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Original Article

Identifying Prospective Factors Affecting Environmental Management Accounting in Oil, Gas and Petrochemical Industry

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Abstract
Background: The oil, gas and petrochemical industries are widely considered as significant contributors to environmental pollution. This recognition stems from the intricate nature and extensive utilization of intermediate and production materials within these industries.
Methods: In this study, the identification and prioritization of potential factors influencing environmental management accounting (EMA) were conducted utilizing the fuzzy Delphi method. To achieve this objective, an initial set of 20 prospective factors pertaining to EMA was delineated through comprehensive review of pertinent background and theoretical literature. Subsequently, a pairwise comparison questionnaire was administered to 34 experts in management accounting, who were purposively sampled. Following this, the identified influential factors were ranked utilizing the analytical hierarchy process (AHP) technique.
Results: Eleven factors out of the initially proposed 20 questions pertaining to prospective factors were prioritized as follows: planning to improve cleaner production techniques, green design, green supply chain management, operational budgeting, research and development expenses, green innovation, designing tools for predicting the environmental consequences, evaluating an environmental investment, investing in renewable environmental projects, environmental cost budgeting, and investing in social responsibility issues.
Conclusion: The research indicates limited and fragmented implementation of EMAin organizations, mainly at reactive and preventive stages. Yet, exceptions show its use for cost savings and operational efficiency. As organizations advance in environmental strategy, there's a rising trend in using EMA for control and monitoring.
Keywords: Environmental protection, Environmental management accounting, Management strategies, Polluting industries, Green development

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Introduction

Environmental pollution has become a serious challenge in developing countries due to weak environmental laws, inappropriate use of industrial systems, lack of awareness of various pollution forms, population development, and the transfer of pollutants from developed countries to developing ones.[1] Identifying the factors leading to the destruction of the environment and natural resources is necessary to achieve green development.[2]

The oil and gas industry stands as a significant consumer of both water and energy resources, thus facing mounting pressure to adhere to progressively stringent environmental regulations. This necessitates a thorough reassessment of their extraction, production, and distribution methods to obtain and sustain their operational licenses. Furthermore, they are compelled to ensure transparency in the environmental management of their activities to maintain public trust and regulatory compliance.[3]

Petrochemical industries produce a large amount of waste which can influence the environment and human health. Petrochemical waste includes by-product of petrochemical production such as toxic waste and greenhouse gases. Natural gas and oil as the main components of petrochemicals produce waste and by-products during the extraction process.[3]

Researchers have investigated various impacts of petrochemicals on the environment. Petrochemical production leads to air, water, and soil pollution. It can even affect smaller systems including individual ecosystems, with implications even on a global scale. For instance, greenhouse gases emitted through the production of petrochemicals can lead to climate change. Petrochemical factories emit hazardous chemicals into the air during production, either through normal or accidental emissions.[2]

Previous research has identified potential cancer-causing factors associated with greenhouse gas emissions from petrochemical companies, alongside reports of exacerbated respiratory diseases in neighboring areas. Air pollutants emitted from these facilities encompass suspended particulate matter, carbon monoxide, nitrogen oxides, hydrogen sulfide, among others.[3] Water pollution occurs as a result of petrochemical production, both on the surface in lakes, ponds, and streams and below ground in groundwater. Wastewater contaminated with sulfides, ammonia, and other chemicals is produced during the petrochemical manufacturing process which has led to the pollution of ground waters and aquifers where people provide their drinking water.[4]

Whereas the oil, gas, and petrochemical industries involve high operational and investment costs, the profitability of these industries depends on the reliability, availability, and maintainability of the used systems and their components; accordingly, a reliable standard and integrated environmental approach are required to access optimal production of these industries that minimizes environmental costs and develop sustainability and social responsibility in these industries.[5]

Producing crude oil and refined products at lower costs to be competitive in the market is one of the crucial challenges of this industry. Therefore, the optimization of production systems and environmental facilities in active sites is one of the priorities of the oil industry.[6] This maximizes production efficiency, decreases extraction and refining costs, and thus compensates the exploration costs.[4] is one of the important measures of business units for cost reduction to be competitive and successful in the market.[7]

As management accounting is intrinsically linked with long-term strategic planning, the deliberate anticipation of societal and environmental evolution and development emerges as a key determinant of success and a gateway to strategic thinking.[8,9] Given the irreparable impacts of polluting industries on the environment and their consequential significance, the identification of prospective factors in environmental management accounting (EMA) holds potential for substantial mitigation of damages and consequences. Consequently, such measures can contribute to heightened economic growth, accountability, and social responsibility within companies.[8,10]

In light of the incomplete establishment of EMA in organizations, including within the investigated industry, this research endeavors to achieve two primary objectives. Firstly, it aims to identify prospective factors influencing EMA, alongside elucidating the detrimental environmental impacts imposed by the oil, gas, and petrochemical industry on other institutions and society at large. Secondly, it seeks to rank the aforementioned identified factors pertinent to EMA.

