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Cost Reduction Strategy In Manufacturing Industries Empirical Evidence From Indonesia

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Abstract: The COVID-19 pandemic has forced manufacturing industries to be efficient in multiple fields. This study examines the effect of raw material management using Material Flow Cost Accounting and waste cost for Non-Product Output cost on implementing cost reduction strategies. Data was gathered by analyzing annual financial reports as well as sustainability reports. The study finds that organizations can reach efficiency by managing the cost of the raw materials using Material Flow Cost Accounting and Non-Product Output costs when implementing a cost reduction strategy. The research contributes to developing the concept of cost reduction through the Environmental Management Accounting approach, which is still rare in this field, in addition to the traditional method of cost accounting that organizations have carried out to achieve cost efficiency.
Keywords: Material Flow Cost Accounting; Non-Product Output; Cost Reduction; Manufacturing; Sustainability.

Abstrak Pandemi COVID-19 telah memaksa industri manufaktur menjadi efisien di berbagai bidang. Penelitian ini menguji pengaruh pengelolaan bahan baku menggunakan Material Flow Cost Accounting dan waste cost untuk biaya Output Non Produk terhadap penerapan strategi pengurangan biaya. Data dikumpulkan dengan menganalisis laporan keuangan tahunan dan laporan keberlanjutan. Studi ini menemukan bahwa organisasi dapat mencapai efisiensi dengan mengelola biaya bahan baku menggunakan Akuntansi Biaya Aliran Material dan biaya Output Non-Produk ketika menerapkan strategi pengurangan biaya. Penelitian tersebut memberikan kontribusi terhadap pengembangan konsep pengurangan biaya melalui pendekatan Akuntansi Manajemen Lingkungan yang masih jarang ditemukan dalam bidang ini, selain metode akuntansi biaya tradisional yang telah dilakukan organisasi dalam mencapai efisiensi biaya.
Kata Kunci: Akuntansi Biaya Aliran Material; Output Non-Produk; Pengurangan Biaya; Manufaktur; Keberlanjutan.

INTRODUCTION

Due to COVID-19, economic structures around the world are in turmoil. As of May 2020, the lockdown has affected billions of individuals worldwide. The coronavirus pandemic has paralyzed global economic activity and has dramatically impacted the manufacturing industry due to weak economic demand. The manufacturing industry is an ultimate sector of the global economy, accounting for nearly 16 per cent of the global GDP in 2018 (Kelp et al., 2020). The pandemic hit the manufacturing sector harder than during the 2007 to 2009 global financial crisis, resulting in a drop in production in 2020 (SDG Report, 2021). Manufacturing production is recovering momentum after dropping due to COVID-19 (Kurniawan & Hasibuan, 2022). Many companies report that their revenues

Jurnal Akuntansi
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have already returned to normal levels (before the current quarter). Moreover, 35 per cent of companies expect their incomes to return to pre-COVID-19 levels.

The manufacturing industry faces many challenges, though it is moving to better conditions today. Thus**,** cost reduction in the manufacturing industry remains a priority for many companies (Bokhan & Romanenko, 2021). Cost reduction is an effort to improve the company's performance in producing low-cost services or products (Bokhan & Romanenko, 2021). Managing costs and aligning them with the organization's business strategy is crucial for businesses today. Traditionally, companies cut short-term costs without thinking about sustainable change, impact on the people, and integration with the overall business strategy. Successful companies are changing their approach to cost structuring and control in the current business environment of increased global competition, new markets, increasing regulation, and changing demographics (Rounaghi et al., 2021).

Implementing a cost reduction strategy in the manufacturing industry in Indonesia has been challenging, as many companies globally suffer due to supply chain disruptions, high raw material costs, attracting and retaining workforce, and trade uncertainties (Bokhan & Romanenko, 2021). The Manufacturing Industry has to reduce production costs that generally contain raw materials covering 65 per cent of the cost of goods produced (Oxford Business Group, 2020) since materials are a cost driver that has a significant amount in many organizations (ISO 14051). On the contrary, the manufacturing sector has to push high-quality products at the lowest possible cost and manage the impact of its company operation on the environment. Thus, there is a need for a systemic and systematic approach to identify and eliminate waste and activities that are not value-added through continuous improvement by flowing products at low cost, high quality, and shorter processing times called *'lean manufacturing'* that aims at the elimination of waste, streamlining the processes, and enhancing value addition, which its goals are reducing cost (Vinodh, 2023).

According to his study, the main effects of Lean Manufacturing on environmental and social sustainability are directly related to the reduction of cost through the removal of unnecessary transportation, manufacturing time, and materials consumption.

Material Flow Cost Accounting (MFCA) is a part of Environment Management Accounting (EMA). It focuses on calculating production costs that revise for material flow by not calculating environmental or sewage treatment costs and emissions or integrated prevention and environmental management. The uniqueness of MFCA lies in allocating all production costs to the intended output (the product) or the unintended output (all waste occurring over all the production steps). Thereby, the transparency of material flows and associated costs increases considerably; the manager will know when material and energy consumption inefficiencies appear and disclose hidden costs (Walz & Guenther, 2021).

Accordingly, the goal of MFCA is a theoretical value of zero non-product output while keeping economic boundaries in mind. One strength of the MFCA method is the integrated plan–do–check–act (PDCA) cycle. After planning and implementing MFCA, the people responsible for the single production process should start with analyzing the data (check), develop the necessary actions to improve the process (act), and make some changes in the process without much coordination, the improvement measures are executed directly after the MFCA analysis. However, most production processes are already optimized; changing a running system is complex, and plant managers are somewhat reluctant to make changes for what are often only minor improvements. Thus,

Jurnal Akuntansi
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one weakness of the MFCA method is its application in complex production processes because, here, the MFCA analysis may not consistently execute to measure the performance.

Furthermore, MFCA is more accurate in providing waste cost information than conventional cost accounting, which puts waste costs into general overhead (Tu & Huang, 2019). Material Flow Cost Accounting (MFCA) is a crucial management tool to manage manufacturing processes related to the flow of materials, energy, and data to ensure that the process takes place efficiently and is often associated with increased eco-efficiency, demonstrating high relevance to strategic decision-making processes within organizations (Tran & Herzig, 2020). One of the main challenges in applying MFCA in developing country studies lies in accounting systems with limited data availability and inadequate cost allocation (Tran & Herzig, 2020).

