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Improving Hospital Cost Performance through Environmental Accounting Practices: Examining Green Innovation as a Moderating Factor

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Abstract. Hospitals are among the most resource-intensive institutions, requiring strategies that balance service delivery with environmental sustainability. This study examines the influence of Environmental Management Accounting (EMA) on hospital economic efficiency, while testing the moderating role of green innovation. Grounded in the Resource-Based View (RBV) and Institutional Theory, EMA is conceptualized as a strategic resource and green innovation as a dynamic capability that enhances its effectiveness. Data were collected through surveys of hospital managers, financial controllers, and sustainability officers in Indonesia, and analyzed using Structural Equation Modeling (SEM-PLS). Reliability and validity were assessed with Cronbach's Alpha, Composite Reliability, and Average Variance Extracted (AVE), while model fit was evaluated using SRMR, R^2, and path coefficients. The results show that institutional pressures strongly influence EMA adoption, but compliance alone does not guarantee efficiency gains. EMA positively impacts economic efficiency, and this effect is significantly amplified by green innovation, which also has a direct positive influence on performance. The findings contribute to RBV and Institutional Theory by demonstrating that sustainable hospital efficiency depends not only on external institutional drivers but also on internal environmental capabilities. Practically, the study highlights the need for hospitals to integrate EMA with innovation strategies to achieve long-term sustainability.

1. INTRODUCTION

Sustainability has emerged as a global priority across industries, including healthcare. Hospitals, as vital public institutions, face the dual challenge of delivering quality healthcare services while mitigating their environmental footprint. Their intensive energy and material consumption, along with medical waste generation, makes them key actors in advancing sustainable development (Smith & Liu, 2022). One effective strategy to address these issues is the adoption of Environmental Management Accounting (EMA). EMA provides hospitals with tools to track, measure, and manage environmental costs, integrating ecological considerations into financial decision-making. This approach not only enhances efficiency but also promotes sustainable operations (Chen et al., 2021; Tan & Rahman, 2023).

Yet, the effectiveness of EMA depends on supporting enablers such as green innovation, which encompasses environmentally friendly technologies, methods, and operational practices designed to reduce ecological harm while improving long-term organizational performance (Alvarez & Santos, 2020). In hospitals, such innovation can take the form of renewable energy use, sustainable procurement, or low-emission medical equipment.

Evidence suggests that EMA, when combined with green innovation, yields stronger performance outcomes (Zhang & Lee, 2022). However, studies exploring this interaction within hospitals—especially in developing nations—remain limited. This study addresses this gap by examining how green innovation moderates the EMA–efficiency relationship, applying the RBV framework, which highlights the strategic importance of internal capabilities like innovation and environmental practices (Porter & Grant, 2021).

Despite growing recognition of EMA, findings on its financial impact remain inconsistent. Some scholars report that EMA adoption reduces operational costs and strengthens financial efficiency (Chen et al., 2021; Tan & Rahman, 2023), while others argue that compliance and reporting requirements can increase costs without clear efficiency gains, particularly in resource-constrained hospitals (Huibrecht, 2024; Smith & Liu, 2022). This inconsistency highlights the need to explore moderating mechanisms such as green innovation that may influence EMA outcomes.

Although Environmental Management Accounting (EMA) has been increasingly adopted in various sectors, its implications for financial efficiency in healthcare remain debated. Prior research has demonstrated that EMA can enhance cost control and accountability by integrating ecological factors into financial decision-making (Burritt & Schaltegger, 2010; Qian et al., 2022). From the perspective of the Resource-Based View (RBV), internal capabilities such as environmental accounting systems and eco-oriented management can serve as strategic resources that create competitive advantage (Barney, 1991; Hart, 1995). At the same time, Institutional Theory suggests that coercive, normative, and mimetic pressures drive organizations toward adopting sustainability practices, particularly in highly regulated industries such as healthcare (DiMaggio & Powell, 1983; Testa et al., 2020). Furthermore, green innovation has emerged as a critical factor in linking sustainability practices to organizational performance, as it enables hospitals to transform compliance requirements into opportunities for efficiency and innovation (Delmas & Pekovic, 2018; Xie et al., 2023). These theoretical insights reinforce the importance of examining how EMA and green innovation jointly affect hospital efficiency in developing countries.

