# Importance of implementing material flow cost accounting technique (MFCA) and its role to enhance environmental sustainability in industrial companies /An analytical study on a set of refining companies / Erbil

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**Abstract**

This paper examines the role of Material Flow Cost Accounting (MFCA) in enhancing innovation for environmental sustainability, specifically in the context of refining companies. The study focuses on the implementation of MFCA as a technique for reducing carbon dioxide emissions and material losses, with an emphasis on both the economic and environmental impacts. The research sample comprises three refining companies (names withheld due to confidentiality), and the aim is to assess whether MFCA can contribute to material loss reduction and improve sustainability practices.SPSS software was employed for statistical analysis to test the research hypotheses. The findings suggest that combining MFCA with environmental sustainability initiatives can serve as a strategic tool for companies to address logistical challenges, reduce environmental harm, and improve competitiveness. By adopting MFCA, companies can not only reduce their carbon footprint but also develop environmentally friendly products, gaining a competitive edge in the global market.Key results indicate that MFCA provides valuable insights into both physical and financial aspects of production, highlighting areas of material waste, CO2 emissions, and non-commodity output. By focusing on material productivity improvements and waste reduction, MFCA enables companies to decrease environmental harm, enhance operational efficiency, and make data-driven decisions that promote long-term sustainability.

**Keywords: MFCA, Environmental Sustainability.**

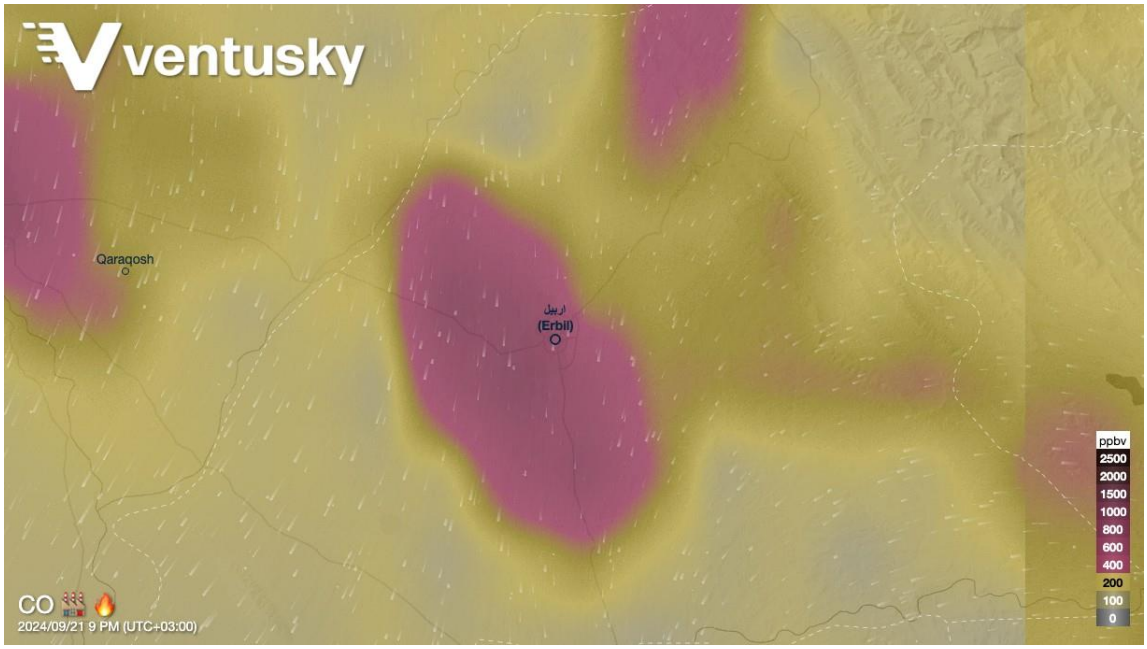
## First axis: The methodological framework of the study and some of the literature review

### 1-1: The methodological framework of the study

**Introduction:** Many countries suffer from environmental pollution such as emission to air, wastewater, waste, and carbon emission, and one of the causes of this pollution is carbon dioxide emissions, which are the main driver of global climate change. It is widely recognized that to avoid the worst effects of climate change, the world needs to reduce emissions urgently. But how to share this responsibility among regions, countries and individuals has been an endless point of contention in international discussions (Hannah et al., 2020). Recent pressures and intentions, such as the growing stakeholder demand for the necessity of industrial companies' commitment to pay attention to environmental issues and the potentially harmful effects they can have on society and the environment in general, as well as the urgent need for all companies, have caused the interest in improving environmental performance to become a major focus in research and accounting studies. (Huang et al., 2019). The modern business environment is witnessing rapid and successive changes in all economic, social, technological and environmental fields, which made it necessary for industrial companies to keep pace with these changes in order to compete in the markets to meet their needs and desires customers. All these changes negatively affect environmental factors from air, water, etc. (Tajelawi & Garbharran, 2015) The sustainable use of resources is becoming an issue of increasing