Research found that the most significant cost in the manufacturing industry is the Non-Product Output (NPO) cost (Tran & Herzig, 2020; Walz & Guenther, 2021). The NPO cost can be higher than disposal costs, depending on the domain of site of the business sector and the country (Hakimi et al., 2021).

Although many studies report the MFCA application, few studies have studied the cost reduction strategy with the environmental cost approach, such as the NPOs. Limited information is available regarding the specific issues because only a few researchers have conducted research with statistics on quantitative and longitudinal research (Christ & Burritt, 2016). As far as we know, this is the only study that uses quantitative statistical-based methods after (Yagi, 2019). We are trying to fill the gap in this area in the context of the current study. Specifically, to answer the following research questions: (1) Does the application of Material Flow Cost Accounting have a positive effect on cost reduction? (2) Does Non-Product Output Costs have a positive impact on cost reduction?

The study contributes to the development of the management accounting theory by providing empirical evidence of the application of Material Flow Cost Accounting and Non-Product Output Costs to Cost Reduction Strategy.

THEORETICAL REVIEW

Legitimacy Theory. Legitimacy Theory states that the more likely it is that an adverse shift occurs in the social perception of how an organization acts, the greater the desire of the organization to try to manage this change in social perception. Generally, the Academician analyses the Legitimacy theory from a managerial perspective that focuses on the different strategies managers may choose to stay appropriate (Chelli et al., 2019). Many researchers have perceived the word "legitimacy" (organizational legitimacy) from different angles over the years. Some have tried to rationalize it by social attitude and values, whereas others have described it from the viewpoints of Justice, legislation, and environmental care. Interestingly, some investigators have gone as far as the angle of cultural aspects and organizational resources to denote organizational legitimacy (Mahmud, 2019).

To remain compliant, organizations can adjust to or, in several ways, seek to change social perceptions, expectations, or values as part of the legitimacy process. The legitimacy theory is an exploratory factor for environmental disclosure (Solikhah & Maulina, 2021). The annual report has become the primary medium of communication and environmental disclosure data source (Gnanaweera & Kunori, 2018). The theory of legitimacy is one of

Jurnal Akuntansi
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the theories underlying the incentives of entities that voluntarily reveal the report of social and environmental accountability (Bartolacci et al., 2022).

Stakeholders Theory. Stakeholders' theory was introduced by the Standford Research Institute (RSI) in 1963 and then published by R. Edward Freeman in 1984. The theory states, "*Any group or individual who can affect or is affected by achieving the firm's objectives*." The groups listed here are examples of categories of stakeholders. The company is one of the elements that shape society in the prevailing social system to create a reciprocal relationship between the company and stakeholders. Thus, the company must carry out its role in a two-way manner both to meet the interests of the company and social interests. Financial, social, and environmental information disclosure is a dialogue between the company and its stakeholders. It provides information about the company's activities that can change perceptions and expectations (Gutterman, 2023).

Material Flow Cost Accounting (MFCA). The MFCA is a new cost accounting method that identifies improvement opportunities in terms of material consumption and accrual of costs (Walz & Guenther, 2021). Material Flow Cost Accounting (MFCA) strongly supports the improvement of energy and material efficiency and is very useful, especially for manufacturing companies, and will contribute to the circular economy by simultaneously achieving both company environmental and economic goals (i.e., environmental performance and economic performance, including profit) through resource efficiency (Kokubu et al., 2023; Tu & Huang, 2019; Weyand et al., 2021). The increase in waste is a sign of inefficient production. The MFCA plays a role in coordinating material flows and eliminating sub-optimizations in the supply chain from both an economic and environmental perspective (Higashida, 2020). By implementing Material Flow Cost Accounting (MFCA) and paying attention to Non-Product Output (NPO) costs, the company can reduce costs and increase company profits.

Cost Flow Accounting (MFCA) is formed by three main elements, as shown in **Figure 1**.

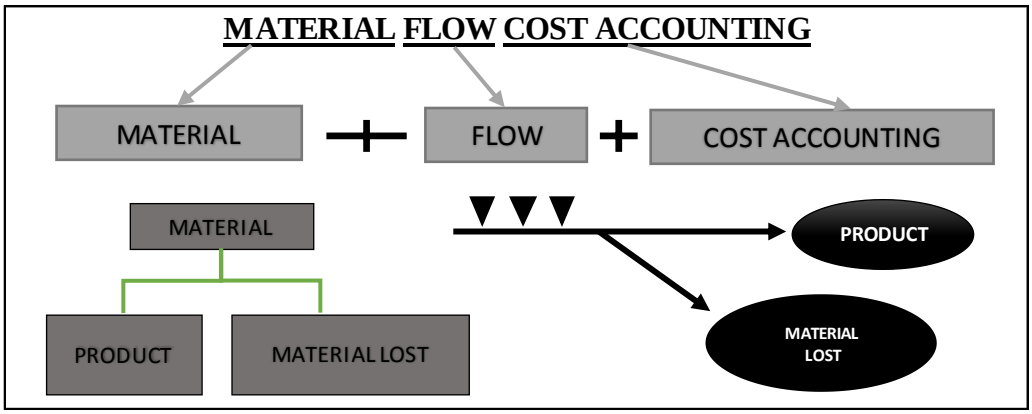

Figure 1. Main Element of MFCA
(Source: ISO 14051, 2011)

This part of the process is defined as the quantity centre in the MFCA (e.g., Material Loss = Input - Product), as shown in **Figure 2** below:

