is embedded in internal managerial processes (Gerged, 2021; Jiang et al., 2021; Qian & Schaltegger, 2017). Such an integrated perspective offers a stronger analytical basis than examining carbon policy, environmental disclosure, and financial performance as disconnected relationships.

The novelty of the study is developed along three dimensions. First, it integrates carbon tax policy and environmental accounting disclosure within a single financial-performance framework, thereby connecting an external policy instrument with an internal and external corporate information mechanism. Second, it treats the energy and manufacturing sectors as sources of structural heterogeneity and explicitly examines whether the magnitude or direction of the relationships differs across these sectors rather than merely controlling for industry membership. Third, by focusing on listed firms, the study connects environmental-policy exposure with capital-market accountability, where disclosure quality, risk perception, and financial performance are simultaneously relevant to managers, investors, creditors, and regulators. The contribution is therefore not simply a new empirical setting, but an integrated test of how policy pressure, environmental information, and sectoral characteristics jointly shape corporate financial consequences.

Accordingly, this study aims to examine the effect of carbon tax policy on corporate financial performance, assess the effect of environmental accounting disclosure on corporate financial performance, and evaluate whether the strength and direction of these relationships differ between listed energy and manufacturing firms. Theoretically, the study is expected to strengthen the dialogue among institutional theory, signaling theory, and environmental management accounting by explaining how external carbon-policy pressure is translated into financial outcomes through corporate information and adaptive capabilities. Empirically, it seeks to provide sector-sensitive evidence on the financial implications of the low-carbon transition. From a practical and policy perspective, the findings may help firms design more effective carbon-risk and environmental-information systems, while assisting investors and regulators in distinguishing between disclosure that reflects substantive transition preparedness and disclosure that primarily represents compliance.

2. Literature Review & Hypothesis Development

2.1. Carbon Tax Policy and Corporate Financial Performance

Nevertheless, the relationship between carbon regulation and corporate financial performance cannot be assumed to be uniformly negative. The Porter hypothesis suggests that appropriately designed environmental regulation may stimulate innovation, reduce operational inefficiencies, and accelerate technological upgrading, thereby offsetting at least

part of the compliance burden. At the firm level, internal carbon pricing illustrates how carbon costs can be incorporated into managerial decisions even before all such costs are formally imposed by regulators. Ma and Kuo (2021) find that internal carbon pricing can enhance financial performance when it functions as a mechanism of environmental self-regulation and anticipatory risk management. Similarly, Zhao et al. (2024) show, in the manufacturing context, that environmental taxation may affect firm performance through technological innovation. These findings imply that carbon policy may create both costs and strategic incentives: firms with stronger adaptive capabilities may transform regulatory pressure into efficiency gains, innovation, and improved resource allocation, whereas less-prepared firms may experience a predominantly adverse financial effect.

Despite these arguments, the empirical literature on environmental and financial performance remains heterogeneous. Improvements in environmental performance may increase operating efficiency, reputation, legitimacy, access to finance, and resilience to regulatory shocks. At the same time, environmental investments may depress short-term earnings when transition costs arise before efficiency gains or market benefits materialize. Tzouvanas et al. (2020), focusing specifically on the European manufacturing sector, show that the relationship between environmental and financial performance is complex and becomes particularly relevant under extreme conditions. Such evidence cautions against assuming a stable linear relationship and highlights the importance of institutional context, time horizon, and sectoral exposure. It also suggests that the financial consequences of environmental accounting disclosure may differ depending on whether disclosure represents costly compliance, strategic adaptation, or credible evidence of improved environmental capability.

Taken together, prior evidence suggests that carbon pricing can initially increase compliance costs but can also encourage efficiency-enhancing innovation. Because the net financial effect depends on firm exposure and adaptive capacity (Liu et al., 2023; Rokhmawati et al., 2024; Zhao et al., 2022, 2024), the first hypothesis is stated as follows.

H1: Carbon-tax policy exposure affects corporate financial performance.

2.2. Environmental Accounting Disclosure and Corporate Financial Performance

A critical problem, however, is that such adaptive capacity is difficult to assess when environmental information is not systematically integrated into corporate accounting and reporting systems. Once carbon carries monetary consequences, firms require information systems capable of identifying environmental costs, allocating those costs to relevant activities, evaluating green investments, estimating environmental liabilities, and communicating the economic implications of carbon risk to external stakeholders. Environmental accounting disclosure is therefore more than a reporting exercise; it is an information and accountability mechanism through which environmental exposures are translated into decision-useful financial signals. Qian et al. (2018) show that environmental management accounting is associated with carbon management and disclosure quality, supporting the argument that internal environmental information systems and external disclosure are complementary elements of corporate carbon governance. This role becomes increasingly important when investors must distinguish between firms that merely acknowledge climate-related risks and those that can quantify, manage, and financially absorb them.

From a signalling perspective, credible disclosure of environmental costs, investments, liabilities, and performance can reduce information asymmetry between managers and

capital-market participants. Yet the economic value of such disclosure depends on how stakeholders interpret it. More extensive environmental disclosure may signal superior risk management, transparency, and preparedness for regulatory transition; conversely, it may reveal high environmental exposure, substantial remediation obligations, or costly adjustment requirements. The same disclosure can therefore convey both capability and vulnerability. Siddique et al. (2021), using international evidence, document meaningful links among carbon disclosure, carbon performance, and financial performance, while Alsaifi et al. (2020) show that carbon disclosure carries financial consequences within a developed environmental-policy setting. These findings suggest that the market implications of environmental accounting disclosure are conditional rather than mechanical, and that their interpretation should account for the firm's regulatory exposure and sectoral characteristics.

Environmental accounting disclosure may also be understood through the resource-based view and the dynamic-capabilities perspective. Environmental information becomes economically valuable when it is used to reconfigure operational and strategic decisions rather than merely expand the volume of corporate reporting. Firms that integrate information on energy use, waste costs, environmental investment, emission intensity, and regulatory risk into budgeting and investment appraisal are better positioned to identify inefficiencies, prioritize low-carbon technologies, and anticipate changes in policy and stakeholder expectations. Deb et al. (2023) provide evidence that environmental management accounting contributes to both environmental and financial performance through organizational mechanisms related to information systems, knowledge, green innovation, and energy efficiency. This implies that environmental accounting disclosure may reflect a deeper managerial capability: the capacity to convert environmental information into resource-allocation decisions with financial consequences.

