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Article

The Role of Material Flow Cost Accounting In Production Efficiency And Waste Reduction In Karya 27 Perabot

Alyani Rahma Putri[1,a], **Muthi Maitsa Zulfatri** [2,b,*]

[1,2] Teknik Logistik, Universitas Sains dan Teknologi Indonesia. Jl. Purwodadi Indah KM.10, Sidomulyo Barat, Kec. Tampan, Kota Pekanbaru, Riau 28294.

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E-mail: [a]alyanirahma@usti.ac.id, [b,*]muthimaitsa@usti.ac.id

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A B S T R A C T

This study aims to analyze the efficiency of the production process in micro, small, and medium enterprises (MSMEs) producing wooden furniture, with a case study of Karya 27 Perabot, which has been operating since 2019. To achieve this objective, this study adopted the Material Flow Cost Accounting (MFCA) approach, an environmental accounting method that allows for the measurement and assessment of costs associated with wasted materials and energy in the production flow. The main focus of this study is to identify and quantify losses in the form of wood, paint, and energy waste, as well as to analyze the potential for implementing Green Productivity (GP) to improve the efficiency and sustainability of the company's operations. The results show that 22.5% of total production costs consist of losses, with wood as the largest contributor (77.8%). Furthermore, the implementation of the Green Productivity (GP) strategy is predicted to significantly reduce losses, with potential cost savings reaching IDR 325,000 per batch, or approximately IDR 3.9 million per year. This study provides empirical insights into the application of MFCA in the context of furniture MSMEs and suggests strategic steps that can improve operational efficiency while supporting environmental sustainability goals in the small manufacturing industry sector.

1. Introduction

This The furniture and home furnishings industry is a strategic sector in the Indonesian economy, particularly for micro, small, and medium enterprises (MSMEs). Its contribution not only includes job creation and strengthening the local economy, but also meets domestic demand for functional, aesthetic, and durable furniture products. According to data from the Ministry of Industry (2022) and the Central Statistics Agency (BPS) (2021), the furniture subsector is dominated by MSMEs, which account for more than 90% of business units in this sector.

However, despite its significant potential, the furniture MSME sector also faces crucial structural challenges—namely, low production efficiency, weak cost management, and the lack of integration of environmentally friendly practices into daily operations (Tambunan, 2019). Inefficiency in the use of raw materials, particularly wood and finishing materials such as paint, is a major challenge that directly impacts business profitability and sustainability.

Various studies show that material loss in furniture MSMEs can reach more than 20% of the total raw materials used (Purwanto & Handayani, 2020). This situation not only increases costs but also generates production waste that has the potential to pollute the environment. Amid growing global awareness of sustainability issues, inefficient and environmentally unfriendly production practices will further reduce the competitiveness of MSMEs in a market that increasingly demands transparency and ecological responsibility (Hapsari, Nugroho, & Putri, 2021).

Karya 27 Perabot is a prime example of a furniture MSME navigating these complexities. Established in 2019 in Pekanbaru, the business produces various types of custom-made wooden furniture, such as tables, chairs, and cabinets, with a limited workforce. Despite its ability to survive and grow amidst local competition, Karya 27 Perabot has not yet fully implemented a production cost measurement system capable of identifying inefficiencies in a structured manner. The large amount of scrap wood, rejected products, and wasted paint is a clear indicator that conventional approaches to production management are no longer adequate.

In this context, the Material Flow Cost Accounting (MFCA) approach becomes highly relevant. MFCA is an environmental accounting method designed to identify and quantify the flow of materials, energy, and waste in the production process quantitatively and monetarily (ISO, 2011; Jasch, 2009). By implementing MFCA, companies can not only see how much material is lost as waste but also understand the monetary value of the "silently lost" during the production process. These findings provide an important basis for formulating Green Productivity strategies (Kokubu & Kitada, 2015).

This research is significant because MSMEs like Karya 27 Perabot generally lack the capability or access to environmentally-based cost measurement approaches. Yet, the potential for cost efficiency and increased sustainability is enormous if MFCA can be implemented systematically. Therefore, this study aims to analyze material flow and production losses through the MFCA approach and formulate an applicable Green Productivity strategy for furniture MSMEs, so that it can increase cost efficiency, strengthen competitiveness, and support the sustainability agenda of the national furniture industry.

