

Analysis of the Impact of Material Flow Cost Accounting (MFCA) on the Circular Economy: The Mediating Role of Sustainable Financial Strategies (Empirical Study on Personal Care Companies in Indonesia, Malaysia, and Thailand 2020–2024)

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Abstract

Keywords:

Circular Economy, Material Flow Cost Accounting, MFCA, Sustainable Finance, Sustainable Finance Strategy

This study analyzes the effect of Material Flow Cost Accounting (MFCA) on the circular economy with sustainable finance strategy as a mediating variable in personal care companies listed on the Indonesia, Malaysia, and Thailand stock exchanges for the 2020-2024 period, amidst the challenges of plastic waste in the ASEAN cosmetics sector. The objective is to test the causal relationship and mediation role using a quantitative panel data regression approach. The population includes non-cyclical consumer companies, a purposive sample of 70 observations from annual reports. Instruments include the CE Index (10 indicators), MFCA ratio, and SDGs Index (17 indicators) via content analysis; the analysis includes the Chow-Hausman test, regression, and Sobel test. The results show that MFCA has a significant negative effect on the circular economy ($\beta=-0.409$, $p=0.042$), sustainable finance strategy has a positive effect ($\beta=1.128$, $p<0.001$), but does not mediate (H2 is not significant). In conclusion, companies need to strategically integrate MFCA into green investments for an effective circular transition.

INTRODUCTION

Rapid global economic growth, particularly in Southeast Asia, has triggered a significant increase in industrial waste volume. The personal care or cosmetics sector is one of the main contributors to plastic and chemical waste, with Indonesia, Malaysia, and Thailand facing urgent environmental management challenges as they meet the Sustainable Development Goals (SDGs) targets (Herrador-Alcaide et al., 2024; Emami et al., 2025).

The traditional linear economic model based on the take-make-dispose pattern is considered no longer relevant and must be replaced with a regenerative circular economy to minimize waste and optimize resources (Ellen Macarthur Foundation, 2015; Kirchherr et al., 2017).

Companies need environmental management accounting instruments such as Material Flow Cost Accounting (MFCA) based on ISO 14051 to accurately identify material inefficiencies, which track positive and negative product costs (waste). However, previous research shows that MFCA information is often limited to administrative reports without real operational transformation (Christ & Burritt, 2015; International Organization for Standardization, 2011).

Strategic funding factors are crucial, as sustainable finance strategies integrate ESG criteria into investment decisions to support circular technologies. While the MFCA provides waste

savings data, its realization requires a visionary finance strategy that links environmental cost transparency with circular implementation (Migliorelli, 2021; Global Reporting Initiative, 2020).

This study examines the mediating role of sustainable finance strategies in the relationship between MFCAs and the circular economy in personal care companies listed on the Indonesia Stock Exchange, Bursa Malaysia, and the Stock Exchange of Thailand for the 2020-2024 period. The main objective is to analyze the influence of MFCAs on the circular economy with this mediation using panel regression and the Sobel test, while its urgency lies in its contribution to the circular transition in ASEAN for the SDGs. The novelty of this study is the rarely explored cross-country empirical testing, providing input on environmental accounting theory and practice for policymakers (Maulana, 2024; Tajuddin & Ahmad, 2021).

RESEARCH METHODS

Types and Methods of Research

This study adopts a quantitative approach with a panel data regression design to analyze the effect of Material Flow Cost Accounting (MFCA) on the circular economy through the mediation of sustainable financial strategies in personal care subsector companies in Indonesia, Malaysia, and Thailand for the period 2020-2024. This approach allows for empirical hypothesis testing using secondary data from annual and sustainability reports, in accordance with the post-positivist paradigm that emphasizes numerical measurement and generalization (Sugiyono, 2023; Sudaryono, 2021). The panel regression method was chosen because it is able to capture variations between entities and over time, with the Chow and Hausman test to determine whether the model is fixed or random effects (Sugiyanto, 2023; Creswell & Creswell, 2023).

