

## GREEN COST ACCOUNTING AND SUSTAINABLE PRODUCTION: IMPLICATIONS FOR PROFITABILITY AND COMPETITIVE ADVANTAGE IN MANUFACTURING FIRMS

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### ABSTRACT

The growing pressure on manufacturing firms to minimize environmental impact has increased the strategic relevance of green cost accounting and sustainable production practices. Although many organizations invest in sustainability initiatives, there remains limited empirical evidence on whether these practices lead to measurable improvements in business performance. This study examines the relationship between green cost accounting, sustainable production efficiency, profitability, and competitive advantage in manufacturing firms. An empirical research design was employed using survey data collected from production and finance managers across selected manufacturing units. The analysis explores the extent to which firms integrate environmental costs into their costing systems and evaluates how these practices influence production decisions, resource utilization, and financial outcomes. The findings reveal that firms that systematically implement green cost accounting achieve higher production efficiency, stronger cost control, and enhanced profitability compared to firms operating under conventional costing and production systems. The results further indicate that sustainability-oriented firms are more likely to develop long-term competitive advantage through innovation capability, brand credibility, and regulatory preparedness. This study contributes to the emerging sustainability accounting literature by highlighting the strategic role of environmental cost integration in managerial decision-making. The paper concludes with practical and policy implications for manufacturing firms, industry regulators, and policymakers seeking to promote environmentally responsible and financially viable industrial growth.

**Keywords:** Green Cost Accounting; Sustainable Production; Environmental Costing; Profitability; Competitive Advantage; Manufacturing Firms; Sustainability Accounting; Resource Efficiency.

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### BACKGROUND

Manufacturing firms across the world are facing increasing pressure to operate in a manner that minimizes environmental damage while maintaining economic performance. Rising energy costs, resource scarcity, waste generation, and stricter environmental regulations have made sustainability a

central concern in industrial production. Traditional cost accounting systems often fail to capture the real financial impact of environmental activities, because many environmental costs such as waste disposal, emission treatment, and resource losses are grouped under indirect overheads. As a result, managers lack accurate information regarding the true costs of unsustainable production practices.

Green cost accounting has emerged as an important approach that integrates environmental costs into organizational costing and decision-making systems. By identifying, measuring, and allocating environmental costs to specific processes, firms gain clearer insights into how environmental practices affect production efficiency and financial outcomes. At the same time, sustainable production emphasizes efficient resource utilization, cleaner technologies, and waste reduction, aligning operational decisions with both environmental responsibility and business performance.

However, despite growing awareness of sustainability, there remains limited empirical evidence on whether green cost accounting actually contributes to profitability and competitive advantage in manufacturing firms. Many studies focus on environmental reporting and disclosure but pay less attention to how cost accounting systems shape production decisions and strategic outcomes. This research addresses that gap by examining how green cost accounting supports sustainable production and influences firm performance.

## Introduction

Sustainability has increasingly moved from the periphery of business strategy to the core of operational and financial decision-making in manufacturing firms. Environmental considerations are now closely linked to how firms manage costs, design production processes, and evaluate long-term competitiveness. Conventional accounting systems often overlook or underestimate environmental costs, leading to incomplete financial assessment of production activities. When environmental costs remain hidden within general overheads, firms fail to recognize inefficiencies arising from resource losses, pollution, or waste-intensive processes.

Green cost accounting provides a structured approach for integrating environmental costs into costing frameworks, making such costs visible and measurable. This enables managers to assess the financial implications of sustainability initiatives and to redesign production systems in ways that improve efficiency and profitability. Sustainable production further strengthens this approach by promoting responsible resource usage, cleaner technologies, energy efficiency, and waste reduction all of which have direct operational and financial benefits.

For manufacturing firms operating in competitive markets, the link between sustainability and profitability is particularly important. Firms must justify sustainability investments in terms of economic outcomes, risk reduction, innovation, and long-term strategic positioning. Yet, the existing body of research offers limited empirical insight into whether green cost accounting influences profitability, operational performance, or competitive advantage. Most prior studies emphasize sustainability reporting or environmental compliance rather than managerial decision-making and cost control.

This study responds to these gaps by examining the relationship between green cost accounting, sustainable production efficiency, profitability, and competitive advantage among manufacturing firms. The research positions green cost accounting not merely as a reporting tool, but as a strategic mechanism that supports informed production decisions and enhances organizational competitiveness.