Although previous studies have demonstrated the effectiveness of Material Flow Cost Accounting (MFCA) in identifying material inefficiencies and hidden environmental costs, most empirical evidence is derived from large-scale manufacturing industries or export-oriented enterprises. Limited attention has been given to the application of MFCA within micro, small, and medium enterprises (MSMEs), particularly in the wooden furniture sector in developing economies. Furthermore, existing studies tend to examine MFCA and Green Productivity (GP) as separate approaches, with insufficient theoretical integration that explains how MFCA-based cost transparency can systematically support GP-oriented improvement strategies. This gap indicates the need for empirical research that not only quantifies material losses using MFCA but also explicitly links these findings to actionable GP strategies within MSME contexts. Based on the identified research gap, this study aims to:

(1) analyze material and energy flows in the furniture production process using the Material Flow Cost Accounting (MFCA) approach;
(2) quantify the economic value of material losses and system inefficiencies;

(3) identify the dominant sources and underlying causes of waste generation; and
(4) formulate Green Productivity (GP) strategies that can reduce production losses and improve operational efficiency in furniture MSMEs.

2. Literature Riview

2.1 Micro, Small, and Medium Enterprises (MSMEs)

MSMEs are one of the main pillars of the Indonesian economy. Based on Law No. 20 of 2008, MSMEs are distinguished by their net worth, assets, and workforce. The role of MSMEs is not only in job creation but also as a means of more equitable income distribution within society. In a macroeconomic context, MSMEs have proven resilient in the face of crises due to their flexibility and close proximity to local markets.

In the furniture sector, MSMEs play a dominant role. Data from the Ministry of Industry (2022) shows that more than 90% of furniture businesses in Indonesia are MSMEs. This demonstrates the furniture industry's high dependence on local labor and creativity. However, this significant contribution is often not matched by strong operational efficiency, resulting in low competitiveness of MSME furniture products in the global market.

Therefore, furniture MSMEs like Karya 27 Perabot play a dual role. First, they act as a driving force for the local economy through job creation. Second, they serve as part of the national furniture industry supply chain, which has export potential. However, to achieve international competitiveness, MSMEs must improve production efficiency, cost management, and the implementation of sustainable practices.

2.2 Wooden Furniture and Furnishings Industry

The wood-based furniture industry is a sector that continues to grow in line with the increasing public demand for functional and aesthetic furniture products. Furniture is not merely a functional tool, but also an integral part of lifestyle and household identity. Therefore, the quality of furniture products is crucial for market acceptance.

Despite significant potential, furniture MSMEs face serious challenges. The main issue is inefficiency in raw material use. A study by Purwanto & Handayani (2020) found that wood wastage in Jepara MSMEs can reach 20–30% of the total raw materials. This increases production costs, makes selling prices less competitive, and adds to the environmental burden through wood waste.

For Karya 27 Perabot, this challenge is evident in the leftover wood scraps and rejected products. If this problem is not addressed, the business will struggle to grow sustainably. Therefore, the wood-based furniture industry must begin adopting modern cost analysis approaches such as MFCA to minimize losses and increase efficiency.

2.3 Environmental Accounting

Environmental accounting is a development of management accounting that emphasizes the recording, measurement, and reporting of environmental costs. This concept has become widely known since the 1990s, along with increasing global awareness of sustainability issues (Schaltegger & Burritt, 2017).

In practice, environmental accounting identifies hidden costs such as waste management, excess energy use, and material waste. For large companies, this has become a standard reporting method. However, for MSMEs, this concept is still relatively new and rarely implemented due to perceived complexity and cost.

By implementing simple methods such as MFCA, MSMEs can begin practicing environmental accounting. This is important because it not only helps reduce costs but also enhances the business’s image as an industry player concerned with sustainability.

2.4 Material Flow Cost Accounting (MFCA)

MFCA is an environmental accounting method that emphasizes measuring the flow of materials, energy, and waste in both physical and monetary units (ISO 14051, 2011). The basic concept is that the value of every input material must be recognized, whether it becomes a product or is discarded as waste.

According to Jasch (2009), MFCA is highly effective because it can uncover hidden costs that are invisible in traditional accounting. In conventional accounting systems, waste is considered worthless, even though wasted materials still have a purchase price and absorb energy, labor, and storage costs.

