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From Recording to Regulation: Integrative Carbon Accounting as a Driver of Energy Transition Regulatory Intensity among Industrial Firms and MSMEs in Indonesia

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Abstract: Carbon accounting has been transformed from a mere supplement to sustainability reports to a critical information infrastructure that underpins the formulation of climate policy as a result of the transition to a low-carbon economy. This research investigates the impact of the Integrative Carbon Accounting (MICA) model on the Energy Transition Regulatory Intensity (IRTE) as perceived by corporate entities. A questionnaire-based survey was implemented as a quantitative methodology. The findings suggest that profitability has a detrimental impact on the value of a firm, while firm size and leverage do not have a substantial impact. These results indicate that the integration of structured and credible emissions data into business recording systems results in a reduction in costs. This study broadens the scope of the carbon accounting literature by presenting carbon accounting as an exogenous variable that influences regulatory dynamics, rather than solely a byproduct of regulation.

Keyword: Carbon Accounting, Energy Transition, Regulatory Intensity, Institutional Theory, MSMEs.

INTRODUCTION

A rising number of organizations have made their global warming initiatives part of their basic policies because they know that turning green may save money through greater energy efficiency and waste management, among other considerations. Under contemporary regulatory reforms meant to address the growing environmental concerns of numerous stakeholders, climate change and energy transitions have become urgent financial and social challenges (Alsaifi et al., 2020a).

Climate change has transformed from an ecological concern into a comprehensive threat that impacts on the framework of global economic, fiscal, energy, investment, and corporate governance policies. In Indonesia, the pledge to attain Net Zero Emissions by 2060 or earlier is integrated into enduring low-carbon development and climate resilience initiatives, concurrently contributing to the fulfillment of Nationally Determined Contribution (NDC) objectives (Sudjono & Suarga, 2024). The energy transition and climate change have transformed carbon-related information from a peripheral sustainability issue to economically relevant information. Operating costs, investment decisions, access to financing, the risk of asset impairment, and market perception can all be influenced by emissions and their associated control policies for companies. International evidence suggests that investors consider carbon risk. Specifically, firms with higher carbon emissions may have a lower value, while those with voluntary carbon disclosures may have a higher value (Sun et al., 2022).

Carbon accounting emerges as a critical instrument for companies to measure, monitor and manage their carbon emissions. Although still largely voluntary, carbon emissions disclosure practices are increasingly being adopted by corporations to reduce information asymmetry and demonstrate commitment to social and environmental issues Disclosures can allow stakeholders, like shareholders and creditors, to make smarter investment decisions (Adhikari & Zhou, 2022; Juniarti & Sasanti, 2025). Carbon disclosure can also allow stakeholders, such as regulatory agencies, institutional investors and the public, to better monitor and oversee a firm's carbon emissions, which is likely to contribute to its improved carbon performance. Improved carbon performance can, in turn, influence the firm's financial performance (Siddique et al., 2021).

The majority of contemporary literature considers regulation as an external factor and carbon accounting as a reactive measure. Institutional pressure, especially coercive influence from the government, propels enhancements in the quality of company carbon information disclosure in China (Tang et al., 2022a). Comparable evidence is present within the framework of UK environmental polic (Alsaifi et al., 2020b). In Indonesia, the institutional efforts that resulted in the compulsory nature of sustainability reporting as stipulated by POJK 51/2017. All these investigations indicate that the influence emanates from regulation to accounting practices (Ardiana et al., 2025a).

This research presents a counterargument that is also complementary: the interplay between carbon accounting and regulation is mutual. When commercial organizations can produce organized and reliable emissions data, the expenses for regulators related to monitoring and enforcement diminish considerably, thus expanding the potential for stricter energy transition legislation. The advancement of carbon accounting methodologies at the micro level could operate as both a necessary technological foundation and a driving force for stricter policies at the macro level. This hypothesis has not been thoroughly examined empirically, especially among a demographic mostly composed of micro, small, and medium-sized firms.

The emphasis on micro, small, and medium-sized enterprises (MSMEs) is particularly pressing. MSMEs in developing countries encounter a variety of challenges when attempting to implement environmental management accounting. These obstacles include the absence of a straightforward, practical framework, as well as limited human resources and costs (Mukwarami & van der Poll, 2024). However, the sector's overall emissions cannot be disregarded. The successful implementation of environmental management accounting in medium-sized entities is highly dependent on the support of top management and coercive coercion (Nguyen, 2022).