## Literature Review

### Green Cost Accounting

Green cost accounting (GCA) refers to the systematic identification, measurement, and allocation of environmental costs within an organization's accounting system. Traditional cost accounting methods

often ignore or aggregate environmental costs under general overheads, limiting managers' understanding of the true cost implications of production processes. Studies by Cooper & Kaplan (2019) and Bebbington et al. (2020) highlight that GCA allows firms to trace costs related to waste treatment, pollution control, and energy consumption to specific production activities, thereby supporting more informed decision-making. Firms adopting green cost accounting can optimize resource utilization, reduce environmental risks, and improve financial transparency.

Empirical research has shown that the implementation of GCA positively influences operational efficiency. For example, in manufacturing sectors, firms that integrate environmental costs into process-level accounting tend to identify inefficiencies that would otherwise remain hidden, thereby improving overall production performance (Elkington, 2021). Moreover, environmental cost visibility encourages managers to prioritize investments in cleaner technologies and resource-efficient processes, aligning financial and sustainability objectives.

### **Sustainable Production**

Sustainable production emphasizes operational processes that minimize negative environmental impact while maintaining economic performance. According to UNEP (2020) and Sarkis et al. (2021), sustainable production involves cleaner technologies, waste reduction, and energy efficiency. Several studies indicate that when firms combine sustainable production practices with green cost accounting, they achieve better resource optimization and cost control. The literature also suggests that sustainable production contributes to enhanced organizational reputation and customer satisfaction, which indirectly supports profitability and long-term competitiveness (Hart, 2022).

Despite its growing importance, research on sustainable production has often focused on technological innovation rather than financial or strategic outcomes. There remains a gap in understanding how managerial accounting systems, specifically green cost accounting, influence the efficiency and effectiveness of sustainable production initiatives.

### **Profitability and Competitive Advantage**

Integrating sustainability into core operations can affect profitability and competitive positioning. Porter & Kramer (2019) argue that environmental responsibility can become a source of differentiation and long-term competitive advantage. Firms that adopt green cost accounting and sustainable production practices are better able to manage costs, improve operational efficiency, and make strategic decisions that enhance profitability. Empirical studies by Wang et al. (2021) in the manufacturing sector demonstrate a significant positive relationship between environmental cost integration and financial performance.

However, while these studies highlight potential benefits, there is limited research exploring the direct link between green cost accounting, sustainable production, and competitive advantage, especially in emerging economies. This gap indicates the need for empirical studies that examine whether sustainability-oriented accounting practices translate into measurable business outcomes.

### **Research Gap**

From the literature, several gaps emerge:

- ❖ Most studies focus either on sustainability reporting or sustainable production, but rarely integrate green cost accounting and operational decision-making in one framework.
- ❖ Limited empirical research exists on the effect of GCA on profitability and competitive advantage in manufacturing firms.
- ❖ There is insufficient evidence from emerging economies where environmental and cost pressures differ significantly from developed countries.

- ❖ Prior studies often ignore managerial perspectives and how accounting systems influence strategic and operational choices.
- ❖ This research aims to address these gaps by empirically examining the relationship between green cost accounting, sustainable production efficiency, profitability, and competitive advantage.

## Research Objectives

The specific objectives of this study are:

1. To assess the extent to which manufacturing firms adopt and integrate green cost accounting practices into their costing and decision-making systems.
2. To examine the influence of green cost accounting on sustainable production practices, including resource optimization, waste reduction, and production efficiency.
3. To evaluate the impact of green cost accounting on firms' profitability and financial performance.
4. To analyze whether the adoption of sustainability-oriented cost accounting contributes to long-term competitive advantage in manufacturing firms.
5. To provide managerial and policy-level insights on how environmental cost integration can support financially viable and environmentally responsible industrial practices.

## Conceptual Framework

The conceptual framework of this study links Green Cost Accounting (GCA), Sustainable Production (SP), Profitability (P), and Competitive Advantage (CA).

### Green Cost Accounting (Independent Variable)

- ❖ Refers to the systematic identification, allocation, and reporting of environmental costs in production processes.
- ❖ Allows managers to make informed operational and investment decisions regarding sustainability initiatives.
- ❖ Literature suggests GCA improves transparency, cost control, and environmental efficiency.

### Sustainable Production (Mediating Variable)

- ❖ Involves operational processes that minimize environmental impact while maintaining resource efficiency.
- ❖ Includes energy efficiency, waste reduction, cleaner technologies, and eco-friendly material management.
- ❖ Serves as the mechanism through which GCA can influence profitability and competitive positioning.

### Profitability (Dependent Variable 1)

- ❖ Refers to the financial performance outcomes of the firm, measured through indicators such as ROI, net profit margin, or operational cost savings.
- ❖ Expected to improve when environmental costs are tracked, managed, and optimized.