Building on these gaps, this research investigates how institutional pressures and environmental strategies encourage EMA adoption, and how EMA subsequently contributes to hospital efficiency. Additionally, the study evaluates the direct and moderating role of green innovation. Accordingly, the following research questions and hypotheses are developed.

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2. LITERATURE REVIEW

Protocols in medical centers the notion of ecological management accounting, or EMA, has gained traction in recent years as firms across all industries strive to integrate environmental factors within their financial decision-making processes. EMA practices, including energy accounting, material flow the accounting profession, management of water accounting, managing carbon accounting, and ecological diversity accounting because are essential to improve ecological and customer service efficiency for the local governments of developing nations. These approaches are crucial for carrying out sustainable development and tackling ecological problems. (Huibrecht, 2024). The healthcare sector, particularly hospitals, can benefit from EMA to identify and quantify the environmental costs connected with their activities. Efforts like the Healthier Hospitals Initiative (HHI) and the American Hospitals Association's Sustainability Roadmap offer tools and resources for hospitals to shift to more sustainable operations. Clinicians also play a key role in resource conservation through efforts like the Choosing Wisely Campaign. However, there is a knowledge gap in the medical community regarding the indirect health repercussions of wasteful activities. The healthcare sector, particularly hospitals, can benefit from EMA to identify and quantify the environmental costs connected with their activities. Organizations like the Healthier Facilities Institute (HHI) and the National Hospitals Association's Green Roadmap offer resources and assistance for hospitals to shift to more sustainable operations. Clinicians also play an essential part in resource conservation through efforts which include the Choosing Wisely Campaign. However, there is an information vacuum in the medical profession recognizing the indirect health effects of wasteful behaviors.

The U.S. healthcare system is Hospitals rank as one of the most energy-demanding types of commercial facilities, positioned just below food service establishments. Despite the sector's significant greenhouse gas emissions, there is little work done to quantify these emissions and their impact on public health (Matthew & Jodi, 2016) (Chris, 2014). The U.S. healthcare system is energy-intensive, with hospitals being the second-most energy-intensive commercial buildings in the country after food service facilities. Despite the sector's significant greenhouse gas emissions, there is little work done to quantify these emissions and their impact on public health. (Matthew & Jodi, 2016) This research will help healthcare organizations make informed decisions that benefit both their bottom line and the environment. By incorporating EMA into their financial strategies, hospitals can not only reduce their environmental impact but also improve their overall efficiency and long-term sustainability.

Ultimately, the integration of environmental considerations into financial decision-making processes can lead to a healthier planet and healthier communities. Ecological performance-based accounting practices, such as energy accounting, material flow analysis, water resource accounting, carbon footprint tracking, and biodiversity valuation make a crucial role in improving environmental and Delivery of care outcomes in local governments of developing countries. These approaches are essential for advancing sustainable development and tackling pressing environmental issues (Huibrecht, 2024).

3. METHODOLOGY

Using a quantitative design, this study explores how sustainability-oriented accounting practices relate to economic performance in hospitals and evaluates the moderating role of green innovation. Guided by the Resource-Based View (RBV), the framework emphasizes that firms may attain enduring competitive advantage through the effective use of rare internal resources, such as innovative strengths and green-oriented management systems. To collect empirical data, a structured and standardized questionnaire was meticulously designed and disseminated to key hospital personnel, including financial controllers, sustainability coordinators, and operations executives, located in several major metropolitan areas across Indonesia. The respondents were identified through purposive sampling techniques, specifically targeting hospitals that have adopted, or are in the transitional phase of adopting, eco-oriented accounting systems as part of their strategic and operational practices.

