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The Role of the Integration between Material Flow Cost Accounting and Cleaner Production in Product Sustainability in Iraqi Units: An Analytical study on a sample of administrative and financial staff in industrial companies in the Kurdistan Region of Iraq

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Abstract: This study explores the potential for enhancing product sustainability in industrial enterprises within the Kurdistan Region of Iraq through the integration of Material Flow Cost Accounting (MFCA) and Cleaner Production (CP). A structured questionnaire was distributed to 275 administrative and financial staff across 74 industrial companies, with 213 valid responses analyzed using SPSS. The results indicate a statistically significant positive effect ($p \leq 0.05$) of MFCA–CP integration on all dimensions of sustainability, with the most substantial impacts observed in economic performance ($R^2 = 31.5\%$) and energy efficiency ($R^2 = 34.2\%$). The integration supports environmental compliance, promotes sustainable industrial practices, and enhances managerial decision-making by enabling more accurate cost tracking.

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دور التكامل بين محاسبة تكاليف تدفق المواد والإنتاج الأنظف في استدامة المنتجات في الوحدات العراقية: دراسة تحليلية لآراء عينة من العاملين في الشركات الصناعية في إقليم كوردستان العراق

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المستخلص

تهدف هذه الدراسة الى إمكانية تعزيز استدامة المنتجات في الشركات الصناعية ضمن إقليم كوردستان العراق من خلال دمج محاسبة تكاليف تدفق المواد (MFCA) والإنتاج الأنظف (CP). تم توزيع استبيان منظم على 275 موظفًا إداريًا وماليًا في 74 شركة صناعية، وقد تم تحليل 213 استجابة صالحة باستخدام برنامج SPSS. أظهرت النتائج وجود تأثير إيجابي ذو دلالة إحصائية ($p \leq 0.05$) لدمج MFCA وCP على جميع أبعاد الاستدامة، حيث كانت أقوى التأثيرات في الأداء الاقتصادي ($R^2 = 31.5\%$) وتحسين كفاءة الطاقة ($R^2 = 34.2\%$). يدعم هذا التكامل الامتثال البيئي، ويعزز ممارسات التنمية الصناعية المستدامة، ويساهم في تحسين عملية اتخاذ القرار من خلال تتبع التكاليف بدقة. وتقدم هذه الدراسة مساهمة نظرية وتطبيقية من خلال اقتراح نموذج متكامل يتماشى مع أهداف الاستدامة الدولية، مما يوفر إطارًا استراتيجيًا لتحسين النتائج البيئية والاقتصادية في القطاع الصناعي.

الكلمات المفتاحية: محاسبة تكلفة تدفق المواد، الإنتاج الأنظف، الاستدامة.

1. Introduction

in the face of growing economic pressures and rapid environmental change, sustainability in the industrial sector is a crucial challenge that calls for the implementation of integrated strategies that maximize resource efficiency, minimize waste, and lessen the environmental impact of production processes (Iriarte et al., 2023). Cleaner Production (CP) and Material Flow Cost Accounting (MFCA) are two powerful techniques that independently assist these objectives.

According to its definition, MFCA is an accounting method that focuses on locating and examining material and energy flows inside production systems while assessing waste and loss-related expenses. This makes it possible for businesses to precisely identify areas of loss and calculate the financial and environmental consequences (Sygulla et al., 2020). In the meantime, CP principles emphasize process and provide a strategic framework for implementing preventive measures to cut waste and pollution at their source. In the meantime, CP principles are a strategy framework that emphasizes process improvement to achieve more efficiency and less environmental effect, while implementing preventive techniques to cut waste and pollution at the source (Yakovleva & Vazquez-Brust, 2022).

Even though both MFCA and CP have made substantial contributions to the advancement of sustainability, there is currently a noticeable lack of integrated models or frameworks that combine the accurate financial analysis that MFCA offers with the environmental and preventive measures that CP offers (Zhang et al., 2023; Kumar & Singh, 2024). This disparity offers a crucial research opportunity to improve the integration of various methods, which should increase the precision of environmental cost assessments, facilitate data-driven decision-making, and improve both economic and environmental performance at the same time(Jaf & Xinping, 2011).

With an emphasis on industrial environments like the Kurdistan Region, which face really environmental and economic challenges, the current research attempts to make a conceptual and practical contribution in this regard by putting forth an integrative model between MFCA and CP as an efficient tool to enhance production sustainability in industries. It is projected that this integration will strengthen regulatory compliance, lower operational and environmental costs, increase resource efficiency, and support sustainable industrial development in line with the global Sustainable Development Goals.

This research contributes both theoretically and practically by proposing an integrated model aligned with international sustainability standards, offering a strategic framework for improving environmental and economic outcomes in the industrial sector.

2. Research problem

Q1. What is statistically significant relationship of integration between applying the Material Flow Cost Accounting (MFCA) and Cleaner Production (CP) on Achieve Product Sustainability by (energy, environmental, resource technical, economic improvement). at industrial company in Kurdistan region?