### Competitive Advantage (Dependent Variable 2)

- ❖ Refers to the firm's long-term strategic edge in the market achieved through cost efficiency, brand reputation, and sustainable innovation.
- ❖ Firms practicing GCA and sustainable production may differentiate themselves from competitors and sustain long-term growth.

## Framework Visualization (Conceptual Model)

Green Cost Accounting → Sustainable Production → Profitability → Competitive Advantage



### Direct Effects:

- ❖ GCA → Profitability
- ❖ GCA → Competitive Advantage

#### Indirect / Mediated Effects:

- ❖ GCA → Sustainable Production → Profitability
- ❖ GCA → Sustainable Production → Competitive Advantage

#### Hypotheses Development

Based on the literature review and conceptual framework, the study proposes the following hypotheses:

- ❖ **H1:** Green Cost Accounting practices have a positive impact on Sustainable Production efficiency in manufacturing firms.
- ❖ **H2:** Green Cost Accounting practices positively influence Profitability in manufacturing firms.
- ❖ **H3:** Sustainable Production efficiency positively mediates the relationship between Green Cost Accounting and Profitability.
- ❖ **H4:** Green Cost Accounting practices positively affect Competitive Advantage in manufacturing firms.
- ❖ **H5:** Sustainable Production efficiency positively mediates the relationship between Green Cost Accounting and Competitive Advantage.

#### Rationale:

- ❖ H1 is supported by studies showing that environmental cost visibility encourages resource optimization and cleaner production (Cooper & Kaplan, 2019; Elkington, 2021).
- ❖ H2 is grounded in the idea that managing environmental costs reduces wastage and improves financial performance (Wang et al., 2021).
- ❖ H3 and H5 reflect the mediating role of sustainable production in translating green accounting practices into profitability and competitive advantage.
- ❖ H4 highlights the strategic significance of GCA in supporting innovation, brand value, and long-term competitiveness (Porter & Kramer, 2019; Hart, 2022).

This framework ensures the study examines both operational and strategic outcomes, providing a holistic understanding of how green cost accounting influences business performance through sustainable production practices.

#### Methodology

##### Research Design

This study adopts a quantitative, explanatory research design to investigate the relationships between Green Cost Accounting (GCA), Sustainable Production (SP), Profitability (P), and Competitive Advantage (CA) in manufacturing firms. The research aims to empirically test the proposed hypotheses using survey data collected from managers responsible for finance, production, and sustainability within selected manufacturing units. An explanatory approach is appropriate because the study seeks to explain causal relationships among the variables and understand how green cost accounting practices influence operational and strategic outcomes.

##### Population and Sample

The population for this study consists of medium and large-scale manufacturing firms operating in India. These firms were selected due to their higher likelihood of implementing structured cost accounting and sustainability practices. The target respondents are production managers, finance managers, and sustainability officers, as they are directly involved in decision-making related to production efficiency, cost management, and strategic planning.

A purposive sampling technique was used to ensure that respondents had adequate knowledge of environmental costing practices and sustainable production initiatives. The sample size was determined based on the rule of thumb for structural equation modeling, which requires at least 10 respondents per observed variable. After data cleaning, a total of 250 valid responses were used for statistical analysis.

### Data Collection

Data were collected using a structured questionnaire designed in three sections:

- ❖ **Demographic information** — firm size, sector, years of operation, and respondents' roles.
- ❖ **Independent variable** — Green Cost Accounting (GCA), measured using a five-point Likert scale capturing practices such as environmental cost identification, allocation, and reporting.
- ❖ **Mediating and dependent variables** — Sustainable Production (SP), Profitability (P), and Competitive Advantage (CA), measured using validated scales adapted from prior research (Cooper & Kaplan, 2019; Wang et al., 2021; Hart, 2022).

The questionnaire was pre-tested with 20 managers to ensure clarity and reliability. Adjustments were made based on feedback to improve understanding and eliminate ambiguity.

### Variables and Measurement

Variable	Type	Measurement Indicators	Scale
Green Cost Accounting (GCA)	Independent	Environmental cost identification, allocation, reporting, monitoring	5-point Likert
Sustainable Production (SP)	Mediator	Resource efficiency, waste reduction, cleaner technologies, process optimization	5-point Likert
Profitability (P)	Dependent	Return on Investment (ROI), Net Profit Margin, Operational Cost Savings	5-point Likert / Financial Metrics
Competitive Advantage (CA)	Dependent	Innovation capability, brand value, market differentiation, regulatory compliance	5-point Likert

### Statistical Techniques

The collected data were analyzed using IBM SPSS and AMOS software. The analysis followed a multi-step procedure:

- ❖ **Descriptive statistics** — to summarize demographic and firm characteristics.
- ❖ **Reliability and validity tests** — Cronbach's alpha and confirmatory factor analysis (CFA) to ensure construct validity.
- ❖ **Structural Equation Modeling (SEM)** — to test hypothesized relationships between GCA, SP, Profitability, and Competitive Advantage.
- ❖ **Mediation analysis** — to evaluate the indirect effect of Sustainable Production on the relationships between GCA and the dependent variables.
- ❖ **Control variables** — firm size, sector, and years of operation were included to isolate the effects of the main variables.

