Presenting a Model of the Role of Strategic Management Accounting in Enhancing Sustainable Development Using an Interpretive Structural Modeling Approach

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Abstract

This study aimed to develop a model explaining the role of strategic management accounting in enhancing sustainable development using an interpretive structural modeling approach. The required data were collected through interviews with management accounting experts, including heads of finance and accounting departments in manufacturing companies who had relevant professional experience and academic qualifications in accounting and finance at the master's or doctoral level, as well as accountants employed in manufacturing companies. The expert panel consisted of 15 participants. Interpretive Structural Modeling (ISM) was employed for qualitative modeling. In this study, ISM was used to design a model explaining the role of strategic management accounting in enhancing sustainable development. The results of Interpretive Structural Modeling (ISM) demonstrated that the achievement of sustainable development is configured across four hierarchical levels. At Level 4 (the foundational level), the variables of "strategic planning" and "strategic management accounting," which exhibited the greatest driving power, were identified as the fundamental drivers. This implies that the formulation of competitive strategies and strategic budgeting can generate organizational transformation only when they are integrated with modern information systems and accounting practices, such as environmental management accounting and value chain costing. At Level 3 (the intermediate level), "executive and operational drivers" serve as a linking mechanism through which organizational value management and the alignment of objectives translate strategic decisions into operational activities. At Level 2, this process results in "sustainable performance improvement," reflected in indicators such as resource productivity, economic efficiency, and social responsibility. Finally, at Level 1 (the ultimate level), "enhancement of sustainable development" is achieved across its three economic, social, and environmental dimensions.

Keywords: *sustainable development enhancement, sustainable development, strategic management accounting.*

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1. Introduction

Sustainable development has become a central concern in contemporary management as organizations face increasing pressure to reconcile economic performance with social responsibility and environmental stewardship. Firms are no longer evaluated solely on the basis of profitability, cost efficiency, or market growth; they are increasingly expected to demonstrate how their strategies, resource allocation decisions, operational systems, and performance measurement practices contribute to long-term economic resilience, social well-being, and environmental protection. This shift has altered the informational requirements of management and has expanded the traditional scope of accounting beyond historical financial reporting. Within this context, management accounting has acquired a broader strategic role because it can generate, integrate, and communicate financial and non-financial information relevant to organizational sustainability. The sustainability agenda therefore requires accounting systems that can connect strategic objectives with operational decisions, identify the economic implications of environmental and social activities, and support managers in evaluating trade-

offs among different dimensions of organizational performance. The development of sustainability management accounting reflects this transition toward a more integrated understanding of organizational accountability and value creation [1]. Similarly, studies on sustainable business models have demonstrated that management accounting control can contribute to translating sustainability orientation into improved corporate performance by ensuring that strategic commitments are embedded in organizational control and decision-making systems [2]. Consequently, the relationship between accounting and sustainable development should not be treated merely as a reporting issue; rather, it represents a strategic managerial problem involving planning, control, resource allocation, cost analysis, organizational learning, and performance improvement.

Strategic management accounting (SMA) is particularly relevant to this transformation because it extends conventional management accounting toward a stronger external, competitive, future-oriented, and strategic focus. SMA incorporates accounting information into strategic analysis by emphasizing competitors, markets, customers, value chains, strategic costs, long-term positioning, and the integration of financial and non-financial information. The literature has identified a broad range of SMA practices, including competitor cost analysis, strategic costing, target costing, value chain analysis, customer profitability analysis, strategic performance measurement, and strategic pricing. A systematic review of SMA practices indicates that the field has progressively moved beyond traditional cost-control functions toward supporting strategic decision-making, competitive positioning, and organizational adaptation [3]. This transformation is important because firms operating under sustainability pressures require accounting systems capable of recognizing costs and benefits that may occur across extended time horizons and beyond organizational boundaries. Strategic management accounting can therefore support managers in evaluating how environmental expenditure, resource productivity, supply-chain relationships, stakeholder expectations, and long-term strategic investments affect organizational performance. Research concerning strategic supply chains further shows that SMA can strengthen strategic supply-chain management by improving both internal and external orientations, thereby providing more comprehensive information for strategic coordination [4]. From this perspective, SMA can be understood as an information and control architecture that links strategic planning with operational execution and organizational outcomes.

The role of management accounting in organizational performance has long been recognized, although sustainability has significantly broadened the nature of that relationship. Management accounting systems support organizations by structuring information, improving coordination, facilitating organizational learning, and increasing the quality of decision-making. Earlier research has shown that management accounting systems can contribute to the development and effectiveness of organizational knowledge-sharing mechanisms, demonstrating that accounting information is not simply a technical output but also an important component of organizational cognition and coordination [5]. In small and medium-sized enterprises, the adoption and use of management accounting practices have likewise been associated with improved planning and decision-support capacity, although the extent of implementation varies considerably depending on organizational characteristics, managerial sophistication, and resource availability [6]. In the context of cost systems, management accounting has also been shown to mediate the relationship between cost-system design and firm performance, indicating that the performance effects of accounting infrastructure depend on the extent to which accounting information is effectively utilized in managerial processes [7]. These findings are especially important for sustainable development because sustainability performance cannot be improved merely by introducing isolated environmental or social indicators. Instead, sustainability-related information must become embedded in strategic planning, budgeting, control, costing, and performance-management processes.

Strategic cost management constitutes one of the most important mechanisms through which SMA can contribute to sustainability. Conventional accounting systems often record environmental costs in aggregated overhead categories, making it difficult for managers to identify the economic consequences of waste, emissions, inefficient resource utilization, regulatory compliance, pollution prevention, and environmental innovation. Strategic cost management addresses this limitation by examining cost structures in relation to strategic objectives, value-chain activities, competitive positioning, and long-term organizational performance. Evidence from environmental cost management suggests that organizations can improve managerial understanding of environmental expenditures when such costs are systematically identified and integrated

into strategic performance analysis [8]. Environmental management accounting (EMA) has therefore emerged as an important extension of management accounting because it combines physical information regarding materials, energy, waste, and emissions with monetary information about related costs and benefits. Recent systematic evidence indicates that EMA can provide essential information for strategic decision-making by enabling managers to understand environmental impacts in economic terms and by supporting resource-efficiency, investment, and environmental-performance decisions [9]. In this regard, environmental accounting is not simply an auxiliary reporting technique; it may operate as a strategic mechanism linking environmental concerns to managerial decision processes.

