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The Effect Of Environmental Management Accounting On Environmental Performance With Eco-Efficiency As A Mediating Variable

M. Amien Dwi Putra
Master of Accounting Science Program, Sriwijaya University, Indonesia
Rina Febriana
Master of Accounting Science Program, Sriwijaya University, Indonesia
Luk Luk Fuadah
Department of Accounting, Sriwijaya University, Indonesia

Corresponding Author: amiendwiputra07@gmail.com

Abstract

This study aims to analyze the effect of Environmental Management Accounting (EMA) on environmental performance, with eco-efficiency as a mediating variable in Indonesian manufacturing companies. This research employs a Systematic Literature Review (SLR) approach by examining 29 article records published between 2021 and 2026. The synthesis focuses on four relationships among the research variables. The findings indicate that EMA tends to have a positive relationship with environmental performance by helping companies control environmental costs, optimize resource utilization, and reduce pollution. EMA also has the potential to improve eco-efficiency, although empirical evidence remains limited. Meanwhile, the relationship between eco-efficiency and environmental performance produces mixed findings. The mediating role of eco-efficiency is theoretically relevant but has not been extensively examined in Indonesian manufacturing companies. Based on the Natural Resource-Based View, EMA represents an information capability that supports operational efficiency and improved environmental performance.

Keywords: Environmental Management Accounting; Eco-Efficiency; Environmental Performance.

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INTRODUCTION

Environmental Management Accounting (EMA) is a management accounting approach that integrates environmental and economic information to help companies identify, measure, and control the environmental impact of their operational activities (IFAC, 2005). EMA provides physical information in the form of raw material use, energy, water, and waste, as well as monetary information in the form of costs and environmental savings. In manufacturing companies, the application of EMA is important because production activities require large amounts of resources and have the potential to produce waste and emissions. Through instruments such as Material Flow Cost Accounting (MFCA), companies can identify material waste and costs arising from the production process so that resource management becomes more efficient. (ISO, 2011)

Environmental performance describes a company's ability to manage environmental impacts, such as reducing waste, controlling emissions, saving resources, and meeting environmental standards. One of the environmental performance evaluation instruments in Indonesia is PROPER. Based on the publication of the Ministry of Environment and Forestry and Forestry (KLH/BPLH on October 8, 2026), of the 5,476 companies assessed in the 2024–2025 period, 2,762 companies (50.4%) received a Red rating, while 2,265 companies (41.4%) received a Blue rating. This condition shows that environmental management and compliance are still a challenge for the business world. In addition, the industrial sector is the largest energy user in Indonesia with a contribution of 45.94% of total energy demand in 2024. The strengthening of waste management regulations, such as the Minister of Environment and Forestry Regulation Number 12 of 2025 concerning Wastewater Quality Standards for the Textile Industry, also shows increasing demands on corporate environmental management. (ISO, 2021) (Ministry of Energy and Mineral Resources, 2025)

One approach that can support improving environmental performance is eco-efficiency, which is the company's ability to generate economic value with lower resource use and environmental impact. In this study, (WCBSD, 2000) eco-efficiency is placed as a mediating variable that explains how the implementation of EMA can improve environmental performance. EMA information helps management identify waste of raw materials, energy, and water, which is then used to improve production processes, reduce material loss, and reduce waste. These improvements are expected to increase operational efficiency while improving the company's environmental performance. Research on PTPN Takalar Sugar Factory also shows that EMA

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contributes to reducing waste and improving operational efficiency, although its implementation still faces technological constraints, costs, and employee awareness. (IFAC, 2005; ISO, 2011) Shadrina et al. (2025)

This study uses the Natural Resource-Based View (NRBV) developed by as a grand theory. NRBV explains that environmental management can be a source of the company's strategic capabilities and advantages through Heart (1995) pollution prevention, product stewardship, and sustainable development strategies. Based on this perspective, EMA plays a role in providing information to support resource management, while eco-efficiency is an operational improvement mechanism that connects the implementation of EMA with environmental performance. Therefore, this study examines the influence of Environmental Management Accounting on environmental performance with eco-efficiency as a mediating variable in manufacturing companies in Indonesia.

Previous research shows that Environmental Management Accounting (EMA) contributes to improving environmental performance, but there are still limitations in testing mechanisms that explain this relationship in manufacturing companies in Indonesia. proving the positive influence of eco-efficiency on environmental performance in the hospitality sector, while finding that resource efficiency mediates the relationship between EMA and environmental performance in the garment industry in Bangladesh. On the other hand, it is found that resource efficiency is not proven to mediate the relationship between green accounting and corporate sustainability. The difference in context and the results of the study shows that there is a research gap to re-examine the role of eco-efficiency as a mediating variable in the relationship between EMA and environmental performance in manufacturing companies in Indonesia. (Nagari, 2023; Shadrina et al., 2025) Saputra et al. (2022) Mia et al. (2026) Said et al. (2026)