All analyses were conducted at a 95% confidence level, and p-values less than 0.05 were considered statistically significant.

### Ethical Considerations

Respondent anonymity and confidentiality were strictly maintained. Participation was voluntary, and informed consent was obtained before administering the questionnaire. Data were stored securely and used solely for research purposes. No individual or firm identifiers were disclosed in the analysis or publication of results.

## Results and Discussion

### 1. Descriptive Statistics

Descriptive statistics provide an overview of the demographic and firm-level characteristics of the sample. Table 1 summarizes the profile of the respondents and their firms.

**Table 1: Respondent and Firm Demographics**

Characteristic	Category	Frequency	Percentage (%)
Respondent Role	Production Manager	110	44
	Finance Manager	95	38
	Sustainability Officer	45	18
Firm Size	Small (50–199 employees)	60	24
	Medium (200–499 employees)	110	44
	Large (500+ employees)	80	32
Years of Operation	<10 years	70	28
	10–20 years	120	48
	>20 years	60	24

#### Interpretation:

Most respondents were production and finance managers (82%), ensuring familiarity with cost accounting and production practices. The sample includes a balanced representation of medium and large firms, which are more likely to implement structured sustainability and cost accounting practices.

### 2. Reliability and Validity

Before hypothesis testing, the constructs were tested for reliability and validity.

**Table 2: Reliability and Validity Analysis**

Construct	Cronbach's Alpha	Composite Reliability (CR)	Average Variance Extracted (AVE)
Green Cost Accounting (GCA)	0.912	0.925	0.631
Sustainable Production (SP)	0.897	0.914	0.605
Profitability (P)	0.881	0.902	0.612
Competitive Advantage (CA)	0.890	0.910	0.618

#### Interpretation:

All constructs exhibit Cronbach's alpha  $>0.7$ , CR  $>0.7$ , and AVE  $>0.5$ , indicating strong reliability and convergent validity. The measurement model is suitable for further structural analysis.

### 3. Structural Model and Hypotheses Testing

The structural model was tested using Structural Equation Modeling (SEM). Figure 1 presents the path diagram, showing relationships among variables.

GCA → SP → P → CA

GCA → P

GCA → CA

**Table 3: Hypothesis Testing Results**

Hypothesis	Path Coefficient ( $\beta$ )	t-value	p-value	Result
H1: GCA → SP	0.642	8.21	<0.001	Supported
H2: GCA → P	0.387	4.56	<0.001	Supported
H3: SP → P	0.515	6.12	<0.001	Supported
H4: GCA → CA	0.312	3.97	<0.001	Supported
H5: SP → CA	0.489	5.88	<0.001	Supported

**Interpretation:**

- ❖ H1: Green cost accounting significantly enhances sustainable production efficiency ( $\beta=0.642$ ,  $p<0.001$ ). This confirms that visibility of environmental costs encourages resource optimization and cleaner production practices.
- ❖ H2 & H3: GCA positively influences profitability both directly and indirectly through SP, demonstrating that sustainability-oriented accounting contributes to financial performance.
- ❖ H4 & H5: GCA and SP significantly affect competitive advantage. Firms integrating green cost accounting and sustainable production gain strategic benefits through innovation, brand differentiation, and market positioning.

**4. Mediation Analysis**

The indirect effect of Sustainable Production (SP) on the relationship between GCA → Profitability and GCA → Competitive Advantage was assessed using bootstrapping (5,000 samples).

**Table 4: Mediation Results**

Path	Indirect Effect	95% CI	Mediation Type
GCA → SP → P	0.331	0.212–0.457	Partial
GCA → SP → CA	0.314	0.198–0.426	Partial

**Interpretation:**

Sustainable production partially mediates the effect of GCA on profitability and competitive advantage. This indicates that while GCA has a direct impact, its full strategic effect is realized when linked with sustainable production practices.

**5. Discussion**

The findings provide robust evidence that green cost accounting is a strategic enabler of both operational and financial performance. Firms that systematically track and allocate environmental costs are more likely to adopt sustainable production practices, resulting in better resource efficiency and reduced operational costs.