Q2. What is the impact of integration between applying the Material Flow Cost Accounting (MFCA) and Cleaner Production (CP) on Achieve Product Sustainability by (energy, environmental, resource technical, economic improvement) at industrial company in Kurdistan region؟

3. Research objective: The main objectives of the research.

A. To develop a conceptual framework that integrates Material Flow Cost Accounting (MFCA) and Cleaner Production (CP) as a strategic approach to enhance product sustainability in industrial environments.
B. To measure the impact of material flow cost accounting (MFCA) application.
C. To measure the impact of Cleaner Production (CP) application.
D. To measure the impact of Achieve Product Sustainability dimension by (energy, environmental, resource, technical and economic improvement.).
E. To measure the impact of the integration between material flow cost accounting (MFCA) application and Cleaner Production (CP) on Achieve Product Sustainability.

4. Significant of the Research

-scientific significance: The scientific significance of this research lies in the scarcity of studies conducted in the Iraq environment, according to the researcher's knowledge. This study may contribute to enriching the scientific literature regarding the integration between MFCA and CP techniques, and the factors related to them, as they are considered among the modern managerial accounting tools. It represents a modest contribution to supporting the management of industrial economic units in applying this integration. Therefore, it can offer a practical addition to the accounting literature by enriching discussions on the integration of MFCA and CP and their role in enhancing product sustainability in the market.

-Practical Significance: The practical significance of this study lies in presenting an applicable approach aimed at enhancing product sustainability in the market, particularly for cost management in industrial economic units. This approach enables managers to address the challenges of the contemporary business environment by providing essential information for cost-related decision-making, such as optimal cost allocation. It also supports the modernization of cost and management accounting systems to make them more integrated and aligned with contemporary developments in production methods and competitive information technology frameworks. This is achieved through the introduction of an integrated cost technique that combines the tools of MFCA and CP in a logical manner, ensuring the complementarity of their roles and maximizing their effectiveness in managing resource costs within the business environment.

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5. Research Hypothesis: The following are the main hypotheses of this Research:

First hypothesis: There is statistically significant relationship at the level of ($\alpha \leq 0.05$) of integration applying the material flow cost accounting (MFCA) application and Cleaner Production (CP) on achieve sustainability for products by (energy, environmental, resource, technical and economic improvement) at industrial company in Kurdistan region.

Second hypothesis: There is statistically significant impact at the level of ($\alpha \leq 0.05$) of the integration between material flow cost accounting (MFCA) application and Cleaner Production (CP) on achieve sustainability for products by energy at industrial company in Kurdistan region.

third hypothesis: There is statistically significant impact at the level of ($\alpha \leq 0.05$) of the integration between material flow cost accounting (MFCA) application and Cleaner Production (CP) on achieve sustainability for products by environmental at industrial company in Kurdistan region.

Fourth hypothesis: There is statistically significant impact at the level of ($\alpha \leq 0.05$) of the integration between material flow cost accounting (MFCA) application and Cleaner Production (CP) on achieve sustainability for products by resource at industrial company in Kurdistan region.

Fifth hypothesis: There is statistically significant impact at the level of ($\alpha \leq 0.05$) of the integration between material flow cost accounting (MFCA) application and Cleaner Production (CP) on achieve sustainability for products by technical at industrial company in Kurdistan region.

sixth hypothesis there is statistically significant impact at the level of ($\alpha \leq 0.05$) of the integration between material flow cost accounting (MFCA) application and Cleaner Production (CP) on achieve sustainability for products by economic improvement at industrial company in Kurdistan region.