MFCA has been widely implemented in large industries, but recent research shows that this method is also relevant for MSMEs (Kokubu & Kitada, 2015). For Karya 27 Perabot, MFCA is crucial because it can reveal the rupiah value lost due to scrap wood, oversprayed paint, and rejected products.

Material Balance:

$MI = MP + ML$ (1)

Symbol description :

MI = Material Input
MP= Material Positive Product
ML = Material Losses

Shows that material input equals product output plus losses.

Persentase Losses:

$L\% = \frac{ML}{MI} \times 100\%$ (2)

Symbol description :

L% = Persentase losses terhadap total input
ML = Material Losses
MI = Material Input

Measuring the proportion of material lost

Biaya Material Losses:

$CML = ML \times HM$ (3)

Symbol description :

CML = Cost of Material Losses
ML = Material Losses
HM = Harga per unit material

Calculating the cost of wasted materials.

Biaya Energi dan Sistem:

$CSE = CE \times \frac{ML}{MI}$ (4)

Symbol description :

CSE = Cost of System and Energy Losses
CE = Total biaya energi dan sistem
$\frac{ML}{MI}$ = Rasio material losses terhadap total material input

Total Losses:

$CL = CML + CSE$ (5)

Symbol description :

CL = Total biaya losses
CML = Cost of Material Losses
CSE = Cost of System and Energy Losses

Efisiensi Material:

Efesiensi $= \frac{MP}{MI} \times 100\%$ (6)

Symbol description :

Efisiensi = Tingkat efektivitas penggunaan material (%)
MP = Material Positive Product
MI = Material Input

2.5 Green Productivity (GP)

Green Productivity is a strategy for increasing productivity that synergizes with environmental conservation. This concept was introduced by the Asian Productivity Organization (APO, 2006) and is now a popular approach in the manufacturing industry.

According to Chen (2018), GP is a win-win solution because it not only increases cost efficiency but also reduces environmental impact. GP implementation includes waste reduction, the use of environmentally friendly technologies, and optimal material utilization.

For furniture MSMEs, GP can be implemented through optimizing wood cutting patterns, using environmentally friendly paints, and utilizing wood waste as a by-product. When implemented in conjunction with MFCA, GP will help MSMEs not only save costs but also build a positive image in the market.

2.6 Relevance of MFCA and GP for MSMEs

MSMEs are often unaware of the magnitude of hidden costs resulting from inefficiencies. Through MFCA, these costs can be identified, while GP provides practical solutions to reduce losses.

Empirical studies support this relevance. Setiawan & Wibowo (2019) demonstrated that implementing MFCA in batik MSMEs reduced losses by up to 20%. Purwanto & Handayani (2020) demonstrated that GP in Jepara furniture MSMEs reduced wood waste by up to 15%.

Thus, the combination of MFCA and GP is highly relevant for Karya 27 Perabot. This approach not only contributes to cost efficiency but also enhances the MSME's competitiveness in both domestic and international markets.

3. Research Methodology

3.1 Research Type and Approach

This research uses a quantitative descriptive approach with a case study method at the Karya 27 Perabot MSME. This approach was chosen to provide an in-depth description of real-world conditions, particularly in the context of production efficiency and waste management. The Material Flow Cost Accounting (MFCA)

method was used as the analytical framework because it is able to identify material flows, hidden costs, and efficiency potential in the furniture production process.

3.2 Research Location and Subjects

The research location is Karya 27 Perabot, a micro-enterprise operating in Pekanbaru since 2019. The research subjects include the business owner and five workers directly involved in the wood-based furniture production process.

3.3 Research Flow

This research process follows the systematic stages shown in the research flowchart. Broadly speaking, the research stages are as follows:

1. Beginning – Determining the research focus, namely the application of MFCA to analyze production efficiency at the Karya 27 Perabot MSME.
2. Problem Identification – Explore existing problems, such as high levels of wasted material, inefficient paint use, and defective products.
3. Literature Review and Objective Formulation – Review theories related to MSMEs, environmental accounting, MFCA, and Green Productivity, which are used to formulate research objectives.
4. Data Validation – Ensure the data obtained is valid and adequate. If not, return to the problem identification stage to complete the information.
5. Field Data Collection – Conducted through observation, interviews, and documentation related to raw material use, production processes, and waste.
6. Data Processing with MFCA – Data is analyzed to identify the amount of material input, output, and losses that occur in the production process.
7. Analysis and Interpretation – The results of the data processing are interpreted in the form of descriptions, tables, and graphs to provide an overview of the level of efficiency.
8. Discussion – Compare the research results with theory and previous research to draw meaning and practical implications.
9. Conclusion – The research concludes with conclusions and recommendations.