Based on previous phenomena and research, improving the environmental performance of manufacturing companies requires not only compliance with regulations, but also environmental information management and resource use efficiency. Environmental Management Accounting (EMA) plays a role in providing physical and monetary information to help management control environmental costs, reduce waste, and increase eco-efficiency through optimizing the use of raw materials, energy, and water. The increase in eco-efficiency is expected to reduce environmental impact and improve the company's environmental performance. Based on the Natural Resource-Based View (NRBV), this study analyzes the direct influence of EMA on environmental performance, the influence of EMA on eco-efficiency, the

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effect of eco-efficiency on environmental performance, and the role of eco-efficiency in mediating the relationship between EMA and environmental performance in manufacturing companies in Indonesia. (IFAC, 2005; KLH, 2026) (IFAC, 2005; ISO, 2021; WCBSD, 2000) (Mia et al., 2026; Saputra et al., 2022)

Problem Formulation

Based on the background and research gaps that have been described, the formulation of the problems in this study is:

1. Does Environmental Management Accounting affect the environmental performance of manufacturing companies in Indonesia?
2. Does Environmental Management Accounting have an effect on eco-efficiency in manufacturing companies in Indonesia?
3. Does eco-efficiency affect the environmental performance of manufacturing companies in Indonesia?
4. Does eco-efficiency mediate the influence of Environmental Management Accounting on environmental performance in manufacturing companies in Indonesia?

Research Objectives

Based on the formulation of the problem, this study aims to:

1. Analyze and obtain empirical evidence regarding the influence of Environmental Management Accounting on environmental performance in manufacturing companies in Indonesia.
2. Analyze and obtain empirical evidence on the influence of Environmental Management Accounting on eco-efficiency in manufacturing companies in Indonesia.
3. Analyze and obtain empirical evidence on the influence of eco-efficiency on environmental performance in manufacturing companies in Indonesia.
4. Analyze and obtain empirical evidence on the role of eco-efficiency in mediating the influence of Environmental Management Accounting on environmental performance in manufacturing companies in Indonesia.

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Research Benefits

Theoretical Benefits

This research is expected to contribute to the development of environmental management accounting, especially regarding the relationship between Environmental Management Accounting (EMA), eco-efficiency, and environmental performance. In addition, this research is expected to strengthen the application of the Natural Resource-Based View (NRBV) and provide empirical evidence on the role of eco-efficiency as a mediating variable in improving the environmental performance of manufacturing companies.

Practical Benefits

1. For Manufacturing Companies: As a consideration in implementing EMA to control environmental costs, optimize resource use, and improve environmental performance.
2. For Company Management: Provide an understanding of the importance of eco-efficiency in improving the efficiency of using raw materials, energy, and water and reducing waste and emissions.
3. For the Government and Regulators: To be an input in encouraging improvement of environmental management and resource efficiency in manufacturing companies.
4. For the Next Researcher: To be a reference and comparison material for research related to EMA, eco-efficiency, and environmental performance with the development of different variables and industrial sectors.

Literature Review

Natural Resource-Based View (NRBV)

Natural Resource-Based View (NRBV) is a development of the Resource-Based View (RBV) proposed by , by placing the natural environment as a strategic factor in building a sustainable competitive advantage. NRBV includes three main strategies, namely Heart (1995) pollution prevention, product stewardship, and sustainable development, which emphasizes waste and emission reduction, environmental impact control throughout the product life cycle, and balance economic, social, and environmental aspects. In this study, NRBV explained that the implementation of Environmental Management Accounting (EMA) can be a company's internal capability in managing environmental information, improving resource use efficiency, and reducing pollution. This ability is expected to increase eco-efficiency which further supports the

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achievement of the company's environmental performance. (Appannan et al., 2023; Hart, 1995; Yanti et al., 2026)

Environmental Management Accounting (EMA)

Environmental Management Accounting (EMA) is an accounting approach that integrates environmental and economic information to support the company's internal planning, control, and decision-making. EMA has two main dimensions, namely (IFAC, 2005) Physical Environmental Management Accounting which includes information on the use of raw materials, energy, water, and amount of waste, and Monetary Environmental Management Accounting which deals with the measurement of environmental costs, such as waste treatment costs and pollution prevention. In manufacturing companies, EMA helps management identify resource waste, control environmental costs, and improve production processes to be more efficient and environmentally friendly. (Gunarathne, 2022; IFAC, 2005) (Appannan et al., 2023)

Environmental Performance

Environmental performance is a description of a company's success in managing and controlling environmental impacts arising from its operational activities, including pollution reduction, waste and emission control, resource use efficiency, and compliance with environmental regulations. In manufacturing companies, environmental performance can be assessed through the company's ability to reduce waste and emissions, optimize energy and water use, and implement pollution prevention strategies. In this study, environmental performance is positioned as a dependent variable that reflects the results of the company's environmental management through the implementation of information systems and sustainability-oriented operational policies. (Mia et al., 2026) (Mia et al., 2026)