The objective of this study is to empirically investigate the impact of the Integrative Carbon Accounting Model on the regulatory intensity of energy transition among industrial

enterprises and MSMEs in Indonesia. Additionally, it will map the literacy levels, constraints, and support requirements of business actors in relation to the adoption of emission recording practices. The contribution of this investigation is twofold. It theoretically advances the application of institutional and legitimacy theories by illustrating that isomorphism does not always flow unidirectionally from the state to organizations; rather, it can reverse when an organization's information capacity enables the state to raise standards. In practice, the results establish a foundation for the development of policy interventions that prioritize the enhancement of the emission-recording capabilities of business actors, a requirement for the success of carbon taxation and carbon trading.

This Research was using three (3) main theory. First, Institutional Theory. Organizations implement particular practices as a reaction to coercive, normative, and mimetic influences from their surroundings (Dimaggio & Powell, 1983). Coercive pressure from governmental regulations serves as the most potent catalyst for carbon information sharing. This research expands the existing theory by including a feedback mechanism: the buildup of carbon accounting capabilities within the organizational population fosters conditions that allow the state to amplify its coercive pressure (Tang et al., 2022b). In the absence of a sufficient emissions database, the enforcement of stringent limits would be challenging and may be devolved into purely symbolic measures.

Second, Legitimacy Theory, Entities endeavor to guarantee their operations conform to societal standards and anticipations. The establishment of a comprehensive carbon accounting system substantiates the validity of assertions related to energy efficiency and ecological accountability. Voluntary reporting practices originally established among certain organizations, ultimately evolved into a normative benchmark for the development of compulsory rules in Indonesia, aligning with the assertions of this research (Ardiana et al., 2025b).

Third, Signalling Theory, Entities possessing greater information will transmit credible signals to mitigate information imbalance (Spence, 1973). Establishing a carbon accounting system necessitates resource allocation, rendering it an expensive-to-imitate indicator. Lee & Cho, (2021) and (Alsaifi et al., 2020c) discovered that the market reacts to reliable carbon signals, whereas Li et al., (2025) demonstrated the significance of environmental information.

The adoption of a comprehensive carbon accounting framework produces organized, uniform, and credible emissions information. From a regulatory economics standpoint, the accessibility of such data diminishes the monitoring and enforcement expenses incurred by authorities. Carbon policy mechanisms are only efficacious when supported by dependable emissions measurement technologies at the entity level. As carbon accounting procedures across businesses mature, regulators have increased opportunities to broaden the scope and intensify the rigor of energy transition requirements (Xu et al., 2023).

From an institutional and legitimacy standpoint, corporate entities that have assimilated the practice of documenting emissions generally exhibit more preparedness and anticipation for the implementation of more stringent laws. They interpret policy directives with greater precision and regard regulatory pressure as tangible and obligatory, whereas commercial entities lacking a documentation system often remain oblivious to their regulatory vulnerabilities. Enhanced climate governance is associated with organizations' cognizance and adaptability to the carbon regulatory framework (Bedi & Singh, 2024). The hypothesis for this research is Integrative Carbon Accounting Model has a positive and substantial influence on the Intensity of Energy Transition Regulations.

METHOD

This research utilizes a quantitative methodology with a cross-sectional survey framework. The research cohort comprises entrepreneurs within the industrial and MSME

sectors in Indonesia. Data gathering was executed by a systematic questionnaire disseminated to individuals in decision-making or operational positions within respective organizational units. A cumulative count of 252 participants satisfied the requirements for comprehensive responses. The makeup of respondents included 209 MSMEs (82.9%) and 43 industrial entities (17.1%), mostly represented by business proprietors (136 individuals; 54.0%) and staff members (92 individuals; 36.5%).

The variable (X) of the Integrative Carbon Accounting Model is assessed by six items on a five-point Likert scale that encompasses awareness of emission sources, documentation processes, internalization of environmental costs, and preparedness for reporting, yielding a total score ranging from 6 to 30. The Energy Transition Regulatory Intensity variable (Y) is quantified by eleven items on a five-point Likert scale that assesses views of regulatory rigor, reporting requirements, incentives, penalties, and expectations of policy alterations, yielding a total score ranging from 11 to 55. The tool additionally comprises category elements to assess literacy levels, document limitations, and identify support need.