Jurnal Akuntansi
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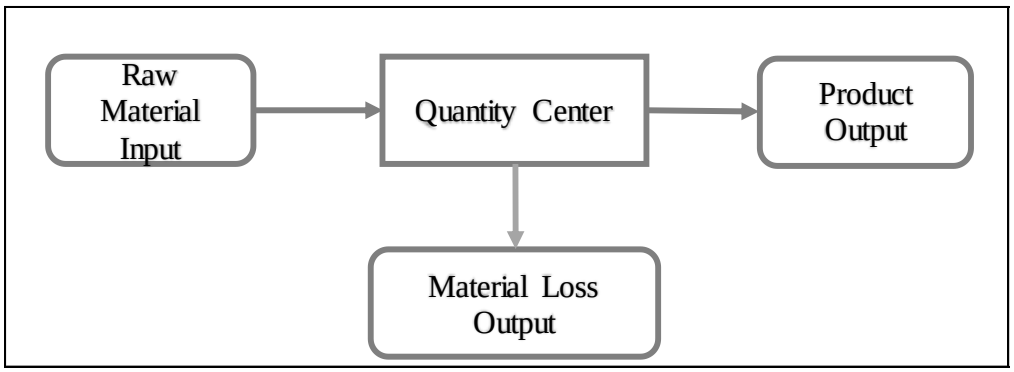

Figure 2. Material Balance Concept
Source: (ISO 14051:2011, clause 3)

Figure 2, described in standard DIN EN ISO 14051 12-2011, provides a general material flow cost accounting (MFCA) framework. Under MFCA, the flows and stocks of materials within an organization are traced and quantified in physical units (e.g., mass, volume). The concepts also evaluated the costs associated with those material flows.

Simple MFCA Model of Materials and Financial Flows in Manufacturing Companies. **Figure 3** represents material and financial flows with straight and dotted arrows. (1) The products are processed raw materials that consist of favourable products (i.e., ordinary products) and harmful products (e.g., waste); (2) Here, harmful products refer to all waste generations, including valuables (for example, reuse and recycling) and waste discharges (or final disposal outside the enterprise) for industrial and ordinary business waste. (3) Meanwhile, financial flows consider Cost of Goods (COGS), namely sales minus gross margin (cost of sales, general, and administration (SGA) and profit). (4) The MFCA divides COGS into four types of costs: material costs (MC), energy costs (EC), system costs (SC; other costs such as labour costs), and waste management costs (WMC), in each quantity centre, depending on the material flow. (5) Therefore, the MFCA does divide COGS into the following seven costs: MC, EC, SC, and WMC for harmful products and MC, EC, and SC for favourable products.

Jurnal Akuntansi
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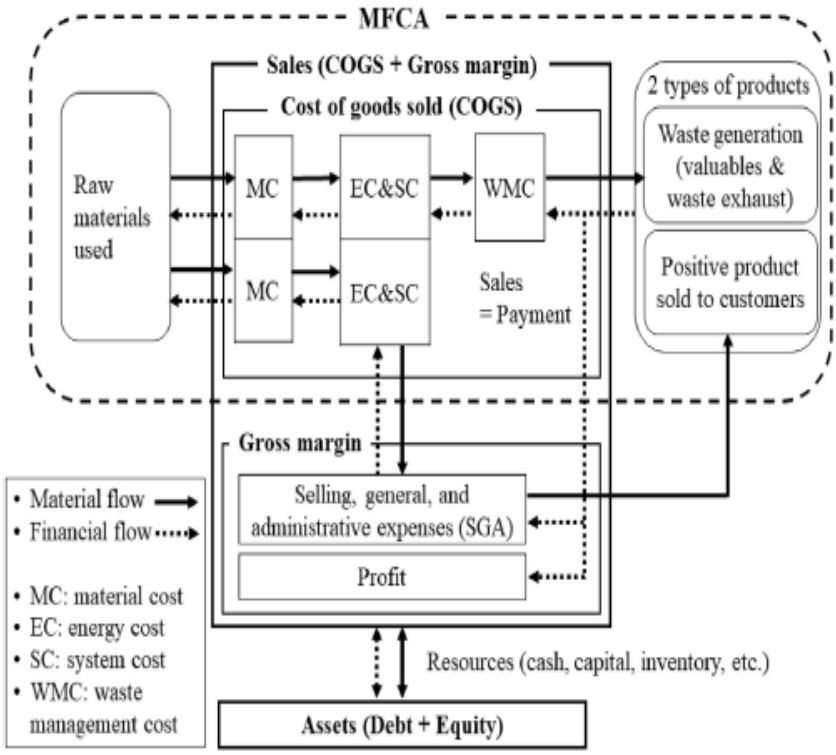

Figure 3. Simple MFCA Model of Materials and Financial Flows in Manufacturing Companies
Source: Yagi and Kokubu, 2019

Non-Product Output (NPO). Non-product output (NPO) is also associated with costs related to economic inefficiency and lousy quality products, which will finally end up in Waste (Walz & Guenther, 2021). The International Federation of Accountants in 2005 (the standards remain current) defined Non-Product Outputs (Waste and Emissions) as Any Output that is not a Product Output. Examples include solid Waste, hazardous Waste, wastewater, and air emissions. These Wastes and Emissions consist of two ways. First, when materials Are intended to leave the facility as product output, they become waste and emissions because of poor equipment efficiency and maintenance, inefficient operating practices, production losses, product spoilage, poor product design, or other reasons. Materials Inputs that contribute to NPO in this way include Raw and Auxiliary Materials, Packaging Materials, Merchandise, and sometimes Water. Waste and Emissions also arise when materials Inputs never intended to become part of Product Output leave an organization. Inputs that contribute to Waste and Emissions in this way are Operating Materials, Water, and Energy. Waste and Emissions can result from continuous losses (for example, continuous heat loss from an un-insulated oven or continuous water leaks from an old storage tank), episodic losses (for example, scrap from a poor quality batch of product), or one-time losses (for example, an accidental spill of some kind), and can come from any part of an organization such as inventory, Manufacturing, building services, shipping, and many others.

Solid waste is considered relatively non-hazardous waste in solid form, such as waste paper, plastic containers, food waste, non-hazardous solid scrap products, and many others. IFAC (2005) defines Hazardous Waste Hazardous Waste as more hazardous waste

Jurnal Akuntansi
e-JA
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materials in solid form (such as discarded batteries), liquid form (such as waste paint and solvents), or mixed form (such as wastewater treatment sludge). Depending on the context, "hazardous" could be defined as infectious, flammable, toxic, or carcinogenic. Some manufacturing sectors have shown that waste disposal costs are usually 1 to 10 per cent of the total environmental costs, while purchasing wasted materials represents 40 to 70 per cent of environmental costs, depending on the business sector under study. (IFAC, 2005) Non-product output (NPO) analysis can reduce the use of raw materials in the production process of several industries, with a study of each production unit that can produce unexpected cost efficiencies compared to before the NPO analysis. In General, the NPO costs ultimately contribute to decision-making because of their impact on the production capacity and will result in loss of production.