The relationship between environmental management accounting and organizational performance is also influenced by broader organizational capabilities. Empirical evidence indicates that EMA can contribute to firm performance through mechanisms such as environmental innovation and stakeholder integration, suggesting that accounting information produces greater value when it is connected to organizational processes that convert environmental information into innovation, coordination, and stakeholder-responsive action [10]. Similarly, the integration of environmental management accounting with business strategies has been shown to facilitate environmental performance and sustainable development, particularly when sustainability is incorporated into strategic orientation rather than treated as an isolated compliance activity [11]. These findings emphasize the need to conceptualize sustainable development as the outcome of interacting managerial mechanisms. Strategic accounting information may influence sustainability through several intermediate pathways, including strategic planning, operational alignment, environmental innovation, resource productivity, cost reduction, and performance control. Therefore, the sustainability consequences of SMA should be examined structurally rather than as a simple direct relationship between an accounting practice and a final sustainability outcome.

This structural perspective is further supported by the increasing integration of strategic management accounting and sustainability practices in manufacturing environments. Manufacturing organizations are particularly exposed to sustainability challenges because their activities are often associated with significant consumption of materials, energy, water, and other resources, as well as waste generation and environmental externalities. Research on green manufacturing demonstrates that strategic management accounting practices can contribute to sustainability by providing information that supports cost control, environmental decision-making, strategic planning, and performance evaluation [12]. The relevance of SMA is similarly evident in sustainable construction businesses, where accounting strategy and sustainability-related management practices influence organizational capability to balance economic, environmental, and operational objectives [13]. These studies suggest that sustainability performance increasingly depends on the ability of firms to establish information systems that connect strategic objectives to operational processes. In such settings, techniques including value chain costing, target costing, competitor cost analysis, strategic budgeting, and environmental management accounting can potentially function as complementary tools for improving the quality of strategic decisions.

The strategic dimension of sustainable development also requires organizations to incorporate environmental and social considerations into long-term planning processes. Strategic planning defines organizational priorities, competitive directions, resource commitments, and performance objectives; accordingly, sustainability cannot become operational unless it is reflected in strategic analysis and resource allocation. Sustainable development therefore depends not only on the availability of accounting information but also on the capacity of managers to utilize such information in strategy formulation, budgeting, strategic resource allocation, and strategic review and control. Research proposing strategic environmental performance models has highlighted the importance of strategic management accounting in creating an information foundation for environmental performance management and strategic sustainability decisions [14]. Likewise, research on management accounting models for sustainable development has emphasized the need for accounting frameworks capable of integrating economic, environmental, and social information to support sustainable organizational decision-making [15]. These perspectives support the argument that strategic planning and strategic management accounting should be regarded as mutually reinforcing organizational capabilities rather than independent managerial functions.

The importance of this integration becomes even more pronounced under conditions of uncertainty and crisis. Contemporary organizations operate in environments

characterized by technological disruption, geopolitical uncertainty, supply-chain instability, environmental risks, and rapidly changing stakeholder expectations. Under such conditions, static accounting systems may fail to provide managers with timely and strategically relevant information. Research on strategic management accounting under crisis conditions has shown the importance of developing accounting databases capable of supporting strategic decisions when uncertainty and environmental complexity increase [16]. Scenario planning research has also emphasized the interaction between social responsibility, management accounting, and corporate economic development, suggesting that accounting systems can support the evaluation of alternative futures and help organizations integrate social considerations into strategic planning [17]. Such findings demonstrate that sustainability-oriented accounting systems need to be dynamic, forward-looking, and capable of supporting adaptive strategic management rather than merely documenting past outcomes.

Technological developments have further expanded the potential scope of management accounting. Artificial intelligence, advanced analytics, automation, and digital information systems are transforming the collection, analysis, and interpretation of managerial accounting information. A comprehensive review of artificial intelligence in management accounting shows that AI can significantly enhance forecasting, anomaly detection, decision support, cost analysis, and the processing of complex accounting information, although its effective implementation also requires new competencies, governance mechanisms, and ethical considerations [18]. In sustainability-related contexts, digital-enabled sustainability management accounting can improve organizational ability to integrate diverse forms of environmental, operational, and financial information and use them to enhance sustainable performance [19]. These developments strengthen the strategic relevance of management accounting because digital systems can facilitate more timely monitoring of sustainability indicators, more sophisticated modeling of resource use and costs, and stronger links between strategic objectives and operational performance. However, technology alone cannot guarantee sustainability outcomes; its effectiveness depends on how digital information is incorporated into organizational planning, control, and managerial decision processes.

Another important consideration concerns the conceptual and educational evolution of strategic management accounting. The growing sustainability orientation of contemporary organizations has created a need to reconsider the competencies expected of management accountants and strategic decision-makers. Scholars have argued that sustainability should be embedded within the teaching and conceptualization of SMA because strategic accounting decisions increasingly involve ecological impacts, stakeholder interests, social responsibility, and long-term value creation [20]. This perspective implies that SMA should no longer be conceptualized exclusively in terms of competitive advantage or financial performance. Instead, the strategic management accountant increasingly acts as an organizational partner who can contribute to sustainability by integrating financial information with environmental and social measures. The evolution of this role corresponds with broader calls for accountants to participate actively in strategic planning, sustainability governance, and organizational transformation rather than functioning solely as providers of financial control information.

Sustainability itself is a multidimensional construct, and this multidimensionality has significant implications for the design of management accounting systems. Corporate sustainability involves economic viability, environmental integrity, and social responsibility, and the relationships among these dimensions are not necessarily linear or harmonious. Organizations frequently encounter trade-offs between short-term profitability and long-term environmental investments, between cost reduction and social responsibility, and between competitive pressures and stakeholder expectations. Research on corporate engagement with sustainability indicates that organizations may be motivated by a combination of ethical and business-case considerations, and that the economic rationale for sustainability often coexists with normative and stakeholder-based motivations [21]. Consequently, accounting systems designed for sustainability should provide information capable of illuminating both economic consequences and broader sustainability impacts. A narrow focus on financial metrics may cause managers to underestimate long-term environmental costs, reputational risks, social impacts, and opportunities for resource efficiency or innovation.

The interaction among sustainability orientation, management accounting control, and corporate performance further supports an integrated framework. Organizations that develop sustainable business models require mechanisms for translating sustainability commitments into measurable objectives, resource allocations, operational responsibilities, and performance controls. Management accounting can provide these mechanisms by establishing indicators,

budgets, costing procedures, monitoring systems, and feedback loops. When aligned with strategic planning, such systems can contribute to sustainable performance by increasing resource productivity, improving economic efficiency, reducing environmental costs, and strengthening social responsibility. These improvements can subsequently support broader economic, environmental, and social sustainability outcomes. Thus, sustainable development may be more accurately understood as the highest-level outcome of a hierarchical chain of managerial capabilities and performance improvements rather than as the immediate consequence of individual accounting practices.