Theoretical Foundations and Review of the Research Literature

In accordance with current global commitments, such as the Global Biodiversity Framework (GBF) sanctioned during COP15 in December 2022, and in alignment with the perspectives of researchers in this field, it is imperative for countries to effectively manage natural resources.[11]

To address these challenges and fulfill their objectives, nations must adopt environmentally friendly financial policies, foster greener financial markets, and implement effective waste management programs. Furthermore, the execution of environment monitoring and resource management plans is essential, alongside the utilization of innovative technologies to overcome these challenges.[11]

The growing acknowledgment of humanity's impact on the environment has spurred the reevaluation and examination of conventional economic, ethical, and accounting paradigms. For instance, during the 1970s, there emerged a notable concern regarding the limitations of the traditional management paradigm. Scholars such as Chastain (1973), Gamar (1974), Ullman (1976), and Dierks and Preston (1977) delved into the relationship between accounting, organizations, and society during this period. Subsequently, in the 1990s, this scrutiny transitioned towards a specific focus on environmental issues. Recently, some efforts have been made to operationalize environmental issues. Undoubtedly, countries around the world have paid special attention to environmental concerns in the last two decades since the inception of Kyoto Protocol.[1] A series of global meetings have been held to discuss climate change. According to Stern report in 2006, there is a new global interest in environmental issues.[12]

Previous studies have demonstrated that the environmental costs reported by companies in their annual reports are approximately half of the actual costs incurred, as revealed through empirical analysis. A pilot testing project on EMA, conducted by Jasch and Schnitzer,[13] involving 10 polluting companies, highlighted a deficiency in communication between environmental managers and cost accountants within these organizations. Insufficient communication channels between the accounting and technical departments contribute to imprecise cost allocation, consequently impacting the accuracy of managerial decisions regarding operations and investments.[14] This ultimately exerts inverse impacts on both a company's environmental and financial performances. EMA emerges as a comprehensive approach to mitigate this communication gap, facilitating the seamless transition of data from cost accounting and financial accounting realms. By enhancing material efficiency, EMA endeavors to reduce environmental impact while simultaneously fostering improved financial outcomes.[15]

Monetary EMA methods rely on corresponding physical information about materials and energy flows which are past-oriented. This type of information can provide managers with an overview of inefficiencies in material and energy usage which is useful in identifying and analyzing potential improvement opportunities.[16]

Bennett et al[17] reported that past-oriented information is found most often in businesses. However, once managers become aware of opportunities for efficiency improvements and other benefits, the future-oriented information will also be needed. Thus, firms will be able to achieve first mover advantage by being proactive in strategic planning. It would be up to managers to select the tools that would best suit their information needs.[18]

Azizi et al[19] presented a comprehensive model of the relative importance of environmental accounting indicators using structural equations using a mixed research method in two qualitative and quantitative sections. In the qualitative section, the statistical population included university faculty members. Further, the statistical population of the quantitative section consisted of 194 managers, experts, and connoisseurs in the field of environmental accounting. The grounded theory approach and structural equations were respectively applied to analyze the qualitative and quantitative data. The findings of the qualitative section revealed the six main categories of senior management commitment, strategy, uncertainty, social legitimacy, environmental control and monitoring, and accounting information systems as the model dimensions. Moreover, according to the results of the quantitative section, the coefficient of the impact of change agents on the consequences confirms the relationships.

According to the results of the study by Ehsani et al[20] entitled “ranking factors affecting the optimal management of environmental accounting costs using the AHP Technique”, the necessity of reporting environmental costs and disclosing their related information is considered as the most important economic factor. Moreover, elevating managers’ awareness regarding the significance and prioritization of environmental cost management issues is deemed the paramount social factor. Concurrently, the examination of the interface between industries and the environment, along with the utilization of natural resources, is acknowledged as the principal institutional factor influencing optimal environmental cost management.

Bahri Sales and Rezaie et al[21] did a study entitled “An integrated approach to green design, product life cycle, AHP Fuzzy and environmental management accounting (Case Study: wire and cable manufacturing company of Tabriz). This research, in addition to analyzing various aspects of management accounting and the product production cycle employing the analytical hierarchy process (AHP) with fuzzy logic, elucidates the evaluation of compliance levels with environmental standards in the wire and cable manufacturing industry of Tabriz.