This argument is reinforced by Gerged et al. (2024), who show that the relationship between environmental management accounting and firm performance operates through environmental innovation and stakeholder integration. Their findings are important because they move the discussion beyond a simple compliance-performance relationship. Environmental accounting creates value when information is translated into innovation, cross-functional coordination, stakeholder engagement, and strategically informed investment. This mechanism is particularly relevant to energy and manufacturing firms, where capital-intensive assets, long investment horizons, and technology lock-in can determine emission profiles for many years. In such settings, environmental accounting disclosure may not merely describe past environmental performance; it may provide evidence of whether management possesses the informational infrastructure needed to navigate the financial consequences of decarbonization.

The combined signalling and resource-based arguments indicate that environmental accounting disclosure can improve decision usefulness, stakeholder confidence, and the internal allocation of environmental resources. Consistent with Qian et al. (2018), Deb et al. (2023), and Gerged et al. (2024), the second hypothesis is stated as follows.

H2: Environmental accounting disclosure positively affects corporate financial performance.

2.3. Sectoral Heterogeneity in Policy Exposure and Disclosure Effects

Sectoral differences are equally important from an institutional perspective because they determine how carbon-tax pressure is transmitted into corporate decisions. In the energy

sector, carbon pricing can directly alter the economics of generation assets, fuel choices, reserve valuation, and long-term investment portfolios. In manufacturing, the effect may be transmitted through energy prices, process efficiency, input costs, product redesign, supplier requirements, and low-carbon market standards. Sectoral heterogeneity is therefore not merely a control issue; it is part of the causal mechanism through which carbon policy influences financial performance. If the same regulatory signal produces different economic effects because firms face different carbon intensities, technological constraints, and adjustment opportunities, then explicit comparison between energy and manufacturing firms is essential for drawing policy-relevant and managerially meaningful conclusions.

These institutional and operating differences imply that the financial consequences of both environmental disclosure and carbon-tax exposure should vary across sectors (Alsaifi et al., 2020; Siddique et al., 2021; Tzouvanas et al., 2020). The sectoral hypotheses are therefore stated as follows.

H3: The effect of environmental accounting disclosure on corporate financial performance differs between energy and manufacturing firms.

H4: The effect of carbon-tax policy exposure on corporate financial performance differs between energy and manufacturing firms.

Based on the preceding theoretical arguments and hypothesis development, the relationships examined in this study are summarized in Figure 1. The framework positions carbon-tax policy exposure and environmental accounting disclosure as the main explanatory variables of corporate financial performance, while sector classification captures whether these relationships differ between energy and manufacturing firms. Firm-specific characteristics are incorporated as control variables in the empirical analysis.

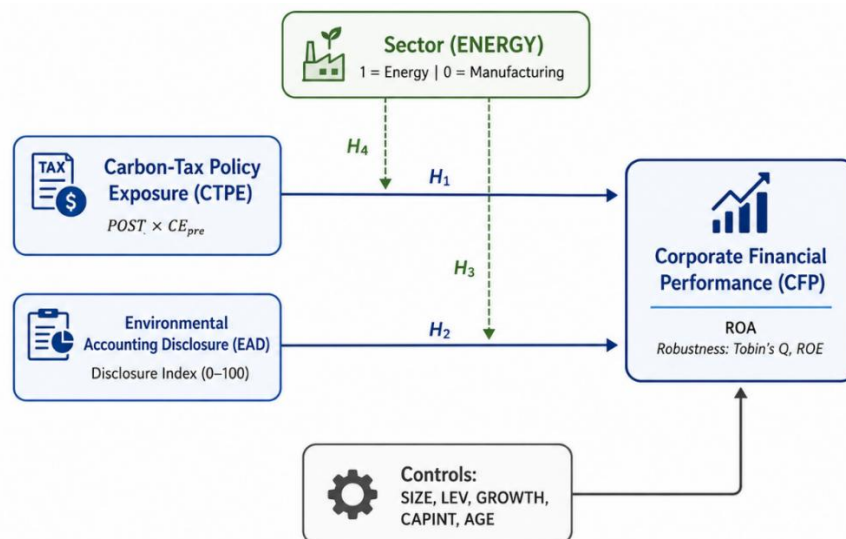


Figure 1. Research Variable Framework

3. Research Method

3.1. Research Design, Population, and Sample

This study adopts a quantitative explanatory design using firm-year panel data to examine the relationship between carbon-tax policy exposure, environmental accounting disclosure, and

corporate financial performance. The population comprises energy and manufacturing firms listed on the Indonesia Stock Exchange (IDX). The observation period covers 2018-2025 to provide sufficient pre-policy and post-policy variation while retaining recent corporate reporting data. Firms are selected purposively when they: (1) are listed for at least two consecutive years during the observation period; (2) publish annual and/or sustainability reports; (3) provide the financial data required to calculate the dependent and control variables; and (4) disclose sufficient environmental information for content analysis. An unbalanced panel is retained to avoid unnecessary loss of observations and survivorship bias.

The study relies exclusively on secondary data. Financial information is obtained from audited annual reports and IDX disclosures, whereas environmental accounting disclosure is coded from annual and sustainability reports. Carbon-tax policy exposure is interpreted as differential exposure to Indonesia's statutory carbon-pricing policy regime rather than as the amount of tax actually paid by each firm. This distinction is necessary because the policy framework has developed progressively and does not impose an identical realized carbon-tax burden on all listed firms.

3.2. Variable Measurement

Corporate financial performance (CFP) is measured primarily by return on assets (ROA), calculated as net income divided by average total assets. ROA is used as the baseline measure because it captures operating profitability relative to the asset base and permits comparison across firms with different financing structures. Tobin's Q and return on equity (ROE) are employed as alternative dependent variables in robustness tests.

Environmental Accounting Disclosure (EAD) is measured through an unweighted content-analysis index. The coding framework covers environmental expenditure, environmental investment, energy use and efficiency, greenhouse-gas emissions, waste and pollution management, environmental provisions or liabilities, environmental compliance costs, emission-reduction targets, environmental risks, and climate-related management initiatives. Each applicable item receives a value of 1 when disclosed and 0 otherwise. The index is calculated as follows:

$$EAD_{it} = (\sum d_{ijt} / N_{it}) \times 100 \quad (1)$$

where d_{ijt} denotes the disclosure score for item j of firm i in year t , and N_{it} is the total number of applicable disclosure items. A higher score indicates more extensive environmental accounting disclosure. To enhance coding reliability, a subsample of reports is independently re-coded and inter-coder agreement is assessed before the final index is used in the regression.