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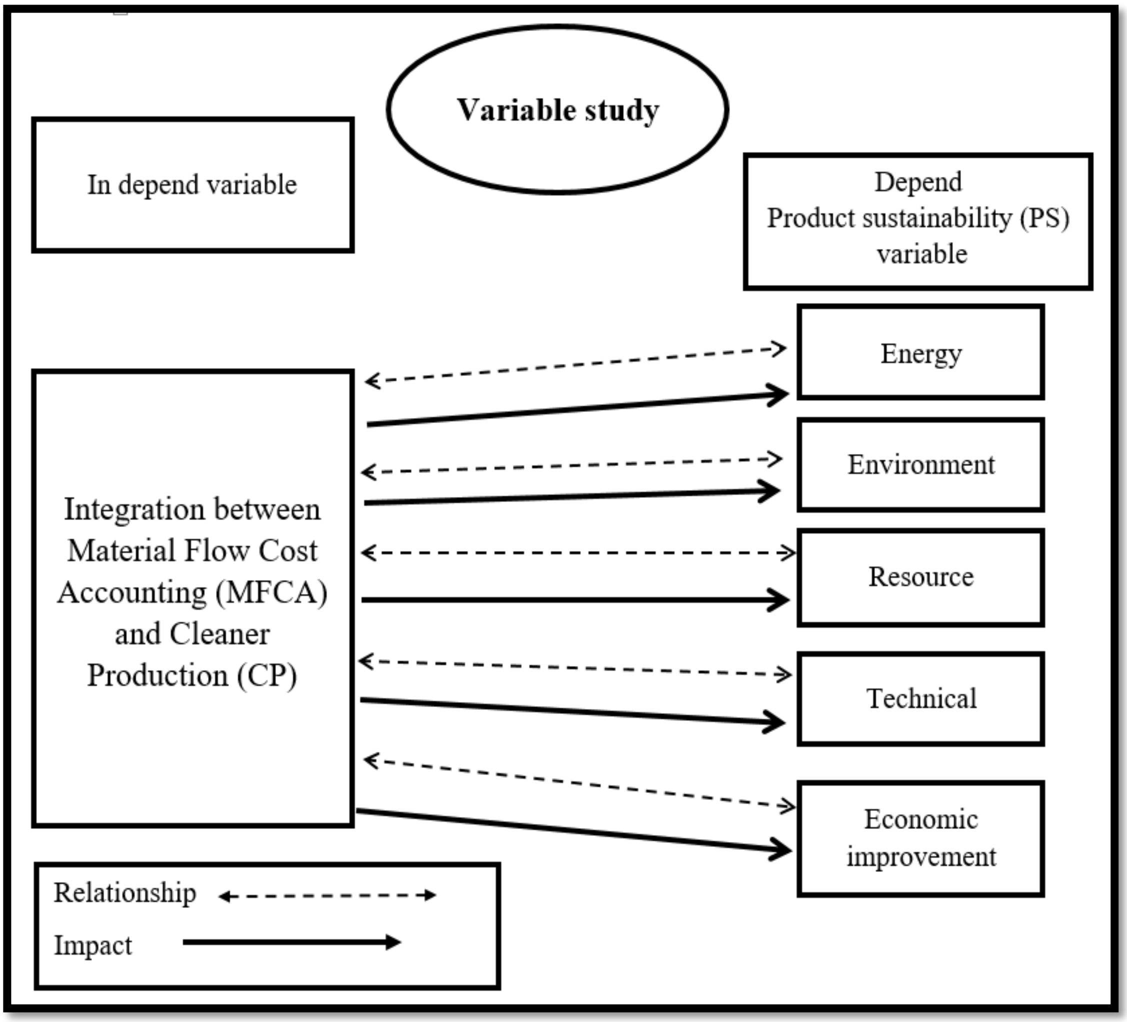
6. Model Structure:



7. Literature Review

7-1. The Material Flow Cost Accounting (MFCA)

7-1-1. Concept of Material Flow Cost Accounting (MFCA): The concept of material flow cost accounting was proposed by professor Bernd Wagner in Augsburg, Germany, in 1990 as an accounting technology that works to protect the environment and focuses on tracking waste, waste and emissions and helps to improve economic and environmental performance, and MFCA accounting is one of the most prominent environmental management accounting technologies (EMA) which has received widespread attention. Because of its ability to provide information on waste, emissions and waste and use that information in the decision-making process (Tajelawi & Garbharran, 2015: 3641).

MFCA is a 'tool for quantifying the flows and stocks of materials in processes or production lines in both physical and monetary units' (ISO

14051: 2011: 3.15). MFCA calculates the cost of material losses that a company disposes, which, if reduced, would benefit the company. (Kokubu & Shinohara, 2023).

MFCA is a new accounting method that measures and provides both physical and monetary information about material, energy, system, and water waste as well as consumption, which can be also classified as an environmental cost accounting (Guenther, et al., 2021).

According to Fatah and Jaf (2023), MFCA can serve as a model for understanding and enhancing production and business operations.

we can say the MFCA is one of the advanced techniques for measuring material flows and energy in both quantity and value in terms of quantity and value in terms of quantity and value. In conclusion, the accounting for the costs of the flow of materials is one of the applications of environmental management accounting, which provides information by tracking materials involved in the production process, measuring their outputs, identifying final products, emissions and residues, thus reducing their costs, improving the production process and reducing their environmental impacts.

7-2. Definitions and Key Focus Areas of the Cleaner Production Concept in Recent Literature

Table (1): Definitions and Key Focus Areas of the Cleaner Production

Source	Definition	Key Point	Notes / Best Use
Hadibarata & Chia (2021)	Cleaner production is the continuous application of an environmental strategy integrated with processes, products, and services to increase efficiency and reduce risks to humans and the environment.	Continuity and integration with processes, products, and services.	Best used to emphasize environmental integration across all stages of production.
Hens et al. (2018)	Cleaner production is about less and more efficient energy and materials use and the substitution of more harmful products (for the environment and health) by less dangerous ones.	Evolution of the concept with socio-economic expansion.	Useful for studies discussing industry response to sustainable development frameworks.

7-2-1. benefits of Cleaner Production: The main benefits can be summarized as follows:

A. Enhancing compliance with environmental legislation and improving the responsibility of managers and employees by focusing on proactive rather than reactive environmental strategies (Giannetti et al., 2008).
B. Implementing a structured methodology that facilitates the gradual improvement of environmental performance and ensures continuous development.
C. Generating significant economic returns, such as reducing material and energy consumption and associated costs (Matos et al., 2018).
D. Improving the company's image and competitiveness, especially in environmentally sensitive markets, which enhances customer loyalty and investor confidence (UNEP, 2020).
E. Shifting responsibility from high-level management to all organizational levels, contributing to better risk management and accountability across departments.
F. Cleaner production is a preventive strategy that aims to eliminate the root causes of pollution rather than treat its effects (El Haggar, 2010). Unlike traditional end-of-pipe technologies, CP intervenes early in the production process by using efficient inputs and innovative technologies (Ozturk et al., 2016).
G. Cleaner production reduces environmental burdens by minimizing emissions and waste generation, especially in industries with high material intensity (Rivera et al., 2009). This can be achieved through recycling, process redesign, or switching to alternative inputs with lower environmental impact. (Mustafa, et., al.,2022).