Cost Reduction. According to (Bokhan & Romanenko, 2021), cost reduction can be done simply by identifying different types of waste. In Manufacturing, cost saving has always been an objective. It means higher profit margins, more market share, and loyal customers. The first step to driving cost reduction in the manufacturing industry is to assess the current situation and determine the primary sources of expenditures, including product cost. Practitioners believe that assessing the primary sources is one of the most effective cost-reduction strategies in Manufacturing (Bokhan & Romanenko, 2021). Cost reductions can come from various sources, which are predictable. Cost reduction is the easiest and surest way to increase profits in the short term because cost reduction is entirely within the company's control, namely by increasing profits (profitability) and cash flow.

METHODS

The study uses three variables: the Application of Material Flow Cost Accounting, Non-Product Output Costs, and Cost Reduction. We collect data from archival annual reports published by manufacturing industry companies on the Indonesia Stock Exchange and sustainable reports published from 2016 to 2020 following the requirement to publish Sustainability Reports for companies listed in IDX in 2017 (Otoritas Jasa Keuangan, 2017). The sampling technique uses the Disproportionate Stratified Sampling technique. We excluded several manufacturing companies that were inactive during the period between 2016 and 2020. The total number of manufacturing industry companies meeting these criteria from 2016 to 2020 was 230. This study follows (Yagi & Kokubu, 2019) to prove their result in a different geographic area.

Model. This research follows the research model conducted by (Yagi & Kokubu, 2019) but modifies their model. This study has two measurement scales: the ratio scale and the dummy ratio result scale. Consequently, we have to present two models in our results and discussion.

Material Flow Cost Accounting. In the research model, RtCR (raw materials divided by COGS) is considered necessary from the perspective of MFCA because MFCA treats raw materials (material flow) and COGS (financial flow) simultaneously to improve resource efficiency (Yagi & Kokubu, 2019). The Raw materials-to-cost ratio (RtCR) is considered necessary from MFCA's perspective because MFCA can simultaneously manage raw materials and costs. The study considers the Raw materials-to-cost ratio (RtCR) to be the most crucial indicator of resource efficiency in the equation, as it relates the degree of material use to financial factors. The model in this study will use the raw materials-to-cost ratio (RtCR) equation. The model (1) is:

Jurnal Akuntansi
e-JA
E-ISSN 2549-8800
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$$\text{RtCR} = \frac{Materials}{COGS} \quad \text{..... (1)}$$

Materials (raw materials stated in Rupiah) and COGS stated in Rupiah. Increasing the raw materials-to-cost ratio (RtCR) is interpreted as an increase in the use of raw materials in specific companies, so it is necessary to do the estimation (dummy). We are conducting the study by using the two scale models: the normal ratio and the dummy scales. We have also compared both ratios to the previous year's ratio. We determine Dummy variables as nominal variables used in multiple regressions and given values 0 (zero) and 1 (one). The purpose of using dummy multiple regression is to predict the magnitude of the value of a dependent variable based on one or more independent variables. Thus, the equation of the RtCR dummy variable and the model (2) is :

RtCRt less thanRtCRt-1, 1, 0.....(2)

Where the Current Year's Raw materials-to-cost ratio (RtCR t) is smaller than the company's RtCR the previous year (RtCRt-1), the less the use of the company's raw materials in the current year, the value is 1 (one); on the contrary, if the Current Year's RtCR (RtCR t) is greater than the company's RtCR t-1 (RtCRt-1) then the increasing use of the company's raw materials in the current year, the value is 0 (zero). We mark a value of 0 (zero) when the company does not report an annual report/sustainability report, so the calculation does not contain the monetary value in the ratio calculation.

This study will potentially generate MFCA by providing financial benefits simultaneously and reducing adverse environmental impacts. In the research model, RtCR is considered important from the perspective of the MFCA because the MFCA treats raw materials (material flows) and COGS (financial flows) simultaneously to improve resource efficiency. The raw materials-to-cost ratio (RtCR) indicates the quantity of cheap raw materials purchased (compared to COGS). RtCR is considered important from an MFCA perspective because the MFCA can simultaneously manage raw materials and costs. The study considers RtCR the most crucial indicator of resource efficiency since it relates the degree of material use to financial factors.

H1: The Implication of Material Flow Cost Accounting positively affects Cost Reduction.

Non-Product Output (NPO) costs are an independent variable in this study. NPOs are a significant cost factor for the company as it copes with the cost of raw materials, although they will dispose of them. Thus, NPO costs have the industry's most incredible potential cost savings. In the (Yagi & Kokubu, 2019) study, the waste ratio of materials (WRMat) is an essential indicator of waste inefficiency. The waste ratio of materials (WRMat) is an unuseful output (Waste) because it shows the loss of production materials. Hence, the waste ratio of materials (WRMat) has the same meaning as non-product output (NPO). In calculating the company's Non-Product Output (NPO) costs with the waste-ratio of materials (WRMat) equation. The waste-ratio of-materials (WRMat) equation in the study is as follows:

$$\text{WRMat} = \frac{WASTE}{MATERIALS} \quad \text{..... (3)}$$

Jurnal Akuntansi
e-JA
E-ISSN 2549-8800
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Waste is generated by (environmental costs/ waste costs) in Rupiah, and Materials are raw materials used in Rupiah. Suppose the result of a sizeable WRMat ratio signals the company's inefficiency in controlling NPO costs. On the other hand, if the result of the WRMat ratio is small, the company will be more efficient in managing and controlling NPO costs. In this study, we are using two scale models, both the standard ratio scale above and the dummy scale ratio results compared to the previous year's ratio results. In this equation, the sifting also performs a dummy variable with the following criteria: **WRMat t less than WRMat t-1, 1,0.**

Where the current year's waste ratio of materials (WRMat t) is smaller than the previous year's company waste ratio of materials (WRMat t-1), then the less the use of the company's raw materials in the current year, the value is 1 (one); on the contrary, if the current year's WRMat (WRMat t) is greater than the company's WRMat t-1, the increasing use of the company's raw materials in the current year, the value is 0 (zero). We give a value of 0 (zero) when the company does not report an annual report/sustainability report, so no monetary value will show in the ratio calculation. This Waste, or NPO approach, is expected to reduce the formation of NPO costs in the production process in the manufacturing industry to produce productivity efficiency and cost reduction.