Carbon Tax Policy Exposure (CTPE) is constructed by combining the post-policy period with a predetermined measure of carbon exposure. Carbon exposure is measured using the firm's average pre-policy greenhouse-gas emission intensity where reliable data are available; otherwise, a stable sector-level carbon-intensity classification is used. Pre-policy exposure is fixed using 2018-2020 information to reduce simultaneity with current financial performance. The policy-exposure variable is specified as:

$$CTPE_{it} = POST_t \times CE_{i,pre} \quad (2)$$

where $POST_t$ equals 1 in the post-policy period and 0 in the pre-policy period, while $CE_{i,pre}$ denotes predetermined carbon exposure. The sector indicator $ENERGY_i$ equals 1 for energy

firms and 0 for manufacturing firms. Control variables include firm size (natural logarithm of total assets), leverage (total liabilities divided by total assets), sales growth, capital intensity (net property, plant and equipment divided by total assets), and firm age.

Because CTPE combines a post-policy indicator with predetermined pre-policy carbon exposure, its structure resembles a continuous-treatment difference-in-differences specification. However, the study does not formally test the parallel-trends assumption; therefore, the estimated CTPE coefficients are interpreted as conditional associations with financial performance rather than as definitive causal effects of the carbon-tax policy.

Table 1. Operational Definition of Variables

Variable	Symbol	Measurement	Source
Financial performance	ROA	Net income / average total assets	Annual report
Environmental accounting disclosure	EAD	Unweighted environmental disclosure index (0-100)	Annual/sustainability report
Carbon-tax policy exposure	CTPE	POST × predetermined carbon exposure	Policy period + firm/sector data
Sector	ENERGY	1 = energy; 0 = manufacturing	IDX classification
Firm size	SIZE	Ln total assets	Annual report
Leverage	LEV	Total liabilities / total assets	Annual report
Sales growth	GROWTH	Annual percentage change in sales	Annual report
Capital intensity	CAPINT	Net PPE / total assets	Annual report
Firm age	AGE	Ln years since establishment/listing	Company profile/IDX

3.3. Empirical Model

The main analysis uses a two-way fixed-effects panel model. Firm fixed effects control for time-invariant unobserved characteristics, while year fixed effects absorb macroeconomic shocks common to all firms. The baseline and sector-heterogeneity effects are estimated simultaneously as follows:

$$CFP_{it} = \alpha_i + \lambda_t + \beta_1 CTPE_{it} + \beta_2 EAD_{it} + \beta_3 (CTPE_{it} \times ENERGY_i) + \beta_4 (EAD_{it} \times ENERGY_i) + \gamma' X_{it} + \varepsilon_{it} \quad (3)$$

In Equation (3), CFP_{it} is corporate financial performance; α_i and λ_t denote firm and year fixed effects; X_{it} is the vector of control variables; and ε_{it} is the error term. β_1 captures the association between carbon-tax policy exposure and financial performance for manufacturing firms, whereas β_3 identifies whether this effect differs for energy firms. Similarly, β_2 measures the association between EAD and financial performance in manufacturing firms, while β_4 captures the additional marginal effect for energy firms. Sector-specific marginal effects are reported to facilitate substantive interpretation of the interaction terms.

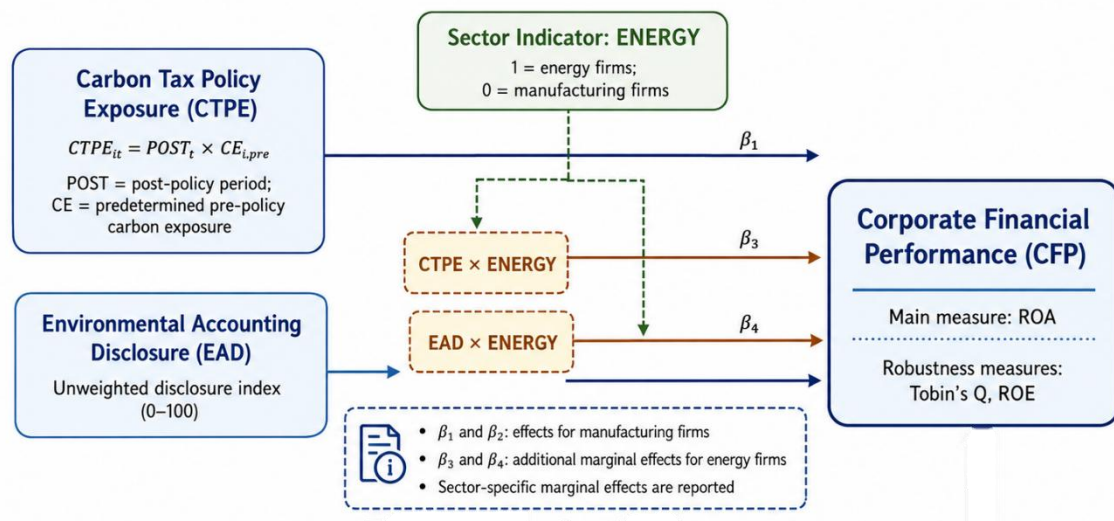


Figure 2. Empirical Model and Sector Heterogeneity Framework

Note: Model estimated using two-way fixed effects with firm and year fixed effects

3.4. Estimation and Robustness Procedures

The analysis begins with descriptive statistics, a correlation matrix, and variance inflation factors to identify extreme distributions and multicollinearity. Pooled OLS, random-effects, and fixed-effects models are estimated as diagnostic benchmarks, with the Breusch-Pagan Lagrange Multiplier and Hausman tests used to support model selection. The principal specification uses firm- and year-fixed effects with standard errors clustered at the firm level to accommodate heteroskedasticity and within-firm serial correlation. Where cross-sectional dependence is detected, Driscoll-Kraay standard errors are reported as an additional robustness check.

Robustness tests re-estimate the model using Tobin's Q and ROE, lag EAD by one year, winsorize continuous variables at the 1st and 99th percentiles, and estimate energy and manufacturing subsamples separately. Where data permit, the analysis also substitutes alternative measures of pre-policy carbon exposure. Statistical significance is evaluated at the 1%, 5%, and 10% levels, while interpretation emphasizes coefficient magnitude and sector-specific marginal effects rather than statistical significance alone.