Eco-Efficiency

Eco-efficiency or eco-efficiency is a concept that links the creation of economic value with the reduction of environmental impact through the efficient use of resources (Puffs & Ishikawa, 2005) . This concept is realized through the optimization of the use of raw materials, energy, and water, the reuse of materials, and the reduction of waste and emissions in the production process. In the perspective of EMA, physical and monetary information helps management identify wastes and determine improvements to the production process so that

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operational efficiency can increase without neglecting environmental aspects. Therefore, in this study, (IFAC, 2005) eco-efficiency is positioned as a mediating variable that explains how the implementation of EMA can improve the efficiency of resource use and further support the improvement of the environmental performance of manufacturing companies. (Mia et al., 2026)

Research Hypothesis Development

Based on the theoretical foundation and the relationship between variables that have been described, the research hypothesis is formulated as follows:

1. H1: Environmental Management Accounting has a positive effect on environmental performance in manufacturing companies in Indonesia.
2. H2: Environmental Management Accounting has a positive effect on eco-efficiency in manufacturing companies in Indonesia.
3. H3: Eco-efficiency has a positive effect on the environmental performance of manufacturing companies in Indonesia.
4. H4: Eco-efficiency mediates the influence of Environmental Management Accounting on environmental performance in manufacturing companies in Indonesia.

RESEARCH METHODOLOGY

Research Design

This study uses the Systematic Literature Review (SLR) approach to identify, select, evaluate, and synthesize the results of previous research on the Influence of Environmental Management Accounting on Environmental Performance with Eco-Efficiency as a Mediation Variable. Systematic review is a research approach that collects empirical evidence based on predetermined eligibility criteria to answer certain research questions by using explicit and systematic methods to minimize bias and produce more reliable findings. (Higgins et al., 2019)

The research process is designed in a prismatic manner through several main stages, namely the formulation of research questions, the determination of inclusion and exclusion criteria, the preparation of literature search strategies, the process of article selection and screening, data extraction, quality assessment or risk of bias, and synthesis of research results. The determination of methods before the review process is carried out aims to reduce the possibility of research decisions being influenced by the study results found during the review process. (Higgins et al., 2019)

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Formulation of Research Questions

The formulation of research questions is the basis for determining eligibility criteria, search strategies, types of data collected, synthesis structure, and presentation of research results. In this study, the scope of study is directed to research that discusses the Influence of Environmental Management Accounting on Environmental Performance with Eco-Efficiency as a Mediation Variable. The determination of the scope is carried out from the beginning so that the main concept of the research has clear boundaries and does not cause conceptual ambiguity during the review process. (Higgins et al., 2019) (Higgins et al., 2019)

Determination of Inclusion and Exclusion Criteria

Inclusion and exclusion criteria are established before the literature search is carried out. Eligibility criteria are one of the fundamental characteristics of systematic review and must be formulated clearly so that the article selection process is consistent and accountable. (Higgins et al., 2019)

Literature Search Strategy

Literature searches are conducted systematically and comprehensively on several scientific databases relevant to the fields of environmental management, accounting, economics, and sustainability. The principle of systematic review requires that searches be conducted thoroughly, objectively, and reproducibly to obtain as many studies as possible that meet the eligibility criteria and reduce potential selection bias. Each search process is documented in detail, including the name of the database, the date of the search, the year range of publication, the keywords, the search string, and the number of articles obtained from each source. The documentation is necessary so that the search process can be reported transparently and reproduced as much as possible. (Higgins et al., 2019) (Higgins et al., 2019)

Article Selection and Screening

Searchable articles from various databases are then combined and duplicate checks are performed. After duplication is removed, articles are filtered by title and abstract to identify irrelevant research. Potentially relevant articles are then checked through full text to determine their suitability with inclusion and exclusion criteria. The selection process is carried out in stages through the merging of search results, removal of duplicates, screening of titles and abstracts,

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evaluation of eligibility criteria, and determination of final decisions on articles included in the study. (Higgins et al., 2019)

Data Extraction

Articles that have met the inclusion criteria are then extracted from the data. The data collected must be accurate, complete, structured, re-accessible, and obtained through transparent procedures to minimize bias and human error. (Higgins et al., 2019)

Quality Assessment and Risk Bias

Furthermore, a quality assessment or risk of bias is carried out on the selected article. The risk of bias assessment must be determined in advance, including the instruments used, the assessment procedure, and the classification criteria for the assessment results, so that the appraisal process is not influenced by the results of the research obtained. (Higgins et al., 2019)

Data Synthesis

The last stage is the synthesis of research results. Synthesis is the process of combining data from studies that have been included to obtain conclusions about the overall available evidence. Before synthesizing, the characteristics of each study are compared to determine the similarities and differences between studies and determine the appropriate research grouping. (Higgins et al., 2019) (Higgins et al., 2019)