The examination was performed utilizing SPSS software via the subsequent phases. Initially, a validity assessment was conducted with Pearson's bivariate correlation, with a significance threshold set below 0.05. Secondly, a reliability assessment was performed with Cronbach's alpha, establishing a benchmark of 0.70. Thirdly, standard assumption evaluations were conducted, including the Kolmogorov-Smirnov normality assessment, a multicollinearity analysis utilizing tolerance and variance inflation factor (VIF) metrics, and a heteroscedasticity examination employing the Glejser test. Fourth, hypothesis evaluation was performed utilizing simple linear regression analysis represented by the subsequent equation.

$$IRTE = \alpha + \beta_1 MICA + \varepsilon$$

RESULT AND DISCUSSION

The composition of the research respondents is represented in Table 1.

Table 1. Characteristics of Research Respondents

Characteristics	Category	Frequency	Percentage (%)
Type of Business	Industry	43	17.1
	MSMEs	209	82.9
Position/Job Title	Business Owner	136	54.0
	Employee	92	36.5
	Manager	11	4.4
	Chief Executive Officer	4	1.6
	Founder	3	1.2
	Others	6	2.4
Total		252	100.0

Source: Processed primary data (2026)

This study is distinguished by the predominance of MSMEs in the respondent pool. In general, this business segment is not subject to formal sustainability reporting requirements; as a result, the carbon accounting practices that have been observed have been implemented either voluntarily or in response to supply-chain pressures, rather than through direct regulatory mandates.

Validity and Reliability Tests

The results of the validity test demonstrate that all statement items for both variables possess significance values below 0.05, therefore affirming their validity. The Pearson correlation coefficients for the MICA variable span from 0.499 to 0.813, whereas those for the IRTE variable extend from 0.608 to 0.755. The outcomes of the reliability assessment are displayed in Table 2.

Table 2. Reliability Test Results

Variable	Cronbach's Alpha	Average	Information
Carbon Accounting (MICA) model	0,801	6	Reliabel
Energy Transition Regulatory Intensity	0,888	11	Reliabel

Source: Processed primary data (2026)

Both variables exhibit Cronbach's alpha coefficients over 0.70; hence, the instrument is deemed reliable and internally consistent.

Descriptive Statistics

Table 3 provides a concise summary of the descriptive statistics for the two variables.

Table 3. Descriptive Statistics of Research Variables

Variable	N	Minimum	Maximum	Average	Dev.Std
Carbon Accounting (MICA) model	252	6,00	30,00	20,92	4,18
Energy Transition Regulatory Intensity	252	11,00	55,00	41,53	6,81

Source: Processed primary data (2026)

The respondents' carbon accounting practices are classified as "fairly good" based on an average MICA score of 20.92 out of a maximum of 30, although there is still substantial room for improvement. The item with the highest score was the awareness that business activities generate emissions (mean: 4.07), while the item related to actual recording practices had the lowest score (mean: 3.15). This pattern indicates a "awareness-practice gap"a situation in which conceptual awareness is relatively high but has not yet been matched by equivalent technical implementation. These results substantiate the arguments presented by Mukwarami & van der Poll (2024) concerning the obstacles to the implementation of environmental management accounting among MSMEs in developing countries. In the interim, the average IRTE score of 41.53 out of a maximum of 55 suggests that business operators perceive the regulatory pressure associated with energy transition to be relatively high.

Literacy, Challenges, and Support Needs

Charting categorical dimensions offers significant context for elucidating the regression findings. A total of 131 participants (52.0%) reported awareness of carbon emission documentation and reporting but lacked comprehension; 97 participants (38.5%) indicated a moderate understanding; whereas 24 participants (9.5%) had no prior knowledge of the subject. A synopsis of limitations and assistance requirements is provided in Tables 4 and 5.