Despite the growing literature, important conceptual gaps remain. Much of the existing research investigates individual relationships, such as the effect of environmental management accounting on firm performance, the relationship between SMA practices and strategy, or the contribution of management accounting control to sustainable business models. Although these studies have generated valuable evidence, the literature remains fragmented regarding the structural relationships among strategic management accounting, strategic planning, operational drivers, sustainable performance improvement, and sustainable development. Reviews of strategic management accounting have explicitly called for more integrated research that clarifies the relationships among SMA techniques, contextual variables, strategic orientation, and organizational outcomes [3]. Likewise, sustainability management accounting reviews highlight the importance of understanding multilevel linkages between accounting practices and sustainability management processes [1]. A structural approach is therefore necessary to determine which components function as foundational drivers, which operate as intermediary mechanisms, and which represent dependent outcomes.

This issue is particularly important in manufacturing companies, where sustainability performance depends on coordinated decisions across finance, accounting, operations, strategy, and environmental management. For example, competitor cost analysis can inform strategic positioning; value chain costing can identify cost and sustainability implications across activities; target costing can integrate cost objectives into product and process design; environmental management accounting can reveal the financial consequences of environmental impacts; and strategic cost management can connect cost structures with long-term competitive and sustainability objectives. At the same time, strategic planning activities such as internal and external environmental analysis, formulation of competitive strategies, strategic resource allocation, strategic budgeting, and strategy review and control can provide the organizational architecture within which accounting information becomes actionable. These strategic capabilities can subsequently influence executive and operational drivers, including organizational value management, alignment of operational objectives with strategy, and performance monitoring. Through these mechanisms, firms may improve resource productivity, economic efficiency, environmental-cost reduction, and social responsibility, ultimately contributing to economic, social, and environmental dimensions of sustainable development. Such a hierarchical conceptualization also responds to the need for management accounting systems to connect organizational knowledge, coordination, and performance processes [5].

Interpretive Structural Modeling (ISM) provides an appropriate methodological framework for examining such complex interrelationships because it enables researchers to identify the direction and hierarchy of relationships among multiple interconnected factors. Instead of assuming that all variables occupy the same conceptual level, ISM allows the construction of a structured model in which highly influential variables can be distinguished from intermediary and dependent variables. This is particularly useful in the context of strategic management accounting and sustainability, where several accounting, strategic, operational, and performance-related mechanisms may interact simultaneously. Complementary MICMAC analysis can further classify the identified components according to their driving and dependence powers, thereby distinguishing independent drivers, linkage variables, dependent variables, and autonomous factors. Such an approach can contribute to theory by clarifying the architecture through which SMA may support sustainable development and can also provide managers with a practical understanding of which organizational capabilities should receive priority in sustainability-oriented transformation.

In light of the increasing strategic importance of sustainability, the expanding scope of strategic management accounting, the growing role of environmental and digital accounting information, and the lack of an integrated hierarchical explanation of the mechanisms connecting accounting practices to sustainable development, there is a clear need for a structured model capable of identifying the relative position and influence of the key components involved. Accordingly, the present study aims to develop an Interpretive Structural Modeling (ISM)-based model of the

role of strategic management accounting in enhancing sustainable development.

2. Methodology

From the perspective of purpose, this study is applied–fundamental in nature. On the one hand, because it seeks to develop a model explaining the role of strategic management accounting in sustainable development through Interpretive Structural Modeling (ISM), it can be regarded as fundamental research. On the other hand, because the findings are intended to be applied in real organizational settings, it also possesses an applied orientation. Based on the nature of the research process and the types of data employed, this study falls within the category of mixed-methods research and adopts inductive reasoning to discover and analyze the phenomena under investigation. In terms of research purpose, the study is exploratory, while in terms of implementation method, it is descriptive–analytical and survey-based. With respect to the time dimension, the study was conducted at a specific point in time and is therefore considered cross-sectional.

The structure of the present study comprises qualitative and quantitative sections and follows a descriptive–analytical approach. The descriptive section is devoted to describing the demographic and professional characteristics of the statistical sample, including experts in the qualitative phase and respondents in the quantitative phase. In the analytical section, the relationships among the variables were examined and the research assumptions were tested. Data were collected using both library-based methods for developing the theoretical foundations and reviewing the literature, and field methods, including semi-structured interviews and questionnaires.

The statistical population of this study consisted of experts in the field of management accounting, including managers and heads of finance and accounting departments in manufacturing companies. The eligibility criteria for selecting experts included holding postgraduate qualifications (master's or doctoral degrees) in accounting or financial management and having at least 10 years of specialized and executive experience in management accounting. In the qualitative phase, purposive sampling continued until "theoretical saturation" was achieved; that is, the interview process continued until no new information emerged and the identified categories became repetitive. Accordingly, theoretical saturation was reached after conducting 15 in-depth interviews with selected experts, at which point sampling was discontinued.

3. Findings and Results

At this stage, the Content Validity Ratio (CVR) was used to determine the content validity of each component. For this purpose, a questionnaire was distributed among the experts, who were asked to evaluate each item using a three-point scale consisting of "essential," "useful but not essential," and "not essential." Given that the expert panel consisted of 15 individuals, the content validity of an item was considered acceptable if its CVR value exceeded 0.49. The results obtained from applying the Content Validity Ratio (CVR) are presented in Table 1.

Table 1. Classification of Items into Components

No.	Items	CVR Value	Components	Result
1	Competitor cost analysis	1	Strategic management accounting	Confirmed
2	Value chain costing	1	Strategic management accounting	Confirmed
3	Target costing	1	Strategic management accounting	Confirmed
4	Environmental management accounting	1	Strategic management accounting	Confirmed
5	Strategic cost management	1	Strategic management accounting	Confirmed
6	Analysis of the internal and external environment	1	Strategic planning	Confirmed
7	Formulation of competitive strategies	1	Strategic planning	Confirmed
8	Strategic resource allocation	1	Strategic planning	Confirmed
9	Strategic budgeting	1	Strategic planning	Confirmed
10	Strategy review and control	1	Strategic planning	Confirmed
11	Organizational value management	1	Executive and operational drivers	Confirmed
12	Alignment of operational objectives with strategy	1	Executive and operational drivers	Confirmed
13	Performance control and monitoring	1	Executive and operational drivers	Confirmed
14	Resource productivity	1	Sustainable performance improvement	Confirmed
15	Economic efficiency	1	Sustainable performance improvement	Confirmed
16	Reduction of environmental costs	1	Sustainable performance improvement	Confirmed
17	Social responsibility	1	Sustainable performance improvement	Confirmed

18	Economic sustainable development	1	Sustainable development enhancement	Confirmed
19	Social sustainable development	1	Sustainable development enhancement	Confirmed
20	Environmental sustainable development	1	Sustainable development enhancement	Confirmed

Table 2. CVR Values of the Main Variables

No.	Components	Items	CVR Value	Result
1	Strategic management accounting	1–5	1	Confirmed
2	Strategic planning	6–10	1	Confirmed
3	Executive and operational drivers	11–13	1	Confirmed
4	Sustainable performance improvement	14–17	1	Confirmed
5	Sustainable development enhancement	18–20	1	Confirmed

The results indicated that all five variables were accepted and that the experts reached complete consensus regarding their inclusion in the model.