Cleaner production thus contributes to both environmental protection and the sustainable development of production units by improving their economic viability, particularly in small and medium-sized enterprises (SMEs), which often face limited sources.

7-3. The concept and development of sustainability product: The concept of sustainable development has gained traction as a way to address the environmental, economic, and social needs of current generations without compromising the well-being of future ones. This paradigm shifts calls for adjustments in our consumption models, production methods, societal organization, and the use of essential natural resources (Zrar Hamad, & Sabir

Jaf, 2024). The sustainable development concept is associated with ongoing efforts to bring about a sustainable transition, requiring collaboration across local, regional, and global networks, involving the public, private, and academic sectors. In response to these challenges, the United Nations formalized the Sustainable Development Goals in 2015 in New York. (de Almeida, et al., 2024: P2).

Sustainable product design (SPD) plays a key role in improving product sustainability and has received considerable attention from manufacturing companies (Han et al. 2021 P1).

The development of sustainable products is a process where the concern with the material resources used throughout the chain of product transformation becoming a consideration for the preservation of the environment. (Bataglin & Ferreira.2020).

Sustainability is defined as a development meeting the present requirements without compromising the ability of future generations to meet their own needs (Sabir & Mahmood, 2023; Dani et al., 2020 P2).

Sustainable Manufacturing is key to achieve the sustainable development envisioned by the United Nations and hence contribute towards a sustainable future that preserves planet earth. The main contribution of sustainable manufacturing lies in building a resilient infrastructure by promoting a sustainable, innovative enshrined in Sustainable Development Goal (SGD) and enabling sustainable consumption and production patterns outlined in SGD. (May, et al., 2023: 185).

sustainable development focuses on environmental protection, while providing economic and social development and welfare to present and future generations. Therefore, the three interrelated concepts of sustainable development – or the main three pillars – are: social sustainability, economic sustainability and environmental sustainability (Purvis et al, 2018). It is understood that natural, human and economic capital should all be taken into consideration in each action or decision, in order to achieve responsible and sustainable development. (Halkos & Gkampoura. 2021).

7-3-1. The dimension used of product sustainability: This table 2 illustrates the connection between various product improvement dimensions (such as energy, environmental, resource, technical, and economic improvements) and the corresponding sustainability dimensions (environmental, economic, and technical). The aim is to show how each type of product enhancement contributes to one or more aspects of sustainability. For instance, improving energy efficiency not only reduces operational costs but also minimizes environmental impact, thereby supporting both environmental and economic sustainability. The integration of these dimensions is essential for achieving sustainable industrial development.

Table (2): The Relationship Between Product Improvement Dimensions and Sustainability Dimensions in Industrial Companies

Proposed Dimension	Corresponding Sustainability Dimension
Energy Improvement	Environmental and Economic Dimension (energy efficiency, cost reduction)
Environmental Improvement	Direct Environmental Dimension
Resource Improvement	Environmental and Economic Dimension (resource management and waste reduction)
Technical Improvement	Technical Dimension, supporting both Environmental and Economic Dimensions
Economic Improvement	Direct Economic Dimension

Recent official sources such as (UNEP, 2024) and (OECD, 2021) clearly support those improvements in energy efficiency, resource management, production technologies, and economic performance are considered essential dimensions for implementing sustainable production in industrial organizations. These improvements fall under environmental, economic, and technical dimensions and serve as practical indicators for the clear scientific application of the sustainable production concept.

Achieving sustainable production requires a strategic focus on specific areas of operational improvement that directly contribute to environmental, economic, and technical performance. Among these areas, five key sub-dimensions have been identified due to their significant importance in supporting sustainability. The following paragraphs will provide a detailed review of the importance of each of these dimensions.

A. **Energy Improvement**: Improving energy efficiency in industrial companies can be effectively achieved through analyzing material flows and identifying waste within production processes. This approach, often referred to as Material Flow Analysis (MFA) or Material Flow Cost Accounting (MFCA), allows companies to trace the path of raw materials and energy throughout their operations. By doing so, they can pinpoint where materials—and consequently energy—are being lost or wasted. (Tran & Herzig 2022: 40).

B. **Environment Improvement:** Enhancing environmental performance in industrial settings can be effectively achieved by implementing preventive practices that focus on minimizing waste and pollutants at the source. Rather than addressing pollution after it has been generated (e.g., through treatment or disposal), preventive environmental strategies aim to redesign processes, materials, and operations in ways that avoid the creation of pollution altogether. This approach is central to concepts like Cleaner Production (CP), Pollution Prevention (P2), and Environmental Management Systems (EMS) such as ISO 1400 (Chen et al. 2019: 3-5).