3.4 Data Types and Data Sources

1. Primary Data
   Direct observation of the production process at Karya 27 Perabot. Interviews with the owner and workers regarding raw material management and production. Documentation in the form of photographs, field notes, and production results.
2. Secondary Data
   Academic literature relevant to the MFCA and MSME concepts. Reports from the Ministry of Industry and BPS regarding the furniture industry. Journal articles and previous research for comparison.

3.5 Data Collection Techniques

Data collection techniques in this study include:

a. Observation: Directly observing the furniture production process from start to finish.
b. Interviews: Gathering information regarding production strategies, material efficiency, and obstacles encountered.
c. Documentation: Collecting visual data and written notes to strengthen the findings.

3.6 Data Analysis Techniques

The collected data was analyzed using the Material Flow Cost Accounting (MFCA) approach in accordance with the ISO 14051 standard. This analysis was conducted by identifying material flows, mapping production inputs and outputs, calculating material losses, and assessing costs arising from inefficiencies. The analysis results were then interpreted to provide recommendations for efficiency improvements and waste management.

3.7 Assumptions, Data Validation and Limitation

This study applies several assumptions consistent with MFCA implementation in MSME contexts. First, material prices and labor costs are assumed to be constant during the observed production batch. Second, all material losses are considered economically relevant, regardless of whether they are physically visible or reused. Third, the production process is assumed to be stable within the observation period.

Data validation was conducted through triangulation methods, including cross-checking observation data with interview responses and

production records. Repeated observations across multiple production batches were performed to ensure consistency in material flow patterns.

Despite these efforts, this study has limitations. The analysis is based on a single MSME case study, which may limit generalizability. In addition, the MFCA calculations rely on descriptive analysis and do not incorporate stochastic variability or long-term production fluctuations. Future research is recommended to apply comparative or longitudinal designs to strengthen external validity.

4. Results and Discussion

4.1 Karya 27 Perabot Profile

1. Structure and Human Resources

Karya 27 Perabot employs five people with a simple but clear division of roles. The business owner also serves as the manager, responsible for managing orders, managing finances, and building relationships with customers. Three other workers focus on the production process, from cutting and assembling to shaping furniture according to the ordered designs. Meanwhile, one worker specifically handles the finishing stage, which includes sanding, painting, and finalizing the products to make them ready for marketing. The work system employed is still labor-intensive, with a predominance of manual skills, so the quality of the output is highly dependent on the precision and expertise of the workforce.

2. Production Location and Facilities

Karya 27 Perabot is located in a workshop with an area of approximately 150 m². The workshop area is divided into several main sections: a wood cutting room, an assembly room, a finishing room used for the painting and polishing processes, and a storage area for raw materials and finished products. However, the workshop is still relatively simple and has not yet fully implemented an efficient production layout. As a result, there is often overlap between production and storage areas, which in turn can impact the smoothness of the workflow and reduce the effectiveness of the production process.

3. Production Equipment

The equipment used consists of a combination of electric and manual tools, including:

a. Electric saws for primary wood cutting.
b. Electric drills and wood planers for detailing and surface leveling.
c. Paint compressors for product finishing.
d. Manual tools (hammers, chisels, brushes, clamps, and measuring tape) to support detail work.

This equipment helps speed up the production process, but the limited number and capacity of machines often become a hindrance when orders increase.

4. Production System

a. Using a custom-made production model, products are highly dependent on customer demand.
b. Occasionally, small batch production is carried out for commonly requested stock items such as study tables, wooden chairs, and simple shelves.
c. Production times are relatively long due to the high level of reliance on worker skills, and the lack of automation systems or large-scale industrial machinery.
d. The primary focus is on design accuracy according to customer desires, not mass production.

