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Beyond Disclosure: Does Sustainability Control Maturity Drive Eco-Efficiency in State-Owned Enterprises?

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ABSTRACT

This study examines whether Sustainability Management Control System Maturity (SMCSM) is associated with eco-efficiency in Indonesian non-financial state-owned enterprises. Using annual reports and sustainability reports from 33 enterprises over the 2015–2024 period, this study develops a report-based SMCSM index covering sustainability target setting, KPI measurement, monitoring and evaluation, managerial accountability and governance, corrective action and learning, and integration with operational and risk control. The full dataset contains 320 firm-year observations, whereas the main energy model uses 90 observations from 12 firms due to uneven availability of environmental data. Eco-efficiency is measured using revenue-based environmental efficiency indicators, with energy eco-efficiency as the main dependent variable and emission and water eco-efficiency as robustness measures. The empirical analysis employs panel regression with firm fixed effects and clustered standard errors. The results do not support a significant association between SMCSM and energy eco-efficiency, and similar patterns appear in lagged models, sensitivity tests, and robustness models using emission and water eco-efficiency. However, changes in the scope of environmental reporting are consistently associated with energy eco-efficiency, indicating that the reporting boundary and measurement coverage affect the comparability of report-based environmental performance. This study contributes to sustainability management accounting by introducing a documentary SMCSM index and highlighting the importance of the reporting scope for interpreting eco-efficiency data. Practically, the findings suggest that managers and regulators should not treat disclosed sustainability control maturity as direct evidence of environmental efficiency improvement unless reporting boundaries and operational embedding are clearly established.

ABSTRAK

Penelitian ini menguji apakah Sustainability Management Control System Maturity (SMCSM) berhubungan dengan eco-efficiency pada BUMN nonkeuangan di Indonesia. Dengan menggunakan annual report dan sustainability report dari 33 perusahaan selama periode 2015–2024, penelitian ini mengembangkan indeks SMCSM berbasis dokumen yang mencakup penetapan target keberlanjutan, pengukuran KPI, monitoring dan evaluasi, akuntabilitas dan tata kelola manajerial, tindakan korektif dan pembelajaran, serta integrasi dengan pengendalian operasional dan pengendalian risiko. Dataset penuh terdiri atas 320 observasi perusahaan-tahun, sedangkan model utama berbasis energi menggunakan 90 observasi dari 12 perusahaan karena ketersediaan data lingkungan yang tidak merata. Eco-efficiency diukur melalui indikator berbasis pendapatan, dengan energy eco-efficiency sebagai variabel utama. Analisis data panel (firm fixed effects) tidak menemukan hubungan signifikan antara SMCSM dan energy eco-efficiency, termasuk pada model lagged dan uji ketahanan (emisi/air). Namun, perubahan cakupan pelaporan lingkungan secara konsisten berhubungan dengan energy eco-efficiency. Temuan ini menunjukkan bahwa batas pelaporan dan cakupan pengukuran memengaruhi keterbandingan kinerja lingkungan berbasis laporan. Secara praktis, hasil penelitian ini menunjukkan bahwa manajemen BUMN dan regulator tidak dapat menafsirkan kematangan kontrol keberlanjutan yang diungkapkan dalam laporan sebagai bukti langsung perbaikan efisiensi lingkungan tanpa kejelasan batas pelaporan serta keterhubungannya dengan praktik operasional.

INTRODUCTION

Sustainability reporting has become an indispensable aspect of corporate accountability, offering insights into environmental, social, and governance issues that traditional financial statements may not comprehensively capture (Adams & Abhayawansa, 2022; Gunawan et al., 2022; Tsang et al., 2023; Wagenhofer 2024). Nonetheless, within the domain of accounting research, the significance of sustainability reporting should not be evaluated solely based on the extent of disclosure. A more critical consideration is whether the information presented in annual and sustainability reports accurately reflects the internal processes employed for goal setting, performance assessment, progress monitoring, deviation analysis, responsibility allocation, and implementation of corrective actions. This is particularly pertinent because the value derived from sustainability information is maximized when it is integrated into management control systems, organizational capabilities, and decision-making processes, rather than being confined exclusively to external communication.

This study is motivated by a tension between disclosed sustainability controls and substantive environmental performance. From institutional and legitimacy perspectives, sustainability reporting reflects organizational responses to regulatory, normative, and public accountability pressures (DiMaggio & Powell, 1983; Suchman, 1995). From a stakeholder perspective, sustainability reports provide a mechanism for firms to communicate sustainability commitments to the state, regulators, investors, creditors, and wider society (Freeman et al., 2018; Tsang et al., 2023). However, from sustainability management accounting and resource-based perspectives, sustainability disclosure can improve environmental performance only when supported by internal capabilities, managerial routines, control systems, and resource allocation mechanisms (Barney, 1991; Beusch et al., 2022; Schaltegger et al., 2022). This theoretical tension is particularly relevant for state-owned enterprises, which operate under both commercial and public accountability pressures.

Recent studies indicate that sustainability reporting and management control systems are interconnected; however, the two should not be regarded as synonymous (Fachrudin et al., 2024; Martinez et al., 2023; Quesado et al., 2024). Sustainability reports may present policies, programs, indicators, and achievements; nevertheless, such disclosures do not necessarily demonstrate whether sustainability considerations are integrated into managerial decision-making and operational control (Edirisinghe et al., 2025; Martinez et al., 2023; Rahi et al., 2022; Traxler et al., 2025). This distinction is significant for sustainability management accounting, as corporate reports can be interpreted not only as disclosure outputs but also as documentary evidence of the extent to which organizations have implemented sustainability-focused management-control practices.

This investigation examines the maturity of sustainability management control systems (SMCSM), which pertains to the extent of the integration of sustainability issues into target setting, key performance indicators, monitoring and evaluation, managerial accountability, corrective actions, learning processes, and operational risk management. Recent scholarly work from Indonesia suggests that sustainability management control systems have the potential to enhance sustainability performance (Kurnianto & Tjahjad, 2025). Conversely, evidence from other developing nations and state-owned enterprises indicates that the integration of sustainability into management accounting and control systems may vary depending on the organizational context (Alsaid & Ambilichu, 2021; Edirisinghe et al., 2025). Consequently, the inquiry persists as to whether a higher level of report-based SMCSM is associated with improved environmental efficiency, especially considering the variation in scope, boundaries, and measurement consistency of environmental data reporting across different firms and periods.

Eco-efficiency is a relevant outcome for assessing the operational implications of sustainability management control because it links economic output to environmental inputs or impacts such as energy consumption, greenhouse gas emissions, water use, and waste generation (Schaltegger et al., 2022). In Indonesian accounting literature, studies increasingly examine environmental, green, climate change, ESG, and sustainability accounting as important topics for understanding corporate environmental accountability and performance (Agustini & Arifa, 2024; Melenia et al., 2023; Musviyanti et al., 2024). However, improvements in sustainability disclosure and control maturity may not immediately translate into measurable eco-efficiency if sustainability information is used primarily for compliance, reputation, or reporting, rather than for operational decision-making.

Indonesian non-financial state-owned enterprises provide a relevant context for this study. These enterprises operate in sectors with varying levels of environmental intensity, including infrastructure, transportation, energy, mining,

manufacturing, logistics, and public services. Simultaneously, they face public accountability, state ownership expectations, governance requirements and sustainability reporting pressures. The 2015–2024 period is also important because it captures the evolution of sustainability reporting in Indonesia from a relatively unstructured practice toward a more institutionalized reporting environment (Gunawan et al., 2022; Luque-Vílchez et al., 2023; Pesci et al., 2023). In this setting, sustainability disclosure is not only a response to market expectations but also reflects institutional pressure, public legitimacy, and the broader mandate of state-owned enterprises (Nicolo & Andrades-Peña, 2024).

An additional methodological concern is the comparability and credibility of environmental performance data. Environmental indicators reported by corporations are frequently influenced by changes in reporting boundaries, consolidation scope, measurement methodologies, and data availability. In longitudinal research, variations in reported energy consumption, emissions, water usage, or waste may reflect modifications in the reporting scope rather than genuine operational improvements or degradation. This concern is often overlooked when sustainability reports are considered fully comparable data sources. Consequently, this study explicitly considers changes in the scope of environmental reporting when analyzing eco-efficiency performance, as comparability and verification remain fundamental considerations in the utilization of sustainability reports as empirical data sources (Hazaea et al., 2022; Korca et al., 2023).

This study addresses three specific research gaps. First, prior sustainability accounting studies have largely examined sustainability disclosure or environmental performance in isolation, whereas fewer studies have linked report-based sustainability management control maturity to eco-efficiency outcomes (Rahi et al., 2022; Traxler et al., 2025). Second, the literature has not sufficiently examined whether sustainability control mechanisms disclosed in corporate reports constitute substantive operational controls or are primarily formal. Third, studies using environmental data from corporate reports often treat such data as comparable across firms and years, even though reported energy consumption, emissions, water use, and waste may be affected by changes in reporting boundaries, consolidation scope, and measurement coverage (Gunawan et al., 2022; Nicolo & Andrades-Peña, 2024). These gaps are important in the context of Indonesian non-financial state-owned enterprises, where firms combine commercial objectives, public service obligations, governance requirements, and sustainability mandates.

Accordingly, this study is guided by the following research questions: First, is report-based SMCSM associated with eco-efficiency in Indonesian non-financial state-owned enterprises? Second, does the relationship remain stable when eco-efficiency is measured using alternative environmental indicators? Third, how do changes in the scope of environmental reporting affect the interpretation of report-based eco-efficiency measures?