The questionnaire included three main constructs:

1. Environmental Management Accounting (EMA): measured by indicators such as environmental cost tracking, integration into budgeting, and environmental performance reporting.
2. Economic Efficiency: measured through operational indicators such as cost-to-income ratio, energy and waste cost reduction, and productivity metrics.
3. Green Innovation: assessed using indicators like adoption of eco-friendly technologies, staff training on sustainability, and investments in green processes.

Data analysis was conducted using SEM with SmartPLS, allowing examination of complex causal relationships including moderation effects. To ensure construct reliability and validity, Cronbach's Alpha, Composite Reliability, and AVE were applied, with the structural model fit evaluated using SRMR, R^2, and path analysis indicators.

Prior to conducting the SEM analysis, a comprehensive set of preliminary diagnostic tests was undertaken to evaluate the reliability and validity of the measurement constructs. Internal consistency reliability was examined using Cronbach's Alpha and Composite Reliability (CR), both of which demonstrated satisfactory levels across all variables. Convergent validity was assessed through the Average Variance Extracted (AVE), with all constructs surpassing the acceptable threshold of 0.50—many exceeding 0.70—indicating a high degree of shared variance among indicators measuring the same construct. Model fit was further evaluated using statistical indices such as the Standardized Root Mean Square Residual (SRMR), R-squared values, and structural path coefficients to ensure robustness.

Table 1. Operationalization of Variables.

Construct / Variable	Dimension	Indicators (Examples)	Measurement Scale	References
Environmental Management Accounting (EMA)	Environmental cost tracking	Identification of environmental-related costs (waste, energy, water)	Likert 1–5	Chen et al. (2021); Tan & Rahman (2023)
	Environmental reporting	Integration of environmental data in financial reports	Likert 1–5	Huibrecht (2024)
	Environmental monitoring	Regular monitoring of resource usage and emissions	Likert 1–5	Zhang & Lee (2022)
Economic Efficiency (EE)	Cost efficiency	Reduction in operational and resource expenses	Likert 1–5	Smith & Liu (2022)
	Productivity improvement	Improvement in service delivery with same or fewer resources	Likert 1–5	Porter & Grant (2021)
	Financial performance	Better cost-to-income ratios through sustainability practices	Likert 1–5	Alvarez & Santos (2020)
Green Innovation (GI)	Eco-technology adoption	Use of renewable energy, waste recycling systems	Likert 1–5	Alvarez & Santos (2020)
	Green product/process design	Procurement of eco-friendly medical equipment	Likert 1–5	Tan & Rahman (2023)
	Training & investment	Staff training on sustainability and eco-innovation investments	Likert 1–5	Zhang & Lee (2022)
Institutional Pressure (IP)	Coercive pressure	Government regulations and compliance requirements	Likert 1–5	Porter & Grant (2021)
	Normative pressure	Professional norms, accreditation requirements	Likert 1–5	Huibrecht (2024)
	Mimetic pressure	Adoption of best practices from peer hospitals	Likert 1–5	Smith & Liu (2022)
Environmental Strategy (ES)	Strategic integration	Inclusion of sustainability in hospital strategy and planning	Likert 1–5	Matthew & Jodi (2016)
	Long-term commitment	Continuous improvement toward environmental goals	Likert 1–5	Tan & Rahman (2023)

4. RESEARCH RESULTS

The moderating role of green innovation was tested by generating an interaction term between sustainability-based accounting mechanisms and green innovation practices. This term was subsequently integrated into the structural model to examine its significance in influencing the Results reveal the intensity of the association between ecological accounting adoption and hospital cost efficiency, while also shedding light on the dynamic role of green innovation in advancing sustainable financial management within healthcare institutions.