4. Result and Discussion

4.1. Results

4.1.1. Sample Profile and Descriptive Statistics

The descriptive panel comprises 132 listed firms and up to 812 firm-year observations over the 2018-2025 period, consisting of 31 energy firms and 101 manufacturing firms. The main regression sample includes 799 complete firm-year observations because sales-growth data are unavailable for 13 observations; this reflects variable-specific data availability rather than a change in the estimation design. The unbalanced panel structure reflects differences in reporting continuity and data availability across issuers. Energy firms account for 23.5% of the sample firms but display substantially greater carbon-policy exposure, whereas manufacturing firms constitute the larger cross-sectional group and exhibit a broader dispersion in operating performance.

Table 2. Descriptive Statistics

Variable	Obs.	Mean	Std. Dev.	Min.	Max.
ROA	812	0.056	0.071	-0.196	0.248
Tobin's Q	784	1.384	0.742	0.612	4.915
CTPE	812	0.287	0.734	0.000	2.984
EAD (%)	812	61.80	14.20	28.60	92.90
SIZE	812	29.43	1.56	25.81	33.72
LEV	812	0.462	0.205	0.073	0.891
GROWTH	799	0.093	0.243	-0.422	0.884
CAPINT	812	0.356	0.207	0.041	0.842
AGE	812	27.60	13.40	5.00	68.00

Note: ROA = return on assets; CTPE = carbon-tax policy exposure; EAD = environmental accounting disclosure. Observation counts vary by variable because of data availability. The main regressions use 799 complete observations, compared with the maximum descriptive sample of 812 observations. Continuous variables are winsorized at the 1st and 99th percentiles.

The average ROA is 5.6%, although the relatively large standard deviation indicates substantial heterogeneity in profitability across firm-years. The mean Tobin's Q of 1.384 suggests that market valuation generally exceeds the book value of assets. Environmental accounting disclosure averages 61.8%, with scores ranging from 28.6% to 92.9%, indicating that firms differ materially in the extent to which they communicate environmental costs, liabilities, emissions, energy use, mitigation expenditure, and transition-related information.

Sectoral differences are economically meaningful. Energy firms record a higher mean EAD score (68.5%) than manufacturing firms (59.6%), but a lower mean ROA (4.9% compared with 5.8%). The average CTPE value is 0.891 for energy firms and 0.102 for manufacturing firms. This pattern is consistent with the institutional structure of carbon pricing: firms whose assets and production processes are more carbon intensive face greater transition exposure and, simultaneously, stronger incentives to disclose environmental information.

4.1.2. Preliminary Diagnostics and Panel Model Selection

The correlation structure indicates that ROA is negatively associated with CTPE ($r = -0.184$) and leverage ($r = -0.298$), while EAD ($r = 0.232$) and sales growth ($r = 0.214$) are positively associated with profitability. CTPE and EAD are positively correlated ($r = 0.271$), implying that firms with stronger carbon-policy exposure tend to provide more extensive environmental disclosure. However, the magnitude remains moderate and does not suggest conceptual overlap between policy exposure and disclosure quality.

Table 3. Correlation and Multicollinearity Diagnostics

Variable	ROA	CTPE	EAD	SIZE	LEV	GROWTH	CAPINT	VIF
ROA	1.000							1.00
CTPE	-0.184	1.000						1.62

Variable	ROA	CTPE	EAD	SIZE	LEV	GROWTH	CAPINT	VIF
EAD	0.232	0.271	1.000					1.84
SIZE	0.091	0.188	0.304	1.000				2.21
LEV	-0.298	0.126	0.081	0.221	1.000			1.48
GROWTH	0.214	-0.041	0.067	0.052	-0.097	1.000		1.18
CAPINT	-0.101	0.314	0.176	0.207	0.118	-0.054	1.000	1.73

Note: All VIF values are below conventional thresholds, indicating that multicollinearity is not a material concern.

Table 4. Panel Model Selection

Diagnostic Test	Statistic	p-value	Inference
F test for individual effects	7.82	<0.001	Fixed effects preferred to pooled OLS
Breusch-Pagan LM	196.40	<0.001	Panel estimator preferred to pooled OLS
Hausman test	27.61	<0.001	Fixed effects preferred to random effects
Pesaran CD	4.68	<0.001	Cross-sectional dependence detected

The model-selection tests support a fixed-effects specification. The F test rejects pooled OLS in favor of firm effects, and the Hausman statistic rejects the consistency of random effects. In addition, the significant Pesaran CD statistic indicates contemporaneous dependence across firms, which is plausible because listed companies are jointly exposed to macroeconomic, commodity-price, financing, and regulatory shocks. Accordingly, the main estimates use two-way fixed effects with firm-clustered robust standard errors, while Driscoll-Kraay inference is reported as a robustness check.

4.1.3. Main Effects on Corporate Financial Performance

Table 5. Two-Way Fixed-Effects Regression Results

Variables	Model 1	Model 2	Model 3
CTPE	—	-0.0118** (0.0049)	-0.0109** (0.0046)
EAD	—	—	0.00041*** (0.00012)
SIZE	0.0048** (0.0022)	0.0044** (0.0021)	0.0039* (0.0020)
LEV	-0.0870*** (0.0150)	-0.0840*** (0.0148)	-0.0810*** (0.0146)
GROWTH	0.0220*** (0.0070)	0.0210*** (0.0069)	0.0200*** (0.0068)

Variables	Model 1	Model 2	Model 3
CAPINT	-0.0190* (0.0110)	-0.0170* (0.0102)	-0.0150 (0.0100)
AGE	0.0030 (0.0027)	0.0028 (0.0026)	0.0025 (0.0025)
Firm FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Observations	799	799	799
Firms	132	132	132
Adjusted R ²	0.381	0.398	0.427

Note: Firm-clustered robust standard errors are reported in parentheses. *** $p < 0.01$; ** $p < 0.05$; * $p < 0.10$.

Carbon-tax policy exposure is negatively associated with corporate financial performance. In the full specification, the CTPE coefficient is -0.0109 ($p < 0.05$), implying that a one-unit increase in policy exposure is associated with a 1.09 percentage-point reduction in ROA, ceteris paribus. Relative to the sample mean ROA of 5.6%, the magnitude is economically substantial. The result indicates that firms with greater pre-existing carbon exposure bear higher adjustment costs as carbon pricing becomes more salient, including compliance expenditure, accelerated asset replacement, energy-efficiency investment, financing pressure, and potential impairment of carbon-intensive assets.

Environmental accounting disclosure has the opposite association. The EAD coefficient is 0.00041 ($p < 0.01$), indicating that a ten-percentage-point increase in disclosure is associated with an approximately 0.41 percentage-point increase in ROA. This represents roughly 7.3% of the sample mean profitability and therefore has non-trivial economic significance. The result is consistent with the view that environmental accounting disclosure reflects not only external transparency but also a firm's internal capacity to identify environmental costs, monitor environmental liabilities, evaluate mitigation expenditure, and integrate transition risks into managerial decisions.