This study advances the field of sustainability management accounting through three significant contributions. First, it devises a comprehensive documentary maturity index that quantifies the degree to which sustainability issues are integrated into target setting, key performance indicator (KPI) measurement, monitoring, evaluation, accountability, corrective actions, learning processes, and operational risk management. Second, it offers longitudinal evidence from Indonesian non-financial state-owned enterprises, a context where commercial objectives coexist with public accountability and sustainability mandates. Third, it underscores the methodological significance of the scope of environmental reporting in the interpretation of eco-efficiency metrics obtained from annual and sustainability reports. Unlike prior research that considers sustainability disclosures as direct indicators of environmental performance improvements, this study differentiates among sustainability disclosure efforts, report-based control maturity, and quantifiable eco-efficiency outcomes.

This study also differs from prior survey-based and general disclosure studies by treating the SMCSM as a documentary, report-based maturity construct. Rather than assuming that sustainability disclosure directly represents internal control effectiveness, this study separates three related but distinct concepts: sustainability disclosure, report-based sustainability control maturity, and reported eco-efficiency. This distinction is important because annual and sustainability reports may provide evidence of formalized control structures, but they do not necessarily reveal how such controls are used in operational decision-making.

THEORETICAL FRAMEWORK AND HYPOTHESES

This study primarily draws on institutional and legitimacy theories, together with sustainability management accounting and resource-based

arguments to explain the expected but uncertain relationship between SMCSM and eco-efficiency. Institutional and legitimacy theories explain why firms, particularly state-owned enterprises, may formalize sustainability reporting and control structures in response to regulatory expectations, public accountability, and legitimacy pressures (DiMaggio & Powell, 1983; Suchman, 1995). However, this formalization may remain partially decoupled from operational practices. In contrast, sustainability management accounting and resource-based arguments suggest that sustainability control mechanisms can improve eco-efficiency only when they are embedded in organizational capabilities, managerial routines, operational processes, learning mechanisms, and resource-allocation decisions (Barney, 1991; Bastini et al., 2022; Beusch et al., 2022; Schaltegger et al., 2022; Zoni & Bustamante, 2025). Stakeholder accountability and contingency considerations provide additional context by recognizing firms' accountability obligations and the variation of control effectiveness across sectors, technologies, and organizational settings (Donaldson, 2001; Freeman et al., 2018; Tsang et al., 2023). Accordingly, the relationship between report-based SMCSM and eco-efficiency is not automatic. However, it depends on whether the disclosed control mechanisms represent substantively embedded practices rather than primarily symbolic or compliance-oriented formalization.

Sustainability Reporting and Sustainability Management Control System Maturity

Sustainability reporting and sustainability management control systems are closely related but represent different aspects of corporate sustainability practice. Sustainability reporting provides formal information about policies, programs, targets, indicators, and achievements. At the same time, management control systems concern how such information is used to guide planning, measurement, monitoring, accountability, evaluation, and corrective action. Therefore, the existence of sustainability disclosure does not automatically indicate that sustainability has been embedded into internal management control processes (Rahi et al., 2022; Traxler et al., 2025).

From a sustainability management accounting perspective, sustainability information becomes more relevant when it is connected to managerial processes rather than treated only as external communication (Ascani et al., 2021; Beusch et al., 2022; Christ et al., 2024; Schaltegger et al., 2022). Management control for sustainability requires integrating environmental and social issues into target setting, key performance indicators, monitoring routines, governance structures, risk management, decision-making processes, and learning mechanisms (Beusch et al., 2022; Edirisinghe et al., 2025; Kuruppu et al., 2024; Martinez et al., 2023; Quesado et al., 2024; Zoni & Bustamante, 2025). This perspective is important because sustainability performance cannot be improved solely through disclosure. It requires internal systems that translate sustainability priorities into operational decisions and management responsibilities.

This study conceptualizes Sustainability Management Control System Maturity (SMCSM) as the extent to which sustainability issues are reflected in the management control mechanisms disclosed in annual and sustainability reports. The SMCSM covers six dimensions: sustainability target setting, sustainability KPI measurement, monitoring and performance evaluation, managerial accountability and governance, corrective action and learning, and integration with operational and risk control. A higher SMCSM score indicates that sustainability information is disclosed in a more structured, measurable, and control-oriented manner.

However, SMCSM in this study should be understood as a report-based measure of maturity. It captures documentary evidence of sustainability management control, not direct observation of internal managerial practice. This distinction is essential because firms may disclose formal sustainability structures while their actual use in operational decision-making remains limited. In institutional and legitimacy terms, such disclosure may reflect conformity to regulatory and public accountability expectations (DiMaggio & Powell, 1983; Suchman, 1995). In stakeholder terms, it may improve transparency and accountability (Freeman et al., 2018). However, from a sustainability management accounting perspective, the operational relevance of SMCSM depends on whether sustainability targets, KPIs, monitoring routines, accountability structures, and corrective actions are integrated into planning, budgeting, procurement, investment, operational control, and performance evaluation (Beusch et al., 2022; Schaltegger et al., 2022; Traxler et al., 2025). Therefore, report-based SMCSM provides a useful but cautious basis for examining whether disclosed control maturity is associated with environmental performance outcomes.

Eco-Efficiency as an Outcome of Sustainability Management Control

Eco-efficiency is a relevant outcome for sustainability management accounting because it links economic output to environmental resource

use or environmental impact. In this study, eco-efficiency was measured using revenue-based environmental efficiency indicators, including revenue relative to energy consumption, greenhouse gas emissions, water use, and waste generation. This measurement reflects firms' ability to generate economic value while managing environmental inputs and impacts more efficiently (Schaltegger et al., 2022).

The relationship between sustainability management control and eco-efficiency can be explained by several mechanisms. First, sustainability targets can direct managerial attention to energy efficiency, emission reduction, water management, and waste control. Second, sustainability KPIs can help firms quantify their environmental performance and compare actual outcomes with planned targets. Third, monitoring and evaluation mechanisms can identify deviations and support corrective action. Fourth, accountability structures can clarify the responsibility for environmental performance across organizational units. Finally, integration with risk control can link environmental issues with broader operational and strategic risks.

Although these mechanisms provide a theoretical basis for expecting an association between SMCSM and eco-efficiency, they should be interpreted as theoretical mechanisms rather than directly tested mediation paths. This study does not observe internal managerial routines, budgeting decisions, procurement practices, or operational control processes. Instead, it examines whether documentary evidence of sustainability control maturity is associated with reported eco-efficiency outcomes. Therefore, a non-significant relationship would not necessarily indicate that sustainability management control is irrelevant. It may indicate that report-based control maturity is not sufficiently embedded in operational routines or that sectoral characteristics, technology, business expansion, public service obligations, and changes in the scope of environmental reporting obscure its effect.

Prior Indonesian accounting studies have increasingly emphasized the relevance of environmental accounting, green accounting, climate change accounting, ESG, and sustainability accounting in understanding corporate environmental accountability and performance (Agustini & Arifa, 2024; Melenia et al., 2023; Musviyanti et al., 2024). Related empirical evidence also suggests that environmental management accounting, green process innovation, sustainability management accounting, and sustainability management control systems are relevant for explaining sustainability-related performance outcomes (Alsaid & Mutiganda, 2024; Cahyaningsih & Ihromi, 2024; Christ et al., 2024; Dharmayanti et al., 2023; Kurnianto & Tjahjadi, 2025). These studies indicate that sustainability information becomes more meaningful when connected to internal processes, performance evaluation, and managerial decision-making.

Nevertheless, the expected relationship between SMCSM and eco-efficiency should not be overstated. Disclosed control maturity may reflect formalization, compliance, or reporting readiness rather than effective operational use. Industry characteristics, technology, asset intensity, regulatory constraints, and business expansion may also influence eco-efficiency. For state-owned enterprises, the relationship may be even more complex because these firms simultaneously pursue commercial, public service, governance, and social objectives. Therefore, the association between SMCSM and eco-efficiency remains an empirical question.

Previous studies have provided mixed reasons for expecting such complexity. Studies on sustainability management control and environmental management accounting suggest that control systems can support sustainability-related performance when sustainability information is incorporated into managerial processes, performance evaluations, and operational decisions (Beusch et al., 2022; Kurnianto & Tjahjadi, 2025; Schaltegger et al., 2022). However, studies on sustainability reporting and institutionalized disclosure also warn that reporting practices may become formalized without producing immediate operational changes (Christensen et al., 2021; Fiechter et al., 2022; Rahi et al., 2022). This creates the possibility of decoupling between what firms disclose and what they implement. In the context of Indonesian SOEs, this possibility is particularly relevant because sustainability reporting may be influenced by public accountability, compliance, and reputational considerations. Simultaneously, eco-efficiency is affected by sector-specific technology, asset intensity, production scale, and public service mandates.

Based on the above arguments, this study proposes the following hypothesis:

H1: Sustainability management control system maturity is associated with eco-efficiency performance.

Reporting Regime and Environmental Reporting Scope

The sustainability reporting environment may influence how firms disclose, organize and use sustainability information. More formal reporting requirements can encourage firms to disclose

sustainability information systematically, develop clearer indicators, and improve the structure of environmental reporting (Christensen et al., 2021; Fiechter et al., 2022; Luque-Vílchez et al., 2023; Pesci et al., 2023). Prior studies have shown that mandatory or more institutionalized sustainability reporting may influence corporate disclosure and, in some settings, corporate behavior, although the effects depend on regulatory design, firm incentives, and the internal use of sustainability information (Christensen et al., 2021; Downar et al., 2021; Fiechter et al., 2022).