importance globally. The use of resources has already exceeded the capacity of the land and the demand is steadily increasing. Thus, achieving the Sustainable Development Goals (SDGs) as defined by the United Nations in 2015 has become a top priority for society. In particular, Goal 12 requires governments as well as private sectors to ensure sustainable consumption and production patterns. One type of sustainability is environmental sustainability, which focuses on reducing the negative effects of the environment by achieving improvements in material and energy efficiency for sustainable production. To achieve SDG 12, Material Flow Cost Accounting (MFCA) is an effective environmental management accounting tool that provides organizations with environmental and economic information about their activities. In particular, ISO 14053, one of the international MFCA standards under development, provides practical guidance for the progressive implementation of MFCA so that organizations, including small and medium-sized enterprises (SMEs), can adopt it to understand and enhance their environmental and economic performance through improvements in material and energy efficiency. (ISO/TC 207/SC1, 2017)

**Research Problem:** City of Erbil is the Capital of Kurdistan region in Iraq, and the Carbon monoxide level is among the highest in the region. The healthy level is between 0-9 ppm, and the actual level is more than 25-30 ppm.

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This critical situation needs an urgent response from all parties involved especially the local government and industrial in the city. Accounting as an information system invented a new technic called (material flow cost accounting technology (MFCA)) to help industrial sector company to manage their resources in such effectively less waste in terms of the best use of water, energy, and other natural resources, the other hand, has good effects on environmental sustainability. The research problem is how to apply the material flow cost accounting technique in the crude oil derivatives refining companies in Erbil province as a research sample and then its role in enhancing environmental sustainability.

The research questions can be determined by the following: -

1)Does the management of the oil derivatives refineries in the city of Erbil, selected as a research sample, and operational industrial companies in general, realize of the high percentage of carbon dioxide emissions?

2) The increasing global emphasis on sustainable development necessitates innovative approaches to environmental management within organizations. Material Flow Cost Accounting (MFCA) has been identified as a critical tool in environmental management accounting, offering detailed insights into material flows and associated costs. Despite its recognized potential, the adoption and integration of MFCA into corporate sustainability strategies remain suboptimal. This research aims to explore the relationship between MFCA and environmental sustainability, focusing on the extent to which MFCA can contribute to reducing material waste, enhancing resource efficiency, and achieving sustainable development goals (SDGs).

**Research Importance:** The study's importance is derived from the potential scientific and practical contributions it might provide, including the following:

(1) Scientific impotence; this study focused as one of the modern approaches to environmental management accounting, which has increased global interest. It has been recently done by professional and governmental organizations and bodies such as; the organization International Standardization (ISO) and the Japanese Ministry of Economy Trade &Industry, and the International Federation of Accountants. Moreover, this study contributes to the possibility of clarifying the material flow cost accounting technique in improving the performance of financial and environmental companies and their role in promoting local environmental sustainability study sample. (2) Practical significance In order to support the results of previous studies on the importance of data derived from the analyzes provided through the material flow cost accounting technique to support management decisions that improve local environmental sustainability in the study sample (Set of refining companies), the current study is expected to provide the experience to reduce the level of carbon dioxide to some extent close to the permissible level that ranges between 0-9 or reduces the actual level to the least possible, as well as the exploitation of natural resources that have good effects for environmental sustainability.

**Research Objectives:** The study's main objective is to "explain the potential application of the material flow cost accounting technique as one of the most significant modern approaches to environmental management accounting in improving financial and environmental performance and its role in promoting environmental sustainability in a company" (the study sample). From this goal, the following sub-objectives flow: (1) Reviewing previous literature to effort research activities and their contributions to this area. (2) Determine the nature of material flow cost accounting technology and how industrial companies may utilize it to enhance environmental sustainability through the efficient utilization of resources that consider future generations. (3) Importance of results of statistical analysis from implementing the material flow cost accounting on the set of refining companies (research sample) to clarify its role in enhancing the sustainability of the local environment.

**Research Hypothesis:** Based on the study problem and achieving its objectives. The main hypothesis of the study is that "the possibility of applying material flow cost accounting technology as one of the accounting methods of modern environmental management contributes to reducing carbon dioxide on the one hand and reducing the costs of products, waste, energy and natural resources on the other hand, and this in turn leads to the promotion of local environmental sustainability"

The main hypothesis is divided into the following sub-hypotheses:

1) There is no awareness among managers at oil derivatives refineries in the research sample city of Erbil and operational industrial companies, in general, are aware of the high proportion of carbon dioxide emissions.
2) There is no impact (or relationship) of MFCA technology on environmental sustainability.