Data Analysis Instruments and Techniques

Measurement instruments include a disclosure content index for the dependent variable Circular Economy (CE Index) with 10 indicators such as waste reduction and circular supply chain, MFCA as the ratio $(RMC + LC + FOC) / \text{Total Production Cost}$, and Sustainable Financial Strategy (SDGs Index) of 17 ESG indicators based on content analysis scoring (1 = disclosed, 0 = not). Analysis techniques include descriptive statistics, classical assumption tests (multicollinearity, autocorrelation), panel regression, path analysis, and the Sobel test for mediation, using software such as EViews (Putri, 2024; Gunady & Shanti, 2025). This approach ensures the validity and reliability of secondary data from the official stock exchange website (Emzir, 2022; Ghozali, 2018).

Population and Sample

The study population consisted of all personal care (cosmetics) subsector companies in the non-cyclical consumer sector listed on the Indonesia Stock Exchange (IDX), Bursa Malaysia, and the Stock Exchange of Thailand (SET) during the 2020-2024 period. These companies were selected due to their high material flow intensity, relevant to MFCA and the circular economy. The sample was purposively selected, with complete data in annual and sustainability reports, resulting in 70 representative panel observations for cross-country analysis (Sugiyono, 2023; Sudaryono, 2021).

Research Procedures

The procedure begins with secondary data collection from annual reports, sustainability reports, and stock exchange websites, followed by content analysis coding for the CE and SDGs indices and calculation of the MFCA ratio. Next, descriptive analysis, assumption tests (Chow, Hausman, Durbin-Watson), panel regression, simultaneous/partial t/F tests, and Sobel tests are performed to verify mediation, with validation using the Wilcoxon rank sum test across countries. This process follows a systematic flow to ensure objectivity and replicability (Creswell & Creswell, 2023; Emzir, 2022).

RESEARCH RESULT

Descriptive Statistical Analysis

Descriptive statistical analysis is data analysis that results from the distribution of data in detail and describes the condition of the data being observed or researched. (Ghozali, 2018). In the descriptive statistical analysis stage to understand the data trend using a 95% confidence interval, standard deviation, standard error, and average value (mean). The following table presents the results of the descriptive statistical analysis of the MFCA value data, the results of the circular economy data content ratio and sustainable financial strategies with the Sustainability Development Goals (SDGs) based on the ratio calculations and data that the researcher has collected through documentation, along with the presentation of the results of the descriptive statistical analysis of the research.

Table 1. Descriptive Analysis Results

Sample: 2020 2024

	CE_INDEX	MFCA	SDGS_INDEX
Mean	0.850000	0.968174	0.877311
Median	0.900000	0.986960	0.882353
Maximum	1.000000	1.245750	0.941176
Minimum	0.500000	0.738140	0.705882
Std. Dev.	0.139096	0.112558	0.057306
Skewness	-1.204149	0.161615	-0.964916
Kurtosis	3.984135	3.055873	3.822159
Jarque-Bera	19.74122	0.313831	12.83390
Probability	0.000052	0.854776	0.001634
Sum	59.50000	67.77219	61.41176
Sum Sq. Dev.	1.335000	0.874180	0.226594
Observations	70	70	70

Based on the results of the descriptive analysis test in Table 1, during the observation period, the sample companies generally had a fairly high level of circular economy implementation. This is indicated by the average CE_INDEX value of 0.850000. There were several companies with higher scores that pushed the average up, as indicated by the median of 0.900000, which is slightly lower than the mean. All sample companies had similar circular economy implementation, as indicated by the relatively small values (minimum 0.50 and maximum 1.00) and low standard deviation (0.139096). Overall, the analysis results indicate that the sample companies were in a fairly well-established state of circular economy implementation during the observation period. Small differences between companies indicate strong uniformity in implementation at the industry

level, while the average CE_INDEX value indicates that circular economy practices have become part of the company's operational standards. This condition suggests that the drive for circular economy implementation is more influenced by external pressures, such as regulations, stakeholder demands, and market expectations than by company-specific strategic efforts. As a result, the circular economy in the sample companies tends to function as a legitimacy and compliance mechanism. Therefore, to improve sustainability performance, circular implementation and innovation must be substantially enhanced rather than simply meeting minimum disclosure standards.

