ENVIRONMENTAL MANAGEMENT ACCOUNTING MODEL FOR SUSTAINABLE MANUFACTURING SMES: EVIDENCE FROM INDONESIA AND MALAYSIA

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Highlights

EMA translates sustainability strategies into SME business outcomes. Technology strategy strengthens EMA implementation in manufacturing SMEs. Green mindfulness reinforces strategy-driven EMA adoption. Stakeholder pressure enhances EMA effects on business sustainability. Indonesia and Malaysia show distinct SME sustainability pathways.

Abstract

This study explores how Environmental Strategy and Technology Strategy influence Business Sustainability through Environmental Management Accounting (EMA) in manufacturing SMEs in Indonesia and Malaysia. It also examines whether Green Mindfulness and Stakeholder Pressure enhance EMA's strategic function in sustainability-focused decision-making. Using a quantitative cross-sectional survey of 288 manufacturing SMEs, the research employs Partial Least Squares Structural Equation Modeling (PLS-SEM) to analyze direct, mediating, moderating, and cross-country effects. The results show that environmental and technological strategies are key drivers of EMA adoption, with EMA serving as an essential mechanism for translating strategic goals into sustainability performance. Additionally, managerial environmental awareness and external stakeholder demand strengthen EMA effectiveness, though these effects are more conditional than those of direct drivers. Comparative findings suggest that Malaysian SMEs are better prepared internally, technologically, and financially, whereas Indonesian SMEs face stronger external sustainability pressures. This research advances understanding of environmental accounting and SME sustainability by framing EMA as a dynamic managerial

capability that links strategy, technology, cognition, and institutional pressures in emerging Southeast Asian economies.

Keywords
Environmental Management Accounting; Business Sustainability; Technology Strategy; Stakeholder Pressure; Manufacturing SMEs

JEL Classification; M41; M14; Q56; O33; L26

Introduction

Environmental degradation, climate change impacts, and increasing resource limitations have intensified pressure on manufacturing companies to shift from solely compliance-driven environmental efforts to comprehensive sustainability strategies. The natural-resource-based view emphasizes that competitive advantage arises from capabilities such as pollution prevention, product stewardship, and sustainable development, thereby making environmental strategy vital for long-term success (Hart & Dowell, 2010). For small and medium-sized enterprises (SMEs), pursuing sustainability is particularly challenging because they must balance economic sustainability with environmental and social duties, all while operating with limited resources (Malesios et al., 2021). Recent studies highlight the triple bottom line as a managerial approach to integrating environmental practices, financial resilience, and social responsibility (Malesios et al., 2021; Usman Khizar et al., 2022). In manufacturing, technology strategies are crucial because Industry 4.0 and digital tools can enhance efficiency, traceability, waste reduction, and sustainable business models, although SME adoption varies widely (Beltrami et al., 2021; Khan et al., 2021; Santos & Sant'Anna, 2024).

Indonesia and Malaysia provide a direct comparative context because both economies share manufacturing firms that are confronted with calls to align environmental strategy, accounting information on emissions inventories, and sustainability performance. On the other hand, (Latan et al., 2018) provide empirical proof in Indonesia of how firms were influenced by environmental strategy, environmental uncertainty, and Environmental Management Accounting (EMA), which brought a relationship between Top management commitment and their corporation's environmental performance in Indonesia Stock Exchange-listed ISO 14001-certified firms. Previous evidence from Indonesia shows that EMA serves as a mediator between environmental strategy and environmental performance (Solovida & Latan, 2017); thus, merely having a strategy is not effective unless backed by an adequate system for gathering environmental information. In Malaysia, Appannan et al. (2023) show that, under the joint logic of a natural-resource-based view and Dynamic Capabilities Theory, environmental strategies and EMA lead to firms' sustainable development towards positive environmental performance. These results make the case for considering Indonesia and Malaysia together – in a systematic comparison, not as identical contexts, but instead as two emergent economies in Southeast Asia where manufacturing sustainability is contingent upon the interplay of strategy, technology, accounting practices, and institutional pressures (Appannan et al., 2023; Latan et al., 2018; Solovida & Latan, 2017).

Despite accumulating evidence, significant gaps in our understanding still exist. Although Environmental Strategy (ES) and Technology Strategy (TS) have been identified as drivers of sustainability-oriented transformation, operational mechanisms within firms can convert strategic intentions into tangible decision-making processes, providing visibility and control over costs and performance (Appannan et al., 2023; Gunarathne et al., 2021; Latan et al., 2018). Environmental Management Accounting (EMA) performs this function by identifying, measuring, and using environmental cost and performance information to inform decision-making and sustainable development (Burritt, 2004; Johnstone, 2020; Swalih et al., 2024). However, EMA adoption remains limited among SMEs due to the absence of formal financial systems, technical capability, and sustainability measurement routines in small firms (Johnstone, 2020; Malesios et al., 2021). Furthermore, EMA's influence on business sustainability (BS) may also be contingent. GM can encourage green innovation and environmental performance by raising managers' awareness of environmental issues (Hoai et al., 2023; Ndubisi et al., 2019; Van et al., 2023). Top management and other employees within SMEs who are sufficiently aware of ER can influence managers to maintain or increase their commitment to achieving an enterprise-wide vision. This is sometimes referred to as green holistic (GH) pressure (Bai et al., 2018). Stakeholder pressure (SP), which includes regulatory, market and organizational pressures, can also force SMEs to adopt green practices, develop environmental capabilities and improve performance (Baah et al.).

Accordingly, this study aims to achieve five research objectives. RO1 is to examine the effect of Environmental Strategy on Environmental Management Accounting in manufacturing SMEs. RO2 examines the effect of Technology Strategy on Environmental Management Accounting in manufacturing SMEs. RO3 examines the effect of Environmental Management Accounting on Business Sustainability in manufacturing SMEs. RO4 examines the moderating role of Green Mindfulness in strengthening the relationship between Environmental Management Accounting and Business Sustainability. RO5 examines the moderating role of Stakeholder Pressure in strengthening the relationship between Environmental Management Accounting and Business Sustainability.
The study is grounded in the natural-resource-based view and Dynamic Capabilities Theory. NRBV explains why environmental strategy can become a source of competitive advantage when firms develop capabilities for pollution prevention, stewardship, and sustainable development (Hart, 1994; Hart & Dowell, 2010, 2011). Dynamic Capabilities Theory explains how firms integrate, reconfigure, and renew resources under technological and environmental change (Teece et al., 1997). Within this framework, EMA is positioned as a dynamic managerial capability that connects ES and TS with BS by transforming environmental intentions into cost information, resource-allocation routines, and performance evaluation systems (Appannan et al., 2023; Gunarathne et al., 2021; Latan et al., 2018). This study contributes by integrating ES, TS, EMA, GM, SP, and BS into a single comparative model and by extending EMA research to manufacturing SMEs in Indonesia and Malaysia, where the combined effects of environmental strategy, technology adoption, managerial awareness, and stakeholder pressure remain underexplored.

The remainder of this paper is organized as follows: Section 2 reviews the literature and develops the hypotheses; Section 3 describes the research methodology; Section 4 presents the results and discusses the findings; and Section 5 offers the conclusion and future research.