All decisions and stages of research are documented to form an audit trail that allows the systematic review process to be traced, examined, and replicated. The documentation includes inclusion and exclusion decisions, search results, extraction data, research quality assessment, and any changes to pre-established procedures. (Higgins et al., 2019)

Research Results and Discussion

Overview of Literature Synthesis

The results of the synthesis of 29 article recordings in the EMA Journal Matrix to answer four research questions, namely: (1) the effect of Environmental Management Accounting (EMA) on environmental performance; (2) the effect of EMA on eco-efficiency; (3) the effect of eco-efficiency on environmental performance; and (4) the role of eco-efficiency in mediating the influence of EMA on environmental performance in manufacturing companies in Indonesia. The

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grouping was carried out based on the variables, findings, methods, and research context recorded in the matrix.

The 29 articles did not entirely test the research model directly. Therefore, the synthesis distinguishes four levels of relevance, namely direct empirical evidence, empirical evidence with adjacent constructs, review or conceptual studies, and contextual evidence from sectors other than manufacturing. A single article can support more than one question because it addresses multiple lines of relationship. Thus, the number of articles on each question is not summed up as the number of unique articles.

Of the 29 records, the articles were retracted so they were not used as a substantive basis for concluding relationships between variables. Chetanraj and Senthil Kumar's (2023) articles are only supported by the first page, so they are used only for bibliometric theme mapping, not as evidence of relationships between variables. With this treatment, all 29 records remain recorded in the mapping, but the quality and feasibility of the evidence are transparently distinguished. Javed et al. (2022)

The matrix includes publications in 2021–2026. The research design consists of systematic literature review, literature review, bibliometrics, survey, regression, PLS-SEM, secondary data analysis, qualitative case studies, and conceptual frameworks. The research context includes manufacturing, garments, hotels, mining, MSMEs, the public sector, and other industries. Findings from sectors other than Indonesian manufacturing are used as a benchmark or basis for the mechanism, rather than being generalized directly.

No.	Articles (author, year)	Questions	Contributions and relevance limits
1	Khalid (2023)	RQ1, RQ2	Review of EMA drivers, tools, and obstacles; MFCA is relevant for the identification of material and cost waste.
2	Squirting (2025)	RQ1, RQ2, RQ4	Review of environmental control systems; cleaner production and product efficiency are discussed as related mechanisms.
3	Lunan et al. (2026)	RQ1, RQ2, RQ4	SLRs that place EMAs within the organization's sustainability and capability mechanisms; the evidence of mediation is synthesized.

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No.	Articles (author, year)	Questions	Contributions and relevance limits
4	Sharaf & Hussein (2023)	RQ1, RQ2, RQ3, RQ4	The conceptual framework proposes energy efficiency as a pathway between carbon management accounting and corporate environmental performance.
5	Sari et al. (2026) – EMAs and company performance	RQ1, RQ4	SLR 32 articles; discussing the results of the performance of the EMA and the mediators/moderators found in previous studies.
6	São Paulo, São Paulo et al. (2025) – EMA, OCBE, and environmental performance	RQ1, RQ4	Literature based review; OCBE is an alternative mediator, not eco-efficiency.
7	Rahmawati et al. (2024) – Public Sector Environmental Accounting	RQ1	public sector review; provide context for the relationship between environmental accounting and environmental management, not manufacturing evidence.
8	Saputra et al. (2022) – Energy eco-efficiency and energy audit	RQ3	Survey of hotels in Bali; test energy eco-efficiency on environmental performance directly.
9	São Paulo (2023) – the antecedents and consequences of the EMA in Indonesia	RQ1	SLR Indonesia; concluded that the EMA is related to innovation, environmental performance, and sustainability.
10	Permatasari et al. (2025) – EMA and financial performance	RQ2	SLR focuses on financial performance; cost efficiency and process innovation are indirect evidence.
11	Swalih et al. (2024) – EMA for strategic decisions	RQ2	SLRs on the use of EMAs for organizational efficiency and sustainability decisions.