**Research limits:** The opinions of managers, worker, engineers, and accountants of a set of three refining companies in the Erbil governorate of the year 2024, was chosen by the two researchers, to achieve their objectives and prove hypotheses. The reason for choosing these companies in the local environment by the researchers is that they are a major cause of local environmental pollution, and they are not being pressured by official bodies to reduce this dangerous phenomenon for the residents of Erbil.

**Research Methodology:** To complete this research, the researcher uses the scientific method, which consists of a set of methods, to attain the research's aims and hypotheses; the inductive approach is to determine the study problem and test hypotheses. The deductive approach is to determine the study axes and set up hypotheses. The historical approach is to review previous studies, review books, scientific references, and periodicals related to the research subject, and the analytical approach uses the opinions of workers of refining companies in Erbil governorate as a research sample.

**Conceptual framework of the research:** The independent and dependent variables can be shown as follows based on the research problem:
Independent variables: "MFCA" technology: This is a technology that has an effect on environmental sustainability.
The dependent variable: Enhancing environmental sustainability: This is affected by "Implementing MFCA" technology.


The study was divided into four parts in an effort to attain the overall objective of the study, which is as follows: The first part dealt with the methodological framework of the study and some of the literature review. The second part presented the theoretical framework of the study. The third part was devoted to an analytical study of the opinions of workers (managers, workers, engineers, and accountants) in refining companies in the Erbil governorate using statistical analysis (SPSS) in the year 2024. The fourth part deals with the most important conclusions and recommendations reached by the two researchers from the Theoretical and practical sides.

**1-2: Previous research and what it distinguishes from the current research:** Sahu et al., (2021) their study aims to investigate how MFCA may be effectively applied in a SME setup to enhance the financial and environmental performance of the business. This study uses case-based research methods to demonstrate how the MFCA tool is applied in a SME that manufactures steel pipes and tubes in India. To find inefficiencies in the SME's manufacturing process, the material cost, system cost, and energy cost at each quantity center were determined as part of the MFCA analysis. Following that, a number of measures were put into place to alleviate these inefficiencies. The installation of the MFCA resulted in annual savings of (USD 302,350) total through an investment of (USD 7123). According to Sulong et al., (2015) this article focuses on one of the organizations' experiences, emphasizing how to use enablers and get over obstacles to implementing MFCA in Malaysian SMEs. The case company discovered the majority of its enablers within MFCA's unique

characteristics, guided by the diffusion of innovation (DOI) theory. The team's makeup, interpersonal communications, and change agents' efforts were all important in the success of the MFCA implementation. The important finding of this study is that failure by senior management to handle performance management concerns could be a barrier to MFCA advancement. These include, for instance, overcoming the conventional viewpoint held by the majority of SMEs and persevering in the implementation processes on their own without direct. But Kokubu & Kitada (2015) This paper argues that Material flow cost accounting (MFCA) that has been developed worldwide as a major tool in environmental management accounting, However, in order to apply MFCA in companies continuously, it is necessary to overcome conflicts between MFCA and existing management perspectives. conflicts are likely to be caused by the essential features of MFCA, and indicates some theoretical solutions based on organizational design. Then, by looking at three example cases of companies that have succeeded in the continuous use of MFCA, specific countermeasures for dealing with conflicts are investigated. The most important conclusion of this paper was reducing conflict between existing management perspective and MFCA for better clean environment. While Nishitani, et al., (2022) this study aims to answer the query of whether material flow cost accounting (MFCA) can support the circular economy. It is anticipated that MFCA, an environmental management accounting tool that evaluates both corporate material and financial flows, will support the circular economy by supporting businesses in achieving both environmental and economic objectives through resource efficiency. It uses a two-stage regression on data from Japanese listed businesses to investigate the triadic relationship between MFCA, environmental performance, and economic performance in order to close this gap. The following are the key conclusions. It is more likely for businesses to enhance their environmental performance in terms of energy use, CO2 emissions, and waste created if they apply MFCA more pro-actively. As a result, MFCA can increase productivity by raising a number of environmental performance indicators since it can enhance numerous areas of environmental performance while conserving resources. In instance, MFCA can raise business productivity and revenue, if only by lowering waste production. And Nyide (2016) the purpose of his study is to highlight Material Flow Cost Accounting (MFCA), one of the Environmental Management Accounting (EMA) tools created to facilitate economically and ecologically advantageous material utilization and hence increase resource efficiency. A single case study with embedded units approach was used to carry out an exploratory study that was qualitative in character. This study included a Hotel Management Group that satisfied the selection requirements. Ten people were given in-depth interviews, and additional papers were examined. The hotels under investigation have created technologies that use MFCA to increase resource efficiency and offer an environmental account in both physical and monetary units. However, the study identified a number of characteristics that have an impact on how MFCA is implemented by the hotel industry in South Africa.