The incremental explanatory power of the full model further supports the relevance of the environmental variables. Adjusted R² increases from 0.381 in the controls-only specification to 0.398 after CTPE is introduced and to 0.427 when EAD is added. Leverage remains negatively related to ROA, while sales growth remains positive and significant across specifications. The stability of these control coefficients suggests that the estimated environmental effects are not driven solely by conventional differences in financing structure or growth conditions.

4.1.4. Sectoral Heterogeneity

Table 6. Sectoral Interaction Estimates

Variables	Coefficient	Robust SE	t-statistic	p-value
CTPE	-0.0064	0.0041	-1.56	0.124
EAD	0.00034***	0.00011	3.09	0.003
CTPE × ENERGY	-0.0157***	0.0054	-2.91	0.004

Variables	Coefficient	Robust SE	t-statistic	p-value
EAD × ENERGY	0.00029*	0.00016	1.78	0.078
SIZE	0.0037*	0.0020	1.85	0.067
LEV	-0.0790***	0.0145	-5.45	<0.001
GROWTH	0.0190***	0.0067	2.84	0.005
CAPINT	0.0021	0.0018	1.17	0.243
AGE	-0.00041	0.00023	-1.78	0.076
Firm FE	Yes			
Year FE	Yes			
Observations	799			
Adjusted R ²	0.446			

Note: ENERGY = 1 for energy firms and 0 for manufacturing firms. Marginal effects are obtained by combining the relevant main and interaction coefficients.

The interaction estimates reveal a pronounced sectoral asymmetry. For manufacturing firms, the CTPE coefficient is negative but not statistically different from zero (-0.0064; $p = 0.124$). By contrast, the interaction between CTPE and the energy-sector indicator is -0.0157 ($p < 0.01$). The implied marginal effect for energy firms is therefore -0.0221, meaning that a one-unit increase in carbon-policy exposure is associated with a 2.21 percentage-point reduction in ROA. The magnitude is more than three times the corresponding estimate for manufacturing firms and confirms that the financial burden of carbon transition is concentrated in firms whose operating models are more directly tied to carbon-intensive assets and energy-related activities.

Environmental accounting disclosure also exhibits sectoral heterogeneity, but in the opposite direction. The baseline EAD effect for manufacturing firms is 0.00034 ($p < 0.01$), while the EAD × ENERGY coefficient is positive at 0.00029 ($p < 0.10$). The combined marginal effect for energy firms is therefore 0.00063. In practical terms, a ten-percentage-point increase in EAD corresponds to an estimated 0.34 percentage-point increase in ROA for manufacturing firms and a 0.63 percentage-point increase for energy firms. This difference suggests that the informational and strategic value of environmental accounting is greatest where environmental exposure is most economically material.



Figure 3. Sector-Specific Marginal Effect of Carbon-Tax Policy Exposure on ROA

Note: Points show estimated marginal effects; error bars represent 95% confidence intervals.

The confidence intervals in Figure 3 reinforce this interpretation. The manufacturing estimate overlaps zero, whereas the energy-sector estimate is entirely below zero. The evidence therefore does not indicate a uniform profitability decline following the emergence of carbon-pricing policy. Instead, it points to a differential-exposure mechanism in which the consequences of policy transition depend on the carbon intensity embedded in the firm's business model.

4.1.5. Robustness Checks

Table 7. Robustness Tests

Variables	Tobin's Q	ROE	Lagged EAD	Driscoll-Kraay
CTPE	-0.0820* (0.0450)	-0.0260** (0.0120)	-0.0104** (0.0048)	-0.0064** (0.0045)
EAD	0.0068*** (0.0021)	0.00110** (0.00045)	0.00031** (0.00014)	0.00039*** (0.00013)
CTPE × ENERGY	-0.0940* (0.0510)	-0.0310** (0.0140)	-0.0146** (0.0060)	-0.0149** (0.0061)
EAD × ENERGY	0.0037 (0.0024)	0.00073* (0.00041)	0.00025* (0.00015)	0.00027* (0.00016)
Controls	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Observations	772	798	671	799

Note: Robust standard errors are reported in parentheses. Sample sizes vary with the availability of Tobin's Q, ROE, and lagged EAD data. *** $p < 0.01$; ** $p < 0.05$; * $p < 0.10$.

The principal findings remain stable across alternative specifications. When Tobin's Q is used as the outcome variable, CTPE remains negative and EAD remains positive, indicating that the direction of the relationships extends beyond accounting profitability to market valuation. The ROE specification produces the same directional pattern, with a larger negative CTPE coefficient, consistent with the greater sensitivity of equity returns to operating and financing shocks.

The lagged-disclosure model provides additional temporal support for the EAD relationship. EAD measured in the previous year remains positively associated with current ROA (0.00031; $p < 0.05$), reducing the likelihood that the baseline result is explained entirely by contemporaneous profitability enabling firms to disclose more. Likewise, the Driscoll-Kraay specification, which accounts for cross-sectional dependence and serial correlation, produces coefficients close to the baseline estimates: -0.0064 for CTPE ($p < 0.05$) and 0.00039 for EAD ($p < 0.01$).

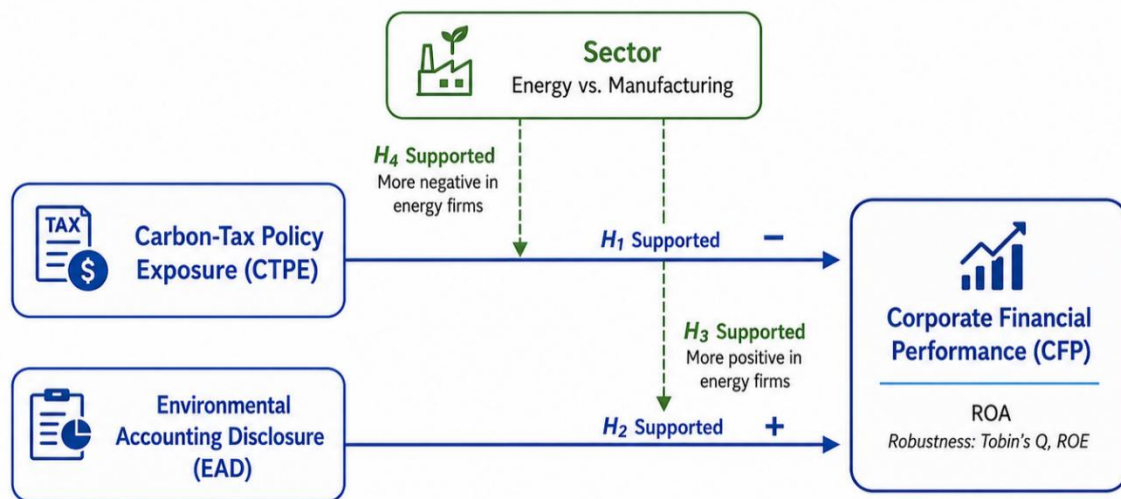
Sector-specific robustness estimates lead to the same substantive conclusion. The carbon-policy coefficient remains materially more negative among energy firms, whereas the manufacturing estimate is smaller and statistically weaker. The consistency across performance measures, temporal specifications, and alternative covariance estimators indicates that the central findings are not artifacts of a particular modeling choice.