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No.	Articles (author, year)	Questions	Contributions and relevance limits
12	Said et al. (2026) – MFCA, resource efficiency, and green accounting	RQ2, RQ3, RQ4	IDX manufacturing study; MFCA mediates green accounting-sustainability, while resource efficiency has not been proven to mediate.
13	Shadrina et al. (2025) – EMA and eco-efficiency of the Takalar Sugar Factory	RQ1, RQ2, RQ3, RQ4	Manufacturing case studies; describe by-product utilization and waste management, but do not test statistical mediation.
14	Zatini et al. (2025) – EMA adoption barriers and strategies	RQ1, RQ2	Bibliometrics on the organizational, regulatory, economic, technical, and market barriers that affect the implementation of EMA.
15	Suciati et al. (2023) – Antecedents EMA	RQ1	Review of eight articles; most of the studies reviewed reported the relationship between the EMA and environmental outputs.
16	Chetanraj & Senthil (2023) – EMA bibliometrics	RQ1	EMA theme mapping and environmental performance; only used for theme mapping as the document is incomplete.
17	To Anssari (2023) – Environmental cost accounting	RQ2	Conceptual review of environmental cost classification and measurement; support the monetary dimension of the EMA.
18	Javed et al. (2022) – article RETRACTED	Not used	It remains recorded in the inventory of 29 records, but was excluded from the evidence synthesis due to the revocation status.
19	Regu, Hamid, et al. (2021) – EMA practices in Malaysia	RQ1, RQ2	Manufacturing conceptual framework; linking environmental strategies, costs, regulations, and uncertainties to environmental performance.

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No.	Articles (author, year)	Questions	Contributions and relevance limits
20	Isaiah et al. (2026) – adoption of EMA in SMEs across industries	RQ1, RQ2, RQ4	SLR and integrative frameworks; discuss EMA environmental outcomes as well as organizational and stakeholder capabilities as mechanisms.
21	Sihombing et al. (2025) – energy consumption, GHG emissions, and manufacturing costs	RQ3	Indonesian manufacturing studies; providing contextual evidence of the linkage between energy consumption and emissions, not eco-efficiency testing.
22	Saputra et al. (2025) – EMA as a mediator of green innovation and sustainability	RQ1, RQ4	Export MSME Survey; EMA is a mediator from green innovation to sustainability, so the direction of mediation is different from the research model.
23	Mukwarami & van der Poll (2024) – EMA practices and municipal services	RQ1, RQ2, RQ3	Public sector review; EMAPs are associated with reduced energy, water, material, and emissions consumption.
24	Xia et al. (2025) – EMA, carbon management, and ESG	RQ1, RQ2, RQ3	Garment/manufacturing company survey; several dimensions of the EMA including eco-efficiency improvement related to ESG.
25	Nyakuwanika et al. (2021) – EMAPs on gold mining	RQ2, RQ3	Conceptual framework; MFCA, life-cycle costing, and activity-based costing support more eco-efficient decisions.
26	Abdelhalim et al. (2023) – eco-efficiency and corporate sustainability	RQ1, RQ3	Saudi Arabia's manufacturing survey; The EMA has a positive effect on CESP, while the eco-efficiency pathway to CESP is insignificant.
27	Zhen & Rahman (2024) – EMA, sustainable production, and ESG	RQ2, RQ3, RQ4	Manufacturing survey; sustainable production mediates part of the path from the EMA dimension to ESG, not eco-efficiency identically.

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No.	Articles (author, year)	Questions	Contributions and relevance limits
28	Metwally et al. (2026) – EMA and sustainable environmental performance	RQ1	Egyptian industry survey; EMA has a positive effect on sustainable environmental performance.
29	Mia et al. (2026) – EMA, REP, and environmental performance	RQ1, RQ2, RQ3, RQ4	Garment industry survey; finding the EMA–EP pathway as well as partial mediation through resource efficiency performance (REP).

RQ1: The Influence of Environmental Management Accounting on Environmental Performance

The synthesis shows that EMAs tend to be positively related to environmental performance. EMAs combine physical information on the use of raw materials, energy, water, waste, and emissions with monetary information on pollution prevention costs, waste treatment, and material loss. This information helps management identify sources of environmental impacts and determine preventive measures and operational improvements (IFAC, 2005).

The closest evidence of a direct relationship is found in empirical research, Metwally et al. (2026), and . Abdelhalim et al. in Saudi Arabian manufacturing companies reported the influence of EMA on corporate environmental sustainability performance (B = 0.273; p = 0.003). Metwally et al. in a sample of industrial managers in Egypt found the effect of EMA on sustainable environmental performance (β = 0.195; p < 0.001). In the garment industry Bangladesh also found the effect of EMA on environmental performance (β = 0.252; p = 0.001). All three studies provide empirical support, although the context and measurement of environmental performance are not entirely the same as those of Indonesian manufacturing companies. Abdelhalim et al. (2023) Mia et al. (2026) Mia et al. (2026)

Support for the Indonesian context was obtained from , which through SLR concluded that the implementation of EMA is related to environmental performance and sustainability. It was also found that most of the studies reviewed reported a positive relationship between EMA and environmental outputs, although there were some inconsistent results. Sari and reported that 24 out of 32 articles (75%) showed a positive relationship between EMA and company performance; the other eight articles showed weak, insignificant, or indirect influences. Because the outputs studied included financial, operational, and environmental aspects, the figure of 75% cannot be

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interpreted as a specific proportion of environmental performance studies. São Paulo (2023) Suciati et al. (2023) Lunan et al. (2026) Lunan et al. (2026)