5. Financial Recording and Business Management

a. The record-keeping system is still manual, using a simple cash book, without a clear separation between personal and business cash flow.
b. Product selling prices are determined based on estimates of raw material costs, labor costs, and reasonable profit margins.
c. A standardized cost accounting system or Material Flow Cost Accounting (MFCA) has not been implemented, making it difficult to measure material and cost efficiency in detail.

4.2 Furniture Production Process

The furniture production process at Karya 27 Perabot involves several main stages:

a. Purchasing raw materials: meranti wood, nails, glue, paint, and finishing materials.
b. Cutting and measuring: The wood is cut to the design dimensions. This stage generates a lot of wood waste.
c. Assembly: The wood is assembled using nails and glue. Sometimes, measurement

errors result in rejects.

d. Smoothing (initial finishing): The wood surface is smoothed using a planer and sandpaper.
e. Painting and coating: using a paint compressor. Material loss is quite high due to overspray.
f. Final assembly & quality control: product inspection before delivery to the customer.
g. Finished product: custom-made tables, chairs, or cabinets.

4.3 Implementation Material Flow Cost Accounting (MFCA)

1. Quantitative Production Data (One Set of Tables and Chairs)

Table 1. Quantitative Production Data

production stage	Input	Output	Losses (kg/liter)	(Rp)	Losses (Rp)
Wood cutting	100 kg of wood	75 kg components	25 kg	25.000/kg	625.000
Assembly	75 kg of components	70 kg assembly	5 kg	25.000/kg	125.000
Smoothing	70 kg of assemblies	68 kg fines	2 kg	25.000/kg	50.000
Painting and coating	5 liters of paint	3.5 liters attached	1,5 liter	50.000/liter	75.000
Quality Control	68 kg of fine furniture	65 kg finished product	3 kg reject	25.000/kg	75.000

Total Losses Material = 35 kg wood + 1,5 liter paint = Rp 950.000

2. Energy and System Costs

Calculation of energy and system costs as follows:

Total electrical energy = Rp 200.000/batch.
Labor costs (5 workers × Rp 60.000) = Rp 300.000/batch.
Total energy and system costs (CE) = Rp 500.000.

Refers to the percentage of material losses = 35/100 = **35%**, then the proportion of energy & system lost is:

$$CSE = CE \times \frac{ML}{MI} = 500.000 \times 0{,}35 = Rp175.000$$

3. Recapitulation MFCA

Table 2. Recapitulation MFCA

Cost Components	Main Product (Positive)	Losses (Negative)	Total Cost
Material (wood & paint)	Rp 3.550.000	Rp 950.000	Rp 4.500.000
energy and system	Rp 325.000	Rp 175.000	Rp 500.000
Total	**Rp 3.875.000**	**Rp 1.125.000**	**Rp 5.000.000**

Thus, losses = 22.5% of total production costs**.**

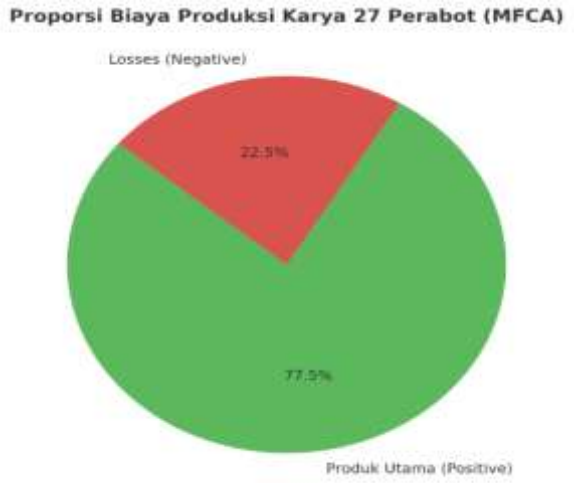

Figure 1. Comparison of main product costs (positive product) and losses (negative product)

The pie chart shows the comparison between main product costs (positive product) and losses (negative product) in the production of a set of tables and chairs at Karya 27 Perabot.

a. **Main Product (Positive):** IDR 3,875,000 or 77.5% of total production costs. This figure represents the cost of materials and energy converted into a finished, marketable product.
b. **Losses (Negative):** IDR 1,125,000 or 22.5% of total production costs. This figure reflects the costs of wasted materials (wood scraps, oversprayed paint, rejects), as well as energy and system losses due to inefficient processes.