The current research is an extension of the previous research that dealt with the topic Importance of implementing material flow cost accounting technology (MFCA) and its role importance to enhance environmental sustainability in industrial companies. This research is distinguished from previous research in several points, and the most it According to the researchers, the current study attempted to demonstrate the viability of applying material flow cost accounting in the local setting as well as the role it plays in promoting a sustainable environment to reduce the waste of natural resources and defective production by industrial companies. It focused particularly on reducing environmental pollution, including carbon dioxide, which was not addressed in earlier studies.

**Second axis: Theoretical aspect of research:**

**2-1: An introduction to (MFCA):** The pressure on manufacturers and other companies to increase productivity while minimizing environmental impacts is growing. This need is thought to be best served by Material Flow Cost Accounting (MFCA), one of the major techniques of environmental management accounting. MFCA was originally developed in Germany and has been further developed in Japan. The inclusion of MFCA in the International Organization for Standardization (ISO) was an initiative from Japan. ISO 14051 was issued in 2011 after becoming acknowledged as a crucial strategy for sustainability (Kokubu & Tachikawa, 2013). The idea of Material Flow Cost Accounting was born in the 1980s. The aim was to develop an instrument to support environmental management and eco-controlling (www.ifu.com). MFCA promotes increased transparency of material use practices through the development of a material flow model that traces and quantifies the flows and stocks of materials within an organization in physical and monetary units. This data can be used to seek opportunities to reduce material use and/or material losses, improve efficient uses of material and energy, and reduce adverse environmental impacts and associated costs (Kokubu & Tachikawa, 2013). Material Flow Cost Accounting can be defined (MFCA) as combining physical flows and monetary units and is located between energy and material efficiency analyses, environmental management, and managerial accounting procedures (Guenther et al., 2012). Or 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). Like environmental management accounting (EMA), it involves the identification, collection, analysis and use of two types of information for internal decision-making (Mueller, 2019): (1) physical information on the use flows, and destinies of energy, water and materials (including wastes) and (2) monetary information on environment-related costs, earnings and savings. However, the MFCA has many advantages, are (Mueller, 2019): (1) Making visible all environmental costs and benefits, (2) helping to increase environmental awareness in the "core" of a company's operations, providing data to create targets and programs for integrated environmental prevention, and giving project managers and line managers an additional perspective – the environmental impacts, costs, and benefits of their decisions – in their decision-making, (3) Giving the annual report data and information (such as non-financial information in the director's report), MFCA explains the "environmental story" of costs, (4) providing for the communication of the gradual transition from emissions control to integrated prevention procedures and thereafter to integrated prevention products, and (5) Possibly assisting management in identifying environmental dangers and adopting measures to reduce them and the associated costs (e.g., insurance). The objective of Material flow cost accounting (MFCA) is to support material flow-oriented analyzes and decision-making to improve resource and cost efficiency. It integrates economic and ecological objectives in order to contribute to reduce or more efficient material use, it is important to note here, that energy flows are usually subsumed under the term of material flows or even neglected. In particular, with MFCA it is possible to visualize and quantify material losses and shift them into the focus of managerial decision-making, therefor this is achieved by improving the overall transparency of the material flows in physical and monetary terms (Sygulla et al., 2011). The cost evaluation of the flows that are thought of as cost objects is another key component of MFCA. All costs that are incurred as a result of the flows or that may be connected to them are included in the so-called flow costs that must be assigned to them. According to ISO's most recent interpretation of MFCA, the following key cost components should be classified as flow costs (ISO/DIS 14051, (2010): (1) Material costs are determined by multiplying the physical amount of the particular materials by their specific input prices and summing up the results. The use of fixed input prices allows a consistent appraisal for all manufacturing steps, (2) If at all specified, Energy costs are calculated similarly to the material costs. Otherwise, as energy is often subsumed under the term of material, the energy costs are understood as part of the material costs, (3) System costs are defined as ‘all expenses incurred in the course of in-house handling of the material flows except for material costs, energy costs, and waste management costs such as labor, maintenance or transport costs, and (4) Waste management costs are all expenses that occur in the context of handling material losses within a

particular quantity center. They are only assigned to the material losses. The process of the application of MCFA as an international standard (ISO 14051) is as follows (Dechampai et al., 2021): (1) Preparation—to identify the target product and the process that needs improvement then analyze the initial process and indicate the scope for further planning, (2) Data collection—to collect information about raw materials, input, and waste in each process, (3) MFCA calculation—to identify the input variables covering both the positive and negative cost of goods under the mass balance concept, (4) Process identification—to point out the process that needs improvement along with identifying lost materials, (5) Solution—to provide options and the feasibility of reducing the material loss for each option followed by a calculation of costs and expenses to prioritize the plans for improvement, (6) Implementation—to implement the solution and collect data following implementation for further evaluation, (7) Evaluation—to assess the intervention. The number of input factors and waste upon the implementing process and MFCA calculation will be done to compare the result before and after implementation.