Chow Test

Table 2. Chow Test Results

Redundant Fixed Effects Tests
Equation: Untitled
Test cross-section fixed effects

Effects Test	Statistic	d.f.	Prob.
Cross-section F	2.231073	(13,55)	0.0199
Cross-section Chi-square	29.647139	13	0.0053

The results of the Chow test presented obtained a probability value in the cross-section F of 0.0199. This value is smaller than the significance level of α 5% ($0.0199 < 0.05$), so H_0 is rejected and H_1 is accepted, meaning that the selected model is a fixed effect model.

Hausman test

Table 3. Hausman Test Results

Correlated Random Effects - Hausman Test
Equation: Untitled
Test cross-section random effects

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	1.009902	1	0.3149

The results of the Hausman test obtained a chi-square probability value of 0.3149. This value is greater than the significance level of α 5% ($0.3149 > 0.05$), so H_0 is accepted and H_1 is rejected, meaning the selected model is a random effect model.

Multicollinearity Test

Table 4. Multicollinearity Test

	MFCA	SDGS INDEX
MFCA	1.000000	0.016092
SDGS_INDEX	0.016092	1.000000

The correlation matrix output results in Table 4 show a correlation between MFCA and SDGs of 0.016092, indicating no high correlation between independent variables above 0.90. Therefore, it can be concluded that there is no multicollinearity between independent variables.

Autocorrelation Test

Table 5. Autocorrelation Test Results

R-squared	0.413605	Mean dependent var	0.414178
Adjusted R-squared	0.376956	S.D. dependent var	0.059370
S.E. of regression	0.046863	Sum squared resid	0.070276
F-statistic	11.28538	Durbin-Watson stat	1.772252
Prob(F-statistic)	0.000195		

The results in table 5 show the Durbin Watson value of 1.772252, with a sample value of 70 and the number of variables ($k = 2$), in the Durbin Watson table the dL value is 1.5542 and dU is 1.6175. So the dw value of 1.772252 is greater than dU (1.6175) and smaller than $4-dU$ (2.3285), or $dU < DW < 4dU = 1.6175 < 1.772252 < 2.3285$. so it can be concluded that there is no autocorrelation in the research data.

Panel Data Regression Results

Table 6. Autocorrelation Test Results

Dependent Variable: CE INDEX
 Method: Panel EGLS (Cross-section random effects)
 Date: 01/08/26 Time: 12:41
 Sample: 2020 2024
 Periods included: 5
 Cross-sections included: 14
 Total panel (balanced) observations: 70
 Swamy and Arora estimator of component variances

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.256693	0.270952	0.947375	0.3469
MFCA	-0.409296	0.197355	-2.073906	0.0419
SDGS INDEX	1.127966	0.202534	5.569261	0.0000

The constant value of 0.256693 means that if the independent variable consisting of material flow cost accounting is 0 (zero) and the intervening variable is Sustainability performance strategy with SGDs, the circular economy variable will have a value of 0.256693. The coefficient value of material flow cost accounting is -0.409296, meaning that if the value of other variables is constant and the material flow cost accounting variable increases by 1 unit, the circular economy variable will decrease by 0.409296 units. Likewise, if the value of other variables is constant and the material flow cost accounting variable decreases by 1 unit, the circular economy will increase by 0.409296 units.