Literature review

Current Conditions and Theoretical Basis

Manufacturing companies are increasingly viewing Environmental Strategy (ES) and Technology Strategy (TS) as significant avenues for strengthening business sustainability (BS). However, the success of these strategies depends on whether firms have the internal systems to transform environmental affairs and technological investments into efficient managerial decisions (Appannan et al., 2023; Beltrami et al., 2021; Khan et al., 2021). Environmental Management Accounting (EMA) provides such a system by enabling the identification, measurement and use of environmental costs and performance data in strategic decision-making (Burritt, 2004; Swalih et al., 2024) However, evidence related to EMA is stronger in larger, more formal organizations (with more than five employees), while research on SMEs remains limited as most do not establish formal accounting routines, environmental measures or management control systems (Johnstone, 2020; Malesios et al., 2021). The Natural Resource-Based View (NRBV) contextualizes this process by arguing that environmental capabilities are strategic resources through which firms can gain a competitive advantage by practicing pollution prevention, product stewardship and sustainable development (Hart & Dowell, 2010, 2011). Furthermore, Dynamic Capabilities Theory (DCT) describes how firms sense changes in their environment or technology and seize sustainability opportunities to renew resources as needed (Teece et al., 1997). Therefore, ES and TS are less likely to independently translate into sustainability value in manufacturing SMEs. Instead, they must be operationalized through EMA as a managerial capability, linking environmental strategy, technological capacity and sustainability performance (Appannan et al., 2023; Solovida & Latan, 2017).

Green Mindfulness (GM) and Stakeholder Pressure (SP) are two important factors affecting the success of EMA_BOOT. In cognitive and mindfulness terms, GM represents managers' awareness of, attention to, and sensitivity to environmental issues, which can promote green innovation (Dumay et al., 2010; Hoai et al., 2023; Van et al., 2023) and environmental performance by enabling firms to recognize ecological risks and opportunities more effectively (Ndubisi et al., 2019). In the context of SP, firms are influenced by external and internal pressures from regulators, customers, communities, and supply chain actors to 'go green', enhance environmental accountability, and seek legitimacy (Baah et al., 2021; Gunarathne et al., 2021; Singh et al., 2022). In this context, EMA serves as a dynamic capability, mediating the relationships among ES, TS, and BS. GM can also facilitate the transformation of ES and TS into EMA by increasing managerial attention to environmental data. Conversely, SP can strengthen the relationship between EMA and BS by fostering trust in environmental accounting information, grounded in legitimacy and performance (Appannan et al., 2023; Gunarathne et al., 2021; Singh et al., 2022). While previous research has examined the elements of EMA, green technology, stakeholder pressure, and SME sustainability individually, to the best of our knowledge, there is little evidence of attempts to enhance a single integrated framework combining NRBV, DCT, the stakeholder perspective, and

mindfulness theory for manufacturing SMEs operating in emerging economies such as Indonesia and Malaysia (Johnstone, 2020; Santos & Sant'Anna, 2024; Swalih et al., 2024).

Theoretical Framework

The research proposes a conceptual framework to describe the rationale on how BS occurs in manufacturing SMEs through ES, TS, and EMA, with GM and SP serving as moderating mechanisms. Figure 1: The Proposed Framework. Our framework integrates aspects of the Natural-Resource-Based View (NRBV), Dynamic Capabilities Theory (DCT), and institutional/stakeholder and cognitive-mindfulness perspectives. In NRBV, ES is treated as a strategic environmental resource through which pollution-prevention, resource-efficiency, and sustainability-oriented capabilities support competitive advantage (Hart & Dowell, 2010, 2011). Accordingly, ES value is realized when internal managerial systems convert environmental orientation into operational decisions and performance enhancement (Appannan et al., 2023). The development of TS can be used to complement ES by enabling manufacturing SMEs to employ digital and production technologies for enhancing efficiency, traceability, and exploration into sustainable transformation (Beltrami et al., 2021; Khan et al., 2021).

DCT builds on this concept by describing how firms detect environmental and technological changes, capitalize on sustainability opportunities, and adjust organizational resources amidst changing conditions (Teece et al., 1997). In this research, Environmental Management Accounting (EMA) is regarded as a dynamic capability because it transforms environmental and technological strategies into environmental cost data, resource allocation processes, and performance measurement tools that support business strategy (Appannan et al., 2023; Solovida & Latan, 2017). The institutional and stakeholder viewpoints explain the moderating influence of social pressure (SP), highlighting how regulatory, customer, community, and supply chain demands create legitimacy, thereby making EMA more strategically valuable for achieving sustainability outcomes (Baah et al., 2021; Singh et al., 2022). Additionally, the cognitive and mindfulness perspectives view GM as managerial attentiveness, interpretation, and responsiveness to environmental data, thereby increasing the likelihood that strategic environmental and technological orientations lead to EMA adoption and utilization (Ndubisi et al., 2019; Van et al., 2023). By combining internal capabilities with external pressures within a unified model, this framework fills a gap in SME sustainability research and provides a comparative perspective on manufacturing SMEs in Indonesia and Malaysia.

Environmental Strategy and EMA Implementation

Proactive Environmental Strategy (ES) entails integrating environmental goals into business activities to minimize pollution, conserve resources, improve efficiency, and enhance stakeholder trust (Adomako et al., 2021; Aftab et al., 2022, 2023). Implementing ES depends on an internal information system that can translate environmental focus into actionable managerial insights. Environmental Management Accounting (EMA) offers this capability by tracking material flows, energy consumption, waste, and environmental costs to aid green decision-making and performance monitoring (Burritt, 2004; Latan et al., 2018; Solovida & Latan, 2017). According to the Natural-Resource-Based View, ES serves as a strategic environmental resource, with its value realized when supported by organizational capabilities such as EMA (Hart & Dowell, 2010, 2011; J. Rahman et al., 2026). Empirical evidence indicates that firms with stronger environmental strategies and institutional responsiveness are more likely to implement EMA and environmental accounting innovations (Appannan et al., 2023; Chaudhry & Amir, 2020; Gunarathne et al., 2021). This is especially relevant for manufacturing SMEs in Indonesia and Malaysia, where data on SME-focused EMA is limited and strategic environmental decisions rely heavily on robust accounting support (Johnstone, 2020; Swalih et al., 2024).

H1: Environmental strategy positively influences EMA implementation.

Technology Strategy and EMA Implementation

The Technology Strategy (TS) is the strategic capability of firms to adopt, integrate, and use various digital and production technologies to improve competitiveness, operational efficiency, and energy and environmental performance. TS, on the other hand, is crucial for manufacturing SMEs, since environmental accounting practices require reliable systems engineered to collect, process, monitor, and interpret environmental data. Companies that have a higher level of technological orientation are better positioned to integrate the digitalization of green accounting, resource monitoring, and environmental cost tracking as well as sustainability-oriented information systems into managerial practices (Appannan et al., 2023; Asa et al., 2026; Kewalramani et al., 2026; Santos & Sant'Anna, 2024). Grounded in Dynamic Capabilities Theory, TS enhances a firm's ability to sense environmental information, seize technology-enabled sustainability opportunities, and reconfigure internal processes to adopt more accountable, data-driven environmental management practices (Beltrami et al., 2021; Teece et al., 1997).

Digitizing tools, due to their ability to enhance traceability, 'visibility' of resource use, and monitoring of production and circular-economy practices in SMEs (Findik et al., 2023; Khan et al., 2021), have the potential to facilitate technological innovation that can accelerate the formalization of EMA. Additional studies over the years have indicated that benefits of technology adoption, technological capability, green capability and AI-based resources might improve sustainability performance by allowing firms to integrate environmental information into strategic decision-making systems (Gokmen et al., 2026; Li et al., 2025; S. Rahman et al., 2026). Thus, SMEs that are technologically prepared should find it easier to apply EMA, given their ready access to digital infrastructure and the analytical capacity to translate environmental information into quantifiable metrics for accounting and managerial practices.