In Indonesia, sustainability reporting has evolved from a relatively unstructured practice to a more institutionalized reporting environment (Gunawan et al., 2022). This development is relevant for state-owned enterprises because they are subject to business performance pressures, public accountability, governance requirements, and sustainability expectations. However, a more structured reporting regime does not automatically guarantee better eco-efficiency. Reporting requirements may improve the form and availability of sustainability information. However, operational environmental performance still depends on whether the information is used in planning, budgeting, monitoring, evaluation, and corrective action.

A critical issue in report-based eco-efficiency research is the scope, comparability, and credibility of environmental reports (Gunawan et al., 2022; Hazaea et al., 2022; Korca et al., 2023; Luque-Vílchez et al., 2023; Pesci et al., 2023). Environmental indicators disclosed in corporate reports may change because firms revise reporting boundaries, expand the consolidation scope, include more operating sites, change measurement methods, or restate prior data. In a longitudinal study, these changes may affect the reported energy consumption, emissions, water use, or waste generation, even when the underlying operational efficiency does not change in the same direction. If such scope changes are ignored, researchers may misinterpret changes in eco-efficiency as actual performance changes.

Therefore, this study treats the scope of environmental reporting as an important methodological issue. The empirical model includes a scope-change flag to identify firm-year observations affected by changes in reporting boundary, consolidation scope, or measurement coverage. This treatment is necessary to avoid treating environmental data from corporate reports as fully comparable across firms and years without considering how the data were produced. In this study, the reporting regime is treated as a contextual control, while the environmental reporting scope is explicitly considered in interpreting the eco-efficiency results.

RESEARCH METHOD

Research Design and Sample

This study uses a quantitative documentary research design to examine the association between Sustainability Management Control System Maturity (SMCSM) and eco-efficiency in Indonesian non-financial state-owned enterprises. A documentary approach is appropriate because annual and sustainability reports contain formal information on sustainability targets, key performance indicators, monitoring activities, performance evaluation, governance structures, corrective actions, and operational risk management. This information can be used to construct a report-based maturity index of sustainability management control (Beusch et al., 2022; Rahi et al., 2022; Traxler et al., 2025).

The population consisted of Indonesian non-financial state-owned enterprises. Financial institutions are excluded because their business models, regulatory environments, asset structures, and environmental indicators differ substantially from those of non-financial enterprises. The final sample includes 33 non-Financial State-Owned Enterprises (SOEs) observed over the 2015–2024 period. Data were collected from annual, sustainability, corporate social responsibility, and governance reports, risk management disclosures, and audited financial statements.

This study uses an unbalanced panel because environmental indicators are not disclosed consistently across firms and years. This approach allows valid firm-year observations to be retained without imputing the missing environmental data. The full dataset contains 320 firm-year observations. However, the number of usable observations varies across models because energy, emission, water, and waste data differ in terms of longitudinal continuity, unit consistency, reporting-boundary comparability, and the availability of complete financial control variables. Energy eco-efficiency is used as the main dependent variable because energy disclosure provides the most consistent firm-level time series after unit-comparability screening. Although 161 firm-year observations contain usable energy eco-efficiency data for descriptive analysis, the main regression sample is reduced to 90 observations from 12 firms after requiring complete data for the dependent variable, SMCSM, reporting scope indicators, and all control variables. Emission and water eco-efficiencies were used as robustness

measures, whereas waste eco-efficiency was reported descriptively because of its more limited and less comparable coverage. Accordingly, the designation of energy eco-efficiency as the main outcome reflects the continuity and comparability of the available firm-level series, rather than the largest number of cross-sectional observations.

The use of an unbalanced panel is a methodological consequence of the uneven availability of environmental indicators across firms over the years. This study does not impute missing environmental data because imputation can create artificial environmental performance values that are unsupported by corporate reports. Nevertheless, the unbalanced data structure reduces the number of usable observations in the regression models and may affect the statistical power. The main energy model is based on 90 observations from 12 firms; therefore, the findings should be interpreted as cautious evidence from firms with relatively more complete energy data rather than as a full generalization to all Indonesian state-owned enterprises.

The limited coverage of the main energy model is treated as a central boundary condition of this study. Firms that disclose usable energy data may differ from firms that do not disclose such data in terms of reporting capacity, environmental exposure, sectoral characteristics, or sustainability governance maturity. Therefore, this study does not interpret the main energy model as evidence for all Indonesian non-financial SOEs. Instead, the results are interpreted as evidence from firms with relatively more complete and comparable energy reporting. This treatment reduces the risk of overstating the generalizability of the findings and makes the potential sample-selection issue explicit.

Variable Measurement

The independent variable is Sustainability Management Control System Maturity. SMCSM is measured using a report-based content analysis index consisting of six dimensions: sustainability target setting, sustainability KPI measurement, monitoring and performance evaluation, managerial accountability and governance, corrective action and learning, and integration with operational and risk control. These dimensions reflect the role of management control systems in translating sustainability information into targets, indicators, monitoring routines, accountability structures, and learning mechanisms (Beusch et al., 2022; Schaltegger et al., 2022; Traxler et al., 2025).

Each SMCSM dimension was scored using a four-level scale. A score of 0 was assigned when no relevant information was disclosed. A score of 1 was assigned when the disclosure was general or narrative. A score of 2 was assigned when the report disclosed identifiable programs, indicators, or targets. A score of 3 was assigned when the report disclosed quantitative targets, achievements, evaluation, and follow-up actions. The SMCSM index is calculated as follows:

$$SMCSM_{it} = \left(\frac{Score_{it}}{18}\right) \times 100$$

Because SMCSM is measured using annual and sustainability reports, the index captures disclosed maturity rather than actual internal maturity. This approach is appropriate for a documentary study. However, it has an inherent limitation: firms may disclose formal control structures, targets, and evaluation mechanisms without fully embedding them into managerial routines and operational decisions. To reduce overstatement, the scoring procedure applies a conservative approach. Higher scores are assigned only when the report provides clear documentary evidence of targets, indicators, monitoring, evaluation, accountability, corrective action, and integration with operational or risk control.

The dependent variable is eco efficiency. Eco-efficiency is measured as the economic output relative to environmental resource use or environmental impact. Revenue is used as an economic output measure because it is available for both listed and non-listed state-owned enterprises. All financial values were normalized into Indonesian rupiah millions before the eco-efficiency ratios were calculated. The main dependent variable is energy eco-efficiency, while emissions and water eco-efficiency serve as robustness checks. Waste eco-efficiency is calculated when data are available, but it is not used as a main regression variable due to limited data availability.

$$EE_{it}^{Energy} = \frac{Revenue_{it}}{Energy_{it}}$$

$$EE_{it}^{Emission} = \frac{Revenue_{it}}{Emission_{it}}$$

$$EE_{it}^{Water} = \frac{Revenue_{it}}{Water_{it}}$$

$$EE_{it}^{Waste} = \frac{Revenue_{it}}{Waste_{it}}$$

Revenue-based eco-efficiency is used because revenue is available for both listed and non-listed state-owned enterprises and allows a comparable measure of economic output across firms.

However, this measure has limitations. Revenue may be affected by price changes, tariff policy, accounting treatment, inflation, exchange rates, and business expansion, not only by operational efficiency. In addition, environmental indicators may be affected by technology, production scale, asset intensity, and reporting boundary. Therefore, eco-efficiency in this study should be interpreted as a report-based environmental efficiency ratio rather than as a complete measure of operational environmental productivity.

Environmental data were checked for unit comparability before calculating eco-efficiency ratios. Energy data were harmonized where firms disclosed convertible units such as kWh, MWh, GJ, or equivalent energy units. Emission, water, and waste indicators were reviewed based on the units reported in corporate reports. Firm-year observations with unclear, inconsistent, or nonconvertible environmental units were flagged and excluded from the relevant regression model. This procedure was applied to reduce the measurement bias caused by heterogeneous environmental reporting practices.

The eco-efficiency variables were transformed into natural logarithms in the regression analysis to reduce skewness and improve interpretability. This study includes several control variables. Firm size is measured as the natural logarithm of total assets in rupiah. Profitability is measured by return on assets, which is calculated as net income divided by total assets. Leverage is measured as total liabilities divided by total assets (TA). Listed status is measured as a dummy variable equal to 1 for firms listed on the Indonesia Stock Exchange and 0, otherwise. The reporting regime is measured as a dummy variable, with 0 for the 2015–2020 period and 1 for the 2021–2024 one. The cut-off reflects the more institutionalized sustainability reporting environment following Financial Services Authority Regulation Number 51/POJK.03/2017 (OJK, 2017) on sustainable finance implementation and Financial Services Authority Circular Letter Number 16/SEOJK.04/2021 (OJK, 2021) on the form and content of annual reports for issuers and public companies. The model also includes a scope-change flag equal to 1 when a firm-year observation is affected by changes in the environmental reporting boundary, consolidation scope, or measurement coverage.

The scope-change flag was identified by reviewing year-to-year changes in environmental reporting boundaries, consolidation scope, measurement coverage, and explanatory notes in annual and sustainability reports. Observations were flagged when the report indicated changes such as expanded consolidation, additional subsidiaries or operating sites, modified environmental measurement coverage, restatement of prior environmental data, or changes in the basis for environmental reporting. However, this procedure does not fully eliminate measurement heterogeneity. However, it allows the analysis to distinguish ordinary year-to-year variations in eco-efficiency from variations that may be affected by reporting boundary changes.