The statistical model revealed that institutional pressure exerts a substantial positive influence on the implementation of environmental management accounting, as reflected in a path coefficient of 0.476. This association is further validated by a T-statistic of 3.194 and a P-value of 0.001, signifying that the effect is not due to random chance. The strong path value suggests that regulatory, normative, and mimetic pressures from institutional environments are conducive to the adoption of EMA practices in hospitals. However, when assessing the direct effect of institutional pressure on hospital efficiency, the path coefficient was slightly negative (-0.013), with a T-statistic of only 0.258 and a P-value of 0.797, indicating no statistically significant relationship. This implies that while institutional mandates may influence accounting practices, they do not necessarily translate into improved operational or economic performance in healthcare institutions. In contrast, the implementation of environmental management strategies showed a meaningful and positive impact on hospital performance. The path coefficient for the relationship between environmental management plans and hospital efficiency was 0.179, accompanied by a T-statistic of 3.218 and a P-value of 0.001. These values demonstrate a robust and statistically significant effect, suggesting that proactive environmental initiatives, such as waste reduction, energy efficiency, and resource conservation, directly contribute to better performance outcomes. Similarly, the application of EMA to hospital operations also yielded a favorable path coefficient of 0.337, with a T-statistic of 2.551 and a P-value of 0.011. These results underscore the vital role of EMA in enhancing cost-effectiveness and resource optimization in the healthcare sector. The SEM findings provide compelling empirical evidence in support of the proposed hypotheses. Specifically, the direct relationship between EMA and economic efficiency was both positive and statistically significant ($\beta = 0.42$, $p < 0.01$), reinforcing the idea that environmental accounting contributes to improved cost control and operational productivity in hospitals.

This aligns with prior research that highlights the dual benefits of EMA—environmental compliance and financial gain. More notably, the moderating effect of green innovation on the EMA–efficiency linkage was also found to be significant (interaction term $\beta = 0.31$, $p < 0.05$). This indicates that hospitals with strong green innovation practices are better positioned to leverage EMA for performance gains. For example, institutions that integrate sustainable technologies in energy and waste systems tend to realize greater returns from EMA due to the compounded benefits of innovation and strategic resource management. Table 2 presents the summary of hypothesis testing.

These results reinforce the resource-based view (RBV), which posits that unique capabilities such as environmental systems and innovation jointly create superior organizational performance. This study also aligns with previous empirical works (e.g., Qi et al., 2021; Zailani et al., 2015) that suggest innovation enhances the strategic value of environmental initiatives. Moreover, it contributes to the limited literature on sustainability accounting in the healthcare sector, offering practical evidence from developing countries like Indonesia. Qualitative feedback collected during the survey process further supports the quantitative results. Respondents noted that EMA adoption led to increased transparency in environmental costs and improved resource planning. When coupled with innovation initiatives—such as installing solar panels or implementing green procurement policies—these accounting practices yielded measurable financial and environmental returns.

$$KRS = 0.337\ IPE + 0.515\ IH + 0.011\ ESE*IH$$

The empirical findings from the structural equation modeling (SEM) analysis provide robust evidence supporting the hypothesized relationships between Environmental Management Accounting (EMA), Green Innovation (GI), and Economic

Efficiency (EE) in hospitals. The regression model estimated from the analysis is as follows: EE = 0.368 EMA + 0.755 GI + 0.0444 (EMA × GI). This result can be interpreted as:EMA has a positive and significant effect on economic efficiency (β = 0.368), indicating that the implementation of environmental cost tracking and resource monitoring systems contributes meaningfully to cost optimization and operational performance. Green Innovation (GI) demonstrates an even stronger influence (β = 0.755) on economic efficiency, underlining the importance of adopting environmentally friendly technologies and sustainable management practices in hospitals. The interaction term (EMA × GI) is also positive and significant (β = 0.0444), confirming that green innovation moderates the relationship between EMA and economic efficiency. The implication is clear: while both EMA and green innovation independently enhance economic efficiency, their combined implementation produces a synergistic effect. Hospitals that embed environmental accounting within a broader green innovation framework—such as sustainable procurement, energy-efficient systems, or eco-design in operations—are more likely to achieve greater cost savings, process efficiency, and financial resilience.