H2: Technology strategy positively influences EMA implementation.

EMA Implementation and Business Sustainability

Implementing environmental management accounting (EMA) involves systematically utilizing physical and monetary environmental data to aid managerial decision-making, resource control, environmental performance evaluation, and sustainability planning. For manufacturing SMEs, EMA's internal information functions allow firms to track material flows, monitor energy consumption, trace waste output, allocate environmental costs, and evaluate the economic effects of environmental activities (Burritt et al., 2019; Solovida & Latan, 2017; Swalih et al., 2024). EMA increases transparency regarding environmental costs and operational inefficiencies, enabling firms to improve eco-efficiency, reduce waste-related expenses, enhance resource productivity, and align environmental practices with broader sustainability objectives (Appannan et al., 2023; Latan et al., 2018). According to Dynamic Capabilities Theory (Teece et al., 1997), EMA can be viewed as an adaptive managerial skill that helps firms detect environmental cost signals, capitalize on efficiency opportunities, and reconfigure internal processes toward sustainable business outcomes.

Earlier empirical studies suggest that EMA improves the quality of environmental information, enhances managerial accountability, and supports strategic decision-making. These benefits contribute to better environmental and organizational performance, ultimately promoting sustainability (Appannan et al., 2023). EMA is particularly relevant for manufacturing SMEs, as sustainability performance requires quantitative control over resource use, environmental costs, and operational impacts. However, adoption of EMA in SMEs may be hindered by limited accounting procedures, inadequate technical skills, poor digital infrastructure, and restricted management control (Johnstone, 2020; Malesios et al., 2021). Consequently, within the Business Sustainability framework, EMA implementation is expected to help SMEs transform environmental data into improved process efficiency, broader bottom-line accountability, and sustainable competitive advantage. Based on this, the study proposes:

H3: EMA implementation positively impacts business sustainability.

The Role of Mediating EMA Implementation

Environmental Strategy (ES) and Technology Strategy (TS) establish the strategic foundation for firms to attain sustainable competitiveness. While neither may be enough on their own to produce tangible sustainability results, they are also insufficient without organizational mechanisms that translate strategic focus into operational data, managerial oversight, and performance metrics. Environmental Management Accounting (EMA) serves this bridging function by converting environmental and techno-environmental goals into practical information such as environmental costs, material flows, resource use, waste-related expenses, and sustainability performance indicators to support managerial decisions (Appannan et al., 2023; Burritt, 2004; Latan et al., 2018; Solovida & Latan, 2017). Although earlier research links EMA with environmental management strategies, institutional pressures, and environmental performance to organizational outcomes, systematic evidence highlights its vital role in strategic sustainability decision-making (Chaudhry & Amir, 2020; Gunarathne et al., 2021; Swalih et al., 2024).

From the Natural-Resource-Based View, EMA enables firms to convert environmental resources and strategic commitments into organizational capabilities that foster sustainable performance and competitive advantage (Hart 1995; Hart & Dowell 2011; Rahman et al.). According to the Dynamic Capabilities Theory, EMA acts as a reconfiguration mechanism, allowing firms to sense environmental cost signals, seize efficiency opportunities, and incorporate sustainability information into operations (Solovida & Latan, 2017; Teece et al., 1997). As a result, we anticipate that both ES and TS influence BS directly and indirectly through EMA implementation. This mediating role is particularly relevant for manufacturing SMEs, where strategic sustainability efforts must be integrated into practical accounting systems to become measurable, manageable, and operationally feasible.

H4: EMA implementation mediates the relationship between ES and BS.
H5: EMA implementation mediates the relationship between TS and BS.

The Moderating Role of Green Mindfulness

Green Mindfulness (GM) refers to managers' awareness, functioning, and consideration of environmental impacts in organizational decision-making. Compared to managers with lower GM, those with high GM are better equipped to interpret environmental information holistically, recognize ecological threats and opportunities, and foster sustainable behaviors across their organization (Ndubisi et al., 2019; Van et al., 2023). From a cognitive and mindfulness perspective, GM enhances the translation of strategic intent into organizational actions by increasing managerial attention, interpretation, learning, and responsiveness to environmental issues (Ndubisi et al., 2019). This enables firms to move beyond mere formal commitments to environmental goals, toward more deliberate, knowledge-based, and operational sustainability practices.

This research posits that GM serves as a moderator between ES and EMA in the context of Environmental Strategy and Technology Strategy. Previous studies have suggested that top managers with strong GM are more inclined to incorporate environmental and technological considerations into routines such as accounting, resource monitoring, and sensitivity analyses within sustainability-focused decision-making. They are also more likely to actively implement EMA (Gokmen et al., 2026; Van et al., 2023). Conversely, weak GM may hinder the integration of environmental concerns into routine accounting and strategic initiatives, rendering these efforts symbolic, anecdotal, or only partially realized (Anggadwita et al., 2023; Appannan et al., 2023; Ooi, 2026).

H6: Green Mindfulness moderates the relationship between ES and EMA Implementation.
H7: Green Mindfulness moderates the relationship between TS and EMA Implementation.

The Moderating Role of Stakeholder Pressure

Stakeholder Pressure (SP) includes regulations, norms, market, community, and supply-chain expectations that compel companies to demonstrate credible sustainability efforts and accountability in environmental practices. At an institutional level, these pressures motivate firms to adopt environmental disclosures, management controls, and accounting systems that help them gain legitimacy, build stakeholder trust, and strengthen their organizational reputation (Baah et al., 2021; Chaudhry & Amir, 2020; Gunarathne et al., 2021; Singh et al., 2022). Research indicates that companies with greater stakeholder empowerment are more likely to improve green practices, transparency, reputation, environmental outcomes, and financial performance (Agyabeng-Mensah et al., 2024; Baah et al., 2021; Singh et al., 2022). Consequently, SP can enhance the strategic importance of Environmental Management Accounting (EMA) by increasing the visibility, decision usefulness, and external accountability of environmental information.

The study introduces SP as a moderator of the relationship between EMA and Business Sustainability (BS). Companies use EMA data to enhance sustainability outcomes, demonstrate regulatory compliance, meet market expectations, and uphold social legitimacy in high-external-pressure environments (Chaudhry & Amir, 2020; Ooi, 2026). Conversely, when stakeholder oversight is weak (Johnstone, 2020; Trivedi et al., 2025), EMA data may be underutilized, leading to fewer gains in performance and sustainability learning. Based on Dynamic Capabilities Theory, SP serves as an external trigger that encourages firms to reconfigure EMA capabilities to improve sustainability outcomes (J. Rahman et al., 2026; Teece et al., 1997). This reasoning is especially pertinent for SMEs in developing economies, where business continuity and long-term competitiveness depend heavily on SME credibility, customer trust, and the overall value proposition related to sustainability (Appannan et al., 2023; Chin et al., 2026). Therefore, this study suggests:

H8: Stakeholder Pressure moderates the relationship between EMA Implementation and Business Sustainability.