Step 1: Identification of Components Related to the Research Problem

As explained in the previous section, 20 items extracted from interviews with experts were confirmed and classified into five components. The Content Validity Ratio (CVR) was used to validate these components. All five components were confirmed by the experts. Accordingly, these five components were used to develop the model.

Table 3. Components Identified for Model Development

No.	Components
1	Strategic management accounting
2	Strategic planning
3	Executive and operational drivers
4	Sustainable performance improvement
5	Sustainable development enhancement

Step 2: Formation of the Structural Self-Interaction Matrix

After identifying the factors, the ISM questionnaire was developed, and the experts examined the factors pairwise and determined the relationships among them using the following symbols:

V: Factor *i* influences factor *j*.

A: Factor *j* influences factor *i*.

X: Factors *i* and *j* mutually influence each other.

O: No relationship exists between factors *i* and *j*.

The results obtained from the questionnaires concerning the components under investigation are presented in the following table.

Table 4. Results Obtained from the Questionnaires

No.	Components	1	2	3	4	5
1	Strategic management accounting	0	25	36	39	28
2	Strategic planning	24	0	37	40	27
3	Executive and operational drivers	10	10	0	36	29
4	Sustainable performance improvement	8	12	20	0	42
5	Sustainable development enhancement	10	10	14	20	0

Step 3: Formation of the Initial Reachability Matrix

The initial reachability matrix is obtained by expressing the relationships in binary form (0 and 1) based on the Structural Self-Interaction Matrix and through two stages.

In the first stage, a single numerical threshold is established, and the values in the preceding table are compared against this threshold. If a value in the table is greater than the threshold, it is assigned a value of 1 in the new matrix; otherwise, it is assigned a value of 0 (Azar et al., 2014).

Bolaños et al. (2005) proposed the following formula for determining the threshold value:

M = 2 × n

where *n* represents the number of respondents and *M* represents the threshold value. Since the number of experts was 15, the following value was obtained:

M = 2 × n = 30

Therefore, according to the logic proposed by Bolaños et al. (2005), all values in Table 4 that are less than 30 are converted to zero (0), whereas values greater than or equal to 30 are converted to one (1). Table 5 presents the resulting Structural Self-Interaction Matrix.

Table 5. Structural Self-Interaction Matrix

No.	Components	1	2	3	4	5
1	Strategic management accounting	0	0	1	1	0
2	Strategic planning	0	0	1	1	0
3	Executive and operational drivers	0	0	0	1	0
4	Sustainable performance improvement	0	0	0	0	1
5	Sustainable development enhancement	0	0	0	0	0

In the second stage, the matrix obtained in the first stage is combined with the identity matrix to derive the initial reachability matrix. Through this process, all diagonal values are converted from 0 to 1. Table 6 presents the initial reachability matrix.

Table 6. Initial Reachability Matrix

No.	Components	1	2	3	4	5
1	Strategic management accounting	1	0	1	1	0
2	Strategic planning	0	1	1	1	0
3	Executive and operational drivers	0	0	1	1	0
4	Sustainable performance improvement	0	0	0	1	1
5	Sustainable development enhancement	0	0	0	0	1

Step 4: Formation of the Final Reachability Matrix

After obtaining the initial reachability matrix, the transitive relationships among the components are examined. A transitive relationship exists when component *i* leads to component *j*, and component *j* subsequently leads to component *k*; under such conditions, component *i* is also assumed to lead to component *k*. If this transitivity condition is not reflected in the initial reachability matrix, the matrix must be modified by adding the omitted relationships. This process is commonly referred to as checking and incorporating transitivity into the initial reachability matrix. At this stage, all transitive relationships among the components were examined, and three transitive relationships were identified. These relationships are marked with *1 in Table 7. In addition, the driving power and dependence power of each component are presented in this matrix. The driving power of a component is calculated as the total number of components influenced by that component, including the component itself. The dependence power of a component is calculated as the total number of components that influence it, including the component itself.

Table 7. Final Reachability Matrix

No.	Components	1	2	3	4	5	Driving Power
1	Strategic management accounting	1	0	1	1	*1	4
2	Strategic planning	0	1	1	1	*1	4
3	Executive and operational drivers	0	0	1	1	*1	3
4	Sustainable performance improvement	0	0	0	1	1	2
5	Sustainable development enhancement	0	0	0	0	1	1
	Dependence Power	1	1	3	4	5	

Step 5: Determining Relationships and Level Partitioning of the Factors

At this stage, the reachability matrix is used to determine the reachability and antecedent sets, after which the intersection of these sets is identified for each component.

- The **reachability set** of a component consists of the component itself and all other components that it influences, which can be identified through the entries marked "1" in the corresponding row.
- The **antecedent set** of a component consists of the component itself and all other components that influence it, which can be identified through the entries marked "1" in the corresponding column.

After determining the reachability and antecedent sets, their intersection is identified for each component. Components whose reachability set and intersection set are identical are placed at the highest level of the Interpretive Structural Model hierarchy. To identify the components constituting the next level of the system, the components assigned to the highest level are removed from the mathematical calculations in the corresponding table, and the same procedure used for identifying the highest-level components is repeated. This process continues until the components at all levels of the system have been identified.

Table 8 presents the first iteration of the level-partitioning process.

Table 8. Level Partitioning (Iteration 1)

No.	Components	Reachability Set	Antecedent Set	Intersection Set	Level
1	Strategic management accounting	5, 4, 3, 1	1	1	
2	Strategic planning	5, 4, 3, 2	2	2	
3	Executive and operational drivers	5, 4, 3	3, 2, 1	3	
4	Sustainable performance improvement	5, 4	4, 3, 2, 1	4	
5	Sustainable development enhancement	5	5, 4, 3, 2, 1	5	1

As shown in Table 8, the reachability set and intersection set of Component 5 (sustainable development enhancement) are identical. Therefore, Component 5 (sustainable development enhancement) is assigned to Level 1 and is removed from the above table before proceeding with the subsequent stages of level partitioning. The remaining stages of the level-partitioning process are summarized in Table 9.