H2: Non-Product Output Cost has a positive effect on Cost Reduction

Cost reduction. The cost reduction approach in this study will use one of the approaches to analyze the company's financial profitability, namely ROA (return on assets). The Corporate Financial Performance (CFP) measurement with ROA has the advantage that ROA is a comprehensive measurement that affects financial statements reflected in this ratio. The cost reduction approach in this study will use one of the approaches to analyze the company's financial profitability, namely ROA (return on assets). Where ROA will use the following equation:

$$\text{ROA} = \frac{NET\ INCOME}{TOTAL\ ASSETS} \quad \text{..... (4)}$$

ROA is the ratio return on assets (return on assets ratio) in percentage, and net income is the company's net profit (in Rupiah). Total Assets are overall company assets (in Rupiah). The result of the return on assets (ROA) assesses the effectiveness of the company in generating profits (profitability) by utilizing its assets. The measurement of Corporate Financial Performance (CFP) with ROA has the advantage that ROA is a comprehensive measurement that affects financial statements reflected in this ratio, that better Corporate Financial Performance (CFP) tends to lead to better Corporate Environmental Performance (CEP) (and vice versa). Corporate Financial Performance (CFP) or a company's financial performance is categorized as good if the size of the company's financial ratio is equal to or above the standard financial ratio. In addition to comparing the financial ratio with the standard ratio, we are assessing the financial performance by comparing the financial ratio of the year assessed with the financial ratio in the previous year. By comparing financial ratios in several years of assessment, We can pay attention to the progress or deterioration of financial performance following the usefulness of each of these ratios.

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Jurnal Akuntansi
e-JA
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P-ISSN 1410-3591

The cost reduction will affect the variable application of MFCA and NPO costs with the percentage of ROA generated between the company's current year ROA (ROA t) divided by the previous year's ROA (ROA-t). The study used two scale models, both with the standard ratio scale above and dummy scale ratio results compared to the ratio results of the previous year. We use dummy variables for ROAt **less than ROA t-1, 1, 0.**

Where the return on assets (ROA) for the current year (ROA t) is greater than the company's ROA of the previous year (ROAt-1), the more significant the reduction in company costs made in the current year, then the value is 1 (one); on the contrary, if the ROA of the current year (ROAt) is smaller than the ROA of the previous year's company (ROAt-1)) then the smaller the cost reduction made by the company in the current year, the maximum is zero (0). We mark a value of 0 (zero) when the company does not report an annual report/sustainability report, so no monetary value is shown in the ratio calculation.

RESULTS

Here are the results of descriptive statistics with two different scaled methods, as shown in **Table 1.**

Table 1. Descriptive Statistical Results with 2 Methods

	Methods 1 Scale 1 (Ratio)			**Methods 2 Scale 2 (Dummy ratio result from t to t-1)**		
	MFCA	NPO	CR	MFCA	NPO	CR
Mean	2.307	0.009	4.576	0.475	0.606	0.3580
Median	1.530	0.000	4.060	0.000	1.000	0.000
Maximum	19.090	0.090	26.400	1.000	1.000	1.000
Minimum	0.000	-0.040	-24.870	0.000	0.000	0.000
Std. Dev	2.475	0.017	6.663	0.500	0.489	0.480
Skewness	3.939	2.610	-0.293	0.096	-0.438	0.592
Kurtosis	20.048	10.958	6.274	1.009	1.1919	1.350
Jarque-Bera	3233.255	830.495	101.422	38.167	38.518	39.338
Probability	0.000	0.000	0.000	0.000	0.000	0.000
Sum	507.690	1.980	1006.830	109.000	139.000	82.000
Sum Sq.Dev	1341.967	0.067	9724.808	57.117	54.628	52.637

Source: Data obtained by researchers, 2022

From the data in **Table 1**, here is an explanation of data processing in each measurement variable:

Statistic Descriptive Analysis. Methods 1: Scale 1 (Ratio). Based on **Table 1,** the average value of research variables such as Material Flow Cost Accounting (MFCA), Non-Product Output (NPO), and cost reduction is smaller than the standard deviation value; thus, the overall data on the research variables have heterogeneous data. The explanation as stated below:

Material Flow Cost Accounting **(MFCA)** is a tool that measures a company's ability to reduce costs. Based on the results of descriptive statistics on MFCA, the average value of MFCA is 2.307. The median value or mean value of the MFCA is 1.530. The maximum

Jurnal Akuntansi
e-JA
E-ISSN 2549-8800
P-ISSN 1410-3591

value of MFCA is 19.090, and the minimum value of MFCA is 0.000. The average MFCA value is smaller than the standard deviation value (2.307 less than 1341.967); thus, all data in the MFCA variable has heterogeneous data. Mark's *skewness* MFCA is 3.939, and the positive value indicates that *skewness*. The MFCA has a long tail on the right side. Mark *kurtosis* MFCA is 20.048, meaning that the height of the MFCA distribution is 20.048, which is more than three, so the data distribution on the MFCA variable is distributed *leptokurtis* against normal. The Jarque-Bera MFCA value is 3233.255, with a probability value of 0.000. The data distribution is not normally linear because the probability value is smaller than the significance level of 0.000 and less than 0.050.

***Cost Non-Product Output* (NPO)** is a tool that measures a company's ability to reduce costs. Based on the results of descriptive statistics on NPOs, the average value of NPOs is 0.009. The median value or middle value of NPOs is 0.000 (zero). The maximum NPO value is 0.090, and the minimum NPO value is -0.040. The average NPO value is greater than the standard deviation value (0.009 less than 0.067), so all data in the MFCA variable have heterogeneous data. Mark's *skewness* MFCA is 2.610, and the positive value indicates that *skewness*. The MFCA has a long tail on the right side. Mark *kurtosis* MFCA is 10.958, meaning that the height of the MFCA distribution is 10.958, which is more than 3, so the data distribution on the MFCA variable is distributed *leptokurtis* against normal. The Jarque-Bera MFCA value is 830.495, with a probability value of 0.000. The distribution data is not linearly normal because the probability value is smaller than the significance level of 0.000 and less than 0.050.