Conceptual Model of Sustainable SME Performance

Figure 1 illustrates the conceptual framework of this study, which explains Business Sustainability (BS) in manufacturing SMEs through strategic, accounting, cognitive, and institutional mechanisms. Environmental Strategy (ES) and Technology Strategy (TS) are positioned as strategic antecedents that encourage Environmental Management Accounting (EMA) implementation, while EMA subsequently enhances BS by translating environmental orientation into measurable information, cost control, and sustainability-oriented decision-making (Appannan et al., 2023; Latan et al., 2018; Solovida & Latan, 2017). EMA also serves as a mediating mechanism that connects ES and TS with sustainability outcomes by converting strategic intent into environmental management routines and performance indicators (Chaudhry & Amir, 2020; Gunarathne et al.,

2021). The model further proposes that Green Mindfulness (GM) moderates the effects of ES and TS on EMA by strengthening managerial attention to environmental information (Ndubisi et al., 2019; Van et al., 2023), whereas Stakeholder Pressure (SP) moderates the EMA–BS relationship by intensifying legitimacy and accountability demands (Baah et al., 2021; Singh et al., 2022). Grounded in NRBV and DCT, this framework explains how strategic, cognitive, and institutional factors collectively support sustainable business performance among manufacturing SMEs in Indonesia and Malaysia (Hart, 1994; S. Rahman et al., 2026; Teece et al., 1997).

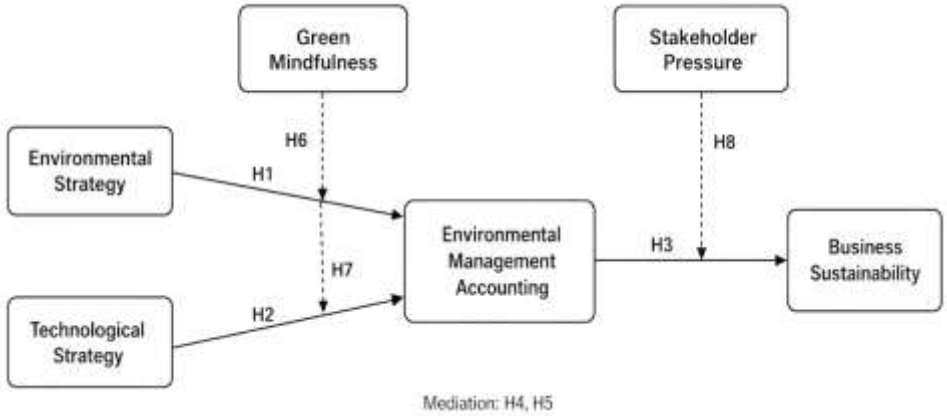

Figure 1. Conceptual model of sustainable SME performance.

The model illustrates the relationships among Environmental Strategy, Technology Strategy, Environmental Management Accounting, Green Mindfulness, Stakeholder Pressure, and Business Sustainability in manufacturing SMEs. EMA is positioned as a mediating mechanism, while Green Mindfulness and Stakeholder Pressure function as moderating variables.

Methodology

A quantitative cross-sectional survey design was used to analyze the interplay between Environmental Strategy (ES), Technology Strategy (TS), Environmental Management Accounting (EMA), Green Mindfulness (GM), Stakeholder Pressure (SP), and Business Sustainability (BS) among manufacturing SMEs in Indonesia and Malaysia. Such a design is suitable since the latent organizational capabilities, sustainability practices, and managerial perceptions are examined across a bounded population of SMEs (Dey et al., 2021; Malesios et al., 2021). The moderated mediation approach was tested through Partial Least Squares Structural Equation Modeling (PLS-SEM) by utilizing SmartPLS 4.0, appropriate for estimating complex models that encompass the interrelations of mediation, moderation, and reflective latent constructs in sustainability and environmental accounting research (Latan et al., 2018; S. Rahman et al., 2026). This two-country examination facilitates a comparative study of manufacturing SMEs operating in different institutional environments, technological preparedness, stakeholder pressures, and governance contexts on sustainability (Appannan et al., 2023; Chin et al., 2026).

Population, Sampling Frame, and Sample Size

This study focuses on manufacturing SMEs registered with SME Corporation Malaysia and the Ministry of Cooperatives and SMEs in Indonesia. We chose manufacturing SMEs because they significantly contribute to economic development but face increasing environmental, technological, and sustainability pressures in developing economies (Appannan et al., 2023; Atikah Candraningtyas & Rahmawati, 2025; Johnstone, 2020; Rahmawati et al., 2025). The sampling frame included SMEs from sectors such as food and beverages, textiles, handicrafts, chemicals, furniture, machinery, and other light manufacturing subsectors, representing diverse sustainability practices and operational performances in SME manufacturing (Malesios et al., 2021; Singh et al., 2022). The eligibility criteria were based on five main aspects: (a) at least 3 years of operation; (b) engagement in the manufacturing sector; (c) fewer than 300 employees; (d) managerial personnel involved in environmental or operational decision-making; and (e) implementation of basic environmental management or technology practices within the firms' administrative processes, as detailed in the references.

Stratified purposive sampling was used to ensure coverage across manufacturing subsectors and both country contexts. This sampling method aligns with previous SME sustainability and environmental accounting research

that adopted a structured survey design to investigate firm-level sustainability practices (Chaudhry & Amir, 2020; Dey et al., 2021)2. G*Power 3.1 was used to estimate the minimum sample size requirement (based on five predictors, effect size $f^2 = 0.15$, significance level 0.05, and power of 0.95), yielding a requirement of at least 138 responses per country. This threshold is in line with quantitative SME sustainability studies adopting multivariate analysis and PLS-SEM logic (Rahman et al., 2026; Singh et al., 2022). A total of 400 electronic questionnaires were distributed, with 200 from Indonesia and 200 from Malaysia. After discarding incomplete responses, 288 questionnaires were valid, with 148 from Indonesia and 140 from Malaysia — yielding a response rate of around 72%, which is considered decent for MSME survey data (Appannan et al., 2023; Latifah et al., 2021).

Respondent and Company Characteristics

The respondents included owners of SMEs, finance managers, operations managers, environmental officers, and senior supervisors who had sufficient knowledge of their companies' practices related to technology adoption and sustainability efforts. Since environmental management and accounting practices in SMEs are typically confined to individuals directly involved in strategic, operational, financial, or environmental decision-making (Appannan et al., 2023; Chaudhry & Amir, 2020; Johnstone, 2020), this key informant approach is suitable. The study used a single-respondent design, assuming that selected informants could thoroughly understand their firm's strategy, accounting routines, and sustainability practices (S. Rahman et al., 2026; Solovida & Latan, 2017). The firms' operational records over five years demonstrate organizational stability and provide managerial insights into business and sustainability practices (Atikah Candraningtyas & Rahmawati, 2025; Chin et al., 2026; Rahmawati et al., 2025). Firm size was determined by the number of employees and annual turnover, following standard SME classifications and previous studies on MSME performance (Appannan et al., 2023; Latifah et al., 2021). To test the hypotheses mentioned earlier, we controlled for firm age and size, as organizational factors could influence sustainability implementation, EMA adoption, and performance outcomes (Baah et al., 2021; Dey et al., 2021; Gunarathne et al., 2021).

Data Collection Procedures and Ethical Considerations

Data were collected from January to March 2026 via a structured online questionnaire distributed through Google Forms. This approach aligns with previous SME and sustainability studies that used survey methods to gauge managerial perceptions and organizational practices (Appannan et al., 2023; Latifah et al., 2021; J. Rahman et al., 2026; Rahmawati et al., 2025). The questionnaire was shared with SME associations, chambers of commerce, local business communities, and manufacturing networks in Indonesia and Malaysia to target respondents with relevant organizational knowledge and sustainability responsibilities (Baah et al., 2021; Johnstone, 2020; Singh et al., 2022). Participation was voluntary, and respondents were informed of confidentiality and anonymity protocols in advance, in accordance with ethical standards in environmental accounting and SME research (Chaudhry & Amir, 2020; Latan et al., 2018; Solovida & Latan, 2017). Electronic informed consent was obtained at the start of the survey, and participants were assured that their data would be used solely for academic research and analyzed collectively (Dey et al., 2021; Latifah et al., 2021; Malesios et al., 2021).