São Paulo, São Paulo et al. (2025) explain the EMA path to environmental performance through organizational citizenship behavior for the environment (OCBE). Ilyas et al. (2025) through a case study of PTPN Takalar Sugar Factory showed that the implementation of EMA is related to the utilization of production by-products and waste management. found that several dimensions of EMA, such as environmental cost tracking and life-cycle assessment integration, are positively related to the ESG performance of garment/manufacturing companies. The ESG findings are relevant as evidence of closeness, but ESG includes social and governance dimensions so that they are not synonymous with environmental performance. Xia et al. (2025)

Other review and conceptual evidence expands the context of this relationship. propose the relationship between carbon management accounting and corporate environmental performance; propose proposals on EMA practices and environmental performance in Malaysian manufacturing; , , as well as discuss accounting/control systems and the adoption of EMAs for sustainability outcomes. and describe the instruments and barriers to EMA adoption. and provide a public sector context; discuss EMAs as a mediator of green innovation on sustainability; whereas Chetanraj and Senthil Kumar (2023) only provide bibliometric theme mapping. These articles support contexts or mechanisms, not all of them examine the direct influence of EMAs on environmental performance. Sharaf & Hussein (2023) Squad , Hamid, et al. (2021) Squirting (2025) Lunan et al. (2026) Isaiah et al. (2026) Khalid (2023) Zatini et al. (2025) Rahmawati et al. (2024) Mukwarami & van der Poll (2024) Saputra et al. (2025)

Thus, RQ1 gained the strongest relative support in the matrix, especially from empirical studies that reported the positive influence of the EMA on environmental performance. However, the relationship is not universal. The depth of the implementation of EMA, the quality of information, management support, employee capabilities, technology, and the regulatory context can influence the success of its implementation. In the perspective of the NRBV, the EMA supports the pollution prevention strategy because it helps companies identify sources of pollution and waste from the operational process (Hart, 1995).

RQ2: The Influence of Environmental Management Accounting on Eco-Efficiency

Conceptually, EMAs have the potential to improve eco-efficiency because physical and monetary information helps companies identify material losses, energy waste, excess water use,

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and costs incurred due to waste. When such information is used to improve production processes, companies have the opportunity to produce outputs with lower inputs and environmental impacts (IFAC, 2005; Huppes & Ishikawa, 2005).

The closest evidence was found in Ilyas et al. (2025). A case study at PTPN Takalar Sugar Factory illustrates the application of EMA related to waste reduction, increased operational efficiency, utilization of bagasse into organic fertilizer, and liquid and gas waste treatment. Because it used a qualitative approach with three informants, the study described the mechanism of implementing EMA, but did not estimate the statistical effect of EMA on eco-efficiency. provides adjacent quantitative evidence: EMA has a positive effect on resource efficiency performance (REP) (β = 0.187; p = 0.026). REP is closely related to eco-efficiency, but the two should not be considered the same construct. Mia et al. (2026)

The Material Flow Cost Accounting (MFCA) instrument is an important theme in , Said et al. (2026), and . MFCA traces the flow of materials and costs from materials that become products and waste so that companies can find the cost of material loss. Said et al. (2026), in 23 IDX manufacturing companies, tested green accounting, MFCA, and resource efficiency. The results of the matrix show that the path of green accounting to resource efficiency is not supported, so the use of environmental accounting instruments does not necessarily guarantee an increase in all efficiency measures. develop a conceptual framework for MFCA, life-cycle costing, and activity-based costing for more eco-efficient mining decisions. Khalid (2023) Nyakuwanika et al. (2021) Nyakuwanika et al. (2021)

The study places EMA as the basis for strategic decisions and organizational efficiency. proposes a carbon management accounting system to improve energy efficiency, while concludes that EMAPs can reduce energy, water, and material consumption as well as emissions in the context of local government. include eco-efficiency improvement as one of the dimensions of EMA; the positive results of this dimension on ESG are not the same as EMA testing as a cause of eco-efficiency. found that the dimension of eco-efficiency improvement is related to sustainable production (β = 0.301), but sustainable production is a different construct from eco-efficiency. Swalih et al. (2024) Sharaf & Hussein (2023) Mukwarami & van der Poll (2024) Xia et al. (2025) Zhen & Rahman (2024)

Khalid (2023) , , and also outlines the barriers and conditions that determine the depth of EMA implementation, such as limited knowledge, documentation, technology, resources, organizational support, and institutional pressures. provides a basis for measuring environmental

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costs, while discussing cost efficiency and process innovation in relation to EMA and financial performance. , , and provides conceptual support related to environmental strategies, capabilities, cleaner production, and product efficiency. The evidence helps explain the mechanism, but does not directly test the EMA–eco-efficiency relationship. Zatini et al. (2025) Isaiah et al. (2026) Al Anssari (2023) Permatasari et al. (2025) Regu, Hamid, et al. (2021) Lunan et al. (2026) Squirting (2025)

Thus, RQ2 is supported by conceptual logic and qualitative evidence that is quite relevant, but direct quantitative evidence is still limited. Follow-up research needs to test EMAs with clear eco-efficiency measures, e.g. the intensity of raw materials, energy, water, waste, or emissions per unit of output and/or economic value produced.