C. **Resource:** Improving technical resources is achieved through adopting cleaner production practices that develop and deploy technologies to minimize waste in industrial processes. Cleaner Production (CP) strategies support the introduction of optimized technologies—which can range from upgraded pressing or cutting tools to AI-enhanced monitoring—in order to reduce waste, conserve raw materials, and boost overall technical efficiency. (Leite et al. 2019: 6-9).

D. **Technology Improvement:** Technological development performs a important role in enabling the adoption of Cleaner Production (CP) practices throughout commercial sectors ،especially in regions undergoing industrial transformation. By introducing modern-day technologies starting from automation and virtual tools to power efficient machinery industries can decrease waste, lessen emissions, optimize assets ،and promote the long-time period sustainability of production structures (Amjad et al., 2021: 3-4).

E. **Economic Improvement:** Economic improvement in commercial organizations is strongly related to the adoption of Cleaner Production (CP) practices. These practices contain remodeling production techniques, enhancing material and energy performance ،decreasing emissions and waste, and introducing cleaner technologies. All of those without delay reduce operational and environmental costs—contributing to lengthy-time period financial sustainability and profitability (Leite et al. 2019: 6-9).

7-4 Integration Between Material Flow Cost Accounting (MFCA) and Cleaner Production (CP) and Their Impact on Sustainable Production Dimensions: Although numerous studies have independently addressed Material Flow Cost Although several research have independently addressed

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Material Flow Cost Accounting (MFCA) and its position in improving efficiency and decreasing waste (Sygulla et al., 2020; Schmidt et al., 2021), and other research has focused on the significance of Cleaner Production (CP) in improving environmental performance and pollution discount (Yakovleva & Vazquez-Brust, 2022; Iriarte et al., 2023), the clinical literature has but to offer studies or implemented fashions demonstrating the integration of MFCA and CP as a unified framework helping manufacturing sustainability. This gap is virtually highlighted in recent literature reviews (e.G., Zhang et al., 2023; Kumar & Singh, 2024), which suggest that integrating material cost evaluation equipment with preventive practices represents a promising but underexplored research place. The integration of MFCA and CP represents a complete version that complements product sustainability in commercial agencies in the Kurdistan Region through enhancing five main dimensions:

Energy Dimension: MFCA appropriately identifies electricity fees related to losses, while CP applies smooth technology to lessen strength consumption and emissions, enhancing power efficiency.

Environmental Dimension: MFCA monitors environmental costs of waste, and CP promotes preventive practices to reduce pollution, supporting compliance with environmental standards.

- **Resource Dimension:** MFCA evaluates material losses and their costs, while CP encourages recycling and efficient resource use, supporting circular economy principles.
- **Technical Dimension:** MFCA measures the impact of technology on waste reduction costs, and CP fosters the adoption of clean and modern technologies to improve production processes.
- **Economic Dimension:** MFCA reveals opportunities for cost reduction through detailed loss analysis, and CP helps reduce environmental and operational costs, thereby enhancing profitability and competitiveness.

This integration supports strategic decision-making based on accurate data, improves energy and resource efficiency, and reduces environmental costs. Moreover, it reinforces compliance with environmental and developmental standards, contributing to achieving a sustainable balance between economic and environmental performance, and promoting sustainable industrial development in the Kurdistan Region.

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8. Methodology

8-1. Data Collection: The most significant part of any research is the data. Research can be conducted in a variety of fields with varying methodologies. However, all researchers examine and interpret data to collect information based on it. In general, data sources are divided into two categories: primary and secondary data. Collecting data directly from first-hand experience can be called primary data while published or collected data in the past is known as secondary data. Because the responses obtained are objective, primary data is collected through a questionnaire for this research. The questionnaire has been sent to the industrial companies in the Kurdistan Region of Iraq. Statistical analysis such as Smart SPSS has been used to prove the results, that have been achieved in this research. (275 forms for 74 company from,213 form is return and we for (company manager, finance manager, manager department, accountant)

8-2. Testing Validity and Reliability

Table (3): Cronbach's Alpha Reliability Analysis

Item	(Items per Dimension)	Cronbach's Alpha
MFCA & CP	5	0.825
Energy Improvement	5	0.826
Environment Improvement	5	0.828
Resource Improvement	5	0.836
Technical Improvement	5	0.842
Economic Improvement	5	0.829
Total	**30**	0.855

Source: Prepared by the researcher based on the SPSS results.

Table 3 shows the results of the reliability analysis using Cronbach's Alpha, which yielded a total value of 0.855, indicating a high level of internal consistency. This confirms the reliability of the scale in measuring the integration of Material Flow Cost Accounting (MFCA) and Cleaner Production (CP) within the context of sustainable performance assessment. All dimensions contribute meaningfully to the overall reliability. The Technical Improvement dimension recorded the highest reliability ($\alpha = 0.842$), followed by Resource Improvement ($\alpha = 0.836$) and Economic Improvement ($\alpha = 0.829$), demonstrating strong internal coherence. The

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MFCA & CP dimension, while having the lowest alpha (α = 0.825), still exceeds the acceptable threshold, confirming its reliability. Additionally, no dimension improved the total alpha when removed, highlighting the importance of each component. Overall, the results confirm that the instrument is valid and reliable for evaluating MFCA and CP integration in industrial sustainability contexts.