Questionnaire Development, Pilot Testing, and Bias Assessment

All measurement items are adapted from existing studies to maximize content validity and theoretical coherence, while aiding comparability with previous research in sustainability or environmental accounting. The respective items for all constructs were operationalized via a seven-point Likert scale, where 1 = strongly disagree and 7 = strongly agree. The Environmental Strategy (ES) and Technology Strategy (TS) were integrated from sustainability strategy and environmental innovation literature (Aftab et al., 2022, 2023; Appannan et al., 2023); Environmental Management Accounting (EMA) from green accounting studies (Burritt et al., 2019; Solovida & Latan, 2017); Green Mindfulness (GM) from mindfulness-based environmental behavior literature in SMEs studies Ndubisi et al. The questionnaire was originally constructed in English and then translated into the Indonesian and Malaysian languages using a back-translation method. The semantic equivalence and conceptual clarity of the instrument were evaluated for cross-country consistency by two experts in an academic bilingual edition (Latan et al., 2018; Latifah et al., 2021; S. Rahman et al., 2026). BS was modeled as a second-order reflective construct comprising the economic, environmental, and social dimensions, in accordance with the multidimensional SME sustainability assessment (Dey et al., 2021; Mulyani et al., 2024).

A pilot study was first pre-tested with 30 SME respondents from each country to assess clarity, wording, reliability, and contextual appropriateness of the items. Minor adjustments to enhance readability and sectoral relevance were made, while pilot results indicate promising reliability, with all constructs yielding Cronbach's

alpha values exceeding 0.70 (Appannan et al., 2023; Budiarto et al., 2019; Johnstone, 2020). Common Method Bias (CMB) was mitigated through procedural and statistical remedies, as the study used self-reported data from individual respondents. With regard to the procedure, anonymity and confidentiality were emphasized to mitigate social desirability bias and evaluation apprehension (Chaudhry & Amir, 2020; Solovida & Latan, 2017). Specifically, collinearity statistics (Variance Inflation Factor; VIF) were assessed, with all values ≤ 3.3 indicating that CMB was unlikely to jeopardize the validity of the results unless stated otherwise (Latan et al., 2018; S. Rahman et al., 2026). Nonresponse bias was tested by comparing early and late responders using independent samples t-tests with no significant differences identified, indicating that nonresponse bias should not be a concern (Appannan et al., 2023; Ooi, 2026).

Measurement Invariance and Justification for PLS-SEM

As this study compares manufacturing SMEs in Indonesia and Malaysia, measurement invariance was checked prior to Multigroup Analysis (MGA). The Measurement Invariance of Composite Models (MICOM) method was employed to assess configurational invariance, compositional invariance, and the equality of composite means and variances. The findings indicated partial measurement invariance, enabling a valid comparison of the structural relationships between Indonesian and Malaysian SMEs using PLS-MGA. This approach aligns with the comparative framework of cross-country SME sustainability research, in which institutional contexts and sustainability practices may differ in emerging economies (Appannan et al., 2023; Atikah Candraningtyas & Rahmawati, 2025; Chin et al., 2026; J. Rahman et al., 2026; Rahmawati et al., 2025).

PLS-SEM was chosen over covariance-based SEM because this study is prediction-focused and aims to expand the Natural Resource-Based View and Dynamic Capabilities Theory to explain sustainability practices among SMEs (Hart, 1994; Teece et al., 1997). The model features moderated mediation, multiple interaction effects, and a higher-order construct, making PLS-SEM a suitable method for estimating complex structural relationships simultaneously (Latan et al., 2018; S. Rahman et al., 2026; Solovida & Latan, 2017). Additionally, PLS-SEM is appropriate for SME sustainability research involving moderate sample sizes, non-normal data, and latent behavioral constructs (Dey et al., 2021; Malesios et al., 2021; Singh et al., 2022).

Data Analysis Techniques and Research Process

Data analysis was conducted using SmartPLS 4.0 through a sequential procedure comprising descriptive statistics, measurement model assessment, structural model evaluation, mediation and moderation testing, predictive relevance assessment, and MICOM-based invariance testing (Appannan et al., 2023; Latan et al., 2018; S. Rahman et al., 2026). The measurement model was evaluated using outer loadings, Cronbach's alpha, rho_A, composite reliability (CR), average variance extracted (AVE), Fornell–Larcker criterion, heterotrait–monotrait ratio (HTMT), and cross-loadings to confirm reliability, convergent validity, and discriminant validity (Hair & Alamer, 2022; Sarstedt et al., 2017). The structural model was assessed through path coefficients, t-values, p-values, confidence intervals, coefficient of determination (R^2), effect size (f^2), predictive relevance (Q^2), and PLSpredict to evaluate explanatory and predictive performance (Chaudhry & Amir, 2020; Gunarathne et al., 2021; Malesios et al., 2021). Bootstrapping with 10,000 subsamples was applied to test the statistical significance and confidence intervals of the hypothesized relationships, including mediation and moderation effects (Baah et al., 2021).

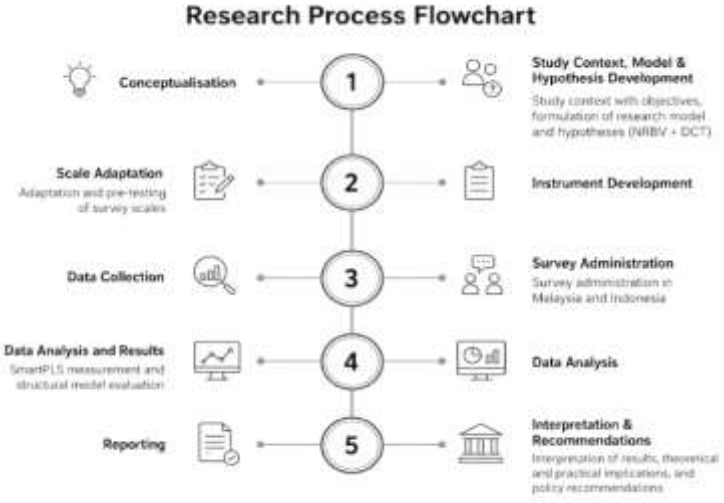

Figure 2. Flowchart of the research process.

The figure summarizes the sequential research procedure, including theoretical development, instrument preparation, data collection, data screening, model estimation, and interpretation of findings. The research process consisted of five sequential phases, with the flowchart in Figure 2 illustrating the progression from initial concept to final report. These phases included developing the theoretical model, adapting and pilot testing the instrument, collecting cross-country data, screening and estimating the model, and interpreting the results. Feedback loops during each phase ensured quality control, maintaining methodological rigor, construct consistency, and comparability between Indonesian and Malaysian samples. This staged approach aligns with previous studies on SME sustainability, environmental management accounting, and systematic research methods that highlight structured design, instrument refinement, and transparent analysis (Johnstone, 2020; Latifah et al., 2021; Rahmawati et al., 2025; Swalih et al., 2024).

Research Findings

This section presents the results of data analysis using Partial Least Squares Structural Equation Modeling (PLS-SEM) with SmartPLS 4.0. The analysis followed two main stages: assessment of the measurement model, followed by evaluation of the structural model to examine the hypothesized relationships among ES, TS, EMA, GM, SP, and BS. Construct validity and reliability were assessed through outer loadings, Cronbach's alpha, composite reliability, Average Variance Extracted (AVE), discriminant validity, and the heterotrait–monotrait ratio (HTMT), consistent with prior environmental accounting and SME sustainability studies (Appannan et al., 2023; Latan et al., 2018; Rahman et al., 2026; Solovida & Latan, 2017).