Table 9. Level Partitioning (Subsequent Iterations)

Iteration	Components	Reachability Set	Antecedent Set	Intersection Set	Level
Second	Sustainable performance improvement	4	4, 3, 2, 1	4	2
Third	Executive and operational drivers	3	3, 2, 1	3	3
Fourth	Strategic management accounting	1	1	1	4
Fourth	Strategic planning	2	2	2	4

Finally, Component 1 (strategic management accounting) and Component 2 (strategic planning) are positioned at Level 4, thereby completing the level-partitioning process.

Step 6: Developing the Final Model

At this stage, an initial model is constructed based on the levels of the components and the final reachability matrix. The final model is then obtained by eliminating transitive relationships from the initial model. Accordingly, the final ISM derived from the components associated with sustainable development enhancement is illustrated in Figure 1.

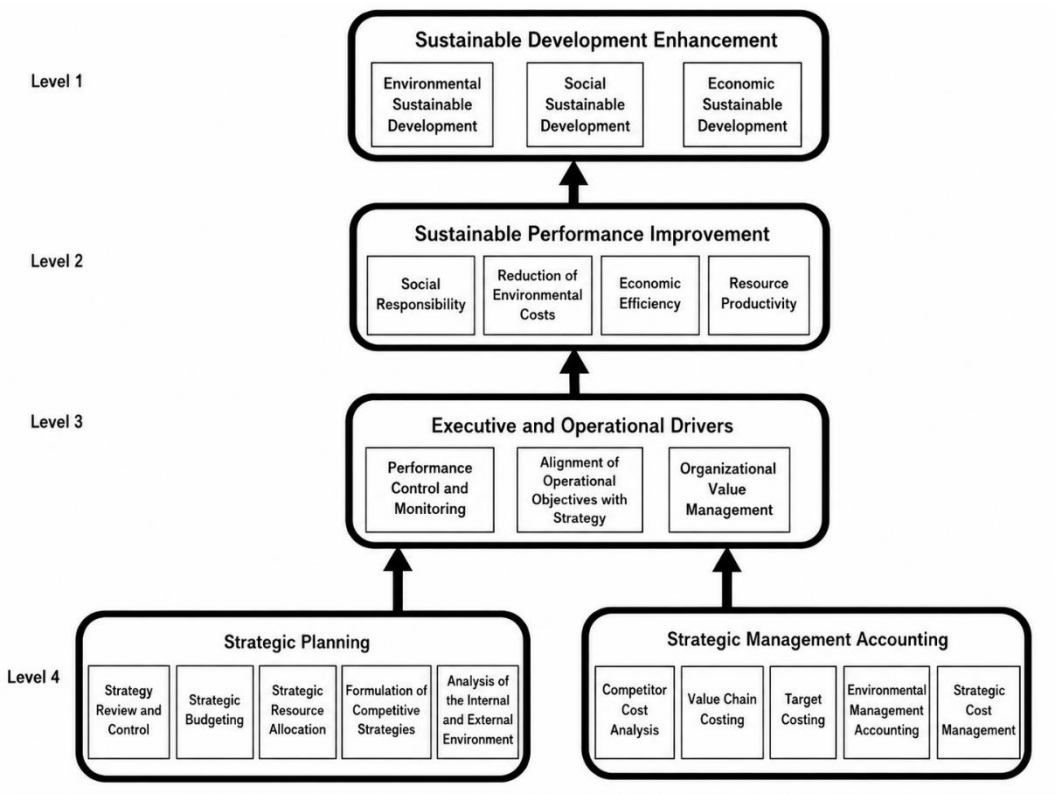

Figure 1. Initial ISM Model

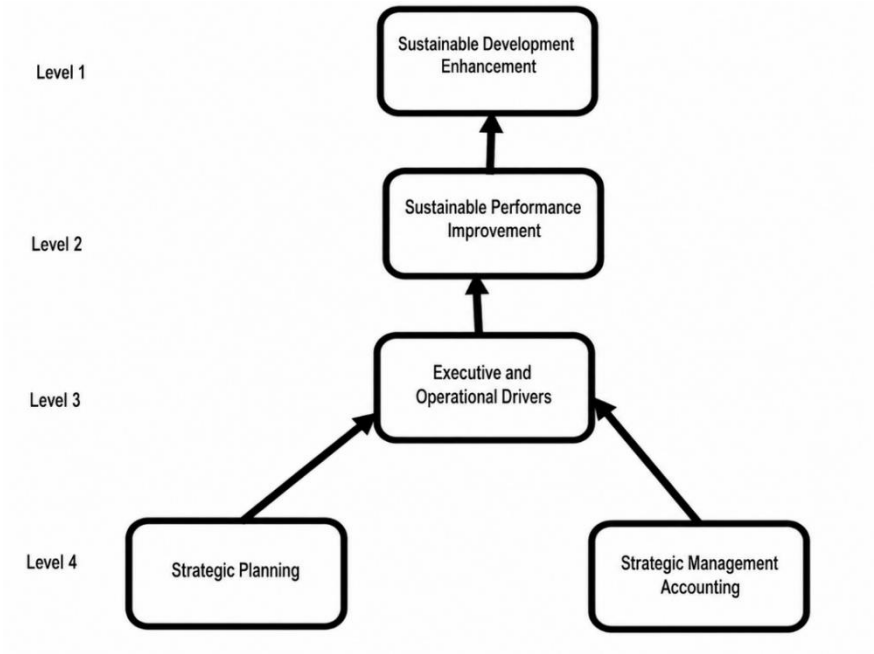

Figure 2. Final ISM Model

As shown in Figure 2, the five components constituting the model are distributed across four levels. Component 5 (sustainable development enhancement), which is located at Level 1 of the ISM graph, is the most affected and highly dependent component in the model. At the lowest or foundational level (Level 4), Component 1 (strategic management accounting) and Component 2 (strategic planning) are positioned as the most influential components with the greatest driving power. At Level 2, Component 4 (sustainable performance improvement) influences

Component 5 (sustainable development enhancement), which is located at Level 1, while simultaneously being influenced by components positioned at lower, more foundational levels. At Level 3, Component 3 (executive and operational drivers) influences components at higher levels while being affected by components located at the foundational level.