Statistic descriptive Methods 2: Scale 2: The average value of research variables such as *Material Flow Cost Accounting* (MFCA) and the cost reduction is smaller than the standard deviation value. Thus, the overall data on the four research variables have heterogeneous data, except *Non-Product Output* (NPO), which shows an average value greater than the standard deviation, so the CR variable is homogeneous. Based on the results in Table 4. descriptive statistics, we explain as follows:

***Material Flow Cost Accounting* (MFCA)**. Based on the results of descriptive statistics on MFCA, the average value of MFCA is 0.475. The median value or mean value of MFCA is 0.000 (zero). The maximum value of MFCA is 1 (one), and the minimum value of MFCA is 0.000. The average MFCA value is smaller than the standard deviation value (0.475 less than 0.500); thus, the overall data in the MFCA variable is heterogeneous. Mark's *skewness* MFCA is 0.096, and the positive value indicates that *skewness*. The MFCA has a long tail on the right side. Mark *Kurtosis*'s MFCA is 1.009, meaning that the height of the MFCA distribution is 1.009, which is less than 3.000, so the data distribution on the MFCA variable is distributed *platykurtic* against normal. The Jarque-Bera MFCA value is 38.167, with a probability value of 0.000. The data distribution is not linearly normal because the probability value is smaller than the significance level of 0.000, less than 0.050.

***Non-Product Output* (NPO)** is a tool that measures a company's ability to reduce costs. Based on the results of descriptive statistics on NPOs, the average value of NPOs is 0.606. The median value or NPO's middle value is 1.000 (one). The maximum NPO value is 1.000 (one), and the minimum NPO value is 0.000 (zero). The average NPO value is greater than the standard deviation value (0.606 less than 0.489), so all data in the NPO variable have homogeneous data. Mark *skewness* NPO is -0.438, and the negative value indicates that *skewness* NPO has a long tail on the left side. Mark *Kurtosis*: The NPO is 1.191, meaning that the height of the NPO distribution is 1.191, which is less than three.

Jurnal Akuntansi
e-JA
E-ISSN 2549-8800
P-ISSN 1410-3591

Hence, the distribution of data on the NPO variable has a normal data distribution (*platykurtic*). NPO's Jarque-Bera value is 38.518, with a probability value of 0.000. The data distribution is not linearly normal because the probability value is smaller than the significance level of 0.000 and less than 0.050.

Here are the results of the multicollinearity test with two different scaled methods, as shown in **Table 2**.

Table 2. Multicollinearity with 2 Methods

	Methods 1 Scale 1 (Ratio)			**Methods 2** Scale 2 (Dummy ratio result from t to t-1)		
	MFCA	NPO	Cost Reduction	MFCA	NPO	Cost Reduction
MFCA	1.000	0.078	-0.034	1.000	0.229	0.181
NPO	0.078	1.000	0.052	0.229	1.000	0.228
Cost Reduction	-0.034	0.052	1.000	0.181	0.228	1.000

Source: Data obtained by researchers, 2022

Multicolinearity Testing. **Methods 1** (**Table 2)**: The correction occurs if the value is above 0.900; we find that the model does not correlate, meaning there is no multicollinearity between independent variables in the model. The coefficient of determination (Adjusted R-squared) indicated by the R-squared is 0.015. Thus, the MFCA and NPO variables influence the cost reduction variable by 1 per cent. Other variables outside this research model influence the remaining 99 per cent.

Methods 2 (Table 2), in the dependent variable of the application of Material Flow Cost Accounting (MFCA) of 0.181 and Non-Product Output (NPO) costs of 0.228 against cost reductions (independent variables), then there is no multicollinearity. The coefficient of determination (Adjusted R-squared) indicated by the R-squared is 0.062. Thus, the MFCA and NPO variables influence the cost reduction variable by 6 per cent. Other variables outside this research model influence the remaining 94 per cent.

Here are the results of hypothesis tests with two different scaled methods, as shown in **Table 3**.

Table 3. Hypothesis Test Results with 2 Methods

	Methods 1 Scale 1 (Ratio)		**Methods 2** Scale 2 (Dummy ratio result from t to t-1)	
Variable	Coefficient	Prob	Coefficient	Prob
C	3.966	**0.000**	0.185	**0.000**
MFCA	0.095	**0.611**	0.124	**0.046**
NPO	43.226	**0.071**	0.187	**0.004**
R-squared	0.015		0.062	
Adjust R-squared	**0.006**		**0.054**	
F-Statistic	1.687		7.558	
Prob(F-statistic)	**0.187**		**0.000**	

Source: Data obtained by researchers, 2022

Jurnal Akuntansi
e-JA
E-ISSN 2549-8800
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Hypothesis Testing. **Methods 1: Table 3**, the following is the result of the (T-Test: a) The results of the regression analysis test showed that the probability value of Material Flow Cost Accounting (MFCA) was 0.611, where 0.611 more than 0.050, then the regression coefficient was insignificant t, so the hypothesis is rejected. The latter means that Material Flow Cost Accounting (MFCA) does not significantly affect cost reduction. So, the conclusion in this hypothesis is that the **hypothesis is rejected**. b) The results of the regression analysis test showed that the probability value of Non-Product Output (NPO) was 0.071, where 0.071 was more than 0.050. The regression coefficient was insignificant, so the hypothesis was rejected. The latter means that Non-Product Output (NPO) does not significantly affect cost reduction. So, the conclusion in this hypothesis is that the **hypothesis is rejected**. With the T-test value and Test F not significantly affecting, it is necessary to conduct further research because it indicates an error in data processing or the existence of different types of industrial technology systems that show insignificant hypothesis results. Thus, the distillation proceeds to data processing using dummy variables. **The multiple linear regression model results from** the statistical value of F, which is 0.187, where the statistical F probability value is 0.187, which is more than 0.050. Thus, we conclude that there is no significant effect on dependent variables. The results of the tests in this study can be used for simultaneous testing (together) the influence of independent variables on dependent variables, meaning that Material Flow Cost Accounting (MFCA) and Non-Product Output (NPO) have a significant influence on cost reduction.