8-3. Testing hypotheses

Testing first hypotheses:

Table (4): Correlation between MFCA & CP Integration and Sustainable Production Dimensions in Industrial Companies in Kurdistan Region

Relationship	Pearson Correlation (r)	Significance (Sig.)	Interpretation
MFCA & CP ↔ Energy Improvement	0.585**	0.000	Indicates that the integration of MFCA & CP significantly contributes to improving energy efficiency in industrial operations.
MFCA & CP ↔ Environmental Improvement	0.511**	0.000	Shows a statistically significant relationship suggesting that MFCA & CP integration enhances environmental performance (e.g., reduced emissions).
MFCA & CP ↔ Resource Improvement	0.457**	0.000	Reflects that applying MFCA & CP positively affects the efficient use of resources and waste reduction in production processes.

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Relationship	Pearson Correlation (r)	Significance (Sig.)	Interpretation
MFCA & CP ↔ Technical Improvement	0.472**	0.000	Suggests that MFCA & CP integration fosters technological enhancements in industrial processes, promoting innovation and efficiency.
MFCA & CP ↔ Economic Improvement	0.561**	0.000	Confirms that the integration of MFCA & CP is positively associated with economic benefits, such as cost reduction and improved financial performance.

Source: Prepared by the researcher based on the SPSS results.

Table 4 presents analysis results confirming that the integration of Material Flow Cost Accounting (MFCA) and Cleaner Production (CP) is significantly associated with key dimensions of sustainable production. The strongest correlation was observed with energy improvement ($r = 0.585$, $p < 0.01$), indicating the integration's effectiveness in enhancing energy efficiency and reducing related costs. Other notable correlations include environmental ($r = 0.511$), economic ($r = 0.561$), technical ($r = 0.472$), and resource improvement ($r = 0.457$), all statistically significant and positive. These findings suggest that MFCA & CP integration supports not only cost and energy optimization but also environmental impact reduction, technological development, and efficient resource use. From an accounting perspective, the integration enhances the visibility of cost drivers, improving strategic decision-making and resource planning. Overall, the findings empirically support the first hypothesis, demonstrating that MFCA and CP integration plays a critical role in advancing sustainable industrial practices in the Kurdistan Region.

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Testing sconed hypotheses:

A. **Testing hypothesis**: The Impact of Integrating Material Flow Cost Accounting (MFCA) and Cleaner Production (CP) on Energy improvement.

Table (5): Regression Analysis of the Impact of Integrating Material Flow Cost Accounting (MFCA) and Cleaner Production (CP) on Energy improvement

Depend variable / Independ variable	Energy improvement				
	Constant -B0	**B1**	**F**	**R2**	**Durbin-Watson**
Integrate MFCA&CP	1.823 Sig. (0.000)	.5850 Sig. (0.000)	109.556 Sig. (0.000)	34.2%	1.809

Source: Prepared by the researcher based on the SPSS results.

Table 5 presents the results of a simple linear regression analysis examining the impact of integrating Material Flow Cost Accounting (MFCA) with Cleaner Production (CP) on energy performance improvement in industrial companies in the Kurdistan Region. The findings show a positive and statistically significant effect ($\alpha \leq 0.05$), with a regression coefficient of 0.585, indicating that each one-unit increase in integration leads to a 0.585-unit improvement in energy performance. The model is statistically valid, with an F-value of 109.556 and an R^2 of 0.342, meaning that 34.2% of the variance in energy improvement is explained by MFCA and CP integration. The Durbin-Watson value of 1.809 indicates no autocorrelation, confirming model reliability. From an accounting perspective, this integration improves the accuracy of measuring energy costs, enhances resource monitoring, and identifies energy inefficiencies. Ultimately, this supports cost reduction and boosts financial and environmental sustainability in the region's industrial sector.

B. **Testing hypothesis**: The Impact of Integrating Material Flow Cost Accounting (MFCA) and Cleaner Production (CP) on Environment improvement.

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Table (6): Regression Analysis of the Impact of Integrating Material Flow Cost Accounting (MFCA) and Cleaner Production (CP) on Environment improvement "

Depend variable / Independ variable	Environment improvement				
	Constant -B0	**B1**	**F**	**R2**	**Durbin-Watson**
Integrate MFCA&CP	2.146 Sig. (0.000)	0.511 Sig. (0.000)	74.628 Sig. (0.000)	0.261%	1.910

Source: Prepared by the researcher based on the SPSS results.

Table 6 showing the regression analysis results revealed a statistically significant positive impact (p = 0.000) of the integration between Material Flow Cost Accounting (MFCA) and Cleaner Production (CP) on environmental improvement in industrial companies in the Kurdistan Region. The regression coefficient (B) was **0.511**, indicating that a one-unit increase in MFCA and CP integration leads to a 0.511 increase in environmental performance.