The researchers note from the foregoing that the use of (MFCA) helps the establishment to fulfill the desires and needs of customers by providing a high quality product through its focus and tracking of all manufacturing processes its stages and work to reduce the percentage of defective and damaged products as well as its interest in environmental aspects through reducing the effects of emissions and exploitation of natural resources such as water by industrial companies.

**2-2: An introduction to Environmental Sustainability:** Currently, one of humanity's most difficult problems is environmental sustainability. Natural resource sustainability is currently under question due to factors including rising global population, an increase in anthropogenic activities, industrialization, and contemporary agricultural techniques that contaminate water, air, and soil as well as rising greenhouse gas emissions (Tauringana & Moses, 2021)**.** Therefore**,** actions to reduce the use of physical resources, the adoption of a "recycle everything/buy recycled" philosophy, the use of renewable resources as opposed to those that are finite, the redesign of production processes and products to stop the production of toxic materials, and the preservation and restoration of natural habitats and environments valued for their beauty or usability are all examples of environmental sustainability programs. These sustainability initiatives must function at a sufficient size and must maintain dependability for as long as the threats exist. Some of the issues that pose major environmental sustainability problems include (Sutton, 2004): (1) destruction of the living environments (habitats) of native species, (2) discharge of polluting chemicals and other materials into the environment, (3) emission of greenhouses gases into the atmosphere than can cause climate change, and (4) depletion of low-cost oil and other fossil fuels. To define environmental sustainability we must first define sustainability "Sustainability in a general sense, is the overall capacity to maintain a certain process or state indefinitely (Worland, 2018) and it is defined as the ability to continue a defined behavior indefinitely, and it has three pillars, are social, economic, and environmental. Environmental sustainability is the rate of renewable resource harvest, pollution creation, and non-renewable resource depletion that can be continued indefinitely. If they cannot be continued indefinitely then they are not sustainable (Sekar, 2017). Or environmental sustainability as the maintenance of natural capital (Morelli, 2011), and it is the ability to maintain the qualities that are valued in the physical environment (Sutton, 2004). The goal of environmental sustainability is the responsibility to conserve natural resources and protect global ecosystems to support health and wellbeing, now and in the future (Sphera's Editorial Team, 2020).

Both researchers note environmental sustainability as responsible interaction with the environment to avoid depletion or degradation of natural resources and to allow for long-term environmental quality.

Practicing environmental sustainability helps ensure that the needs of today's population are met without compromising the ability of future generations to meet their needs.

**2-3: The impact of MFCA on environmental sustainability:** In the previous theoretical study, it was shown that material flow cost accounting as one of the main techniques of environmental management accounting has a significant impact on the current environment by focusing on both financial and non-financial economic unit information in order to make a decision on how to use it to exploit its resources and helps in identifying areas of inefficiency in the use of resources by tracking and measuring material and energy flows in quantitative and financial form, which creates better opportunities for cost control and reduction and reducing negative impacts on the environment at the same time and thus enhances the competitiveness of companies and achieves sustainability for them, and it is clear that the material flow cost accounting approach aims to achieve sustainability for economic units by focusing on coordinating financial and environmental goals at the same time. Therefore, this technique helps in sustainability from the environmental aspect as well as the economic aspect of economic units.

**2-4 Analyzing and interpreting the questionnaire results:**

To complete the practical side of the research and analysis of the Material Flow Cost Accounting (MFCA) technology and its role in enhancing environmental sustainability, a questionnaire form was designed, and to verify its validity, it was presented to a group of specialists from the university professors, and the questionnaire was distributed to a random sample consisting of (60) individuals working in banks in the Erbil, of which (56) questionnaires were retrieved and (51) of which were valid for analysis through the statistical program SPSS and the program EasyFit, and the analysis was as follows.

**2.4.1. General Information:**

The personal characteristics of the sample covered by the questionnaire were described by specifying the categories, frequencies, and percentages of some personal information of the respondents, which are summarized in Table (1):

**Table (1): Frequency distribution according to personal information**

| The information | Classes | Number | Percent |
|---|---|---|---|
| Career positions | Manager | 23 | 45.1 |
| | Workers | 8 | 15.7 |
| | Engineers | 20 | 39.2 |
| Academic qualification | Less than a Bachelor's | 37 | 72.5 |
| | Bachelor's degree | 11 | 21.6 |
| | Postgraduate degree | 3 | 5.9 |
| Specialization | Accounting | 8 | 15.7 |
| | Management | 20 | 39.2 |
| | Banking sciences | 7 | 13.7 |
| | Others | 16 | 31.4 |
| Total | | 51 | 100% |

Through Table (1), we note that the general information of the research sample was for career positions, distributed between 45.1% for the position (Manager), 15.7% for the position (Workers), and 39.2% for the position (Engineers). Academic qualification: The largest percentage of respondents had (Less than a Bachelor's), at 72.5%, compared to a bachelor's degree at 21.6% and 5.9% for postgraduate degree. Regarding specialization, it was distributed between 15.7% for accounting, 39.2% for management, 13.7% for the banking sciences, and finally by 31.4% for others.