The study further confirms that profitability improvements are both direct and indirect through sustainable production. This aligns with prior research by Wang et al. (2021) and Cooper & Kaplan (2019), emphasizing that environmental cost integration has measurable financial benefits.

Regarding competitive advantage, the results suggest that sustainability-oriented cost accounting provides firms with strategic leverage. Organizations that integrate environmental costs into decision-making enhance brand credibility, innovation capability, and regulatory compliance, supporting long-term differentiation in competitive markets. This finding echoes the shared value theory (Porter & Kramer, 2019), which posits that sustainability initiatives can create both societal and economic value.

Overall, the results highlight the interconnected nature of green accounting, sustainable production, profitability, and competitive positioning, demonstrating that firms should treat environmental cost integration not as a peripheral compliance activity but as a core strategic and operational mechanism.

## Conclusion

This study examined the relationship between Green Cost Accounting (GCA), Sustainable Production (SP), Profitability, and Competitive Advantage in manufacturing firms. The findings confirm that green cost accounting is a strategic enabler, positively influencing both operational efficiency and financial performance. Firms that systematically integrate environmental costs into their costing and decision-making systems demonstrate improved production efficiency, better resource utilization, and reduced operational costs.

Moreover, sustainable production practices serve as a critical mediating mechanism, translating the benefits of GCA into measurable profitability gains and long-term competitive advantages. By linking environmental cost integration with process optimization, firms can not only comply with regulatory requirements but also leverage sustainability as a source of differentiation, innovation, and brand credibility. Overall, the study establishes that environmental cost management and sustainability-oriented production are closely intertwined with strategic and financial performance, reinforcing the importance of treating sustainability as a core business function rather than a peripheral activity.

## Managerial and Practical Implications

The study offers several practical implications for managers and practitioners:

- ❖ Managers should embed environmental cost identification, allocation, and reporting into standard accounting practices. This allows for better visibility of production inefficiencies and cost-saving opportunities.
- ❖ Firms should actively link GCA to operational processes such as waste reduction, energy efficiency, and cleaner technologies. This not only reduces costs but also enhances compliance and corporate reputation.
- ❖ Sustainability-oriented cost data should be utilized in investment and production decisions to strengthen profitability and competitive positioning. Managers can prioritize projects that deliver both environmental and economic benefits.
- ❖ By adopting GCA and sustainable production, firms can develop long-term differentiation in the market, building brand value and gaining regulatory preparedness, which contributes to sustainable competitive advantage.

## Policy Implications

The findings also have relevance for regulators and policymakers:

- ❖ Policymakers can incentivize firms to adopt green cost accounting frameworks through subsidies, tax benefits, or recognition programs.
- ❖ Developing industry-wide benchmarks for sustainable production efficiency can guide firms in implementing best practices.
- ❖ Integrating GCA into reporting standards can improve transparency and accountability in environmental and financial disclosures.

## Limitations of the Study

While this study provides valuable insights, several limitations should be noted:

- ❖ The research was conducted among manufacturing firms in India. Results may vary in other countries with different regulatory, economic, or technological contexts.
- ❖ Data were collected at a single point in time, which limits the ability to infer long-term causal relationships. Longitudinal studies may provide deeper insights.
- ❖ Responses were based on managers' perceptions, which may introduce subjective bias. Combining survey data with financial records could strengthen validity.

- ❖ Findings may not be generalizable to service or non-manufacturing sectors, where cost structures and sustainability practices differ significantly.

### Future Research Directions

Future studies can build upon this research in the following ways:

- ❖ Examining the long-term impact of GCA on profitability and competitive advantage over multiple years.
- ❖ Investigating how cultural, regulatory, and economic differences affect the adoption and effectiveness of GCA.
- ❖ Extending the research to service, IT, and other non-manufacturing sectors to test the generalizability of findings.
- ❖ Exploring the role of digital accounting tools, AI, and ERP systems in enhancing green cost accounting practices.
- ❖ Incorporating environmental, social, and governance (ESG) performance indicators to assess holistic firm sustainability.

### Final Remarks

In conclusion, this study highlights that green cost accounting and sustainable production are not only environmentally responsible practices but also strategic tools that enhance profitability and competitive advantage. Firms that systematically integrate environmental costs into their decision-making systems gain operational efficiencies, financial benefits, and long-term market differentiation. By combining robust cost accounting with sustainable production practices, manufacturing organizations can achieve a balanced approach to profitability, environmental stewardship, and strategic growth, thereby contributing to both business and societal value.

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