The scope-change flag was specified as a methodological covariate rather than a primary explanatory variable. It was included to account for potential discontinuities in report-based environmental data arising from changes in reporting boundaries, consolidation scope, operating-site coverage, restatements, or measurement practices. Accordingly, its coefficient was interpreted as a secondary methodological finding concerning data comparability and not as evidence of a causal effect of reporting-scope changes on operational environmental performance.

Table 1. Variable Measurement

Variable	Symbol	Measurement
Sustainability Management Control System Maturity	SMCSM	Actual SMCSM score divided by maximum possible score × 100
Energy Eco-Efficiency	ENERGY_EFF	Revenue in rupiah million divided by energy consumption
Emission Eco-Efficiency	EMISSION_EFF	Revenue in rupiah million divided by greenhouse gas emissions
Water Eco-Efficiency	WATER_EFF	Revenue in rupiah million divided by water use
Waste Eco-Efficiency	WASTE_EFF	Revenue in rupiah million divided by waste generated
Firm Size	SIZE	Natural logarithm of total assets in rupiah million
Profitability	ROA	Net income divided by total assets
Leverage	LEV	Total liabilities divided by total assets
Reporting Regime	REGIME	Dummy variable: 0 = 2015–2020; 1 = 2021–2024
Listed Status	LISTED	Dummy variable: 1 = listed firm; 0 = non-listed firm
Reporting Scope	SCOPE	Dummy variable: 1 = reporting

Variable	Symbol	Measurement
Change		scope or boundary change; 0 = otherwise

Content Analysis Procedure

Content analysis is used to convert qualitative and quantitative disclosures in corporate reports into the SMCSM index. The coding procedure was based on a scoring protocol that defined each SMCSM dimension, score level, acceptable evidence, and treatment of missing or ambiguous information. Content analysis is appropriate because it enables the systematic classification of textual and numerical information in corporate reports into quantitative indicators while maintaining a clear link to documentary evidence (Ascani et al., 2021; O'Connor & Joffe, 2020; Rahi et al., 2022; Vanini & Bochert, 2024).

The coding process follows several steps. First, available reports are collected and classified by firm and year. Second, relevant sections are identified, including sustainability strategy, environmental performance, key performance indicators, corporate governance, internal control, risk management, management discussion, and social and environmental responsibility. Third, each of the six SMCSM dimensions is scored based on documentary evidence. Fourth, the total score is converted into a 0–100 index. Fifth, notes and flags are added when the disclosure is affected by reporting boundary changes, restatements, mergers, holding restructurings, or incomplete environmental data.

A conservative scoring approach is applied to avoid overstating the maturity of sustainability management control. A higher score is not assigned merely because a report contains broad sustainability statements. Higher scores require clearer evidence of targets, indicators, evaluation, responsibility, and follow-up actions. This approach is important because the index measures disclosed maturity rather than the direct internal use of sustainability information. The detailed scoring criteria used to construct the SMCSM index are presented in Appendix Table A1.

No formal intercoder reliability test or external validation through interviews was conducted in this study. Therefore, the SMCSM index should not be interpreted as a direct measure of internal control effectiveness. Rather, it represents a structured assessment of the disclosed sustainability control maturity based on documentary evidence. This limitation is explicitly acknowledged because report-based content analysis may be affected by reporting bias, selective disclosure, and differences in reporting style across firms (O'Connor & Joffe, 2020). Future research should validate this report-based index using multiple coders, inter-coder reliability statistics, interviews with managers or internal auditors, and survey-based measures of actual sustainability management control practices. Accordingly, the SMCSM index should be treated as a conservative documentary measure rather than a validated measure of actual internal control maturity. This treatment is important to avoid over-claiming the extent to which disclosed sustainability control mechanisms reflect internal managerial practices.

Empirical Model

The hypothesis was tested using panel regression. The main empirical model was specified as follows:

$$\ln(EEP_{it}) = \beta_0 + \beta_1 SMCSM_{it} + \beta_2 SIZE_{it} + \beta_3 ROA_{it} + \beta_4 LEV_{it} + \beta_5 REGIME_t + \beta_6 SCOPE_{it} + \mu_i + \varepsilon_{it} \quad \text{..... (1)}$$

The supplementary specification incorporating both firm and year fixed effects is expressed as follows:

$$\ln(EEP_{it}) = \beta_0 + \beta_1 SMCSM_{it} + \beta_2 SIZE_{it} + \beta_3 ROA_{it} + \beta_4 LEV_{it} + \beta_5 SCOPE_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad \text{..... (2)}$$

where $\ln(EEP_{it})$represents the natural logarithm of eco-efficiency for firm $i$in year t, with energy eco-efficiency serving as the main dependent variable. $SMCSM_{it}$is the Sustainability Management Control System Maturity index, while, ROA_{it}, and LEV_{it}represent firm size, return on assets, and leverage, respectively. $REGIME_t$captures the sustainability-reporting regime, whereas $SCOPE_{it}$identifies changes in environmental reporting boundaries, consolidation scope, or measurement coverage. $\mu_i$represents firm fixed effects, $\lambda_t$represents year fixed effects, and $\varepsilon_{it}$is the idiosyncratic error term. The reporting-regime variable is omitted from Equation (2) because it varies only over time and is absorbed by the year indicators. Listed status is included only in the pooled OLS and random-effects comparison models because it is time-invariant for most firms and is absorbed by firm fixed effects.

Firm fixed effects control for unobserved time-invariant firm characteristics, such as long-term business models, sectoral positioning, ownership-related characteristics, and organizational history. However, fixed effects cannot fully address time-varying omitted variables,

including technological change, capital investment intensity, changes in operational scale, management quality, and regulatory pressure. Therefore, the results are interpreted as associations rather than causal effects.

The coefficient of interest is β_1. A statistically significant $\beta_1$indicates that SMCSM is associated with eco-efficiency. The main estimation uses firm fixed effects with standard errors clustered at the firm level. Clustered standard errors are applied to address heteroskedasticity and within-firm serial correlation (Cameron & Miller, 2015; Petersen, 2009). Multicollinearity was assessed using variance inflation factors, and the diagnostic results did not indicate severe multicollinearity among the main regressors. Pooled OLS and random-effects models are estimated for comparison. At the same time, the firm fixed-effects specification is retained as the main model because it better accounts for unobserved firm-level heterogeneity.

The main energy model contains 12 firms and, consequently, 12 firm-level clusters. Because cluster-robust inference may be less precise when the number of clusters is limited, the reported statistical significance should be interpreted cautiously, particularly for coefficients close to conventional significance thresholds. Therefore, the estimates are interpreted as cautious associational evidence rather than definitive population-level inference.

Robustness and Sensitivity Tests

Several robustness and sensitivity tests were conducted to assess the stability of the results. First, emission and water eco-efficiency were used as alternative dependent variables. Second, a lagged SMCSM model was estimated to examine whether sustainability control maturity affects eco-efficiency with a one-year delay. Third, the model was re-estimated after excluding the COVID-19 years to reduce the influence of pandemic-related disruptions. Fourth, observations affected by changes in the reporting scope were excluded to examine whether boundary changes drive the results. Fifth, a winsorized version of the dependent variable was used to reduce the influence of extreme values.

The COVID-19 sensitivity test excludes the 2020 and 2021 fiscal years. The log-transformed energy eco-efficiency variable is winsorized at the 1st and 99th percentiles, while SMCSM and the control variables remain unadjusted for this. Firm-year observations are classified as financially stressed when ROA is negative or when a documented exceptional restructuring condition indicates financial distress. The no-stress specification excludes observations with stress_flag = 1.

These tests are important because report-based environmental data may be affected by missing values, outliers, inconsistent reporting boundaries, and changes in measurement coverage. The purpose of the robustness tests was not to search for statistical significance but to examine whether the main conclusion remained stable under alternative specifications. More complex designs, such as mediation analysis, threshold models, or structural equation modeling, would require direct measures of internal managerial processes and larger balanced samples. Therefore, these approaches are beyond the scope of this documentary panel study but are suggested as directions for future research.

DATA ANALYSIS AND DISCUSSION

Sample Coverage and Descriptive Statistics

The final dataset comprises 33 Indonesian non-financial state-owned enterprises observed over the 2015–2024 period, yielding 320 firm-year observations. The panel is unbalanced because environmental indicators are not consistently disclosed across firms and years. This study does not impute missing environmental data; therefore, each regression model uses only observations with valid data for relevant eco-efficiency measures.

Energy eco-efficiency was used as the main dependent variable because energy data provided the most stable coverage in the main regression sample. The main energy model uses 90 observations from 12 firms. Emission and water eco-efficiency were used as robustness measures, with 138 and 159 observations, respectively. Waste eco-efficiency is reported descriptively because the number of usable observations is more limited and less comparable across firms.

The relatively small number of observations in the main energy model should be considered when interpreting the results. Although the full dataset covers 33 firms and 320 firm-year observations, the main regression uses only observations with valid energy eco-efficiency data and complete control variables. This limitation reduces the statistical power and may raise selection concerns if firms that disclose energy data differ systematically from those that do not disclose them. Therefore, the results should be interpreted as evidence from firms with more complete energy reporting rather than as evidence that can be generalized without qualification to all non-financial SOEs.

The pattern of missing environmental data is unlikely to be completely random. Firms with stronger reporting capacity, more formal

sustainability reporting practices, or higher environmental exposure are more likely to disclose energy, emission, water, or waste indicators. This possibility creates a selection issue in report-based environmental studies. To reduce unsupported assumptions, this study did not impute missing environmental data and transparently reported model-specific coverage.