Hypothesis Testing (Methods 2); Table 3. Scale 2 (Dummy result of ratio t to t-1). By looking at the previous research more carefully, the researcher found a statement from previous studies about the efficiency of each variable by looking at the results of the ratio of the current year compared to the value of the previous year. Dummy results from the variable ratio of Material Flow Cost Accounting (X1) set out in the research methodology. Based on **Table 1,** the average value of research variables such as Material Flow Cost Accounting (MFCA) and cost reduction is less than the standard deviation value; thus, the overall data on the four research variables have heterogeneous data, except for Non-Product Output (NPO) which shows the average value more significant than the standard deviation, so the CR variable is homogeneous. The following is the probability results of the T-test: a) The results of the regression analysis test showed that the probability value of Material Flow Cost Accounting (MFCA) was 0.046, where 0.046 less than 0.050, then the regression coefficient was significant, so the hypothesis was accepted. The latter means Material Flow Cost Accounting (MFCA) significantly influences cost reduction, so the conclusion in this hypothesis is that the **hypothesis is accepted**. b) The results of the regression analysis test showed that the probability value of Non-Product Output (NPO) is 0.004, where 0.004 is less than 0.050. The regression coefficient is significant, so the hypothesis is accepted. The latter means non-product output (NPOs) significantly influence cost reduction. So, the **hypothesis is accepted**.

The results of the multiple regression model with dummy variables, the statistical value of F is 0.000. In contrast, the statistical F probability value is 0.000, less than 0.050. Thus, we used a confidence level of 95 per cent, which resulted in at least one independent variable significantly influencing the dependent variable. The results of the tests in this study can be used for simultaneous testing (together) the influence of independent variables on dependent variables, meaning that Material Flow Cost

Jurnal Akuntansi
e-JA
E-ISSN 2549-8800
P-ISSN 1410-3591

Accounting (MFCA) and Non-Product Output (NPO) have a significant influence on cost reduction.

DISCUSSION

Findings. The study shows that applying MFCA affects cost reduction in manufacturing companies. We also find that eliminating the NPO costs significantly impacts Cost Reduction. This study conducted an experiment testing the significance of variables in the study. Our study extends the literature on the effects of MFCA and NPO cost on Cost Reduction, and the conclusions have important implications for improving the manufacturing industry's cost management strategy.

Effect of MFCA Implementation on Cost Reduction. The results above indicate that assessing the application of Material Flow Cost Accounting (MFCA) by focusing on the company's raw materials (materials) has influenced the manufacturing company's cost reduction strategy. To prove our hypothesis, we used dummy variables in the raw materials-to-cost ratio (RtCR) equation of the lower current year with the raw materials-to-cost ratio (RtCR) in the previous year. Adjusting the RtCR ratio impacts the company's financial performance, as seen from an increased return on Assets (ROA). The result is in line with The Legitimacy Theory that reports social and environmental accountability, which is a fundamental reason for the company to get its legitimacy from citizens. The legitimacy process seeks to change the organization's perception, expectations, or social values. The firms must be accountable and responsible to fulfil expectations from investors and society (Akhter et al., 2022). The premise of the theory of legitimacy is the belief that a company influences the society in which it operates (Zyznarska-Dworczak, 2018). Implementing cost reduction with the MFCA approach in a company's operation will improve resource efficiency and have a sustainable impact on economic, social, and corporate governance.

This study supports the findings from (Dunuwila et al., 2018; Kokubu et al., 2023; Mahmoudi et al., 2017; Rossi et al., 2019; Wang et al., 2017; Yagi & Kokubu, 2019). The difference between the research was proved empirically by the concept of MFCA, NPO, and Cost Reduction, which is rare in this field.

Effect of NPO Costs on Cost Reduction. Based on the hypothesis testing using the dummy variable analysis method with a second scale, namely the comparison of the results of the current year ratio to the results of the previous year ratio (t to t-1), we conclude that Non-Product Output Costs (NPO) had a significant effect on cost reduction in the manufacturing industry. These results indicate that the calculation of Non-Product Output (NPO) costs by focusing on waste/environmental costs in manufacturing industry companies using dummy variables with a waste-ratio of-materials (WRMat) equation for the current year that is lower than the waste-ratio of-materials (WRMat) in the previous year influences cost reduction. With the result of a small WRMat ratio, the company will be more efficient in managing the company in controlling Non-Product Output (NPO) costs, which has the most impact on the company's financial performance as seen from the results of a greater return of assets (ROA) than the previous year. Non-product output (NPO) costs, especially waste/ environmental costs, will impact the cost reduction of manufacturing industry companies in Indonesia. The hypothesis corresponds to the theory of legitimacy and the theory of stakeholders. Planning and controlling NPO materials will

Jurnal Akuntansi
e-JA
E-ISSN 2549-8800
P-ISSN 1410-3591

monitor environmental costs well so there are no hidden costs. The statements support the legitimacy and stakeholder theories, similar to previous disclosures supporting the MFCA.

The results of this study align with previous research (Yagi & Kokubu, 2019) in reinforcing researchers' thinking that it is crucial to conduct research related to independent variables of Non-Product Output costs (NPO) have a significant effect on dependent variables-cost reductions in manufacturing companies in Indonesia, with a focus on research on waste and the environment following the research of, who said that the loss of raw materials that occur during the process of the enterprise is an integral part of the flow of materials (for example, defective products of poor quality, scrap, waste, and defective products. Minimizing waste, improving manufacturing efficiency, and implementing energy-saving initiatives are some of the measures that the industry implements to reduce risks because environmental management can be cost control and waste treatment simultaneously.

This research is in line with research by (Yagi & Kokubu, 2019) that material waste ratio (WRMat) is an essential indicator of waste inefficiency (i.e., aggregate material loss) in MFCA or WRMat can be interpreted the same as Non-Product Output (NPO) because it shows as a loss of production material.