Table 4. Challenges in Carbon Emission Recording

Challenges	Frequency	Percentage (%)
Lack of adequate recording tools or systems	111	27.5
Lack of knowledge or training on how to implement it	95	23.6
Lack of knowledge regarding the number of emissions generated by the business	89	22.1
No mandatory regulations requiring implementation	59	14.6
High implementation costs	49	12.2
Total	403	100.0

Source: Processed primary data (2026)

Table 5. Support Needs of Business Actors

Type of Support	Frequency	Percentage (%)
Easy-to-understand training or outreach programs	109	43.3
Financial assistance or implementation cost subsidies	48	19.0
Direct assistance from experts or researchers	41	16.3
Affordable or free recording applications	32	12.7
Practical recording guidelines and templates	22	8.7
Total	252	100.0

Source: Processed primary data (2026)

The breakdown of restrictions in Table 4 demonstrates that the principal hurdles relate to technical capabilities and knowledge, rather than merely costs. The lack of recording tools, unfamiliarity with methodologies, and ignorance of emission levels collectively account for 73.2% of all cited restrictions, whereas cost factors comprise just 12.2%. Consistent with this, 43.3% of respondents indicated training as the most needed type of help. These findings challenge the common assumption that financial limitations are the main barrier to carbon accounting adoption among MSMEs, aligning instead with the propositions of Mukwarami & van der Poll (2024) and Nguyen (2022) which emphasize the importance of capability and knowledge dimensions.

Classical Assumption Test

Hasil uji normalitas Kolmogorov-Smirnov memperoleh nilai Z sebesar 1,127 dengan signifikansi asimtotik 0,158. Karena nilai signifikansi lebih besar dari 0,05, residual model dinyatakan berdistribusi normal. Uji multikolinieritas menghasilkan nilai tolerance dan variance inflation factor sebesar 1,000; nilai tersebut merupakan konsekuensi logis dari penggunaan satu variabel independen sehingga model terbebas dari masalah multikolinieritas. Uji heteroskedastisitas dengan metode Glejser memperoleh koefisien sebesar -0,089 dengan t hitung -1,526 dan signifikansi 0,128. Karena nilai signifikansi lebih besar dari 0,05, model dinyatakan terbebas dari heteroskedastisitas. Dengan demikian seluruh prasyarat regresi linier terpenuhi.

Hypothesis Testing Results

The results of the simple linear regression analysis are presented in Table 6.

Table 6. Results of Simple Linear Regression Analysis

Variable	B	Std. Error	Beta	t	Sig.
(Constant)	23.728	1.874	–	12.661	0.000
Integrated Carbon Accounting Model	0.851	0.088	0.522	9.688	0.000

Dependent variable: Energy Transition Regulation Intensity. R-squared = 0.273; Adjusted R-squared = 0.270; F = 93.848; Sig. F = 0.000. Source: Processed primary data (2026)

The coefficient of determination of 0.273 implies that the variance in the Integrative Carbon Accounting Model explains 27.3% of the variation in Energy Transition Regulatory Intensity, while the remaining 72.7% is explained by factors outside the model. The F-test produced a score of 93.848 with a significance of 0.000, showing that the regression model is correct. The partial test revealed a standardized beta coefficient of 0.522, with a calculated t-value of 9.688 exceeding the t-table value of 1.96 and a significance of 0.000. Thus, H1 is accepted: the Integrative Carbon Accounting Model has a positive and considerable effect on Energy Transition Regulatory Intensity.

Substantively, each one-unit rise in the MICA score is associated with a 0.851-unit increase in the IRTE score. The constant figure of 23.728 demonstrates that, even at the

lowest level of carbon accounting standards, corporate organizations still perceive a baseline level of regulatory pressure regarding the energy transition.

Discussion

The finding that MICA has a positive and significant impact on IRTE can be understood through three complementary processes.

First, the mechanism of reduced monitoring expenses. When commercial organizations can offer precise and consistent carbon emission disclosures, the compliance and monitoring expenses paid by authorities diminish. The availability of integrated data provides an empirical basis for regulators to expand the scope of carbon levies, tighten reporting duties, and apply punishments in a measured manner. Xu et al. (2023) underline that the comparative effectiveness of carbon taxes versus emissions trading is largely decided by the reliability of monitoring methods at the entity level. Within this perspective, carbon accounting is not only a subject of regulation but the infrastructure that enables the legislation itself to function.

Second, the institutional and legitimacy mechanism. Institutional theory states that organizations adopt specific practices owing to environmental constraints in order to attain legitimacy Dimaggio & Powell (1983). This study illustrates the reciprocal nature of that process. The aggregation of carbon accounting methods across the organizational population provides a credible and transparent emissions data system, which in turn motivates regulators to devise more enforceable and measurable energy transition rules. This pattern resonates with the findings of Ardiana et al. (2025a) in Indonesia, which indicated that GRI-based sustainability reporting practices initially accepted voluntarily served as a normative reference for the drafting of POJK 51/2017. Thus, coercive isomorphism does not necessarily transfer in a single path from the state to the organization.