These findings reinforce the Resource-Based View (RBV) of the firm, suggesting that environmental capabilities (like EMA) and innovation (like GI) serve as strategic assets that, when integrated, create sustainable competitive advantages. The results are also consistent with prior research (e.g., Chen et al., 2020; Zailani et al., 2015; Qi et al., 2021), which show that innovation enhances the organizational value of environmental initiatives. Although the moderating effect (β = 0.0444) is smaller in magnitude than the direct effects, it remains statistically significant. This implies that green innovation not only adds value on its own but also strengthens the utility and impact of environmental management accounting practices, making hospitals more adaptive, cost-efficient, and sustainable in the long run.

Based on the analysis results, the path coefficient of green innovation on hospital performance is 0.515 with a P-value of 0.000, which is below the 0.05 significance level. This indicates that green innovation positively influences hospital performance. This test results in the following equation model:

$$KRS = 0.515\ IH$$

Table 2. Recapitulation of Hypothesis Testing Results.

Relationship (Variables)	Coefficient (β)	T-Statistic	P-Value	Conclusion
Institutional Pressure → EMA (IPE)	0.476	3.305**	0.001	Hypothesis rejected
Environmental Strategy → EMA (ESE)	0.358	2.760**	0.008	Hypothesis rejected
Institutional Pressure → Efficiency (KRS)	0.157	1.838	0.053	Hypothesis accepted
Environmental Strategy → Efficiency (KRS)	0.350	3.821**	0.000	Hypothesis rejected
EMA (IAML) → Efficiency (KRS)	0.377	2.785**	0.004	Hypothesis rejected
Green Innovation (IH) → Efficiency (KRS)	0.515	4.333**	0.000	Hypothesis rejected
Institutional Pressure × EMA → Efficiency (KRS)	0.161	2.125*	0.034	Hypothesis rejected
Environmental Strategy × EMA → Efficiency (KRS)	0.121	1.895	0.0529	Hypothesis accepted
EMA × Green Innovation → Efficiency (KRS)	0.011	0.561	0.09	Hypothesis accepted

Note: ** P < 0,01 *** P < 0,001 * P < 0,05.

5. DISCUSSION

The findings underscore the role of institutional contexts in shaping sustainability practices in healthcare. While regulatory and normative pressures encourage EMA adoption, performance improvements depend on organizational readiness and alignment with innovation strategies. These results support institutional theory but also reveal its limitations in contexts where enforcement and infrastructure are weak. EMA proved to be a valuable tool for enhancing efficiency, though its effectiveness increases when supported by green innovation. Hospitals that invested in renewable energy, sustainable procurement, and eco-friendly technologies achieved greater efficiency gains, aligning with RBV's assertion that unique internal resources create competitive advantage. The integration of EMA with innovation fosters both environmental responsibility and financial resilience.

This study advances theoretical contributions in two ways. First, it extends RBV by identifying EMA as a strategic resource and green innovation as a dynamic capability that together create sustainable advantage. Second, it enriches institutional theory by clarifying that external pressures are insufficient without internal resources to translate compliance into performance gains. Integrating both theories, the study highlights how external forces and internal capacities interact to shape sustainable outcomes.

Resource-Based View (RBV)

This study extends the RBV by demonstrating that Environmental Management Accounting (EMA) is not merely a financial tool but a *strategic resource* that improves hospital cost efficiency. Green innovation is conceptualized as a *dynamic capability* that amplifies the benefits of EMA. The combined effect of EMA and green innovation provides hospitals with a sustainable competitive advantage. Theoretically, this research broadens the scope of RBV by emphasizing that *intangible resources*—such as environmental practices and eco-innovation—are as crucial as tangible assets in driving superior economic performance.

5.1. Institutional Theory

The findings also contribute to institutional theory by showing that coercive, normative, and mimetic pressures are significant drivers of EMA adoption, yet they do not automatically translate into improved efficiency. This highlights that institutional pressure is effective in encouraging environmental practices, but the actual performance outcomes depend on the organization's internal capacity (e.g., green innovation). Hence, the study enriches institutional theory by clarifying that compliance with external pressures alone is insufficient; organizational alignment with innovation is necessary to achieve meaningful performance gains.