Table 2. Sample and Model Coverage

Item	Value
Total firms	33
Total firm-year observations	320
Main energy model observations	90
Main energy model firms	12
Emission robustness observations	138
Emission robustness firms	27
Water robustness observations	159
Water robustness firms	27
Waste descriptive observations	64
Transition-only observation	1

Note: AP_INJ is treated as a transition-only observation and is excluded from the panel regression models.

Table 3 presents descriptive statistics. The mean SMCSM index is 78.98, indicating that many state-owned enterprises have disclosed relatively structured sustainability control mechanisms. However, the variation in SMCSM remains substantial, suggesting differences in the quality and maturity of sustainability control disclosures across firms and years. Eco-efficiency variables exhibit high dispersion, particularly in waste eco-efficiency. This supports the use of log-transformed eco-efficiency variables in the regression analysis.

Table 3. Descriptive Statistics

Variable	Obs.	Mean	Std. Dev.	Min.	Max.
SMCSM index	300	78.98	22.58	0.00	100.00
Energy eco-efficiency	161	570.96	1,819.85	0.17	14,273.28
Emission eco-efficiency	139	2,449.36	7,905.40	1.28	55,014.97
Water eco-efficiency	159	611.82	1,254.86	0.02	10,672.16
Waste eco-efficiency	64	306,176.50	857,006.80	11.12	6,170,036.00
Firm size	288	16.94	2.00	11.90	21.30
ROA	288	0.03	0.11	-0.95	0.60
Leverage	288	0.57	0.28	0.10	2.85
Reporting regime	300	0.40	0.49	0.00	1.00
Listed status	300	0.53	0.50	0.00	1.00
Scope flag	300	0.23	0.42	0.00	1.00

Note: Descriptive statistics exclude transition-only observations. Eco-efficiency variables are revenue-based ratio variables. Financial values were normalized into IDR millions before the ratios were calculated.

Main Regression Results

Table 4 reports the main regression results using log energy eco-efficiency as the dependent variable. Pooled OLS is presented as the baseline model, while firm-fixed effects are used as the main specification. Random effects and firm fixed effects with year effects are reported as comparison models.

The study does not use instrumental variables or the generalized method of moments because the research design does not specify a dynamic dependent variable, and no credible external instrument is available for the report-based SMCSM. Given the relatively small number of firms in the main energy model, adding more complex estimators may reduce the reliability of the estimates. Therefore, this study relies on fixed effects, clustered standard errors, and robustness tests while explicitly acknowledging endogeneity and statistical power limitations.

The coefficient of SMCSM is not statistically significant in any of the main specifications. In the firm fixed effects model, the coefficient of SMCSM is -0.0189, with a p-value of 0.419. This result does not provide sufficient empirical support for the proposed association between higher sustainability management control maturity and energy eco-efficiency in the available samples. The random-effects model yielded a similar result, with a coefficient of -0.0146 and a p-value of 0.521. When year effects are included, the SMCSM coefficient remains statistically insignificant at the 5% level. These findings indicate that no statistically discernible association between report-based SMCSM and energy eco-efficiency was detected in the main sample.

The negative sign of the SMCSM coefficient should not be interpreted as evidence that SMCSM reduces eco-efficiency, given that the coefficient is statistically insignificant. It should not be read as evidence of a trade-off between formalized sustainability reporting and operational efficiency. A more cautious interpretation is that firms with more extensive sustainability control disclosure may also have larger, more complex, or more environmentally intensive operations. These firms may disclose more structured control mechanisms precisely because they face greater environmental exposure, operational complexity, or reporting pressure. In addition, measurable improvements in eco-efficiency may require longer investment cycles, technology adoption, process redesign, and operational learning. Therefore, the coefficient is

better understood as indicating the limits of report-based maturity as a proxy for operational environmental improvement, rather than as evidence that SMCSM reduces eco-efficiency.

Given the limited number of observations and firm-level clusters, the non-significant coefficient should not be interpreted as proof that the relationship is absent. This indicates that the study was unable to identify a statistically reliable association under the available documentary data and model specifications.

A more consistent result was observed for the scope flag. In the firm fixed effects model, the scope flag has a coefficient of -1.3158 and is significant at the 1% level. The coefficient remains negative and significant in both the random-effects and firm fixed-effects models with year effects. This suggests that changes in the environmental reporting boundary, consolidation scope, or measurement coverage are strongly associated with reported energy eco-efficiency.

The economic interpretation of the scope flags is also important. A negative and significant coefficient indicates that firm-year observations affected by changes in the reporting boundary, consolidation scope, or measurement coverage tend to report lower energy eco-efficiency. This does not necessarily imply that operational performance has deteriorated. Instead, it may indicate that the reported denominator, such as energy consumption, expanded because the firm included more sites, subsidiaries, projects or activities in its environmental reporting boundary. This finding supports the argument that the reporting scope is not merely a disclosure detail but a methodological issue that affects the interpretation of report-based environmental performance ratios.

The scope-related finding can be illustrated conceptually. If a firm expands its environmental reporting boundary from selected operating units to a broader consolidated boundary, reported energy consumption, emissions, water use, or waste may increase because the denominator now covers more activities. In a revenue-based eco-efficiency ratio, this expansion may reduce the reported eco-efficiency figure, even when operational efficiency has not necessarily deteriorated. This illustrates why reporting boundary consistency is essential for interpreting environmental performance trends derived from corporate reports.

Table 4. Main Regression Results: Energy Eco-Efficiency

Variable	Pooled OLS	Firm FE	Random Effects	Firm FE + Year FE
SMCSM index	-0.0022	-0.0189	-0.0146	-0.0467
p-value	0.955	0.419	0.521	0.103
Scope flag	-0.3700	-1.3158***	-1.2211***	-1.3419***
p-value	0.530	0.001	0.000	0.004
Controls	Yes	Yes	Yes	Yes
Firm effects	No	Yes	No	Yes
Year effects	No	No	No	Yes
Observations	90	90	90	90
Firms	12	12	12	12
R-squared / within R-squared	0.3197	0.4195	—	—

Note: The dependent variable is the natural logarithm of energy eco-efficiency. The control variables include firm size, return on assets, and leverage. The reporting regime variable is included in the pooled OLS, random-effects, and firm fixed-effects models without year effects. However, it is omitted from the firm fixed-effects model with year effects because the year indicators absorb it [insert reference]. Listed status is included in the pooled OLS and random-effects models but is omitted from the fixed-effects models because it is time-invariant for most firms. Standard errors are clustered at the firm level. The main sample contains 12 firm-level clusters; therefore, statistical significance should be interpreted cautiously. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Robustness and Sensitivity Tests

Additional tests were conducted to assess whether the main finding remained stable under alternative specifications. The detailed results are reported in Appendix Table B1. First, lagged SMCSM models were estimated to examine whether sustainability control maturity affects eco-efficiency with a one-year delay. The coefficient of lagged SMCSM remained statistically insignificant, indicating that the absence of a significant relationship is not merely due to same-year measurement. However, this test does not rule out the possibility that the effect of sustainability control maturity may require a longer time horizon to appear in operational environmental outcomes.

Second, the model is re-estimated by excluding the COVID-19 years, observations affected by reporting scope changes, observations with financial stress, and using a winsorized dependent variable. Across these specifications, the SMCSM remained statistically insignificant. The consistency of the estimates suggests that the main conclusion is not highly sensitive to the exclusion of pandemic years, scope-change observations, extreme dependent-variable values, or financially stressed observations.

Emission and water eco-efficiency were also used as alternative dependent variables. The estimated SMCSM coefficients remained statistically non-significant in both models. These additional specifications produced a pattern that was consistent with the main energy model, although they should not be interpreted as confirming the absence of an association. Rather, they indicate that a statistically discernible relationship was not detected across the alternative report-based eco-efficiency measures examined in this study. Overall,

the results do not provide empirical support for a significant relationship between report-based SMCSM and eco-efficiency. In contrast, the scope flag consistently remained negative and significant across most energy-based models, indicating that changes in the reporting boundary, consolidation scope, or measurement coverage substantially affect the comparability of report-based eco-efficiency measures.

Discussion

The findings show that no statistically discernible association between report-based Sustainability Management Control System Maturity and eco-efficiency was detected in the available sample of Indonesian non-financial state-owned enterprises. A similar pattern appears in the main energy model, lagged specifications, sensitivity tests, and alternative models using emission and water eco-efficiency. This finding does not imply that sustainability management control is irrelevant. Instead, it suggests that report-based control maturity does not automatically translate into measurable environmental efficiency. This result is theoretically consistent with the possibility of decoupling between disclosed sustainability control and substantive operational improvement. However, the documentary research design does not directly test the existence of such decoupling. Firms may disclose targets, KPIs, governance structures, monitoring mechanisms, and corrective actions, but such disclosure does not necessarily show how sustainability information is used in budgeting, procurement, investment, production, strategic learning, or operational decision-making (Kuruppu et al., 2024; Rahi et al., 2022; Traxler et al., 2025; Zoni & Bustamante, 2025).

There are several possible explanations for this non-significant finding. First, the SMCSM index captures disclosed maturity rather than actual internal maturity. If the disclosed control mechanisms are primarily formal or symbolic, they may not result in measurable efficiency improvements. Second, the effect of sustainability control may require a longer time horizon than the one-year lag examined in this study. Environmental efficiency improvements often require capital investment, technology adoption, process redesign, and behavioral change, which may not appear immediately in the report-based eco-efficiency ratios. Third, SMCSM may affect qualitative outcomes, such as accountability, awareness, coordination, and risk identification, which are not fully captured by revenue-based eco-efficiency measures.