Step 7: Analysis of Driving Power and Dependence Power (MICMAC Analysis)

At this stage, the components are classified into four groups. The first group consists of **autonomous components** (Quadrant 1), which have weak driving power and weak dependence. These components are relatively disconnected from the other components and have limited relationships with them. The second group consists of **dependent components** (Quadrant 2), which have weak driving power but high dependence. The third group includes **linkage components** (Quadrant 3). These components possess both high driving power and high dependence. In practice, any action affecting these components may result in changes in other components. The fourth group consists of **independent or driver components** (Quadrant 4). These components have high driving power and low dependence. Components possessing high driving power are generally referred to as key components. Clearly, such components fall within either the independent or linkage categories. The driving power and dependence power of each component are calculated by summing the entries marked "1" in each corresponding row and column. On this basis, the driving power–dependence diagram is constructed.

Using the data obtained in Step 4, the components under investigation can be categorized according to the driving power of each component over the other components and its dependence on the other components into the following four categories:

1. **Autonomous:** Components that have minimal dependence on and minimal driving power over other components.
2. **Dependent:** Components that exhibit a high degree of dependence on other components.
3. **Linkage:** Components that have reciprocal relationships with other components.
4. **Independent (Driver):** Components that exert substantial influence over other components.

To determine the coordinates of each component in the MICMAC matrix, the driving power and dependence power of that component must be used. These values are derived from the final reachability matrix. Table 10 presents the driving power and dependence power of each component.

Table 10. Driving Power and Dependence Power of the Components

No.	Components	Dependence Power	Driving Power
1	Strategic management accounting	1	4
2	Strategic planning	1	4
3	Executive and operational drivers	3	3
4	Sustainable performance improvement	4	2
5	Sustainable development enhancement	5	1

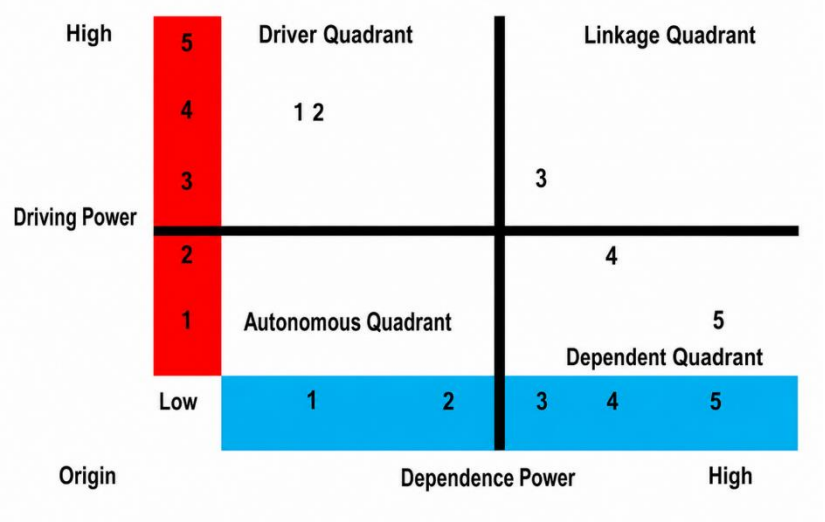

Figure 3. MICMAC Matrix

Based on the results obtained from the MICMAC cross-impact matrix, the dependence and influence patterns of the model's main components can be identified precisely. According to the analysis, Component 4 (sustainable performance improvement) and Component 5 (sustainable development enhancement) are located in the dependent quadrant. This position indicates that these components have relatively low driving power but a high level of dependence on other components within the system. In other words, their realization and effective functioning are strongly influenced by other key variables, and they cannot independently perform a driving or guiding role. By contrast, Component 1 (strategic management accounting) and Component 2 (strategic planning) are positioned in the independent or driver quadrant. This classification indicates that these two components possess high driving power and minimal dependence on other components. Thus, they function as strategic and driving factors within the model structure, and changes in these components may generate extensive and consequential effects across the other dimensions of the system. Component 3 (executive and operational drivers), meanwhile, is located in the linkage quadrant. This position indicates that this component has relatively high levels of both driving power and dependence, making it a sensitive and potentially unstable component characterized by reciprocal effects. Changes in this component can immediately affect other components in the model while simultaneously being influenced by changes occurring in those components. With the completion of this analysis and the identification of the position of each component within the four main MICMAC quadrants, the Interpretive Structural Modeling (ISM) process for developing the final model is completed. The results of this stage provide a valid and systematic basis for depicting the hierarchical structure and determining the causal relationships among the components in the subsequent stages of the research.

4. Discussion and Conclusion

The present study aimed to develop a structural model explaining the role of strategic management accounting in enhancing sustainable development. The findings derived from Interpretive Structural Modeling (ISM) showed that the five principal components of the proposed framework were distributed across four hierarchical levels. Strategic management accounting and strategic planning were positioned at the fourth and most foundational level and exhibited the greatest driving power, whereas executive and operational drivers were located at the third level as an intermediary mechanism. Sustainable performance improvement occupied the second level, and sustainable development enhancement was positioned at the first and most dependent level. The MICMAC analysis further demonstrated that strategic management accounting and strategic planning were independent or driving components, executive and operational drivers constituted a linkage component, and sustainable performance improvement and sustainable development enhancement represented dependent components. Taken together, these findings indicate that sustainable development does not emerge directly from isolated accounting practices; rather, it is the ultimate result of a hierarchical process in which strategic accounting information and strategic planning shape operational mechanisms, which subsequently improve sustainability-related performance and ultimately contribute to economic, social, and environmental development.

One of the most important findings was the placement of strategic management accounting at the foundational level of the model, with high driving power and low dependence. This result suggests that strategic management accounting acts as a primary organizational capability that can initiate and influence subsequent changes throughout the sustainability system. In the present model, strategic management accounting comprised competitor cost analysis, value chain costing, target costing, environmental management accounting, and strategic cost management. The centrality of these practices is consistent with the broader literature that conceptualizes strategic management accounting as a future-oriented and externally focused information system capable of supporting strategic decisions. Systematic evidence indicates that strategic management accounting practices enhance the strategic relevance of accounting by extending attention beyond internal cost control toward competitors, customers, markets, value chains, and long-term positioning [3]. Similarly, the role of management accounting systems in generating, organizing, and sharing strategically useful information has been shown to support organizational coordination and decision effectiveness [5]. Therefore, the high driving power of strategic management accounting in the present study can be explained by its capacity to provide decision-makers with the information necessary to evaluate strategic alternatives, identify inefficiencies, allocate resources, and connect economic objectives with environmental and social considerations.