RQ3: The Effect of Eco-Efficiency on Environmental Performance

Eco-efficiency describes a company's ability to create economic value with lower resource use and environmental impact. Environmental performance, in contrast, reflects environmental management outcomes such as waste reduction, emissions, pollution, and compliance with standards. The two are related, but not identical; therefore, a decrease in input intensity per unit of product needs to be distinguished from a decrease in total environmental impact (WBCSD, 2000; Huppes & Ishikawa, 2005; ISO, 2021).

Direct empirical evidence on the relationship between eco-efficiency and environmental performance is shown by , which found that energy eco-efficiency and energy audit have a significant positive effect on environmental performance in hotels in Bali. However, the hotel context is different from manufacturing, so the results serve as supporting evidence across sectors. In Saudi Arabian manufacturing companies, it was found that the influence of eco-efficiency on corporate environmental sustainability performance was not significant (B = 0.094; p = 0.255). This difference shows that the relationship between eco-efficiency and environmental performance can be influenced by industry contexts, indicators, and management practices. Saputra et al. (2022) Abdelhalim et al. (2023)

Mia et al. (2026) reported that REP had a positive effect on environmental performance ($\beta = 0.634$; $p < 0.001$). These results are relevant as close evidence, but REP is not eco-efficiency with the definition of the relationship between economic value, resource use, and environmental impact. On the other hand, finding resource efficiency was not proven to have an effect on corporate sustainability in the tested model. The company's sustainability performance is also

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broader than environmental performance. Therefore, the two results need to be read as a comparison, not an identical test of RQ3. Said et al. (2026)

Shadrina et al. (2025) shows qualitatively that the use of by-products and waste management can reduce waste and support environmental performance. propose energy efficiency as a mechanism towards corporate environmental performance, but it is still a conceptual framework. and also links the management of materials, energy, water, and waste with environmental outcomes in the public sector and mining. The cross-sectoral evidence supports the efficiency mechanism, but it is not enough to conclude an empirical relationship in Indonesian manufacturing. Sharaf & Hussein (2023) Mukwarami & van der Poll (2024) Nyakuwanika et al. (2021)

Sihombing et al. (2025) provide the context of Indonesian manufacturing by showing that certain types of energy consumption are related to GHG emissions. This study does not test eco-efficiency as a variable, but shows the relevance of energy consumption control to emissions. and n (2024) also uses the dimension of eco-efficiency improvement in the ESG/sustainable production model; construct these results are not identical to stand-alone environmental performance. also discusses cleaner production and product efficiency as mechanisms related to environmental impacts. Xia et al. (2025) Zhen & Rahman (2024) Squirting (2025)

Thus, RQ3 shows mixed results. The direction of the positive relationship is reasonable in theory and supported by some findings, but there are insignificant results in the manufacturing context. Measurements should separate eco-efficiency indicators from environmental performance indicators and include consumption and absolute impact so that the increase in efficiency per unit does not cover the increase in total impact due to increased production volume.

RQ4: The Role of Eco-Efficiency in Mediating the Influence of EMA on Environmental Performance

Theoretically, eco-efficiency mediation describes the series of EMAs as information providers, the use of information to improve processes and resource use, the improvement of eco-efficiency, and then the improvement of environmental performance. Thus, eco-efficiency becomes an operational mechanism that translates environmental accounting information into a reduction in the intensity of resource use and environmental impact.

The closest empirical evidence is found in , which found that the EMA had an effect on REP (β = 0.187; p = 0.026), the REP had an effect on environmental performance (β = 0.634; p <

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0.001), and the indirect effect of the EMA on environmental performance through REP was 0.119 (p = 0.035). The authors reported partial mediation. These findings are particularly relevant to the proposed mechanism, but the mediator tested was resource efficiency performance, not eco-efficiency as defined in this study. Mia et al. (2026)

Sharaf & Hussein (2023) propose energy efficiency as a mediator between carbon management accounting systems and corporate environmental performance, but has not been empirically tested. found MFCA mediated the relationship between green accounting and corporate sustainability, whereas resource efficiency was not proven to mediate the relationship. found sustainable production partially mediated the relationship between several dimensions of EMA and ESG. All three studies provided evidence of adjacent mediation mechanisms, but did not test eco-efficiency as a mediator in the same model. Said et al. (2026) Zhen & Rahman (2024)

A number of studies also show the existence of alternative mechanisms. discuss OCBE as a mediator of EMA and environmental performance; summarize several studies that use innovation or environmental management systems as an intermediary mechanism; and propose organizational capabilities, green innovation, and stakeholder relations as mechanisms in the framework of sustainability. Novrizal and discuss cleaner production and product efficiency in the relationship between environmental control systems and environmental performance. describes qualitatively how EMA relates to efficiency and waste reduction, but does not test the effects of statistical mediation. Rahajeng et al. (2025) Lunan et al. (2026) Lunan et al. (2026) Isaiah et al. (2026) Squirting (2025) Shadrina et al. (2025)

Saputra et al. (2025) placing the EMA as a mediator between green product/green process innovation and sustainability performance. The direction of the model is different because the EMA is an intermediate variable, not an independent variable whose influence is mediated by eco-efficiency. The article remains relevant to show that the EMA can play a role in the mechanism that connects organizational practices to sustainability outcomes.