### 2.4.2. Study variables:

The study variables were measured by representing the default variable "The extent to how much managers at oil derivatives refineries in the research sample city of Erbil and operational industrial companies, in general, are aware of the high proportion of carbon dioxide emissions" with the general average into (7) items, the independent variable "MFCA technology" with the general average into (7) items. The dependent variable, "Environmental sustainability" represents the general average of (7) items, using a five-point Likert scale (strongly disagree = 1, disagree = 2, neutral = 3, agree = 4, and strongly agree = 5).

### 2.4.3. Testing the reliability of the internal consistency:

Before analyzing the questionnaire variables, the extent of internal consistency and consistency of the respondents' answers regarding its variables and the questionnaire, in general, must first be measured (Omar et al. 2020) through the Cronbach's alpha coefficient shown in the following table:

**Table (2): Cronbach's alpha test**

| Variables | Cronbach's alpha | Number of items |
|---|---|---|
| Default variable | 0.832 | **7** |
| Independent Variable | 0.774 | 7 |
| Dependent Variable | 0.802 | **7** |
| **Questionnaire items** | **0.925** | **21** |

From Table (2), Cronbach's alpha reliability coefficient for all questionnaire items for the measurement tool has a high degree of reliability because it is greater than 60% (the lowest value was 77.4%). Thus, this means there is internal consistency for the questionnaire variables items, and the overall questionnaire items in general, as the Cronbach Alpha coefficient reached 92.5%.

### 2.4.4. Testing the distribution of questionnaire data:

It can be ensured that the data follows a normal distribution through the use of the Kolmogorov-Smirnov Test (abbreviated as K.S.) and the Chi-Square Test (Ali et al. 2023), based on which the appropriate test for the research hypotheses will be determined, i.e., testing the following hypothesis:

Null hypothesis: the questionnaire variables have a normal distribution.

Alternative hypothesis: the questionnaire variables do not have a normal distribution.

The statistical program (EasyFit) was used to test the above hypothesis at a level of significance (0.05), and the most important results of the two tests are summarized in Table (3):

**Table (3): Test of normal distribution of questionnaire data**

| Variable | Kolmogorov-Smirnov Test | | | Chi-Square Test | | |
|---|---|---|---|---|---|---|
| | Statistics | p-value | Tabulated Value | Statistics | p-value | Tabulated Value |
| **Default** | 0.19748 | 0.032 | 0.18659 | 6.1831 | 0.186 | 9.4877 |
| **Independent** | 0.11266 | 0.501 | 0.18659 | 6.9700 | 0.223 | 11.070 |
| **Dependent** | 0.09637 | 0.695 | 0.18659 | 3.0605 | 0.691 | 11.070 |

From Table 3, we notice that the K.S. test shows that the independent and dependent variables follow a normal distribution because the statistic values were equal to (0.11266 and 0.09637), respectively,

which are less than their tabulated value, which is equal to (0.18659), this is confirmed by the p-values equal to (0.501 and 0.695), respectively, which are greater than the significance level (0.05) but the default variable doesn't normal distribution.

The chi-square test also shows that the three variables follow a normal distribution because the statistical values were equal to (6.1831, 6.9700, and 3.0605), respectively, which are greater than the significance level less than its tabular value, which is equal to (9.4877 and 11.070). This is confirmed by the p-values, which are equal to (0.186, 0.223, and 0.691) and greater than the significance level (٠,٠٥).

**2.4.5. Measuring study variables**:
The study included three variables, default, independent and dependent, which were measured, and descriptive statistics were given as follows:

**Default variable:** The extent to how much managers at oil derivatives refineries in the research sample city of Erbil and operational industrial companies, in general, are aware of the high proportion of carbon dioxide emissions includes (7) items summarized in Table (4):

**Table (4): Descriptive statistics for the items of the default variable**

| S | Items | Mean | Degree of agreement | Standard Deviation |
|---|---|---|---|---|
| 1 | The research sample's managers and workers are not sufficiently informed about the negative outputs. | 4.1373 | 82.75 | .80049 |
| 2 | The research sample does not train workers to help reduce emissions produced by refineries. | 4.3333 | 86.67 | .76594 |
| 3 | Workers and managers do not fully understand negative outputs and how to minimize them. | 4.0196 | 80.39 | .83643 |
| 4 | The cost management measures for damaged units are not fully known to both managers and workers. | 4.4902 | 89.80 | .75822 |
| 5 | The materials used in production are of poor quality and a cause of pollution in the local environment. | 4.1765 | 83.53 | .86501 |
| 6 | The experience and qualifications of managers and workers do not contribute to reducing the effects of environmental pollution. | 4.4510 | 89.02 | .64230 |
| 7 | The research sample's control methods are ineffective at reducing environmental violations. | 3.6667 | 73.33 | .93095 |
| Overall Mean | | 4.1821 | 83.64 | 0.7999 |

Table (4) shows that the overall mean of the default variable was (4.1821), which is higher than the hypothetical average (3) by (1.1821), which indicates the agreement of the sample studied with the paragraphs of the default variable, with an agreement degree of 83.64% and a limited standard deviation of (0.7999) indicates the convergence of the opinions of the sample studied and their lack of dispersion regarding the items measuring the default variable.