This result supports the view that sustainability reporting and management control systems are closely related but should not be treated as identical concepts (Edirisinghe et al., 2025; Martinez et al., 2023; Rahi et al., 2022; Traxler et al., 2025). Prior studies argue that sustainability reporting can interact with management control systems; however, the two domains may remain disconnected when sustainability information is used mainly for accountability, compliance, or legitimacy (Rahi et al., 2022; Traxler et al., 2025). In this study, the SMCSM captures report-based maturity. This reflects what firms formally disclose about sustainability-oriented control mechanisms, not the full internal use of sustainability information. Therefore, the insignificant relationship between SMCSM and eco-efficiency may indicate a gap between documented control maturity and operational embedding in the company.

This finding aligns with the broader literature on sustainability management accounting. Effective management control for sustainability encompasses more than merely the existence of sustainability statements or formal governance frameworks (Beusch et al., 2022; Christ et al., 2024; Edirisinghe et al., 2025; Schaltegger et al., 2022). It necessitates integrating sustainability objectives, key performance indicators (KPIs), monitoring, evaluation, accountability, and corrective measures into budgeting, operational planning, investment decisions, risk management, and performance assessment (Beusch et al., 2022; Schaltegger et al., 2022). If these mechanisms remain solely formal or report-focused, their impact on energy consumption, emissions, water usage, and waste production may be minimal. Consequently, this underscores a cautionary message: the maturity of sustainability controls documented in corporate reports should not be construed as unequivocal evidence of enhanced environmental performance.

The characteristics of state-owned enterprises may further explain this insignificant relationship. Indonesian non-financial SOEs operate under multiple objectives, including commercial performance, public service obligations, strategic national assignments, governance, and social legitimacy. These multiple objectives may weaken the direct link between sustainability control maturity and eco efficiency. For example, a company may improve its sustainability governance and reporting practices while simultaneously expanding its infrastructure, production capacity, service coverage, or operational sites. In such cases, energy consumption or emissions may increase even as sustainability control mechanisms mature. This multi-objective tension is particularly relevant for

SOEs in energy, construction, transportation, mining, cement, and logistics, where environmental outcomes are strongly influenced by technology, asset intensity, investment cycles, and public policy.

A consistent secondary methodological finding concerns the scope of environmental reporting. Because SCOPE is included as a methodological covariate, this result should be interpreted as evidence of a comparability problem in report-based environmental data rather than as a causal effect of reporting scope changes on actual operational efficiency. The scope flag is negative and significant in the energy-based models, indicating that changes in the reporting boundary, consolidation scope, or measurement coverage substantially affect report-based eco-efficiency measures. This finding is methodologically significant. When firms expand their reporting boundaries from the head office to projects, subsidiaries, operating sites, or consolidated entities, the reported environmental data may increase sharply. A higher reported energy consumption or emission figure may reduce the eco-efficiency ratio, even if the change reflects broader reporting coverage rather than a real decline in operational efficiency. Therefore, changes in eco-efficiency reported in corporate reports should be interpreted cautiously.

This scope-related result contributes to sustainability accounting research by showing that environmental data disclosed in corporate reports are not always directly comparable across firms and years. Many studies treat report-based environmental indicators as stable and consistent, although the comparability of sustainability reporting depends on boundary consistency, measurement continuity, and credibility of the reporting process (Hazaea et al., 2022; Korca et al., 2023). However, this study shows that reporting boundaries and measurement coverage can significantly affect eco-efficiency calculations. This finding extends prior research on sustainability reporting in Indonesia by emphasizing that the development of reporting practices does not automatically solve the problem of data comparability (Gunawan et al., 2022). It also complements recent accounting studies on environmental disclosure, green accounting, ESG, and sustainability accounting by highlighting that the quality of environmental performance analysis depends not only on the availability of disclosures but also on boundary consistency (Agustini & Arifa, 2024; Melenia et al., 2023; Musviyanti et al., 2024).

This scope-related finding also has theoretical implications. It suggests that the credibility of environmental performance analysis depends not only on the existence of sustainability reporting but also on the consistency of reporting boundaries. From an institutional perspective, more formal sustainability reporting may increase the availability of disclosures (Christensen et al., 2021; Fiechter et al., 2022). However, unless firms clearly explain changes in reporting scope, the resulting environmental data may remain difficult to compare over time. From a management accounting perspective, this finding indicates that measurement consistency is a prerequisite for using sustainability information as a reliable basis for performance evaluation.

The findings also provide a cautious perspective on institutionalized sustainability reporting. Prior studies have shown that mandatory or more formal sustainability reporting may influence corporate disclosure and, in some contexts, corporate behavior (Christensen et al., 2021; Downar et al., 2021; Fiechter et al., 2022). However, these effects depend on regulatory design, firm incentives, and whether sustainability information is used internally. In the present study, the movement toward more structured sustainability reporting in Indonesia improves the availability of sustainability information. However, it does not necessarily mean that report-based control maturity improves eco-efficiency. This suggests that sustainability reporting regulation may strengthen transparency, but its effect on environmental efficiency depends on how firms connect reporting with internal control and operational management.

These findings have several implications for future research. For sustainability management accounting, the results suggest that researchers need to distinguish between sustainability disclosure, report-based control maturity, and actual environmental performance outcomes. A firm may appear mature in its sustainability reporting, but the operational impact of that maturity remains uncertain unless control mechanisms are embedded in managerial routines and resource allocation decisions. For SOE management, sustainability targets and KPIs should be linked more directly to budgeting, procurement, capital expenditure planning, operational risk management, unit-level performance evaluation and corrective action routines. For regulators and standard setters, the findings indicate the need for clearer guidance on reporting boundaries, restatements, the scope of consolidation, and changes in measurement coverage. Without consistent boundary disclosure, stakeholders may misinterpret the environmental performance trends. For researchers, the findings suggest that report-based SMCSM should be

validated in future studies using interviews, surveys, internal documents, or mixed-methods designs to determine whether disclosed maturity reflects actual internal control practice.

This study had several limitations that affected the interpretation of the findings. First, the SMCSM is measured from disclosed information, not from direct observation of internal management control practices. Therefore, the index may overstate actual control maturity when disclosure is more advanced than internal implementation. Second, the panel is unbalanced because environmental data are not consistently available across firms and years. This may introduce selection bias if firms that disclose environmental indicators systematically differ from those that do not. Third, the main energy model is based on 90 observations from 12 firms; therefore, the findings should be interpreted as cautious evidence from firms with relatively more complete energy data rather than as a full generalization to all Indonesian SOEs. Fourth, Fourth, revenue-based eco-efficiency may be affected by non-operational factors, including price changes, tariff policy, accounting treatment, business expansion, and inflation. Fifth, although the scope-change flag helps identify major comparability issues, it cannot fully capture all the differences in environmental measurement methods across corporate reports. Finally, because this study focuses on Indonesian non-financial SOEs, the findings may not be directly generalizable to private firms, financial institutions, or SOEs in other institutional settings.

In addition, the relatively small number of firm-level clusters limits the precision of the cluster-robust statistical inference. Coefficients close to conventional significance thresholds should therefore be interpreted cautiously, and the non-significant findings may partly reflect the limited statistical power.

Future research may address these limitations in several ways. First, report-based SMCSM can be validated through interviews with managers, sustainability officers, controllers, and internal auditors. Second, future studies may develop survey-based measures of actual sustainability management control practices and compare them with report-based maturity scores. Third, sector-specific eco-efficiency models may provide more precise evidence because the environmental logic of energy, mining, transportation, cement, logistics, and public service enterprises differs substantially. Fourth, comparative studies between SOEs and private firms may clarify whether the ownership structure affects the relationship between sustainability control and environmental performance. Fifth, future research may examine the effects of sustainability reporting mandates or changes in reporting boundaries using event-study or quasi-experimental designs. Finally, qualitative deep dives into high- and low-SMCSM firms may help explain why disclosed control maturity does or does not translate into operational environmental improvements.

Several suggested extensions remain beyond the scope of the present study. This study did not perform subgroup analysis, Granger causality testing, or dynamic-panel estimation because the main energy sample is limited to 90 observations from 12 firms. Adding such analyses may reduce estimation reliability and increase the risk of overinterpretation. Future research may address these issues using longer panels, larger samples, physical output-based eco-efficiency measures, sector-specific models, primary data, and mixed qualitative-quantitative designs. Such designs would allow researchers to examine whether report-based SMCSM reflects substantive internal control practice or primarily formalized sustainability reporting.

CONCLUSION

This study examines whether report-based Sustainability Management Control System Maturity is associated with eco-efficiency in Indonesian non-financial state-owned enterprises. Using documentary data from annual reports and sustainability reports over the 2015–2024 period, the study develops an SMCSM index and tests its association with energy eco-efficiency, with emission and water eco-efficiency used as alternative measures. The results do not provide sufficient empirical support for a statistically discernible association between SMCSM and eco-efficiency in the available sample. However, changes in environmental reporting scope are consistently associated with reported energy eco-efficiency, indicating that reporting boundaries, consolidation scope, and measurement coverage materially influence the comparability and interpretation of report-based environmental performance. This study contributes to sustainability management accounting by showing that disclosed sustainability control maturity should not automatically be interpreted as evidence of operational environmental improvement. It also highlights the importance of reporting-boundary consistency for regulators, SOE management, and researchers using corporate reports as environmental-performance data. Future research should validate the report-based SMCSM index through interviews, surveys, internal documents, or multiple-coder assessments

and should develop sector-specific eco-efficiency models using longer and more complete environmental data series.