4.1.6. Summary of Hypothesis Testing

Table 8. Summary of Hypothesis Testing

Hypothesis	Empirical Evidence	Decision
H1: CTPE affects CFP	Negative and significant in the aggregate model	Supported
H2: EAD positively affects CFP	Positive and significant	Supported
H3: EAD effect differs by sector	Larger positive marginal effect in energy firms	Supported
H4: CTPE effect differs by sector	Substantially more negative marginal effect in energy firms	Supported

Overall, the results reveal a dual and asymmetric transition mechanism. Carbon-tax policy exposure is associated with a financial penalty, but the penalty is concentrated among energy firms rather than being uniformly distributed across listed companies. At the same time, environmental accounting disclosure is positively associated with financial performance, and its marginal value is greater in the sector facing the highest carbon-policy exposure. The combined evidence therefore suggests that environmental accounting functions as an economically relevant organizational capability in the transition toward carbon pricing, particularly where transition risk is most material. The overall pattern of the empirical findings is summarized in Figure 4.

**Figure 4.** Sectoral Dynamics of Carbon-Tax Policy Exposure, Environmental Accounting Disclosure, and Corporate Financial Performance

4.2. Discussion

4.2.1. Carbon-Tax Policy Exposure and the Financial Cost of Transition

The negative association between carbon-tax policy exposure (CTPE) and corporate financial performance suggests that greater exposure to the transition toward explicit carbon pricing is associated with weaker financial performance among listed firms. In the full specification, greater exposure is associated with lower return on assets, and the effect remains directionally

stable across alternative performance measures. This finding is consistent with Liu et al. (2023), who show that carbon-emission policy can transmit regulatory pressure into firm-level financial outcomes, and with Rokhmawati et al. (2024), whose Indonesian carbon-tax scenarios demonstrate that the consequences of carbon pricing depend critically on the adjustment behavior of emission-intensive sectors. The result is consistent with an institutional-economic interpretation in which carbon-pricing policy may alter the relative cost of carbon-intensive production and increase the relevance of environmental costs for firms' operating and investment decisions.

The negative CTPE association can be interpreted as being consistent with a transition-cost channel rather than as evidence that environmental regulation is inherently value destroying. Carbon-intensive firms must often reallocate capital toward energy efficiency, cleaner production, monitoring systems, technology replacement, and compliance infrastructure before the full financial benefits of transition are realized. Bento and Gianfrate (2020) show that firms adopt internal carbon prices precisely because carbon risk has become economically relevant to investment decisions, while Bento et al. (2021) demonstrate that national climate-policy environments shape corporate carbon-pricing practices. Trinks et al. (2022) further distinguish external carbon costs from internal carbon prices, highlighting the financial importance of translating climate externalities into decision-relevant corporate metrics. In this sense, the negative CTPE coefficient is consistent with near- to medium-term adaptation costs under increasing policy salience, although the observational design does not establish that these costs were caused by the policy itself.

The findings also help explain why anticipatory carbon management can moderate financial vulnerability. Ma and Kuo (2021) find that internal carbon pricing can enhance financial performance when it operates as an instrument of environmental self-regulation, while Veeravel et al. (2025) report evidence that internal carbon pricing can improve firm performance among listed companies. Desai et al. (2025) similarly show that internal carbon pricing can alter how carbon emissions are translated into firm value. These studies suggest that the key distinction is not simply between regulated and unregulated firms, but between firms that passively absorb carbon-policy costs and firms that incorporate carbon signals into capital budgeting, product strategy, and risk assessment. The present result is therefore compatible with a dynamic view in which the initial financial burden of policy exposure may be partially offset when firms develop credible internal mechanisms for pricing and managing carbon.

A related mechanism operates through environmental performance itself. Zhu et al. (2022) show that internal carbon pricing can improve corporate environmental performance, whereas Qin et al. (2023) demonstrate that the carbon-reduction effects of internal pricing depend on how the mechanism is implemented. These findings imply that policy exposure does not automatically generate emission reductions or financial benefits. Carbon pricing becomes strategically useful when the price signal is sufficiently integrated into operational decisions to change energy use, process design, investment selection, and technology choice. The present evidence of a negative short-run financial association is therefore plausible in a setting where corporate adaptation remains uneven: firms may recognize the regulatory signal before they have fully captured the efficiency gains generated by low-carbon restructuring.

This interpretation is also consistent with the Porter-hypothesis literature. Zhao et al. (2022) show that environmental taxation can improve firm performance through the quality of technological innovation, while Zhao et al. (2024) document a similar innovation channel among manufacturing firms. Gorbach et al. (2022) emphasize that the effectiveness of internal carbon-pricing methods depends on organizational fit and decision context, and Ben-Amar et al. (2022) show that climate-change exposure shapes the likelihood that firms adopt internal carbon pricing. Taken together, these studies clarify the apparent tension between regulatory cost and strategic opportunity. Greater carbon-tax policy exposure may be associated with lower current profitability when compliance and capital-adjustment costs are more salient, yet the same pressure may stimulate innovation, managerial discipline, and technological upgrading that improve performance over a longer horizon. The results thus support a conditional rather than deterministic reading of the carbon-policy–performance relationship.

4.2.2 Environmental Accounting Disclosure as an Information and Adaptive Capability

The positive association between environmental accounting disclosure (EAD) and financial performance provides evidence that environmental information has economic value beyond symbolic reporting. A ten-percentage-point increase in EAD is associated with a meaningful improvement in ROA, and the direction of the effect remains positive when alternative outcome measures and lagged disclosure are used. This result is consistent with Qian et al. (2018), who demonstrate that environmental management accounting strengthens carbon management and disclosure quality, and with Deb et al. (2023), who show that environmental management accounting contributes to both environmental and financial performance. The central implication is that disclosure quality may reveal the existence of internal information systems capable of identifying environmental costs, liabilities, resource inefficiencies, and transition risks before these factors become visible in conventional financial statements.