The coefficient value of sustainable financial strategy with SGDs is 1.127966, meaning that if the value of other variables is constant and the sustainable financial strategy variable with SGDs increases by 1 unit, the circular economy variable will decrease by 1.127966 units. Conversely, if the value of other variables is constant and the sustainable financial strategy variable with SGDs decreases by 1 unit, the circular economy will increase by 1.127966 units.

Simultaneous Test (F Test)

Table 7. Simultaneous Results (F Test)

<i>Hypothesis</i>	<i>Effect</i>	<i>F-statistic</i>	<i>F- table</i>	<i>Prob(F-statistic)</i>	<i>Result</i>
H4	MFCA & SDGs Against EC	19.04944	3,267	0.000000	<i>Significant</i>

The results of the f test presented in Table 7 show that the results of the simultaneous test (f test) in this study are The influence of material flow cost accounting (MFCA) and sustainable finance strategy (SDGs) on the circular economy where the value is known F_{hitung} of 19.04944, this value is greater than F_{tabel} ($19.04944 > 3.627$) and the Prob(F-statistic) value is 0.000000, this value is smaller than the α level of 5% ($0.000000 < 0.05$) then $H_a H_0$ is accepted and H_0 is rejected, meaning that material flow cost accounting (MFCA) and sustainable financial strategy (SDGs) simultaneously have a significant effect on the circular economy.

Partial Test (t-Test)

Table 8. Partial Results (t-Test)

<i>Hypothesis</i>	<i>Effect</i>	<i>Coefficient</i>	<i>t-Statistic</i>	<i>t-table</i>	<i>Prob.</i>	<i>Result</i>
H1	MFCA Against EC	-0.409296	-2.073906	1.66792	0.0419	<i>Significant</i>
H2	MFCA on SDGs	-0.011701	-0.137681	1.66757	0.8909	<i>Not significant</i>
H3	SDGs Against EC	1.127966	5,569261	1.66792	0.0000	<i>Significant</i>

The results of the hypothesis testing indicate that Material Flow Cost Accounting (MFCA) has a significant but negative influence on the Circular Economy (H1), indicating that the identification of high waste costs has not been able to be converted by companies into effective circular production practices. Meanwhile, MFCA was found to have no effect on Sustainable Financial Strategy (H2), reflecting the existence of communication barriers between environmental operational data and financial policy making at the management level. On the other hand, Sustainable Financial Strategy was proven to have a positive and significant influence on the Circular Economy (H3), confirming that green financing commitments are the main driver in increasing the efficiency of corporate circularity. However, Sustainable Financial Strategy failed to play a mediating role (H4) due to the weak relationship between the material cost accounting system and the formulation of long-term financial strategies in this study sample.

DISCUSSION

The Impact of Material Flow Cost Accounting (MFCA) on the Circular Economy (CE)

Partial test results indicate that material flow cost accounting (MFCA) has a significant impact on the circular economy. With a negative coefficient and a probability value below the 5% significance level, this finding indicates that the implementation of MFCA is more frequent than the decline in the circular economy index in the cosmetics and personal care companies included in the study sample. Empirical results indicate that MFCA is still focused on internal efficiency and production cost control, not yet optimally used as a strategic instrument to encourage circular economy practices. The results of the Wilcoxon difference test CE_INDEX show a significant difference in the median circular economy between Indonesia and Malaysia–Thailand ($p = 0.0016$), which supports this finding. The results indicate that the existence of MFCA as an internal accounting tool does not determine the level of circular economy achievement but rather the national policy and institutional context that determines it. In other words, the influence of MFCA on the circular economy is highly dependent on the policy system and company strategy in each country even though it is implemented.

According to Stakeholder Theory (Freeman, 1984 in Syafis, 2022) MFCA is an environmental management accounting tool that aims to increase the transparency of material

flows and environmental costs in response to stakeholder demands for efficiency and accountability. However, this theory also emphasizes that meeting stakeholder demands is gradual and contextual. MFCA tends to be internally oriented and does not fully align with circular economy principles that emphasize production system redesign, resource recovery, and long-term value creation. This is due to its focus on reducing material losses and saving costs in the short term.