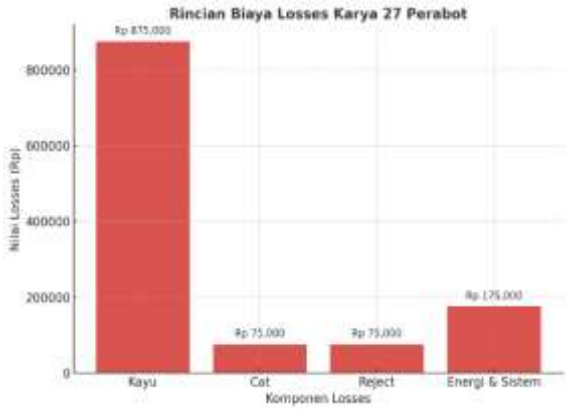

Figure 2. Loss Components at Karya 27 Perabot

The bar chart provides a detailed overview of the loss components that occurred at Karya 27 Perabot:

a. **Wood (Rp 875,000, 77.8% of total losses)**
This is the largest source of losses. Wood waste arises from unused pieces (25%), sizing errors (5%), and minor rejects (3%).
b. **Paint (Rp 75,000, 6.7%)**
This occurs due to overspray during the painting process. Approximately 30% of the paint used does not adhere to the product.
c. **Rejected Products (Rp 75,000, 6.7%)**
Minor defective products prevent the materials and energy used from reaching their full resale value.
d. **Energy and Systems (Rp 175,000, 15.6%)**
The proportion of electrical energy and labor costs wasted due to allocation to defective products.

4. Identification of Factors Causing Losses

The following are the results of the identification of factors causing losses at Karya 27 Perabuk:

a. Manual cutting → produces 25% wood waste.
b. Worker skills → 5 kg of wood (5%) is the wrong size.
c. Smoothing → 2 kg (2%) is lost to powder.
d. Painting → 1.5 liters of overspray (30% of the paint).
e. Quality Control → 3 kg of minor rejects (4%).

5. Green Productivity Strategy Simulation

If Karya 27 Perabuk implements the following efficiency strategies:

a. Optimizing wood cutting patterns → reducing waste from 25% to 15%.
b. Using efficient spray paint → reducing overspray from 30% to 15%.
c. Early Quality Control → reducing rejects from 4% to 2%.

Then the savings can be calculated:

$$CL_{Baru} = \mathrm{CL} - \Delta\mathrm{CML}$$

wood 10 kg × Rp 25.000 = Rp 250.000.
Paint 0,75 liter × Rp 50.000 = Rp 37.500.
Reject 1,5 kg × Rp 25.000 = Rp 37.500.
Total savings = Rp 325.000 per batch.

4.2 Discussion of Results

Technology can enhance environmental performance, this study demonstrates that even low-cost GP interventions—such as adjusting spray distance and training workers—can yield measurable cost savings.

Claims regarding improvements in company image and consumer perception are not empirically tested in this study. Therefore, these aspects should be interpreted as potential indirect benefits rather than confirmed outcomes, suggesting avenues for future research incorporating consumer surveys or market-based performance indicators.This aligns with the findings of Purwanto & Handayani (2020) on furniture MSMEs in Jepara, which also experienced high losses in wood and paint.

Furthermore, implementing a Green Productivity strategy not only impacts cost efficiency but also improves the company's image, as consumers today value environmentally friendly products more. This is relevant to the study by Hapsari et al. (2021), which emphasized the importance of integrating MFCA with circular economy principles to strengthen the competitiveness of MSMEs.

5. Conclusion

Based on the research conducted at Karya 27 Perabot, the following conclusions can be drawn:

1. The application of MFCA at Karya 27 Perabot shows that material and system losses account for 22.5% of total production costs.
2. Wood is the largest component of losses (77.8%), followed by energy and systems (15.6%), paint (6.7%), and rejects (6.7%).
3. The main factors causing losses are simple technology, worker skills, and painting techniques.
4. The Green Productivity strategy has been proven to reduce losses by up to 15% and provide savings of IDR 325,000 per batch or IDR 3.9 million per year.
5. This study contributes to the literature by empirically demonstrating the integration of MFCA and Green Productivity in a furniture MSME context, an area that remains underexplored. Practically, the findings provide a replicable framework for MSMEs to identify hidden costs and prioritize efficiency improvements using limited resources.

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