This study supports the results of previous research that there is an influence of the application of Material Flow Cost Accounting and Non-Product Output costs on cost reduction. Based on the results of hypothesis testing on the research model with two research methods, the first method with a normal ratio scale, the second method with a dummy scale with the results of the ratio of the current year to the results of the ratio of the previous year (t to t-1), then the second method of the two studies found that in the second method with using a dummy scale of the current year ratio result to the previous year ratio result (t to t-1) more precisely in its data processing. Meanwhile, with the first method, the normal ratio scale has limitations and other obstacles. We find that a different type of industrial technology system might show insignificant hypothesis results in the study using the second scale; the study also had limitations in obtaining the data to be studied because the secondary data from the annual report and the company's sustainability report were not presented successively. So, researchers need to take samples by Disproportionate Stratified Sampling. The sample techniques determine the number of samples with a stratified but less professional study population and treat the results of ratios inconsistent with the dummy values specified in the second scale method, so this method is an alternative improvement from the research that has been found by (Yagi & Kokubu, 2019). The study used theories and actual practice to show cost reduction from year to year using EMA, which is still a rare study.

The pros and cons of MFCA application in practice today. Despite the result of this study, the MFCA is relatively unpopular and has limited application in practice (Christ & Burritt, 2015), including in Indonesia. As suggested in the literature, the evidence presented above suggests that MFCA may not be a tool that can be well-known by itself (Christ & Burritt, 2015; Walz & Guenther, 2021). Furthermore, even when organizations know about MFCA, they must learn to adopt the practice. Further investigation is required, such as applying new research methods to gather evidence, statistically based quantitative and longitudinal research that are absent at present and theoretically driven projects, so it will open width opportunities for researchers and practitioners to study and understand what, how, and why the application of MFCA is under-developing in practice (Christ & Burritt, 2016).

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Jurnal Akuntansi
e-JA
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CONCLUSION

The research results on the effect of applying Material Flow Cost Accounting (MFCA) and Non-Product Output (NPO) on cost reduction in manufacturing companies listed on the IDX in 2016 – 2020 support both hypotheses and problem formulations. The manufacturing industry has to grow sustainably and perform efficiently in various fields, especially cost efficiency. In Traditional Cost Accounting, the organization generally uses the production cost efficiency approach but rarely uses cost-cutting strategies through an Environmental Management Accounting approach. Using a cost reduction strategy with an environmental management accounting approach has a three-way impact: increasing productivity to increase profits and contributing to the sustainability of human life and the environment.

The study used Quantitative Methods. We collect data from annual financial statements and sustainability reports. Sampling techniques use Disproportionate Stratified Sampling, with a sample size of 230 companies. The data samples were not consecutive in 2016-2020, so the study had limitations in obtaining consistent data. This research uses two scales to prove the hypothesis by comparing two measurement scales, namely the normal ratio scale and the dummy ratio result scale (t - (t -1).

In hypothesis testing of the result ratio dummy scale (t – (t -1), this research method provided a hypothesis that supported previous research. Here are the conclusions of the study: **1)** The effect of the implementation of Material Flow Cost Accounting (MFCA) has a significant influence on cost reduction in the manufacturing industry. Adjusting the raw materials-to-cost ratio (RtCR) is defined as the decline in the use of raw materials in specific companies, which has the most impact on the company's financial performance, as seen from the results of an increased Return of Assets (ROA). With descriptive statistical results, the study was symmetrically distributed normally and flatly, with a positive regression coefficient value, hypothesis testing with probability, and probability-F results of less than 0.050. The application of Material Flow Cost Accounting (MFCA), particularly raw materials, will reduce costs in manufacturing companies in Indonesia. We perform the dummy variable method through the raw materials-to-cost ratio (RtCR) equation to the Return of Asset (ROA). The latter statement aligns with previous theories and studies that have produced a similar hypothesis: Material Flow Cost Accounting (MFCA) significantly influences cost reduction. **2)** The effect of Non-Product Output (NPO) costs has a significant influence on cost reduction in the manufacturing industry. Lowering the WRMat ratio is defined as the deduction of waste / environmental costs in specific companies, which has the most significant impact on the company's financial performance, as seen from the results of an increased Return of Assets (ROA). With descriptive statistical results, the study was symmetrically distributed normally and flatly, with a positive regression coefficient value; hypothesis testing with probability and probability-F results of less than 0.050. So, paying attention to non-product output (NPO) costs, especially waste / environmental costs, will affect the reduction of costs in manufacturing companies in Indonesia. We use the dummy variable method through the waste-ratio of materials (WRMat) equation to calculate the return of asset (ROA). This method aligns with previous theories and studies that have produced a similar hypothesis: Material Flow Cost Accounting (MFCA) significantly influences cost reduction.

Limitation. The study had limitations in the sample used, namely the manufacturing company sector between 2016 and 2020, and was not consecutive. Annual and

sustainability reports are also minimal, especially for waste and environmental costs. Because this study aims to cover all sectors of manufacturing companies listed on the IDX during this period, it cannot be interpreted based on each sub-sector contained in Manufacturing. The data in the study using the standard ratio scale will be distributed abnormally because of the extreme scores contained in each research variable, and the data on the variables are heterogeneous, so the data variance is quite a lot. The research then needs to be adjusted using dummy variables to see the results of categorical variables that influence the variables.

This study focused on measuring the conditions of application of material use in Material Flow Cost Accounting (MFCA) and Non-Product Output (NPO) costs, especially waste and environmental costs, against cost reductions focusing on corporate financial performance (CFP) so that researchers did not test other measurement tools. We need help with previous research aligned with our study because only a few current studies discussed the concepts we are studying that are similar to those we are discussing. Even the Standard of MFCA still uses the standard issued from eighteen years ago. With the minimum of previous research, this study needs more references for the research process. Mainly research on Material Flow Cost Accounting (MFCA) and Non-Product Output (NPO) costs in secondary data and quantitative methods. The research method is less comprehensive because waste is a sensitive issue in Indonesia with many procedures, such as regulations, surrounding community organizations, and others, so it is necessary to add qualitative data by conducting interviews/surveys with related companies to get better results.

Suggestion. The findings of this study show that the manufacturing industry has an alternative option to do the cost reduction strategy besides the traditional cost reduction while protecting the environment. Future research can use other research methods, such as qualitative, to get a deeper understanding of the concept through the practitioner's lens.

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