The results of this study differ from those of Fatah and Jaf (2023) and Walls et al. (2023), who showed that MFCA can encourage sustainability practices and a circular economy. This difference may be due to the fact that the cosmetics industry in Indonesia still relies on primary raw materials, single-use packaging, and is mass-market oriented. However, these findings align with those of Fatimah et al. (2023), who stated that the implementation of MFCA does not always have an immediate impact.

According to sustainability reports and websites of Indonesian cosmetic companies, MFCA is typically used to improve production efficiency, reduce scrap costs, and control waste. However, it is not used as a basis for circular economy transformation. Rather than converting products to circularity, companies focus more on cost leadership due to economic factors such as exchange rate fluctuations, imported raw material costs, and price competition. As a result, at this stage, MFCA serves more as a microeconomic efficiency tool than as part of a systemic circular economy instrument.

The Impact of Material Flow Cost Accounting (MFCA) on Sustainable Finance Strategy (SDGs)

The partial test results, with a probability value greater than 0.05, indicate that the implementation of MFCA in cosmetic and healthcare companies does not directly affect sustainability-oriented financial decision-making, such as green investment allocation, ESG financing, or the integration of environmental risks in corporate financial policies. A cross-country MFCA difference test corroborates this finding, with no significant difference in MFCA between Indonesia and Malaysia–Thailand ($p = 0.2367$). This diversity in MFCA procedures suggests that MFCA is a relatively consistent internal management tool and is not significantly affected by country conditions. However, no country has a uniform sustainable finance strategy.

When stakeholder pressure—particularly from investors, regulators, and financial institutions—is strong enough to drive financial policy changes, sustainable finance strategies emerge, according to Stakeholder Theory. Information on production costs is the focus of MFCA, which is technical-operational in nature. According to Migliorelli (2021), in the absence of external pressure or green financial incentives, MFCA information tends to stop at the operational level and does not escalate into sustainable finance strategies.

According to Angelin and Ulfah (2024) and Fatimah et al. (2023), MFCA does not always have a significant impact on a company's strategic aspects if it is not supported by a mature green finance policy or green accounting. Conversely, in the macro context and financial institutions, research by Taera and Lakner (2025) shows a positive relationship between sustainability practices and sustainable finance. Empirically, the annual reports of cosmetics companies in Indonesia show that, as a basis for transforming sustainable finance strategies towards the SDGs, MFCA has not been used. This is due to economic factors such as limited green fiscal incentives, relatively high sustainable financing costs, and a focus on short-term profitability.

The Impact of Sustainable Finance Strategy (SDGs) on Circular Economy (CE)

The test results show that sustainable finance strategies (SDGs) have a positive and significant impact on the circular economy. A positive coefficient indicates that the stronger a company's orientation toward the SDGs, the more circular economy practices are implemented by cosmetics and personal care companies. The Wilcoxon SDGs_INDEX test showed that Indonesia and Thailand did not have a significant difference in sustainable finance strategies ($p = 0.0001$). This confirms this finding. These findings suggest that, rather than differences in MFCA, differences in sustainable finance strategies most significantly influence variations in circular economy outcomes between countries. Sustainable finance strategies reflect a company's response to demands from strategic stakeholders such as ESG investors, regulators, and environmentally conscious consumers, according to Stakeholder Theory. A circular economy relies on ESG-based capital allocation, which allows companies to fund process innovation, the use of recycled materials, waste reduction, and energy efficiency (Migliorelli, 2021).

These findings are consistent with the claims of Taera and Lakner (2025), Munteanu et al. (2024), and Fernando et al. (2023), who stated that sustainable finance helps drive a circular economy. Companies are better able to shift from a linear to a circular model when investment decisions consider social and environmental risks. The sustainability report of an Indonesian cosmetics company shows that sustainable finance strategies are evident in investments in energy efficiency, emission reduction, and environmentally friendly packaging innovation. From an economic perspective, these strategies improve resource efficiency, reduce environmental externalities, and strengthen the company's long-term competitiveness due to increasing consumer interest in sustainable products.