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CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest related to this research, whether financial, professional, personal, organizational, relational, or belief-based, that could have influenced the design, data collection, analysis, interpretation, or reporting of this study.

USE OF ARTIFICIAL INTELLIGENCE TECHNOLOGY

The authors used ChatGPT, an artificial intelligence language model developed by OpenAI, only to assist with language refinement, manuscript structuring, readability improvement, consistency checking, and organization of the narrative presentation of statistical results. ChatGPT was not used to collect data, code the SMCSM index, conduct statistical analysis, generate empirical results, or make substantive research decisions. The authors conducted the statistical analysis using STATA. All data, citations, empirical results, interpretations, and conclusions were reviewed, verified, and approved by the authors of this study. The authors take full responsibility for the accuracy, integrity, and scholarly content of this manuscript.

REFERENCES

Adams, C. A., & Abhayawansa, S. (2022). Connecting the COVID-19 pandemic, environmental, social and governance (ESG) investing and calls for 'harmonization' of sustainability reporting. *Critical Perspectives on Accounting*, *82*, 102309. https://doi.org/10.1016/J.CPA.2021.102309

Agustini, A. T., & Arifa, C. (2024). Climate change accounting and disclosure: A systematic literature review. *The Indonesian Accounting Review*, *14*(1), 25–41. https://doi.org/10.14414/TIAR.V14I1.3829

Alsaid, L. A. Z. A., & Ambilichu, C. A. (2021). The influence of institutional pressures on the implementation of a performance measurement system in an Egyptian social enterprise. *Qualitative Research in Accounting & Management*, *18*(1), 53–83. https://doi.org/10.1108/QRAM-03-2020-0027

Alsaid, L. A. Z. A., & Mutiganda, J. C. (2024). Sustainability Management Accounting in Urban Development: A Case Study of an Egyptian State-Owned Enterprise. *Sustainability, 16*(18), *Page 8235*, https://doi.org/10.3390/SU16188235

Ascani, I., Ciccola, R., & Chiucchi, M. S. (2021). A Structured Literature Review about the Role of Management Accountants in Sustainability Accounting and Reporting. *Sustainability, 13*(4), 2357, https://doi.org/10.3390/SU13042357

Barney, J. (1991). Firm Resources and Sustained Competitive Advantage. *Journal of Management*, *17*(1), 99–120. https://doi.org/10.1177/014920639101700108

Bastini, K., Getzin, F., & Lachmann, M. (2022). The effects of strategic choices and sustainability control systems in the emergence of organizational capabilities for sustainability. *Accounting, Auditing & Accountability Journal*, *35*(4), 1121–1153. https://doi.org/10.1108/AAAJ-04-2020-4515

Beusch, P., Frisk, J. E., Rosén, M., & Dilla, W. (2022). Management control for sustainability: Towards integrated systems. *Management Accounting Research*, *54*, 100777. https://doi.org/10.1016/J.MAR.2021.100777

Cahyaningsih, C., & Ihromi, F. U. (2024). Environmental Accounting Disclosure, Green Process Innovation, and Environmental Management Accounting Improving Economic Performance. *AFRE (Accounting and Financial Review)*, *7*(1), 107–116. https://doi.org/10.26905/AFR.V7I1.10840

Cameron, A. C., & Miller, D. L. (2015). A Practitioner's Guide to Cluster-Robust Inference. *Journal of Human Resources*, *50*(2), 317–372. https://doi.org/10.3368/JHR.50.2.317

Christ, K. L., Dijkstra-Silva, S., Burritt, R. L., & Schaltegger, S. (2024). Sustainability management accounting – enabling macro-level sustainability transformation towards the United Nations Sustainable Development Goals. *Meditari Accountancy Research*, *32*(3), 923–944. https://doi.org/10.1108/MEDAR-03-2023-1952

Christensen, H. B., Hail, L., & Leuz, C. (2021). Mandatory CSR and sustainability reporting: economic analysis and literature review. *Review of Accounting Studies*, *26*(3), 1176–1248. https://doi.org/10.1007/S11142-021-09609-5

Dharmayanti, N., Ismail, T., Hanifah, I. A., & Taqi, M. (2023). Exploring sustainability management control system and eco-innovation matter sustainable financial performance: The role of supply chain management and digital adaptability in Indonesian context. *Journal of Open Innovation: Technology, Market, and Complexity*, *9*(3), 100119. https://doi.org/10.1016/J.JOITMC.2023.100119

DiMaggio, P. J., & Powell, W. W. (1983). The Iron Cage Revisited: Institutional Isomorphism and Collective Rationality in Organizational Fields. *American Sociological Review*, *48*(2), 147–160. https://doi.org/10.2307/2095101

Donaldson, L. (2001). *The contingency theory of organizations*. Sage. https://doi.org/10.4135/9781452229249

Downar, B., Ernstberger, J., Reichelstein, S., Schwenen, S., & Zaklan, A. (2021). The impact of carbon disclosure mandates on emissions and financial operating performance. *Review of Accounting Studies*, *26*(3), 1137–1175. https://doi.org/10.1007/S11142-021-09611-X

Edirisinghe, U. C., Hossain, M. M., & Alam, M. (2025). Sustainability integration in management control systems: evidence from a developing country. *Journal of Management Control, 36*(2), 163–204. https://doi.org/10.1007/S00187-025-00395-8

Fachrudin, A., Setiawan, D., Djuminah, D., & Risfandy, T. (2024). Exploring the recent development of management control systems study. *Cogent Business & Management*, *11*(1). https://doi.org/10.1080/23311975.2024.2357709

Fiechter, P., Hitz, J. M., & Lehmann, N. (2022). Real Effects of a Widespread CSR Reporting Mandate: Evidence from the European Union's CSR Directive. *Journal of Accounting Research*, *60*(4), 1499–1549. https://doi.org/10.1111/1475-679X.12424

Freeman, R. E., Harrison, J. S., & Zyglidopoulos, S. (2018). *Stakeholder theory: Concepts and strategies*. Cambridge University Press.

Gunawan, J., Permatasari, P., & Fauzi, H. (2022). The evolution of sustainability reporting practices in Indonesia. *Journal of Cleaner Production*, *358*, 131798. https://doi.org/10.1016/J.JCLEPRO.2022.131798

Hazaea, S. A., Zhu, J., Khatib, S. F. A., Bazhair, A. H., & Elamer, A. A. (2022). Sustainability assurance practices: a systematic review and future research agenda. *Environmental Science and Pollution Research* 29(4), 4843–4864. https://doi.org/10.1007/S11356-021-17359-9

Korca, B., Costa, E., & Bouten, L. (2023). Disentangling the concept of comparability in sustainability reporting. *Sustainability Accounting, Management and Policy Journal*, *14*(4), 815–851. https://doi.org/10.1108/SAMPJ-05-2022-0284

Kurnianto, S., & Tjahjadi, B. (2025). Sustainability management control system and sustainability performances in Indonesia. *International Journal of Management and Sustainability*, *14*(1), 102–120. https://doi.org/10.18488/11.V14I1.4032

Kuruppu, S. C., Milne, M. J., & Tilt, C. A. (2024). Sustainability control systems in short-term operational and long-term strategic decision-making. *Meditari Accountancy Research*, *32*(1), 234–265. https://doi.org/10.1108/MEDAR-12-2021-1548

Le, O. T. T., Le, A. T. H., Vu, T. T. T., Tran, T. T. C., & Nguyen, C. Van. (2024). Management control systems for sustainable development: a bibliographic study. *Cogent Business & Management*, *11*(1). https://doi.org/10.1080/23311975.2023.2296699

Luque-Vílchez, M., Cordazzo, M., Rimmel, G., & Tilt, C. A. (2023). Key aspects of sustainability reporting quality and the future of GRI. *Sustainability Accounting, Management and Policy Journal*, *14*(4), 637–659. https://doi.org/10.1108/SAMPJ-03-2023-0127

Martinez, C., Morales Pachon, A., Alexandre Castanho, R., Florêncio, M., Oliveira, L., & Costa Oliveira, H. (2023). Management Control Systems and the Integration of the Sustainable Development Goals into Business Models. *Sustainability, 15*(3), 2246. https://doi.org/10.3390/SU15032246

Melenia, F., Agustini, A. T., & Putra, H. S. (2023). The effect of implementing green accounting on the environmental performance of cement, energy, and mining companies in Indonesia. *The Indonesian Accounting Review*, *13*(1), 49–60. https://doi.org/10.14414/TIAR.V13I1.3135

Musviyanti, M., Syakura, M. A., & Ramadhani, M. H. Z. K. (2024). Beyond profit: How to create value in business by integrating ESG and sustainability accounting. *The Indonesian Accounting Review*, *14*(2), 289–300. https://doi.org/10.14414/TIAR.V14I2.4765

Nicolo', G., & Andrades-Peña, F. J. (2024). Does corporate governance influence environmental, social and governance disclosure practices of state-owned enterprises? An international study. *Corporate Social Responsibility and Environmental Management*, *31*(5), 4715–4731. https://doi.org/10.1002/CSR.2824

O'Connor, C., & Joffe, H. (2020). Intercoder Reliability in Qualitative Research: Debates and Practical Guidelines. *International Journal of Qualitative Methods*, *19*. https://doi.org/10.1177/1609406919899220