**Independent variable:** MFCA technology includes (7) items summarized in Table (5):

**Table (5): Descriptive statistics for the items of the default variable**

| S | Items | Mean | Degree of agreement | Standard Deviation |
|---|---|---|---|---|
| 1 | Both managers and workers in the research sample were unaware of the (MFCA) technology, which helps to reduce production spoilage. | 4.1373 | 82.75 | .82510 |
| 2 | The research sample management does not work on developing quality equipment and production lines to reduce losses and waste in raw materials as a technical component of (MFCA). | 3.8039 | 76.08 | .89487 |
| 3 | The research sample management are familiar with the principles of Material Flow Cost Accounting (MFCA) | 4.2745 | 85.49 | .72328 |
| 4 | Management does not attach great importance to focus on technical management and control (MFCA). | 4.0784 | 81.57 | .71675 |
| 5 | The (MFCA) technique focuses on environmental information, which is not prepared or disclosed by the management of the research sample to decision-makers (internal and external). | 4.1176 | 82.35 | .76543 |

| | | | | |
|---|---|---|---|---|
| 6 | The management of the research sample is not required by law or environmental standards for applying the (MFCA) technique, which lowers environmental costs. | 4.1176 | 82.35 | .84017 |
| 7 | The management of the research sample is not interested in holding training courses to educate managers and employees about the usefulness of MFCA technology to reduce the defects resulting from lack of experience. | 4.0588 | 81.18 | .64535 |
| Overall Mean | | 4.0840 | 81.68 | 0.7730 |

Table (5) shows that the overall mean of the independent variable was (4.0840), which is higher than the hypothetical average (3) by (1.0840), which indicates the agreement of the sample studied with the paragraphs of the independent variable, with an agreement degree of 81.68% and a limited standard deviation of (0.7730) indicates the convergence of the opinions of the sample studied and their lack of dispersion regarding the items measuring the independent variable.

**Dependent variable:** Environmental sustainability includes (7) items summarized in Table (6):

**Table (6): Descriptive statistics for the items of the dependent variable**

| S | Items | Mean | Degree of agreement | Standard Deviation |
|---|---|---|---|---|
| 1 | (MFCA) technology is focused on evaluating economic and environmental performance, which are the two key pillars of environmental sustainability. | 3.9412 | 78.82 | .83455 |
| 2 | MFCA technology plays in reducing waste of materials and capacity to the lowest possible level to enhance environmental sustainability. | 4.4314 | 88.63 | .70014 |
| 3 | Using (MFCA) technology allows a company to check and evaluate the raw materials used in production, removing any dangerous elements that would otherwise pollute the environment and lowering environmental costs. | 4.1961 | 83.92 | .66392 |
| 4 | An environmentally sustainable objective is the protection of natural and environmental resources, which is achieved by companies using (MFCA) technology. | 4.4314 | 88.63 | .67097 |
| 5 | Achieving social and environmental development through the use of (MFCA) technology requires identifying appropriate solutions to the issue of environmental pollution (carbon dioxide). | 3.8039 | 76.08 | .89487 |
| 6 | The management of the research sample companies is assisted in making the following decisions by technology (MFCA) and environmental sustainability: Choosing devices and equipment that help reduce environmental risks, such as reducing emissions or producing environmentally friendly products, as well as choosing the best ways to use water, energy, and raw materials. | 4.2745 | 85.49 | .72328 |
| 7 | The application of (MFCA) technology by the management of companies helps in determining the cost of products and their revenues correctly and measuring the negative effects of environmental pollution, including carbon dioxide, which has a role in improving environmental sustainability. | 4.0784 | 81.57 | .71675 |
| Overall Mean | | 4.1653 | 83.31 | 0.7435 |

Table (6) shows that the overall mean of the dependent variable was (4.1653), which is higher than the hypothetical average (3) by (1.1653), which indicates the agreement of the sample studied with the paragraphs of the dependent variable, with an agreement degree of 83.31% and a limited standard deviation of (0.7435) indicates the convergence of the opinions of the sample studied and their lack of dispersion regarding the items measuring the dependent variable.

### 2.4.6. Testing the study hypotheses

The questionnaire tested the following hypotheses:

**First hypothesis:**

**Null hypothesis:** There is no awareness among managers at oil derivatives refineries in the research sample city of Erbil and operational industrial companies, in general, are aware of the high proportion of carbon dioxide emissions.