The Mediating Role of Sustainable Finance Strategy (SDGs) on the Influence of Material Flow Cost Accounting (MFCA) on the Circular Economy (CE)

The Sobel test results indicate that the influence of MFCA on the circular economy cannot be overcome by sustainable finance strategies. The Z-score value is smaller than the Z-table and the probability is above 0.05, indicating that the indirect effect of MFCA through the SDGs is not statistically significant. Furthermore, based on the results of the test of differences between countries, MFCA between countries cannot explain the significant differences between the SDGs and the CE. This suggests that sustainable finance is not a direct extension of MFCA, but rather a macro-strategic domain influenced by legislation, capital markets, and institutional pressures.

Theoretically, MFCA should provide environmental cost data to drive the development of sustainable finance strategies. However, in Stakeholder Theory, mediation only occurs when financial management uses MFCA information to make strategic decisions. The mediation pathway is broken when MFCA no longer functions as an operational tool. These findings align with research by Angelin and Ulfah (2024), who found that MFCA is more effective when financial strategy does not support MFCA. Conversely, research by Taera and Lakner (2025) shows that sustainable finance does not function as a direct link to micro-environmental accounting practices, but rather as a macro-environmental accounting component. Cosmetic companies in Indonesia, Malaysia, and Thailand face significant challenges in cross-functional integration between production and finance. While sustainable finance strategies are developed separately, MFCA is overseen by operational units. Due to this situation, MFCA has not yet become a primary driver of circular economy financing. Practically, for MFCA to contribute strategically to the circular economy, companies must integrate MFCA into green investment policies and capital budgeting.

CONCLUSION

This study found that Material Flow Cost Accounting (MFCA) had a significant but negative effect on the circular economy in personal care companies in Indonesia, Malaysia, and Thailand for the 2020-2024 period, indicating that waste cost identification has not translated into effective circular production practices (coefficient -0.409296, $p=0.0419$). Sustainable finance strategies were shown to have a significant positive effect on the circular economy (coefficient 1.127966, $p=0.0000$), but failed to mediate the MFCA-circular economy relationship due to weak integration of operational data into financial decisions (H2 not significant, Sobel test not significant). Simultaneously, both variables influenced the circular economy ($F=19.04944$, $p=0.0000$), with significant differences between countries in the CE and SDGs indices. Practical implications, management should use MFCA as a basis for green investment for circular transitions, while ASEAN regulators need to harmonize reporting standards and tax incentives (Ghozali, 2018; Sugiyanto, 2023).

However, limitations of this study include reliance on secondary disclosure data, which is susceptible to reporting bias, a limited sample size of 70 observations from the personal care subsector, and the absence of primary data for operational validation of the MFCA. Future research is recommended to expand to other sectors, integrating mixed-methods approaches with manager interviews to explore barriers to cross-functional integration, and the post-2024 period to capture the impact of the new ASEAN Taxonomy for Sustainable Finance regulations (Creswell & Creswell, 2023; Putri, 2024).

SUGGESTION

For Company Management: Companies in the personal care subsector need to integrate MFCA reports into strategic financial policies. Data on negative product costs (waste) should serve as a basis for allocating green investments to upgrade more circular production technologies.

For Regulators: Governments and stock exchange authorities in the Southeast Asian region need to harmonize sustainability reporting standards and provide tax incentives or funding opportunities for companies that successfully implement MFCA and the circular economy in an integrated manner.

For Further Researchers: Future research is expected to expand the industrial sector beyond personal care or use qualitative methods through in-depth interviews to explore the psychological barriers of management in integrating environmental costs into financial decisions.

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