The F-value (74.628) confirms the strength and validity of the model, while the coefficient of determination (R^2 = 26.1%) shows that the integration explains approximately 26.1% of the variance in environmental improvement. Additionally, the Durbin-Watson value (1.910) indicates no autocorrelation, supporting the reliability of the results.

From an accounting perspective, these findings suggest that integrating MFCA with CP enables more accurate tracking of environmental costs, improves waste management, and supports eco-efficiency. This integration enhances financial and operational decision-making, aligning environmental sustainability goals with economic performance in industrial firms.

C. Testing hypothesis: The Impact of Integrating Material Flow Cost Accounting (MFCA) and Cleaner Production (CP) on Resource Improvement.

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Table (7): Regression Analysis of the Impact of Integrating Material Flow Cost Accounting (MFCA) and Cleaner Production (CP) on Resource Improvement"

Depend variable / Independ variable	Resource improvement				
	Constant-B0	B1	F	R2	Durbin-Watson
Integrate MFCA&CP	2.226 Sig. (0.000)	0.457 Sig. (0.000)	55.546 Sig. (0.000)	20.8%	1.840

Source: Prepared by the researcher based on the SPSS results.

Table 7 showing the results of the simple linear regression analysis revealed a statistically significant and positive impact of the integration between Material Flow Cost Accounting (MFCA) and Cleaner Production (CP) on resource improvement in industrial companies operating in the Kurdistan Region. The regression coefficient (B) reached a value of **0.457**, indicating that increased application of this integration leads to tangible improvements in resource efficiency through waste reduction, better raw material management, and enhanced operational performance.

The coefficient of determination (R^2) was 0.208, meaning that the integration between MFCA and CP explains 20.8% of the variation in resource improvement levels—an acceptable proportion in industrial contexts where multiple productivity factors are involved. This interpretation is further supported by the high F-test value (F = 55.546, Sig. = 0.000), confirming the reliability and significance of the statistical model.

From an accounting perspective, these results highlight the importance of adopting MFCA integrated with CP practices as effective tools for measuring and analyzing the costs and flows of resources. This integration allows management to make data-driven decisions to enhance both environmental and economic performance. Industrial firms can, as a result, reduce waste and achieve financial savings through improved efficiency in the use of production resources.

Therefore, these findings support the study's hypothesis that there is a statistically significant positive impact of this integration on sustainability dimensions. They also underscore the strategic value of advanced environmental accounting practices in achieving sustainable industrial development objectives.

D. Testing hypothesis: The Impact of Integrating Material Flow Cost Accounting (MFCA) and Cleaner Production (CP) on technical improvement.

Table (8) Regression Analysis of the Impact of Integrating Material Flow Cost Accounting (MFCA) and Cleaner Production (CP) on technical improvement

Depend variable / Independ variable	technical improvement				
	Constant-B0	**B1**	**F**	**R2**	**Durbin-Watson**
Integrate MFCA&CP	2.067 Sig. (0.000)	0. .472 Sig. (0.000)	60.542 Sig. (0.000)	21.9%	1.719

Source: Prepared by the researcher based on the SPSS results

Table 7 presents the results of a simple linear regression analysis, revealing a statistically significant and positive impact of integrating Material Flow Cost Accounting (MFCA) with Cleaner Production (CP) on resource improvement in industrial companies in the Kurdistan Region. The regression coefficient (B = 0.457) indicates that greater integration leads to improved resource efficiency through waste reduction and better raw material management. The model's R^2 value of 0.208 suggests that 20.8% of the variation in resource improvement is explained by the integration, supported by a significant F-value (F = 55.546, Sig. = 0.000). From an accounting perspective, this integration enhances the ability to measure and analyze resource-related costs and flows, supporting informed decision-making and operational efficiency. These findings support the hypothesis and highlight the strategic importance of adopting MFCA and CP as tools for improving sustainability performance and achieving financial and environmental goals in the industrial sector.

E. Testing hypothesis: Impact of Integrating Material Flow Cost Accounting (MFCA) and Cleaner Production (CP) on Economic improvement.

Table (9): Regression Analysis of the Impact of Integrating Material Flow Cost Accounting (MFCA) and Cleaner Production (CP) on Economic improvement

Depend variable / Independ variable	Economic improvement				
	Constant-B0	**B1**	**F**	**R2**	**Durbin-Watson**
Integrate MFCA&CP	1.641 Sig. (0.000)	0.561 Sig. (0.000)	96.935 Sig. (0.000)	31.5%	1.791.

Source: Prepared by the researcher based on the SPSS results

Table 9 presents regression analysis results showing a statistically significant and positive impact of integrating Material Flow Cost Accounting (MFCA) with Cleaner Production (CP) on economic improvement in industrial companies in the Kurdistan Region. The regression coefficient (B = 0.561) indicates that a one-unit increase in integration leads to a 0.561-unit rise in economic performance. The coefficient of determination ($R^2 = 31.5\%$) suggests that MFCA and CP integration explains 31.5% of the variance in economic improvement, reflecting strong explanatory power. The model's F-statistic (96.935, Sig. = 0.000) confirms the robustness and significance of the relationship. Additionally, the Durbin-Watson value (1.791) indicates no autocorrelation, supporting the model's reliability. From an accounting perspective, the integration enhances cost management, reduces waste-related expenses, and improves resource efficiency. These outcomes lead to more accurate cost tracking and better financial decisions, supporting long-term profitability and economic sustainability in the industrial sector.