**Alternative hypothesis:** There is awareness among managers at oil derivatives refineries in the research sample city of Erbil and operational industrial companies, in general, are aware of the high proportion of carbon dioxide emissions.

Since the data of the default variable has a normal distribution, a parameter test can be used to test the second sub-hypothesis, specifically a one-sample t-test, as shown in the following table:

**Table (7): One-Sample Test for default variable**

| Mean test value = 3 | | | | | | |
|---|---|---|---|---|---|---|
| Mean | P value | t tabulated | t calculated | Std. Error Mean | Mean Difference | Result |
| 4.1821 | 0.000 | 1.96 | 14.865 | 0.07952 | 1.1821 | Sig. |

Table (7) shows that the agreement mean with the hypothesis is (4.1821), which is greater than the hypothetical Likert mean (3) by (1.1821). The p-value is equal to (0.000) which is less than the significance level (0.05), and the t-calculated was (14.865) which is greater than the t-tabulated value (1.96), therefore, the null hypothesis is rejected and accepted the alternative hypothesis which states that "There is awareness among managers at oil derivatives refineries in the research sample city of Erbil and operational industrial companies, in general, are aware of the high proportion of carbon dioxide" According to the opinions of the researched sample, which was tested.

**Second hypothesis:**

**Null hypothesis:** There is no impact of MFCA technology on environmental sustainability.

**Alternative hypothesis:** There is an impact of MFCA technology on environmental sustainability.

MFCA technology represents the independent variable, while environmental sustainability represents the dependent variable. The hypothesis will be tested by estimating a simple linear regression model (Ali, 2022). The results are summarized in Table (8):

**Table (8): Analysis of the model of the impact of MFCA technology on nvironmental sustainability**

| Regression Coefficients | | *p*-value | *t* | *F* | *p*-value | *R* | $R^2$ |
|---|---|---|---|---|---|---|---|
| Constant | 0.465 | 0.066 | 1.883 | 227.774 | 0.000 | 0.907 | 0.823 |
| Slope | 0.906 | 0.000 | 15.092 | | | | |

Through Table (8), we notice that MFCA technology explains 82.3% of the changes occurring in environmental sustainability, and the *p*-value of the regression slope test is close to (0.000), which indicates its significance and the importance of the presence of the MFCA technology variable in the estimated model. We also note that the *F*-value, the calculated value is (227.774), which is greater than its tabulated value, which is under the significance level (0.05), and the degrees of freedom (1 and 49), which amounted to (3.951). This means that the estimated model is suitable for the data, and this is confirmed by the *p*-value, which is close to (0.000), which is less than the significance level (0.05). Therefore, the null hypothesis will be rejected, and the alternative hypothesis will be accepted, which states that there is an impact (or relationship) of MFCA technology on environmental sustainability, which has been tested and its results circulated to the research community as a whole, and a simple linear regression model.

$$\hat{y}_i = 0.465 + 0.906x_i$$

There is a strong positive and significant relationship between MFCA technology and environmental sustainability as it reached 90.7%.

**2-5: Results:** The research reached several results in its theoretical and practical aspect, which are: The shortcomings of traditional management accounting methods in providing financial and non-financial information in a timely manner about loss at all stages of the product life cycle provide limited opportunities to rationalize management decisions that achieve sustainability for the company. Therefore, there is a need for a modern management accounting method that provides the necessary information to rationalize decisions to reduce losses and harmful emissions to the environment. The material flow cost accounting technique has emerged as one of the most important modern techniques of management accounting in the recent period, which determines the costs of the good product and the losses of the negative product (waste losses) for each process. Determining the percentage of the quantity and losses of loss reveals the level of inefficiency in the production process, and identifying the centers of quantities that cause loss losses. Then, management can find economically appropriate solutions and implement them to reduce or eliminate these losses, and keep waste losses away from product costs and determine them in the form of a separate report at all stages of production. As practical side, that agreement mean with the hypothesis is (4.1821), which is greater than the hypothetical Likert mean (3) by (1.1821). The p-value is equal to (0.000) which is less than the significance level (0.05), and the t-calculated was (14.865) which is greater than the t-tabulated value (1.96), therefore, there is awareness among managers at oil derivatives refineries in the research sample city of Erbil and operational industrial companies, in general, are aware of the high proportion of carbon dioxide" on one hand. and MFCA technology explains 82.3% of the changes occurring in environmental sustainability, and the *p*-value of the regression slope test is close to (0.000), which indicates its significance and the importance of the presence of the MFCA technology variable in the estimated model. the *F*-value, the calculated value is (227.774), which is greater than its tabulated value, which is under the significance level (0.05), therefore, which states that there is an impact of MFCA technology on environmental sustainability, which has been tested and its results circulated to the research community as a whole, and a simple linear regression model. On the other hand, according to the opinions of the researched sample, which was tested

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