The identification of environmental management accounting as one of the core elements of strategic management accounting further reinforces the sustainability orientation of the proposed framework. Environmental management accounting makes environmental impacts visible in both physical and monetary terms by identifying information related to materials, energy use, waste, emissions, environmental expenditures, and resource efficiency. The present findings suggest that such information is not merely supplementary but forms part of the strategic foundation required for sustainable organizational transformation. This interpretation is strongly supported by Swalih et al., who concluded that environmental management accounting can improve strategic decision-making by providing managers with more relevant information concerning environmental costs and resource use [9]. Gerged et al. likewise showed that environmental management accounting contributes to firm performance through mechanisms such as environmental innovation and stakeholder integration [10]. Moreover, Appannan et al. found that organizational strategies and environmental management accounting can jointly promote environmental performance and sustainable development [11]. These studies support the structural position identified in the present research: environmental accounting practices function upstream in the sustainability process by shaping the information base on which strategic and operational sustainability decisions are made.

The second foundational driver identified in the ISM model was strategic planning. Strategic planning included analysis of the internal and external environment, formulation of competitive strategies, strategic resource allocation, strategic budgeting, and strategy review and control. Its position at the same hierarchical level as strategic management accounting suggests that sustainable development requires the interaction of strategic information and strategic action. Accounting systems may generate sustainability-relevant information, but such information can affect organizational outcomes only when it is incorporated into strategic priorities, budgets, resource commitments, and monitoring mechanisms. This finding is consistent with research emphasizing the integration of strategy and management accounting in achieving sustainability objectives. Pumiviset and Suttipun found that strategic management accounting practices within green manufacturing environments are closely associated with sustainability-oriented strategic processes [12]. Similarly, Jafari et al. emphasized the role of strategic management accounting in constructing strategic environmental performance frameworks, implying that accounting information becomes valuable when linked with strategic planning and environmental performance objectives [14]. The results also correspond with the findings of Pramono et al., who showed that strategic management accounting influences strategic supply-chain processes through internal and external orientations [4]. Thus, strategic planning can be interpreted as the mechanism through which strategic accounting information is transformed into organizational priorities and coordinated actions.

The simultaneous placement of strategic management accounting and strategic planning at the foundational level also indicates that these two components are mutually complementary. Neither is sufficient on its own to produce sustainable development. Strategic planning without reliable accounting information may result in goals and resource commitments that are insufficiently grounded in cost, performance, environmental, or competitive evidence. Conversely, sophisticated accounting practices without strategic integration may generate information that remains disconnected from managerial action. This complementary relationship has become increasingly important as sustainability challenges have expanded the range of information that managers must consider. Schaltegger et al. demonstrated that sustainability management accounting operates through multilevel organizational linkages, suggesting that accounting tools must connect organizational strategies, management processes, and operational activities rather than functioning in isolation [1]. Alawattage and Wickramasinghe similarly argued for integrating sustainability into strategic management accounting because contemporary strategic decisions increasingly involve environmental, social, and long-term value considerations [20]. The present findings extend these arguments by positioning accounting and planning together as the primary driving layer of the structural model.

At the third level, executive and operational drivers were identified as the linkage component connecting foundational strategic variables with sustainability performance outcomes. This component included organizational value management, alignment of operational objectives with strategy, and performance control and monitoring. Its position in the linkage quadrant of the MICMAC analysis indicates both relatively high driving power and relatively high dependence. In other words, executive and operational drivers are influenced by strategic management accounting and strategic planning, but they also exert substantial

influence on subsequent performance outcomes. This result is conceptually important because it demonstrates that strategies and accounting information must be translated into operational routines before sustainability improvements can occur. Management accounting control mechanisms can provide this translation by linking objectives, responsibilities, performance indicators, and feedback systems. Al-Baghdadi et al. showed that management accounting control plays a mediating role in the relationship between sustainable business models and corporate performance [2]. This evidence supports the present finding that operational and control mechanisms constitute a bridge between strategic sustainability orientation and organizational outcomes.

The mediating role of executive and operational drivers can also be explained through organizational alignment. Sustainable development requires managers to ensure that strategic objectives are reflected in departmental goals, employee responsibilities, budgeting practices, resource allocation, and performance measurement. If sustainability is formally included in corporate strategy but not embedded in operational systems, the organization may experience a strategy–implementation gap. The findings of the present study suggest that aligning operational objectives with strategy and continuously monitoring performance are essential mechanisms for reducing such a gap. Research on strategic management accounting under crisis conditions similarly emphasizes the importance of accounting databases and decision-support systems capable of enabling managers to translate environmental uncertainty into coordinated strategic actions [16]. Mohebi et al. also highlighted the importance of combining management accounting and social responsibility within scenario planning for corporate economic development [17]. These studies support the conclusion that sustainability depends not only on strategy formulation but also on organizational mechanisms that transmit, operationalize, and monitor strategic commitments.

The second hierarchical level consisted of sustainable performance improvement, represented by resource productivity, economic efficiency, reduction of environmental costs, and social responsibility. This finding indicates that improvements in sustainable performance function as intermediate outcomes rather than as the ultimate objective of the system. Sustainable performance is therefore generated through the combined influence of strategic accounting, strategic planning, and operational implementation. The importance of resource productivity and environmental cost reduction is consistent with research on strategic cost management. Henri et al. demonstrated that strategic management of environmental costs can improve organizational understanding of the economic implications of environmental activities and can strengthen performance management [8]. Likewise, Saeidi et al. found that management accounting can mediate the relationship between cost-system design and firm performance, indicating that appropriate accounting information helps transform cost-management capabilities into performance outcomes [7]. These findings reinforce the present model by suggesting that sustainable performance is not automatically produced by accounting systems; instead, accounting systems influence performance through managerial use, strategic integration, and operational control.

The inclusion of social responsibility alongside economic efficiency and environmental-cost reduction also demonstrates the multidimensional nature of sustainable performance. This result is important because it indicates that sustainable organizational performance should not be reduced to environmental efficiency alone. Firms must simultaneously address economic viability, environmental impact, and social responsibility. Schaltegger and Burritt argued that corporate sustainability engagement is shaped by both business-case and ethical motivations, meaning that organizations pursue sustainability through a combination of economic, reputational, stakeholder, and normative considerations [21]. In a similar direction, Mohebi et al. emphasized the integration of social responsibility and management accounting within long-term corporate development [17]. Therefore, the placement of social responsibility within sustainable performance improvement is consistent with the broader understanding of sustainability as an integrated organizational construct rather than a narrowly environmental one.