9. Conclusions and Recommendations

9-1. Conclusion:

A. This study highlights that integrating Material Flow Cost Accounting (MFCA) with Cleaner Production (CP) offers a novel and effective strategy for sustainable production. By combining MFCA's cost and waste analysis with CP's preventive methods, the integration enhances resource efficiency and supports informed decision-making. This approach also addresses a key knowledge gap overlooked in prior research.

B. The results revealed a statistically significant positive relationship between the integration of Material Flow Cost Accounting (MFCA) and Cleaner

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Production (CP) and the achievement of sustainable production dimensions in industrial companies in the Kurdistan Region. This integration plays a key role in improving resource efficiency, reducing costs, and enhancing environmental and technical performance.

C. The analysis revealed a significant positive impact of integrating Material Flow Cost Accounting (MFCA) with Cleaner Production (CP) on improving energy efficiency in industrial companies in the Kurdistan Region. This integration accounts for 34.2% of the variance in energy performance, highlighting its effectiveness in reducing energy waste, enhancing cost management, and supporting environmental and economic sustainability goals.

D. The study concludes that integrating Material Flow Cost Accounting (MFCA) with Cleaner Production (CP) has a significant positive impact on environmental improvement in industrial companies in the Kurdistan Region. With a regression coefficient of 0.511 and R^2 of 26.1%, the integration effectively reduces emissions, minimizes environmental waste, and enhances eco-efficiency. The findings highlight the strategic value of MFCA and CP in promoting sustainable environmental performance through accurate and transparent environmental cost accounting.

E. The findings indicate a significant positive impact of integrating Material Flow Cost Accounting (MFCA) with Cleaner Production (CP) on enhancing resource efficiency in industrial companies in the Kurdistan Region. This integration reduces waste and optimizes material inputs, supported by a moderate regression coefficient ($\beta = 0.457$) and a strong model fit ($R^2 = 0.208$, Sig. = 0.000), reinforcing its role in promoting sustainable resource use.

F. The study confirms a significant positive effect of integrating Material Flow Cost Accounting (MFCA) with Cleaner Production (CP) on technical development in industrial companies in the Kurdistan Region. This integration enhances technical performance by promoting innovation, reducing technical waste, and optimizing equipment efficiency. With a regression coefficient of 0.472 and R^2 of 21.9%, the findings highlight its value in improving operational effectiveness and supporting sustainable industrial growth.

G. The research confirms a significant positive impact of integrating Material Flow Cost Accounting (MFCA) with Cleaner Production (CP) on economic

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improvement in industrial companies in the Kurdistan Region. With a regression coefficient of 0.561 and R^2 of 31.5%, the integration enhances economic performance by improving cost management and optimizing resource use, underscoring its strategic role in supporting sustainable economic growth.

9-2. Recommendation

A. The researcher recommends that industrial organizations in the Kurdistan Region adopt an integrated framework combining Material Flow Cost Accounting (MFCA) and Cleaner Production (CP) within their environmental and production policies. This integration enhances resource efficiency, reduces environmental costs, and promotes production sustainability. Additionally, conducting field studies is advised to evaluate the model's effectiveness and explore its applicability across various industrial sectors.

B. It is recommended to promote the integration of Material Flow Cost Accounting (MFCA) with Cleaner Production (CP) in industrial organizations in the Kurdistan Region due to its positive impact on enhancing resource and energy efficiency, reducing costs, and supporting environmental and economic sustainability.

C. 3-It is recommended to strengthen the integration of Material Flow Cost Accounting (MFCA) and Cleaner Production (CP) in Kurdistan’s industrial sector, given its significant role in improving energy efficiency and reducing operational costs. Additionally, developing related technical and accounting skills is essential to achieve sustainable performance and boost the sector’s competitiveness.

D. It is recommended that organizations in the Kurdistan Region adopt and enhance the integration of MFCA and CP to improve environmental sustainability, better manage environmental costs, and ensure regulatory compliance. This approach aligns environmental and economic goals, supporting long-term sustainable development.

E. Industrial organizations in the Kurdistan Region are recommended to adopt the integration of MFCA and CP to improve resource utilization, enhance operational performance, reduce material losses, and achieve long-term economic and environmental sustainability.

F. It is recommended that industrial companies in the Kurdistan Region adopt and strengthen the integration of MFCA and CP in their production processes to promote technical innovation, enhance resource efficiency, reduce waste, and improve equipment utilization, thereby supporting long-term sustainability.

G. Industrial corporations in the Kurdistan Region are recommended to actively implement and strengthen the integration of MFCA and CP within their operations to improve economic performance, enhance cost management, and promote sustainable development aligned with environmental and technical advancements.

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