5.2. Integrating RBV and Institutional Theory

This study offers a novel integration of RBV and institutional theory by proposing that hospital efficiency is shaped not only by external institutional forces but also by internal resources and capabilities. Specifically, institutional pressures encourage the adoption of EMA, while the effectiveness of EMA depends on internal dynamic capabilities such as green innovation. The contribution lies in linking external compliance mechanisms with internal resource-based perspectives, thereby explaining how hospitals in developing countries can achieve cost efficiency through the combined effects of regulation and innovation.

The findings of this study enrich both the RBV and Institutional Theory perspectives. From an RBV standpoint, the results confirm that hospitals can develop sustainable competitive advantage by leveraging EMA as a strategic resource, while green innovation acts as a dynamic capability that strengthens efficiency outcomes (Barney, 1991; Hart, 1995). This supports earlier

claims that environmental capabilities represent critical intangible resources for organizational sustainability (Qian et al., 2022). From an institutional lens, while regulatory and normative pressures encourage the adoption of EMA, the results show that such pressures alone do not guarantee performance improvements—aligning with prior findings that institutional mandates often require internal capabilities to be effective (DiMaggio & Powell, 1983; Testa et al., 2020). Moreover, the moderating role of green innovation demonstrates how hospitals can convert institutional constraints into strategic opportunities, echoing previous evidence that sustainability-oriented innovation fosters productivity and organizational resilience (Delmas & Pekovic, 2018). Thus, this study contributes to bridging the gap between compliance-driven adoption of EMA and resource-based efficiency gains in healthcare institutions.

6. CONCLUSIONS

This study investigates the influence of organizational pressures and ecological leadership structures on hospital performance, emphasizing the role of Environmental Management Accounting (EMA) and green innovation as an enabling mechanism. The research aims to provide insights for hospitals in identifying environmental risks and leveraging green innovation to enhance operational efficiency and service quality. By incorporating environmentally sustainable technologies—such as eco-friendly medical equipment—into hospital operations, institutions can potentially improve both patient care outcomes and institutional resilience. The findings suggest that while integrating EMA and green innovation into strategic leadership frameworks holds theoretical promise for generating competitive advantage, practical implementation is often hampered by internal limitations. Notably, the analysis reveals that green innovation does not significantly strengthen the influence of environmental leadership or EMA on performance due to restricted financial resources and limited availability of skilled personnel.

Further, the study finds that the standalone application of EMA does not exhibit a significant direct effect on hospital performance, indicating that its success is contingent upon complementary factors such as organizational capacity and managerial awareness. The lack of significant outcomes is attributed to budgetary constraints, a shortage of trained environmental accounting professionals, and a general lack of environmental literacy among hospital staff and leadership. While legitimacy theory underscores the importance of gaining stakeholder approval to ensure organizational legitimacy, the present findings challenge previous claims that EMA independently enhances the efficacy of environmental strategies. Nevertheless, EMA remains a vital tool for assessing environmental impacts, identifying areas for improvement, and informing strategic decision-making regarding ecological initiatives.

Although green innovation has the theoretical potential to amplify the effectiveness of EMA within hospital contexts, its practical benefits are often undermined by institutional and systemic challenges. Barriers such as inadequate funding, limited institutional readiness, insufficient technical expertise, and cultural resistance to change restrict the full-scale adoption of green technologies. High initial investment costs for green technologies and employee training further limit the willingness of institutions to adopt such innovations, particularly when financial returns are not immediately evident. Consequently, the findings of this study offer limited support for stakeholder theory, as not all stakeholder groups may fully endorse or prioritize green innovation, resulting in inconsistent or partial implementation. This underscores the need for stronger institutional frameworks, standardized environmental accounting regulations, and targeted investment in human capital to successfully integrate green innovation into hospital operations.

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