Gunarathne and Lee[22] investigated the corporate cleaner production strategy development and environmental management accounting: A contingency theory perspective. This study sought to identify how the uses of EMA and information characteristics vary among organizations at different stages of cleaner production strategy development. This research found that EMA uses to be limited and fragmented in organizations at the reactive and preventive stages except for using EMA for cost savings and efficiency improvements. However, the findings suggest that when organizations progress into higher levels of cleaner production strategy development, there is a relatively high level of use of EMA in terms of integrative tools, and for control and stewardship purposes.

Karimi Khorrami et al[23] conducted research entitled “environmental Strategy, environmental accounting, and organizational performance”. In this study, data were gathered through questionnaires distributed to companies listed on stock markets, and analysis was conducted using structural equation modeling. The findings revealed that environmental strategy significantly influences the extent of EMA adoption, and a positive correlation exists between EMA implementation and organizational performance.

Research Questions

First, what are the prospective factors affecting EMA in the oil, gas, and petrochemical industries?
Secondly, how are the prospective factors influencing EMA ranked within the oil, gas, and petrochemical industries?

Methods

The present research is an applied and descriptive-survey research. In the initial phase, the study seeks to identify influential factors and subsequently establish relationships among these variables. Multi-criteria decision-making techniques, such as hierarchical analysis, are employed to rank and assign weights to these variables.[24]

The research methodology follows a deductive-inductive approach in terms of implementation logic, wherein the researcher not only observes accounting phenomena but also endeavors to evaluate accounting models and theories within real-world contexts. The examination of the relationship between management theories and environmental accounting is conducted through a comparative approach. Data collection is accomplished via questionnaires, and analysis is performed using an inductive approach.[25]

The information used in EMA to measure past performance or future decision-making is classified into two categories of monetary and non-monetary information. It is of special importance to distinguish between decisions related to long-term strategic information and operational information that entail a shorter period.[26]

In addition to financial data, which primarily reflects a corporation's historical performance, non-financial information—particularly prospective non-financial data—pertains to the company's future growth trajectory. Such data offer more pertinent insights and a clearer outlook on the company's future performance, thereby empowering users to make informed decisions.

Foresight can provide managers and researchers with useful information in the field of possible environments in which companies operate, as well as the impact of these environments and activities on the environment. In addition, foresight can play a significant role in improving the production and innovation process, which results in protecting the environment. It is believed that corporate foresight is effective in strategy formulation in different ways. Therefore, it is necessary to expand the application of corporate foresight beyond providing information to understand it.[27] In this context, the research is classified as a qualitative study. Initially, prospective factors influencing EMA were identified (Table 1) through a comprehensive examination of theoretical frameworks and pertinent literature sourced from library databases. Additionally, an extensive review of the relevant research background was conducted to inform this identification process. Then, using the fuzzy Delphi method in two phases, the intended factors were submitted to the experts and connoisseurs in the field of management accounting and environmental management in the oil, gas, and petrochemical industries to identify the factors affecting EMA. Also, the significant effective factors were recognized after the experts' consensus about each of the indicators. In the subsequent and final phase, the indicators identified during the Delphi Fuzzy stage as influential in EMA were prioritized. This ranking process involved the utilization of multi-criteria decision-making components and techniques, including the fuzzy AHP. Additionally, the insights and opinions of targeted experts and specialists were incorporated to ensure a comprehensive evaluation of the identified indicators.

Population, Sampling Method, and Sample Size

The statistical population for the fuzzy Delphi method in this research comprised environmental accounting experts and professionals within the country. These individuals were selected using purposive judgmental sampling methods. Eligible participants held at least a doctoral degree in a relevant field such as accounting or management and possessed significant expertise in budgeting, with a minimum of ten years of relevant professional experience. This requirement ensured an equivalent blend of academic knowledge and practical proficiency. Consequently, the research sample, consisting of 34 participants, was selected using the judgmental method to develop and validate the initial questionnaire.

Table 1. Fuzzy Spectrum Equivalent to Five-Hour Scale in AHP Technique

Fuzzy number	Linguistic	Scale of Fuzzy Number
1	Very little effect	(0,0,0.3), (0.0,0.0,0.25)
2	Low effect	(0.1,0.3,0.5), (0.0,0.25,0.5)
3	Average	0.3,0.5,0.7), (0.25,0.5,0.75)
4	Full effect	(0.5,0.7,0.9), (0.5,0.75,1.0)
5	Very impressive	(0.7,1,1), (0.75,1.0,1.0)

Research Algorithm Based on Fuzzy Delphi

In this section, the fuzzy Delphi method and its implementation algorithm are initially elucidated. Subsequently, the approach for assessing linguistic variables is delineated through the formulation of triangular fuzzy numbers (TFNs). This formulation encompasses the intended fuzzy calculations required to execute the Delphi method effectively.