The finding also reinforces the view that environmental accounting becomes valuable when it is embedded in managerial processes. Burritt et al. (2019) document the diffusion of environmental management accounting as a cleaner-production mechanism across organizational settings, indicating that accounting practices can influence how environmental information enters operational decisions. Latan et al. (2018) show that environmental strategy, environmental uncertainty, and top-management commitment interact with environmental management accounting in shaping corporate environmental performance. Gunarathne et al. (2021) similarly demonstrate that institutional pressure and environmental strategy are linked to organizational performance through environmental management accounting. The positive EAD coefficient can therefore be interpreted as evidence that firms capable of systematically measuring and communicating environmental information are also more likely to possess the internal governance routines needed to convert environmental pressure into resource-allocation discipline.

From a capability perspective, the results are particularly aligned with research that treats environmental accounting as part of organizational adaptation. Scarpellini et al. (2020) link environmental accounting with dynamic capabilities in circular-economy business models, while Bresciani et al. (2023) show that environmental management accounting and environmental knowledge-management practices jointly influence environmental performance. Gerged et al. (2024) extend this logic by demonstrating that environmental innovation and stakeholder integration help explain the relationship between environmental

management accounting and firm performance. These studies suggest that the financial value of disclosure is unlikely to arise from disclosure volume alone. Rather, disclosure can function as an observable manifestation of deeper capabilities: data collection, cross-functional coordination, environmental cost tracing, risk anticipation, and the ability to redesign activities in response to regulatory and market signals.

The positive financial association also has an external-information dimension. Gerged (2021) shows that corporate-governance structures influence environmental disclosure in emerging markets, indicating that disclosure quality is partly a product of governance and accountability arrangements. Tang and Demeritt (2018) demonstrate that mandatory carbon reporting can alter business processes and performance, which reinforces the proposition that reporting requirements can produce internal organizational consequences rather than merely external compliance outputs. In capital-market settings, credible EAD can reduce uncertainty about environmental liabilities, transition expenditure, and managerial preparedness. This informational function is especially important where investors face difficulty distinguishing firms with substantive transition strategies from those whose environmental narratives are primarily reputational.

The lagged-disclosure robustness result strengthens this interpretation because prior-year EAD remains positively associated with current financial performance. Although this does not establish causality, it reduces the likelihood that the relationship is driven entirely by more profitable firms having greater resources to produce sustainability reports. Instead, the pattern is consistent with a sequencing mechanism in which stronger environmental information systems precede at least part of the subsequent financial benefit. For SINTA 2 and Scopus-level interpretation, the substantive point is therefore not that disclosure mechanically raises profitability, but that environmental accounting disclosure can proxy for organizational preparedness, transparency, and decision capability that become economically valuable when environmental risks are increasingly priced.

4.2.3. Sectoral Asymmetry between Energy and Manufacturing Firms

The sector-interaction results reveal that the financial effects of carbon transition are strongly heterogeneous. The marginal effect of CTPE is substantially more negative for energy firms than for manufacturing firms, while the positive marginal effect of EAD is also larger in the energy sector. This asymmetry is consistent with Tzouvanas et al. (2020), who show that the relationship between environmental and financial performance in manufacturing is complex and sensitive to extreme conditions, and with Ganda and Milondzo (2018), who document financially relevant consequences of carbon emissions at the firm level. Miah et al. (2021) similarly find that carbon emissions and firm performance are related across emerging economies. These studies support the proposition that the economic consequences of environmental exposure depend on sector-specific production technologies, asset structures, and carbon intensity rather than on regulation alone.

For energy firms, carbon-policy exposure is more likely to affect the economics of core assets, fuel choices, reserve valuations, generation technologies, and long-horizon capital expenditure. The corresponding effect in manufacturing is more diffuse because carbon costs may be transmitted through electricity prices, process efficiency, input substitution, supplier requirements, and product redesign. This distinction helps explain why the manufacturing CTPE coefficient is weaker while the energy interaction is strongly negative. The result is also

consistent with Siddique et al. (2021), who show that the relationships among carbon disclosure, carbon performance, and financial performance vary across institutional contexts, and with Alsaifi et al. (2020), who demonstrate that carbon disclosure has financial consequences under an established environmental-policy regime. Sectoral exposure therefore conditions the financial materiality of both carbon costs and carbon information.

The stronger positive EAD effect among energy firms is equally important. In a high-exposure sector, environmental disclosure contains more decision-relevant information because it speaks directly to future cash flows, stranded-asset risk, capital requirements, and regulatory vulnerability. Jiang et al. (2021) show that voluntary carbon disclosure can be value relevant across the United States and BRIC economies, suggesting that markets can price carbon information when it contains credible signals about firm risk and strategy. Hassan and Romilly (2018) likewise identify interrelationships among corporate economic performance, environmental disclosure, and greenhouse-gas emissions. The present interaction result extends this logic by suggesting that the value of environmental information rises with the underlying economic materiality of environmental exposure.

The sectoral evidence also helps reconcile mixed findings in the broader literature. Velte et al. (2020), in their systematic review, document heterogeneous governance determinants and financial consequences of carbon performance and disclosure, implying that a single universal coefficient is unlikely to characterize all firms. Trumpp and Guenther (2017) identify a U-shaped relationship between environmental and financial performance, while Hang et al. (2019) show through meta-analysis that the causal relationship between environmental and financial performance is partly time dependent. These findings indicate that both non-linearity and adjustment horizons matter. Energy firms may initially experience stronger financial pressure because transition costs are immediate and asset-specific, whereas the benefits of technological upgrading, lower emissions, and reputational improvement may emerge later.

Finally, the results are consistent with the legitimacy and management perspectives articulated by Qian and Schaltegger (2017). Firms do not disclose carbon information solely to satisfy external legitimacy demands; disclosure can also support internal management and performance improvement. The larger EAD premium in the energy sector suggests that this managerial function becomes more consequential when environmental risk is central to the business model. Thus, the contribution of the sector interaction is conceptual as well as empirical: it demonstrates that carbon policy and environmental accounting should be analyzed jointly with sectoral exposure. Without this interaction structure, an aggregate model would understate the financial penalty borne by energy firms and obscure the comparatively higher value of environmental accounting in the same sector.