Peraturan Otoritas Jasa Keuangan Nomor 51/POJK.03/2017 Tentang Penerapan Keuangan Berkelanjutan Bagi Lembaga Jasa Keuangan, Emiten, Dan Perusahaan Publik (Financial Services Authority Regulation Number 51/POJK.03/2017 Concerning the Implementation of Sustainable Finance for Financial Services Institutions, Issuers, and Public Companies), Pub. L. 51/POJK.03/2017, Otoritas Jasa Keuangan (2017). https://ojk.go.id/id/kanal/perbankan/regulasi/peraturan-ojk/Pages/POJK-Penerapan-Keuangan-Berkelanjutan-bagi-Lembaga-Jasa-Keuangan,-Emiten,-dan-Perusahaan-Publik.aspx

Pesci, C., Vola, P., & Gelmini, L. (2023). Flattening or addressing complexity? The future role of GRI in light of the sustainability accounting (r)evolution. *Sustainability Accounting, Management and Policy Journal*, *14*(4), 792–814. https://doi.org/10.1108/SAMPJ-05-2022-0287

Petersen, M. A. (2009). Estimating Standard Errors in Finance Panel Data Sets: Comparing Approaches. *The Review of Financial Studies*, *22*(1), 435–480. https://doi.org/10.1093/RFS/HHN053

Quesado, P., Silva, R., & Oliveira, H. C. (2024). Management Control Systems and Sustainability: A Bibliometric Analysis. *Sustainability* *16*(12), 5067. https://doi.org/10.3390/SU16125067

Rahi, A. F., Johansson, J., Fagerström, A., & Blomkvist, M. (2022). Sustainability Reporting and Management Control System: A Structured Literature Review. *Journal of Risk and Financial Management, 15*(12), 562. https://doi.org/10.3390/JRFM15120562

Schaltegger, S., Christ, K. L., Wenzig, J., & Burritt, R. L. (2022). Corporate sustainability management accounting and multi-level links for sustainability – A systematic review. *International Journal of Management Reviews*, *24*(4), 480–500. https://doi.org/10.1111/IJMR.12288

Suchman, M. C. (1995). Managing Legitimacy: Strategic and Institutional Approaches. *The Academy of Management Review*, *20*(3), 571. https://doi.org/10.2307/258788

Surat Edaran Otoritas Jasa Keuangan Nomor 16/SEOJK.04/2021 Tentang Bentuk Dan Isi Laporan Tahunan Emiten Atau Perusahaan Publik (Financial Services Authority Circular Letter Number 16/SEOJK.04/2021 Concerning the Form and Content of Annual Reports of Issuers or Public Companies), Pub. L. 16/SEOJK.04/2021, Otoritas Jasa Keuangan (2021). https://ojk.go.id/id/regulasi/Pages/Bentuk-dan-Isi-Laporan-Tahunan--Emiten-atau-Perusahaan-Publik.aspx

Traxler, A. A., Schrack, D., Greiling, D., Feldbauer, J., & Lautner, M. (2025). The interplay of sustainability reporting and management control – an exploration of ways for dovetailing to develop reporting beyond accountability. *Journal of Applied Accounting Research*, *26*(6), 160–182. https://doi.org/10.1108/JAAR-08-2022-0222

Tsang, A., Frost, T., & Cao, H. (2023). Environmental, Social, and Governance (ESG) disclosure: A literature review. *The British Accounting Review*, *55*(1), 101149. https://doi.org/10.1016/J.BAR.2022.101149

Vanini, U., & Bochert, S. (2024). Integration of sustainability issues into management accounting textbooks. *Journal of Accounting Education*, *66*, 100886. https://doi.org/10.1016/J.JACCEDU.2024.10

0886

Wagenhofer, A. (2024). Sustainability Reporting: A Financial Reporting Perspective. *Accounting in Europe*, *21*(1), 1–13. https://doi.org/10.1080/17449480.2023.2218398

Zoni, L., & Bustamante, C. W. (2025). Leveraging on levers of control to learn how to integrate sustainability in management. *Journal of Accounting & Organizational Change*, *21*(7), 217–243. https://doi.org/10.1108/JAOC-02-2024-0064

Appendix A. SMCSM Scoring Rubric

The SMCSM index is constructed through report-based content analysis of annual reports and sustainability reports. Each firm-year observation is scored across six dimensions. Each dimension receives a score from 0 to 3 based on the quality and specificity of documentary evidence. The total score is converted into a 0-100 index using the following formula: SMCSM Index = (Actual SMCSM Score / Maximum Possible SMCSM Score) × 100. With six dimensions and a maximum score of 3 per dimension, the maximum possible score is 18.

Appendix Table A1. SMCSM Scoring Rubric

Dimension	Score 0	Score 1	Score 2	Score 3
Sustainability target setting	No sustainability targets or objectives were disclosed.	A general sustainability commitment is disclosed, but no specific targets can be identified.	A specific sustainability target, program objective, or performance direction was disclosed, but the evaluation was limited.	Quantitative targets, timeframes, or baselines, achievement, evaluation, and follow-up are clearly disclosed.
Sustainability KPI measurement	No sustainability KPI or measurable indicators were disclosed.	The indicators are mentioned only in a general narrative form.	Specific sustainability indicators or KPIs are disclosed using identifiable units, programs, or categories.	KPIs are disclosed with quantitative measures, targets, benchmarks, achievements, and comparisons across periods.
Monitoring and performance evaluation	No evidence of monitoring or evaluation was disclosed.	Monitoring or evaluation is mentioned in general terms without procedures, frequencies, or results.	Monitoring activities or performance evaluation mechanisms are disclosed; however, the link to the results is limited.	Periodic monitoring, target realization comparison, deviation analysis, and performance evaluation are clearly documented.
Managerial accountability and governance	No responsible unit, committee, or governance structure was disclosed.	General responsibility for sustainability is mentioned without a clear managerial role being defined.	The responsible unit, committee, board function, or management role is identified.	The accountability structure, managerial responsibility, governance oversight, and performance reporting lines are clearly disclosed.
Corrective action and learning	No corrective action, follow-up, or learning mechanism was disclosed.	General improvement intention is disclosed without any evidence of action.	A specific improvement program or corrective initiative has been disclosed, but the evaluation of its effectiveness is limited.	Corrective actions are linked to evaluation results and include evidence of follow-up, learning, or improvement.
Integration with operational and risk control	No integration with operations, internal controls, or risk management was disclosed.	Sustainability risk and operational concerns are mentioned in general terms.	Sustainability issues are linked to operational processes, risk management, internal controls, and compliance mechanisms.	Sustainability information is integrated into operational control, risk management, budgeting, procurement, investment, and performance management.

Note: The scoring was conservative. A higher score was assigned only when the report provided sufficient documentary evidence. Broad sustainability statements alone are insufficient for high scores. The index captures disclosed maturity, not the direct observation of internal management practices.

Appendix B. Robustness and Sensitivity Tests

Appendix Table B1 reports additional tests used to assess the stability of the main results. These tests include lagged SMCSM specifications, exclusion of COVID-19 years, exclusion of observations affected by scope changes, winsorization of the dependent variable, exclusion of financially stressed observations, and alternative dependent variables based on emissions and water eco-efficiency.

Appendix Table B1. Robustness and Sensitivity Tests

Model	Dependent Variable	Estimator / Sample	SMCSM Coef.	SMCSM p-value	Scope Coef.	Scope p-value	Obs.
Lagged SMCSM, Firm FE	ln energy efficiency	Firm FE, clustered SE; main energy	-0.0167	0.507	-1.3462***	0.001	89
Lagged SMCSM, Firm FE + Year FE	ln energy efficiency	Firm FE + year FE, clustered SE; main energy	-0.0296	0.266	-1.3802***	0.005	89
Lagged SMCSM, no scope-change	ln energy efficiency	Firm FE, clustered SE; scope_flag = 0	-0.0054	0.813	—	—	56
Excluding the COVID years	ln energy efficiency	Firm FE, clustered SE; excluding 2020-2021	-0.0176	0.567	-1.3631***	0.002	67
Excluding scope-change observations	ln energy efficiency	Firm FE, clustered SE; scope_flag = 0	-0.0038	0.859	—	—	57
Winsorized dependent variable	ln energy efficiency	Firm FE, clustered SE; winsorized log DV	-0.0176	0.435	-1.3214***	0.001	90
Excluding financial-stress observations	ln energy efficiency	Firm FE, clustered SE; stress_flag = 0	-0.0209	0.370	-1.2591**	0.017	70
Emission robustness, Firm FE	ln emission efficiency	Firm FE, clustered SE	-0.0018	0.856	-0.3153	0.396	138
Emission robustness, Firm FE + Year FE	ln emission efficiency	Firm FE + year FE, clustered SE	-0.0012	0.915	-0.2691	0.530	138
Water robustness, Firm FE	ln water efficiency	Firm FE, clustered SE	-0.0202	0.171	-0.9254*	0.056	159
Water robustness, Firm FE + Year FE	ln water efficiency	Firm FE + year FE, clustered SE	-0.0296	0.129	-0.6740	0.115	159

*Note: Rows for lagged SMCSM use lagged SMCSM as the coefficient of interest. All models use firm fixed effects with clustered standard errors, unless otherwise stated. The controls include firm size, ROA, and leverage. The reporting-regime variable is included only in specifications without year fixed effects because it is absorbed by the year indicators in year fixed-effects models. The scope coefficient is omitted when scope-change observations are excluded. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.*