Descriptive Statistics

A total of 288 valid responses were obtained from manufacturing SMEs in Indonesia and Malaysia, comprising 148 from Indonesia and 140 from Malaysia. The overall response rate of 72% indicates satisfactory participation in SME-based survey research and is consistent with prior studies on sustainability, stakeholder pressure, and SME performance (Appannan et al., 2023; Baah et al., 2021; Rahmawati et al., 2025). Respondents represented diverse manufacturing subsectors, including food and beverages, textiles, handicrafts, chemicals, furniture, and machinery. Most participating firms had operated for more than five years, while respondents were mainly owners, operations managers, accounting managers, and senior supervisors involved in environmental and technology-related decisions (Johnstone, 2020; Latifah et al., 2021; Malesios et al., 2021; Singh et al., 2022).

Descriptive comparisons reveal that Malaysian SMEs generally score higher in Technology Strategy and EMA implementation, while Indonesian SMEs tend to perceive stronger Stakeholder Pressure. These patterns suggest differences in institutional readiness and operational maturity between the two countries, with Malaysian SMEs exhibiting stronger capabilities in technology and environmental accounting (Appannan et al., 2023; Chin et al., 2026; Ooi, 2026). In contrast, Indonesian SMEs seem more attuned to external stakeholder demands, such as regulatory requirements, community influence, and environmental disclosures (Chaudhry & Amir, 2020; Gunarathne et al., 2021; Rahmawati et al., 2024; Rahman et al., 2026).

Measurement Model Assessment: Reliability and Convergent Validity

The measurement model assessment was conducted to examine indicator reliability, internal consistency reliability, and convergent validity. As presented in Table 1, all retained items had outer loadings above the recommended threshold of 0.70, ranging from 0.721 to 0.912, indicating satisfactory indicator reliability. Several indicators with loadings below 0.70 in the initial analysis were carefully removed while maintaining theoretical consistency. Cronbach's alpha values ranged from 0.853 for Stakeholder Pressure to 0.924 for Business Sustainability, while rho_A values ranged from 0.859 to 0.928. Composite Reliability (CR) ranged from 0.895 to 0.941, and all values exceeded the recommended threshold of 0.70, confirming adequate internal consistency reliability. The Average Variance Extracted (AVE) values ranged from 0.681 to 0.792, exceeding the recommended threshold of 0.50. Business Sustainability recorded the highest AVE (0.792), whereas Stakeholder Pressure recorded the lowest AVE (0.681), confirming adequate convergent validity. Overall, all constructs demonstrated satisfactory reliability and convergent validity, supporting their suitability for subsequent structural model analysis.

Table 1. Internal consistency reliability and convergent validity.

Construct	Cronbach's Alpha	rho_A	Composite Reliability	AVE
Environmental	0.887	0.892	0.915	0.682

Strategy				
Technology Strategy	0.901	0.907	0.926	0.714
Environmental Management Accounting (EMA)	0.918	0.921	0.936	0.746
Green Mindfulness	0.864	0.871	0.902	0.697
Stakeholder Pressure	0.853	0.859	0.895	0.681
Business Sustainability	0.924	0.928	0.941	0.792

Discriminant Validity and Common Method Bias Assessment

Discriminant validity was evaluated using the Fornell–Larcker criterion and the Heterotrait–Monotrait Ratio (HTMT). The square root of the AVE for each construct was higher than its correlations with other constructs, satisfying the Fornell–Larcker standards. In addition, all HTMT values remained below the strict threshold of 0.85, confirming adequate discriminant validity among the latent constructs. The cross-loading analysis further showed that each indicator loaded highest on its respective construct compared with other constructs, providing additional evidence of construct distinctiveness. These results indicate that the constructs included in the model are empirically unique and measure conceptually different phenomena.

Because this study relied on self-reported survey responses from a single respondent in each SME, common method bias (CMB) was assessed using both procedural and statistical approaches. Procedurally, respondent anonymity and confidentiality were emphasized to reduce social desirability bias and evaluation apprehension, while the questionnaire design separated predictor and criterion constructs to minimize response-pattern bias. Statistically, full collinearity VIF assessment was performed following Kock's approach. All VIF values ranged from 1.324 to 2.917, remaining below the recommended threshold of 3.3, indicating that common method bias is unlikely to threaten the validity of the findings. As an additional check, Harman's single-factor test was conducted, and the first factor explained less than 50% of the total variance, suggesting that common method variance was not a dominant issue in the dataset.

Structural Model Assessment

The structural model was evaluated using path coefficients, t-statistics, p-values, confidence intervals, coefficient of determination (R^2), adjusted R^2, effect size (f^2), predictive relevance (Q^2), and collinearity diagnostics. The collinearity assessment showed that the Variance Inflation Factor (VIF) values ranged from 1.218 to 2.864, well below the conservative threshold of 5, indicating no critical multicollinearity among the predictor constructs. The coefficient of determination indicates that the model explains 68.1% of the variance in EMA implementation (R^2 = 0.681; Adjusted R^2 = 0.673) and 68.9% of the variance in Business Sustainability (R^2 = 0.689; Adjusted R^2 = 0.681). These values demonstrate substantial explanatory power, suggesting that the exogenous constructs collectively predict both the mediating and outcome variables strongly. The blindfolding procedure produced Q^2 values greater than zero for both endogenous constructs (EMA = 0.417; Business Sustainability = 0.438), confirming satisfactory predictive relevance. PLSpredict further showed that most indicators produced lower prediction errors than the linear benchmark model, while f^2 values ranged from small to medium, supporting the substantive relevance of the hypothesized relationships.

As depicted in Figure 3, Environmental Strategy (X1_EnvStr) and Technology Strategy (X2_TechStra) are directed toward Environmental Management Accounting (X3_EMA), which subsequently points to Business Sustainability (Y_BSSUST). The endogenous constructs display strong R^2 values inside the blue circles: 0.681 for EMA and 0.689 for Business Sustainability. The figure shows a visible coefficient of 0.377 on the Environmental Strategy → EMA path. The Technology Strategy → EMA and EMA → Business Sustainability paths are labelled 0.000 in the figure, which appears to represent statistical significance rather than substantive path coefficients. The moderating paths are also shown: Green Mindfulness (X4_GMind) interacts with the ES/TS pathways toward EMA, with displayed values of 0.139 and 0.078, while Stakeholder Pressure (X5_SHPres) moderates the EMA → Business Sustainability relationship with a displayed value of 0.088. The indicator links in Figure 3 are mostly labelled 0.000, indicating significance values rather than readable outer loadings; therefore, the exact outer loading range cannot be inferred from the figure. Overall, Figure 3 confirms that ES and TS influence EMA, EMA predicts Business Sustainability, and the model has strong predictive capacity.