Third, the perception and readiness process. Business entities that have implemented emissions recording possess a clearer grasp of their regulatory vulnerability, leading them to perceive regulatory intensity as higher and more realistic. Conversely, business operators lacking record-keeping systems tend to be uninformed of forthcoming duties. This conclusion is backed by literacy statistics showing that 52.0% of respondents had heard of the concept of emissions reporting but did not yet grasp it. These findings coincide with those of Tang et al. (2022a) about the role of explicit institutional pressure in altering the quality of carbon disclosure, as well as with (Bedi & Singh, 2024) addressing the link between climate governance and an entity's responsiveness to regulatory frameworks.

The coefficient of determination of 27.3% should be considered in right context. This figure is considered reasonable for an organizational behavior study involving a single explanatory variable; it also indicates that perceptions regarding regulatory intensity are shaped by factors outside the model—such as media exposure, global supply chain pressures, sectoral characteristics, and the intensity of interaction with oversight bodies. Alatawi et al., (2023) emphasize that the relationship between sustainable practices and organizational performance is typically influenced by sectoral contextual characteristics.

The policy implications of these findings are simple. If carbon accounting maturity is a prerequisite for the efficacy of energy transition rules, then policy investments focused at boosting the emissions-tracking capability of business entities—particularly MSMEs—should precede, or at least run parallel to, the tightening of regulations. Data in Tables 4 and 5 demonstrate that the most essential solutions are not financial subsidies, but rather training, mentoring, and the supply of basic recording equipment. Hartono et al., (2023) have underlined that the success of a carbon tax in Indonesia depends on an implementation design that takes into consideration the readiness of economic actors on the ground.

CONCLUSIONS AND RECOMMENDATIONS

Conclusion

This study shows that the Integrative Carbon Accounting Model has a positive and significant impact on Energy Transition Regulatory Intensity among industrial businesses and MSMEs in Indonesia, with a standardized beta coefficient of 0.522 and a coefficient of determination of 27.3%. The deployment of integrated carbon accounting serves not just as an internal compliance instrument but acts as a catalyst affecting the dynamics of tightening national energy transition rules targeted at reaching Net Zero Emissions by 2060. Conversely, the study identifies a separate capacity gap—specifically, strong conceptual understanding that has not been matched by technological recording capabilities—where the key impediments are a lack of tools and expertise rather than financial limits.

Limitations

This study contains a number of limitations that need to be addressed in interpreting the results. First, the cross-sectional design limits the capacity to draw causal inferences; the relationship discovered is associative and theoretically can be reciprocal. Second, both variables are measured by respondents' judgments on the same instrument, thus potentially giving rise to common method bias. Third, the use of one independent variable without control variables limits the model's capacity to separate the influence of MICA from structural characteristics such as business size, sector, and exposure to export supply chains. Fourth, the prevalence of MSME respondents limits the application of the findings to large-scale corporate organizations that are subject to formal sustainability reporting obligations.

Recommendations

1. For commercial entities, carbon accounting should not be viewed solely as a reporting formality; instead, it should be integrated into management accounting systems to enable continuous monitoring of emissions data and its usage in operational decision-making.
2. Businesses should utilize carbon accounting data to predict future tightening of energy transition laws, so preventing policy moves from triggering compliance shocks or incurring considerable adjustment costs.
3. For regulators and agencies assisting MSMEs, intervention priorities should center on training, technical help, and the supply of simple, affordable technologies for recording emissions, given that the key impediments relate to capacities and knowledge.
4. Future researchers are advised to incorporate variables such as green dynamic capabilities, environmental awareness, and information technology readiness—alongside structural control variables—and to consider longitudinal or mixed-methods designs to more convincingly test the direction of causal relationships.

Author Contributions

All authors made substantial contributions to this work. These contributions comprised research conceptualization, construction of the theoretical framework, data collection, data analysis, interpretation of results, manuscript preparation, scholarly revision, and final approval of the paper for publication. All authors certify that they have read and approved the final version of the article.

AI Disclosure Statement

During the preparation of this manuscript, the author used Quillbot for paraphrase. The author has thoroughly reviewed and revised the content and takes full responsibility for the entire publication.

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