At the first hierarchical level, sustainable development enhancement was identified as the ultimate and most dependent component of the model. It encompassed economic, social, and environmental sustainable development. Its very high dependence power indicates that sustainable development is primarily an outcome generated by the functioning of upstream strategic, operational, and performance-related variables. This finding is consistent with the proposition that organizations cannot achieve sustainable development merely by declaring sustainability objectives. Instead, economic, social, and environmental sustainability must emerge from integrated managerial systems that guide planning, resource use, cost management,

performance control, and organizational responsibility. Amirbeiki Langroudi et al. similarly emphasized the need for management accounting models that integrate information relevant to the multiple dimensions of sustainable development [15]. The present model provides further structural clarification by showing that sustainable development is located at the endpoint of a chain in which strategic accounting and planning influence operational mechanisms, which then produce improvements in sustainable performance.

The results concerning sustainable development are also consistent with empirical evidence from sustainability-oriented industries. Kasorn et al. highlighted the importance of accounting strategic management in sustainable construction organizations, indicating that accounting-related strategic capabilities can contribute to the integration of organizational performance and sustainability objectives [13]. Research in green manufacturing has likewise demonstrated that sustainability is strengthened when strategic management accounting is integrated with organizational strategy and environmentally oriented practices [12]. Appannan et al. further showed that strategic approaches and environmental management accounting can promote sustainable development through improvements in environmental performance [11]. Collectively, these studies provide empirical support for the present finding that sustainability is an organizational outcome dependent on the effective coordination of strategic, accounting, environmental, and operational capabilities.

The MICMAC classification provides additional insight into the dynamic structure of the proposed model. Strategic management accounting and strategic planning were located in the independent or driver quadrant, meaning that interventions directed toward these components are likely to generate effects throughout the system. Their low dependence suggests that they constitute relatively fundamental organizational capacities. Executive and operational drivers were classified as a linkage variable, indicating a potentially sensitive position because changes in this component can influence downstream variables while simultaneously responding to upstream drivers. Sustainable performance improvement and sustainable development enhancement were categorized as dependent variables, confirming that their realization is largely contingent on the proper functioning of earlier stages of the system. This arrangement reinforces the hierarchical logic of the ISM model and offers a managerial sequence for intervention: organizations should initially strengthen strategic accounting and strategic planning, subsequently improve operational alignment and performance control, and then expect improvements in sustainability-related performance and broader sustainable development.

Recent technological developments further strengthen the importance of the model's foundational accounting component. Digital technologies and artificial intelligence are increasingly changing the ways in which management accounting information is collected, processed, analyzed, and communicated. Abbas emphasized that artificial intelligence can expand the analytical and predictive capacity of management accounting through enhanced forecasting, automated analysis, and decision support [18]. More specifically, Alshahrani and Hakim demonstrated that digitally enabled sustainability management accounting can support sustainable organizational performance by improving the integration and use of sustainability-related information [19]. These findings suggest that the driving role of strategic management accounting identified in the present study may become even stronger as digital technologies enable firms to process increasingly complex combinations of financial, environmental, operational, and stakeholder data.

Overall, the findings indicate that the enhancement of sustainable development should be understood as a staged and interconnected managerial process. Strategic management accounting and strategic planning establish the informational and strategic foundation; executive and operational drivers translate that foundation into organizational action; sustainable performance improvement reflects the immediate organizational consequences; and economic, social, and environmental sustainable development constitutes the ultimate outcome. This hierarchical interpretation is compatible with the broader literature showing that management accounting becomes most effective when it is embedded within organizational strategy, control, knowledge systems, and performance management [1, 6]. The study therefore contributes to the literature by moving beyond fragmented relationships between individual accounting practices and sustainability indicators and by offering an integrated structural explanation of how strategic management accounting can contribute to sustainable development.

The present study has several limitations that should be considered when interpreting its findings. First, the qualitative phase relied on the judgments of 15 experts drawn from manufacturing companies, and although theoretical saturation was achieved, the relatively

specialized composition of the expert panel may limit the transferability of the findings to service, public-sector, financial, or non-profit organizations. Second, Interpretive Structural Modeling relies substantially on expert judgments regarding the direction and hierarchy of relationships; therefore, the resulting model reflects informed professional perceptions rather than experimentally established causal effects. Third, the cross-sectional nature of the study does not permit examination of how the proposed relationships may evolve over time as organizations modify their strategies, accounting systems, sustainability priorities, or technologies. Fourth, the model focuses on five major components and may not incorporate all contextual variables that could affect sustainable development, such as organizational culture, leadership commitment, regulatory pressure, market uncertainty, firm size, technological maturity, or stakeholder activism. Finally, the hierarchical structure simplifies potentially reciprocal and nonlinear relationships among the components, particularly in the case of executive and operational drivers, which may simultaneously influence and be influenced by other organizational mechanisms.

Future studies should empirically test the structural model using larger and more diverse samples and quantitative techniques such as structural equation modeling, partial least squares modeling, or longitudinal path analysis. Replication across manufacturing industries, service organizations, public institutions, and small and medium-sized enterprises could determine whether the identified hierarchy is context-specific or broadly generalizable. Longitudinal research would be especially useful for examining whether changes in strategic management accounting practices precede measurable improvements in operational alignment, sustainable performance, and sustainable development outcomes. Researchers could also examine potential moderators such as organizational size, environmental uncertainty, digital maturity, sustainability orientation, leadership support, and regulatory pressure. Further studies may disaggregate strategic management accounting into specific techniques and compare their relative effects on economic, environmental, and social sustainability. Comparative research across countries and institutional contexts could also clarify how regulatory frameworks and cultural conditions influence the effectiveness of the proposed relationships. In addition, future investigations could examine digital sustainability accounting, artificial intelligence, real-time data analytics, and integrated information systems as extensions of the present framework.

Managers should treat strategic management accounting and strategic planning as foundational capabilities in the pursuit of sustainable development rather than as separate administrative functions. Manufacturing companies should strengthen the systematic use of competitor cost analysis, value chain costing, target costing, environmental management accounting, and strategic cost management and explicitly incorporate the resulting information into strategic budgeting, resource allocation, competitive strategy formulation, and strategic control. Organizations should also establish mechanisms to align operational objectives with sustainability strategy, assign clear responsibilities for implementation, and continuously monitor economic, environmental, and social performance indicators. Particular attention should be given to improving resource productivity, reducing environmental costs, enhancing economic efficiency, and institutionalizing social responsibility because these represent the immediate performance pathways through which strategic accounting contributes to sustainable development. Investment in integrated information systems, staff training, cross-functional collaboration, and managerial dashboards can further strengthen the connection between accounting information and operational decision-making. By prioritizing foundational drivers before focusing exclusively on final sustainability outcomes, organizations can build a more coherent and durable pathway toward sustainable development.

Authors' Contributions

Authors equally contributed to this article.

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Declaration of Interest

The authors report no conflict of interest.

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Ethical Considerations

All procedures performed in this study were under the ethical standards.

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