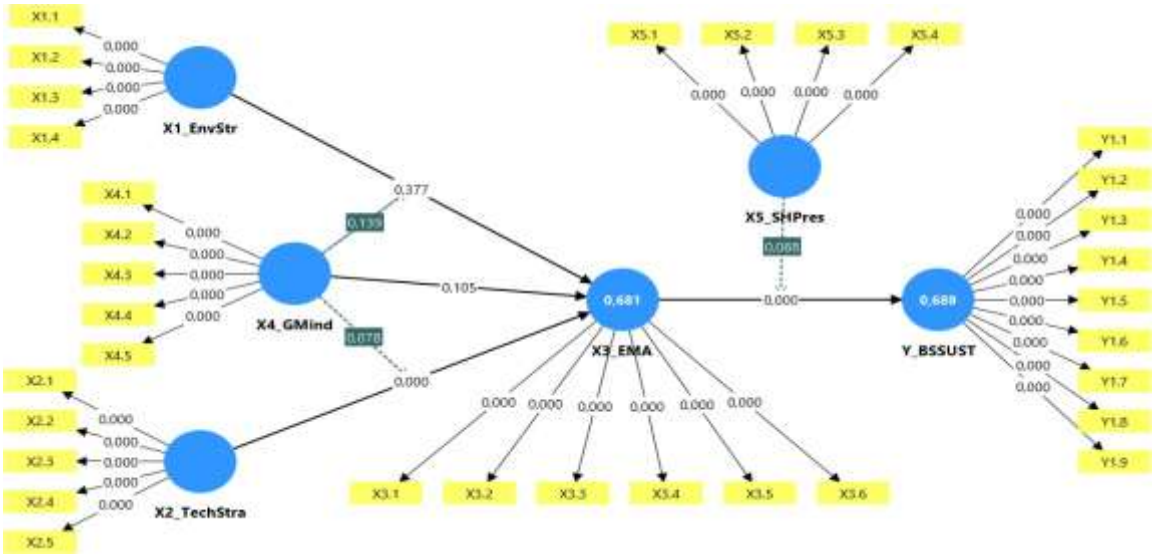

Figure 3. Structural model assessment using PLS-SEM.

The figure presents the estimated structural relationships among the study constructs, including direct effects, mediation through EMA implementation, and moderation by Green Mindfulness and Stakeholder Pressure.

Hypothesis Testing

The hypothesis testing results indicate that Environmental Strategy and Technology Strategy have significant positive effects on EMA implementation, while EMA, in turn, has a significant positive effect on Business Sustainability. These findings confirm the proposed moderated mediation model in which Environmental Strategy (X1_EnvStr) and Technology Strategy (X2_TechStra) influence Business Sustainability (Y_BSSUST) through Environmental Management Accounting (X3_EMA). The indirect effects were assessed using the bootstrap procedure, and the results confirm that EMA significantly mediates the relationship between Environmental Strategy and Business Sustainability; therefore, H4 was supported. Similarly, EMA significantly mediates the relationship between Technology Strategy and Business Sustainability, thereby supporting H5. The direct effects of Environmental Strategy and Technology Strategy on Business Sustainability remained significant after EMA was included in the model, indicating partial mediation rather than full mediation. This suggests that EMA is an important operational mechanism for translating strategic orientation into sustainability performance, while strategic initiatives remain directly relevant to sustainable business outcomes.

The moderation analysis was conducted using interaction terms and simple slope procedures. Green Mindfulness significantly strengthened the effects of Environmental Strategy and Technology Strategy on EMA implementation. Thus, H6 and H7 were supported, indicating that when managers demonstrate stronger environmental awareness and attentiveness, strategic environmental and technological orientations are more effectively converted into EMA practices. Conversely, in firms with lower mindfulness, strategy may remain symbolic or weakly embedded in operational accounting routines. Stakeholder Pressure also strengthened the relationship between EMA and Business Sustainability, supporting H8. This result indicates that when external pressure from regulators, customers, and supply-chain partners is high, firms are more likely to use EMA information to improve sustainability outcomes and maintain legitimacy. Under weak stakeholder monitoring, EMA data may remain underutilized, reducing its contribution to sustainability performance.

Multi-Group Analysis, Endogeneity, and Robustness Checks

Before conducting cross-country comparisons, the Measurement Invariance of Composite Models (MICOM) procedure was applied. The results supported configurational and compositional invariance, indicating partial measurement invariance between Indonesia and Malaysia and allowing valid Multi-Group Analysis (MGA). As presented in Table 2, the MGA results reveal differences in the strength of structural relationships across the two countries. The relationship between Technology Strategy and EMA was stronger in Malaysia (β = 0.463) than in Indonesia (β = 0.287), suggesting that technological readiness and business digitalization in Malaysia more effectively support EMA implementation. The Environmental Strategy–EMA relationship was also slightly stronger in Malaysia (β = 0.428) than in Indonesia (β = 0.351), whereas the EMA–Business Sustainability relationship was stronger in Indonesia (β = 0.521) than in Malaysia (β = 0.487). For moderation effects, Green

Mindfulness was stronger in Malaysia (β = 0.118) than in Indonesia (β = 0.071), while Stakeholder Pressure was stronger in Indonesia (β = 0.126) than in Malaysia (β = 0.067). These findings suggest that Indonesian SMEs are more sensitive to external sustainability pressures, whereas Malaysian SMEs rely more strongly on technological readiness and internal managerial systems.

Table 2. Multigroup analysis results.

Relationship between variables	Indonesia	Malaysia
Environmental Strategy -> EMA	0.351	0.428
Technology Strategy -> EMA	0.287	0.463
EMA -> Business Sustainability	0.521	0.487
Green Mindfulness Moderation	0.071	0.118
Stakeholder Pressure Moderation	0.126	0.067

This study also acknowledges the possibility of reverse causality, whereby more sustainable SMEs may be more likely to adopt environmental and technology strategies. To address potential omitted variable bias and endogeneity concerns, the analysis included control variables such as firm size, firm age, manufacturing subsector, country, export orientation, ownership type, environmental certification, and digital maturity. Additional robustness checks using Gaussian copula analysis indicated no significant endogeneity problem in the structural model. Nevertheless, given the cross-sectional nature of the research design, potential reciprocal relationships among sustainability-related factors cannot be fully ruled out. Overall, the robustness checks support the stability of the hypothesized relationships while acknowledging the need for cautious causal interpretation.

Comparative Descriptive Analysis between Indonesia and Malaysia

Deriving Comparative Macro Analysis of Construct Scores for Manufacturing Firms in Indonesia and Malaysia. Table 3., Comparative Mean Scores of Main Constructs by Manufacturing SMEs (Indonesian vs Malaysian). In general, however, Malaysian SMEs achieved higher mean scores on most internal capability-related constructs. The first factor, Environmental Strategy, was higher in Malaysia (M = 5.71) than in Indonesia (M = 5.42), suggesting that SMEs in Malaysia were more environmentally oriented than their counterparts in Indonesia, as shown in Table 1 below. Technology Strategy, for example, had the largest difference across countries at 5.88 in Malaysia, compared with 5.11 in Indonesia, indicating that firms in Malaysia are better prepared to use technology platforms and data-driven capabilities than those in Indonesia. For EMA Implementation, Malaysian SMEs (M = 5.79) scored higher than Indonesian SMEs (M = 5.06), also indicating that internal environmental accounting practices are already more advanced in the latter country of study. For Green Mindfulness, Malaysia (M = 5.68) scored only marginally higher than Indonesia (M = 5.63), indicating similar levels of managerial environmental awareness between the two countries. The study concluded that the Malaysian businesses were perceived to be more sustainable than the Indonesian firms in Business Sustainability (M = 5.81, 5.28). On the contrary, per our results for Stakeholder Pressure Indonesian SMEs (M = 5.94) felt more pressure from external sustainability demand than did Malaysian ones (M = 5.37), indicating that there are greater external pressures on them from regulatory compliance, market forces and social legitimacy issues These patterns of descriptive suggest that Malaysian SMEs shows relatively higher strengths in internal strategic, technological and accounting capabilities where as Indonesian SMEs faces more severe external stakeholder pressure.