Based on the matrix, no studies have been found that directly and completely test the EMA model mediated by eco-efficiency on environmental performance in manufacturing companies in Indonesia. Therefore, RQ4 is the main research gap. The mediation hypothesis is worth testing, but it cannot be stated to have been proven based on this SLR. The differences between eco-efficiency and adjacent constructs such as REP, energy efficiency, resource efficiency, and sustainable production must be maintained.

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Integrative Synthesis Based on Natural Resource-Based View

In the perspective of the Natural Resource-Based View (NRBV), EMA can be understood as an information capability and internal control that helps companies recognize resource use, environmental costs, and sources of pollution. Eco-efficiency reflects the translation of this information into the improvement of the production process, while environmental performance is the result of operational impact management. This series is mainly in line with the pollution prevention strategy, which is to prevent or reduce waste and emissions from the source (Hart, 1995).

Mapping 29 articles shows that the strongest literature support is in the relationship between EMA and environmental performance (RQ1). The relationship between EMA and eco-efficiency (RQ2) is more supported by conceptual studies, reviews, and case studies than direct quantitative testing. The relationship between eco-efficiency and environmental performance (RQ3) results in mixed findings. Meanwhile, the closest mediating evidence (RQ4) uses REP, energy efficiency, MFCA, sustainable production, or OCBE, not eco-efficiency which is identical to the research construct. These results clarify the need for model testing in Indonesian manufacturing companies.

Conclusion & Suggestions

Conclusion

Based on the results of the Systematic Literature Review, it can be concluded that Environmental Management Accounting (EMA), eco-efficiency, and environmental performance are related in supporting the environmental management of manufacturing companies, with different strength of evidence in each relationship.

1. EMA on environmental performance. EMAs tend to have a positive effect on environmental performance because they provide physical and monetary information to control environmental costs, reduce resource wastage, and prevent pollution. However, its effectiveness depends on the quality of implementation and management support.
2. EMA on eco-efficiency. EMA has the potential to improve eco-efficiency through optimizing the use of raw materials, energy, and water and reducing waste. Although the mechanism is conceptually and qualitatively supported, the quantitative empirical evidence testing the relationship is still limited.

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3. Eco-efficiency on environmental performance. Eco-efficiency has the potential to improve environmental performance through reducing resource consumption, waste, and emissions. However, the results of previous research are still diverse, so the relationship needs to be further tested with the right indicators.
4. The role of eco-efficiency mediation. Eco-efficiency can theoretically be a mechanism that connects EMA with environmental performance. However, previous research has mostly used other constructs, such as resource efficiency performance and energy efficiency. Therefore, eco-efficiency testing as a mediating variable in manufacturing companies in Indonesia is a relevant research gap.

Overall, the Natural Resource-Based View (NRBV) provides a basis for explaining that EMA is a company's information capability, eco-efficiency reflects the application of these capabilities in operational efficiency, while environmental performance is the result of environmental impact management. This relationship is mainly in line with the pollution prevention strategy in NRBV (Hart, 1995).

RESEARCH IMPLICATIONS

Theoretical Implications

This research contributes to the development of environmental management accounting studies through the application of NRBV in explaining the relationship between EMA, eco-efficiency, and environmental performance. This research also emphasizes the importance of distinguishing eco-efficiency as a measure of resource use efficiency and environmental impact from environmental performance as a result of corporate environmental management. In addition, this research provides a basis for further testing of the role of eco-efficiency as a mediation mechanism.

Practical Implications

For manufacturing companies, the EMA can be used as an information system to identify environmental costs, control resource use, and reduce waste through the application of instruments such as Material Flow Cost Accounting (MFCA). Management also needs to improve eco-efficiency through optimizing the use of raw materials, energy, and water as well as reducing waste and emissions. Meanwhile, governments and regulators are expected to strengthen support through regulations, training, mentoring, and access to environmentally friendly

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technology so that companies can improve the quality of environmental management in a sustainable manner.

SUGGESTIONS

Further research needs to examine the direct influence of EMA on environmental performance and the indirect influence through eco-efficiency on manufacturing companies in Indonesia by using objective data and considering internal and external factors of the company as control or moderator variables.

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