4.2.4 Integrated Theoretical, Managerial, and Policy Implications

Taken together, the results support an integrated framework in which carbon policy operates as institutional-economic pressure, while environmental accounting disclosure represents an informational capability that shapes how firms absorb and respond to that pressure. The negative CTPE coefficient is consistent with transition-cost exposure, whereas the positive EAD coefficient indicates that informational preparedness can partially counterbalance the financial burden of decarbonization. This integrated reading connects the carbon-pricing literature (Bento & Gianfrate, 2020; Ma & Kuo, 2021; Trinks et al., 2022) with the environmental management accounting literature (Qian et al., 2018; Gerged et al., 2024). It also provides a

clearer explanation for why similar policy signals can produce different financial outcomes across firms: exposure determines the size of the shock, while accounting and managerial capability influence the quality of the response.

The findings carry direct implications for corporate managers. First, carbon-related costs should be incorporated into investment appraisal, capital budgeting, procurement, and asset-management decisions before regulatory costs become fully binding. Second, environmental accounting systems should move beyond descriptive sustainability reporting toward cost tracing, carbon-risk quantification, environmental capital-expenditure evaluation, and scenario analysis. The evidence from internal carbon pricing and environmental management accounting suggests that anticipatory mechanisms are most useful when they influence actual decisions rather than remain stand-alone reporting exercises (Gorbach et al., 2022; Gunarathne et al., 2021). For energy firms in particular, the stronger negative CTPE effect implies that delaying such integration may create greater future adjustment costs.

For investors and creditors, the results imply that environmental accounting disclosure can improve the assessment of transition risk, but disclosure volume should not be treated as equivalent to disclosure quality. Investors should distinguish between generic environmental narratives and disclosures that quantify emissions, environmental expenditure, liabilities, transition targets, and the financial consequences of climate strategy. The evidence that carbon disclosure can be financially and value relevant (Alsaifi et al., 2020; Jiang et al., 2021; Siddique et al., 2021) suggests that market participants can use environmental accounting information to differentiate between firms that merely communicate environmental commitment and firms that demonstrate measurable preparedness. This distinction is particularly valuable in the energy sector, where transition risk has more direct implications for asset values and long-term cash flows.

The policy implications are equally important for Indonesia. Rokhmawati et al. (2024) emphasize that the environmental effectiveness of carbon-tax design depends on the interaction between policy parameters and sectoral responses. The present sectoral evidence suggests that a uniform regulatory architecture may generate uneven adjustment burdens because energy firms face substantially greater exposure than manufacturing firms. A credible carbon-pricing framework should therefore be accompanied by transparent transition pathways, consistent reporting standards, and incentives for technological upgrading so that the policy signal encourages genuine decarbonization rather than only short-term cost absorption. At the same time, disclosure regulation should encourage comparability between carbon metrics and financial consequences, enabling stakeholders to evaluate whether corporate transition strategies are operationally substantive.

The robustness results strengthen these implications because the central relationships persist when performance is measured using Tobin's Q and ROE, when disclosure is lagged, and when Driscoll-Kraay standard errors address cross-sectional dependence. This stability suggests that the principal findings are not artifacts of a single accounting ratio or covariance estimator. Nevertheless, the interpretation should remain appropriately bounded: the evidence supports robust associations within the specified panel design, while stronger causal claims would require quasi-experimental identification, more granular verified emissions data, or exogenous variation in carbon-policy exposure. The study's contribution therefore lies in demonstrating a coherent and economically meaningful pattern: carbon transition creates

asymmetric financial pressure, and environmental accounting capacity is most valuable precisely where that pressure is most material.

5. Conclusion

This study examines the relationship between carbon-tax policy exposure, environmental accounting disclosure, and corporate financial performance among listed energy and manufacturing firms. The empirical pattern shows that greater exposure to the carbon-policy regime is associated with weaker financial performance, while stronger environmental accounting disclosure is associated with higher profitability. These findings indicate that greater exposure to the transition toward carbon pricing is associated with measurable differences in financial performance at the firm level and that environmental information quality is economically relevant to how firms navigate those conditions.

The sectoral analysis provides the most important qualification to the aggregate results. The negative effect of carbon-tax policy exposure is substantially larger among energy firms, whereas the corresponding effect for manufacturing firms is smaller and statistically weaker. At the same time, the positive marginal effect of environmental accounting disclosure is greater in the energy sector. These results demonstrate that the financial implications of carbon transition are not uniform across industries; they depend on the extent to which carbon intensity is embedded in assets, technologies, and operating models.

The study contributes theoretically by integrating institutional pressure, signalling, and environmental-management-accounting perspectives within a single firm-level framework. Carbon-policy exposure represents an external economic constraint, while environmental accounting disclosure reflects an internal and external information mechanism through which firms identify, manage, and communicate transition-related risks. The findings therefore move beyond a simple regulation-versus-performance debate and show that the quality of organizational response is central to understanding the financial consequences of decarbonization.

From a managerial and policy perspective, the results highlight the importance of anticipatory transition management. Firms, particularly in the energy sector, should embed carbon costs and environmental information into capital budgeting, technology selection, risk management, and performance evaluation. Regulators should complement carbon-pricing instruments with consistent disclosure standards, credible transition pathways, and policy arrangements that promote technological adaptation. Investors should likewise evaluate the substantive content of environmental accounting information rather than rely only on the existence of sustainability reporting.

6. Limitations and Future Research

Several limitations provide directions for future research. The analysis relies on listed firms and therefore may not fully capture the responses of private or smaller companies. The purposive sampling criteria may also introduce selection bias because firms with incomplete annual or sustainability reporting, including those with weaker environmental reporting systems, are less likely to be included in the analytical sample. Consequently, the estimated relationship between environmental accounting disclosure and financial performance may not be fully representative of firms with less developed environmental disclosure practices.

Future studies should incorporate independently verified firm-level emissions, explicit carbon-cost data, longer post-policy horizons, and quasi-experimental designs capable of strengthening causal inference. Additional research could also test non-linear effects, transition-speed differences, and the mediating roles of green innovation, financing conditions, or operational efficiency. Extending the analysis across ASEAN markets would further clarify how institutional quality and carbon-policy design condition the relationship between environmental accounting and financial performance.

Declaration of AI and AI-assisted technologies in the writing process

ChatGPT was used to assist with English translation, citation and reference completeness checks, and the identification of potential inconsistencies or anomalies in the manuscript. All outputs were reviewed and verified by the authors.

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