Table 3. Comparison of mean scores between Indonesia and Malaysia.

Variable	Indonesia	Malaysia
Environmental Strategy	5.42	5.71
Technology Strategy	5.11	5.88
EMA Implementation	5.06	5.79
Green Mindfulness	5.63	5.68
Stakeholder Pressure	5.94	5.37
Business Sustainability	5.28	5.81

Discussion

The results reveal that Environmental Strategy and Technology Strategy, respectively, serve as significant antecedents to the implementation of Environmental Management Accounting (EMA) among Manufacturing SMEs in Indonesia and Malaysia. This implies that sustainability-focused strategies require internal accounting

systems that link strategic goals to operational outcomes. It is a managerial capability that enables firms to recognize, process, and use information on environmental costs, material flows, energy use, and resource efficiency in decision-making (Appannan et al., 2023; Latan et al., 2018; Solovida & Latan, 2017). The descriptive influence of EMA on corporate sustainability indicates that it is not only a matter of strategic orientation but also the ability of firms to institutionalize environmental information systems that support ecological efficiency, cost-control transparency, and long-term competitiveness (Chaudhry & Amir, 2020; Gunarathne et al., 2021; Swalih et al., 2024).

The positive relationship between environmental strategy and EMA aligns with the view that formalizing and adopting environmental-focused systems are most effective when integrated into daily processes and management controls. According to the Natural Resource-Based View of the Firm, environmental strategy becomes a strategic resource, especially when firms develop capabilities for pollution prevention, resource efficiency, and sustainability (Hart, 1994; Hart & Dowell, 2010, 2011). To adapt these macro concepts to SME practices, practical accounting tools are needed to monitor energy use, waste, and material flows, incorporating environmental costs and efficiency gains. Without EMA, a firm's commitment to environmental strategy might remain just a statement rather than an operational reality. This is especially significant for developing economies, where SMEs often face resource limitations, informal control systems, and uneven sustainability governance (Dey et al., 2021; Johnstone, 2020; Malesios et al., 2021).

Likewise, Technology Strategy strengthens EMA implementation by building firms' ability to obtain, analyze, and interpret data on their economic interactions with the environment. Technologically oriented SMEs are more compatible with digital accounting systems, production monitoring tools, and mechanisms for tracking environmental costs, and integrate them into managerial routines. This also highlights concepts from the Dynamic Capabilities Theory (DCT) on how firms sense, seize, and reconfigure sustainable technologies to derive exploitative benefits from sensed environmental and technological changes and remain competitive (S. Rahman et al., 2026; Teece et al., 1997). The comparative pattern suggests that Malaysian SMEs have stronger techno capacity and EMA implementation, implying that digital infrastructure and internal system maturity are prerequisites for environmental accounting adoption. This finding aligns with the Industry 4.0 and SME digitalization literature, which emphasizes technology as a mechanism to facilitate traceability, circular-economy practices, and sustainability-oriented decision-making (Asa et al., 2026; Findik et al., 2023; Kewalramani et al., 2026; Santos & Sant'Anna, 2024).

EMA acting as a mediator suggests that environmental and technological strategies alone do not guarantee sustainability outcomes unless they are translated into actionable and measurable information, managerial controls, and operational routines. EMA serves as a link between strategic orientation and Business Sustainability by turning environmental priorities and technology system priorities into clear cost visibility, resource allocation, and performance metrics (Burritt, 2004; Solovida & Latan, 2017). The partial mediation result indicates that strategy remains directly connected to sustainability, but its operational significance increases with EMA support. This underscores that EMA should be regarded not merely as an accounting technique but more as a tool for sustainability management.

The moderation results also indicate that sustainability outcomes are contingent on both internal cognition and external pressure. Green Mindfulness reinforces the linkages among Environmental Strategy, Technology Strategy, and EMA implementation, suggesting that managers who are conscientious and perceptive are more likely to identify ecological threats, assimilate environmental information, and translate strategic commitments into accounting routines (Ndubisi et al., 2019; Van et al., 2023). However, given the still-modest moderating effect, Green Mindfulness should function more as a reinforcing condition than as a leading condition. Team awareness requires accounting knowledge, digital infrastructure, and organizational commitment (O) to be effective.

Stakeholder Pressure further enhances the EMA–Business Sustainability nexus, suggesting that greater accountability and legitimacy pressures experienced by firms can increase the strategic value of EMA. As a result, external stakeholders, such as regulators, customers, communities, and supply chain partners, can push firms to use EMA information for more proactive purposes related to compliance with sustainability regulations (Baah et al., 2021; Singh et al., 2022; Trivedi et al., 2025). The comparative finding implies that Indonesian SMEs are more responsive to stakeholder pressure than Malaysian SMEs, whereas Malaysian SMEs depend significantly on technology readiness and internal system development. These findings illustrate that the journey to Business

Sustainability is a pathway specific to each context, not universal. Ten: descriptive framework model and pathways. Malaysia illustrates a technology-driven, internally structured pathway. Indonesia has a stakeholder-driven, legitimacy-oriented pathway. In summary, this paper contributes to NRBV and Dynamic Capabilities Theory by explicating the associations among SME sustainability, strategic orientation, technological capability, EMA implementation, managerial cognition, and institutional pressure in emerging-economy contexts.

Conclusion

This study concludes that Environmental Strategy and Technology Strategy play a critical role in strengthening the implementation of Environmental Management Accounting, thereby enhancing Business Sustainability among manufacturing SMEs in Indonesia and Malaysia. The findings demonstrate that sustainability-oriented strategies require more than managerial intent; they must be supported by internal accounting systems that translate environmental and technological priorities into measurable operational practices. EMA emerges as a central mechanism linking strategic orientation to sustainability performance by improving environmental cost visibility, resource monitoring, decision quality, and accountability. The results also show that Green Mindfulness strengthens the transformation of strategy into EMA practices, while Stakeholder Pressure reinforces EMA's contribution to sustainable business outcomes. Comparative findings further indicate that Malaysian SMEs benefit more from technological readiness and internal system development, whereas Indonesian SMEs are more responsive to external stakeholder and legitimacy pressures. Overall, this study confirms that SME sustainability in emerging economies is shaped by the interaction of strategic capability, environmental accounting practices, managerial awareness, and institutional pressure.

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CRediT Author Statement

R: Conceptualization, Methodology, Supervision, Project administration, Writing – original draft, Writing – review and editing, Corresponding author.
A.K.W: Methodology, Validation, Formal analysis, Writing – review and editing.
S.M: Conceptualization, Supervision, Resources, Writing – review and editing.
S.R.I: Methodology, Validation, Investigation, Writing – review and editing.
C.J: Conceptualization, Validation, International research context, Writing – review and editing.
S.A: Investigation, Data curation, Project administration, Writing – review and editing.
J.M.S: Validation, Supervision, Writing – review and editing.
A.D: Formal analysis, Software, Data curation, Visualization, Writing – review and editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Ethical Approval and Informed Consent

This study was conducted in accordance with ethical principles for research involving human participants. Participation was voluntary, and all respondents were informed of the study's purpose before completing the questionnaire. Respondents were assured that their responses would remain anonymous and confidential and would be used only for academic research purposes. Electronic informed consent was obtained from all participants prior to data collection. No personally identifiable information is reported in this manuscript.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request. The data are not publicly available because they contain confidential firm-level survey responses from participating SMEs in Indonesia and Malaysia.

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