Fuzzy Delphi Method

The Delphi method is a process mostly used in research for a group of experts to gain consensus on a specific topic or research question, which is done through several rounds of questionnaires and opinion polls as well as resulting feedback. In this method, the experts' mental data are converted into almost objective data using statistical analysis.[28] The use of fuzzy numbers in the fuzzy Delphi method is reliable since the issues around us cannot be divided into two or more black-and-white categories, but every issue fits into a spectrum. In addition, the use of linguistic variables by experts are more common and convenient in many cases, such as examining efficiency, level of satisfaction, etc. The utilization of the fuzzy Delphi method is particularly advantageous in situations where goals and parameters are not explicitly defined, as it yields highly reliable findings. A key attribute of this method is its flexibility, enabling the resolution of numerous inaccuracies and clarity-related barriers within the research context.[27] The general fuzzy Delphi algorithm is represented in Figure 1.

The Delphi algorithm is executed by experts typically expressing their opinions in the form of minimum, maximum, and most likely values, represented as TFNs. Subsequently, the average of experts' opinions (provided scores) and the deviation of each expert's opinion from this average are computed. This data is then relayed to obtain new opinions from the experts. In the subsequent stage, each expert offers a new opinion or revises their previous one based on information gleaned from the preceding phase. This iterative process persists until the average fuzzy numbers attain sufficient stability.[28]

TFN is represented by F = (l, m, u), where l, m, and u are the smallest, most promising, and largest possible values respectively. U is the maximum membership value that a fuzzy number F takes on. l is the minimum membership value that the fuzzy number F can take on. And ultimately, M is the most likely value of a fuzzy number. The fuzzy membership degree or the membership function of a TFN

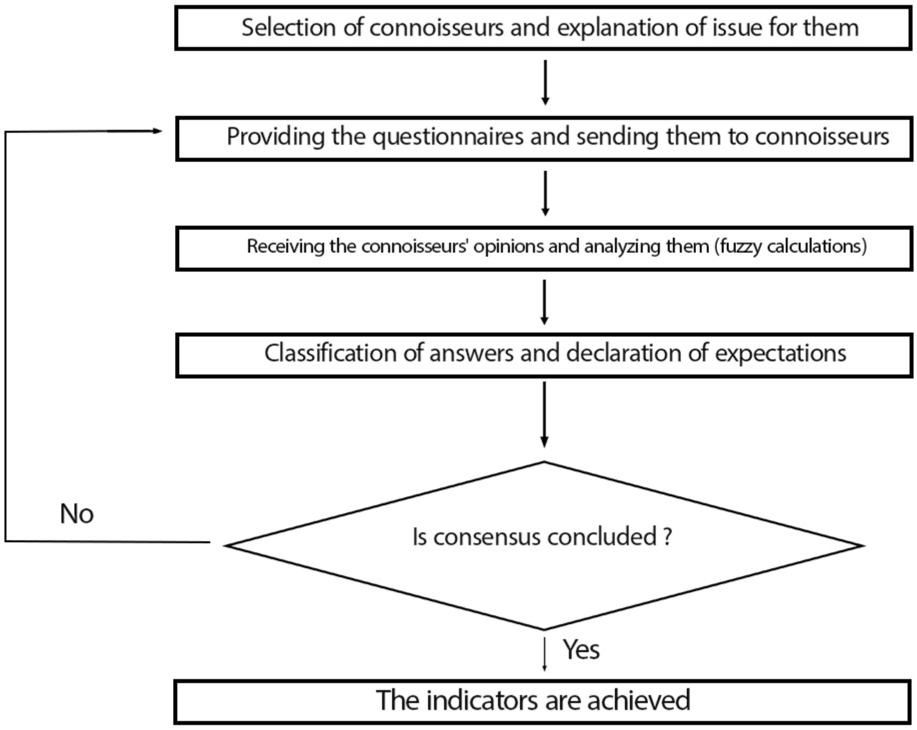

Figure 1. Fuzzy Delphi Algorithm

is represented in equation 1.

$$\mu_l(x) = \begin{cases} \dfrac{x-l}{m-l} & l < x < m \\ \dfrac{u-x}{u-m} & m < x < u \\ 0 & otherwise \end{cases} \quad (1)$$

Definition of Linguistic Variables

Given that experts were required to select suitable factors from the proposed ones during the Delphi process, using variables with specific values posed challenges in expressing their opinions. Consequently, such variables were omitted from consideration. It appears that employing qualitative variables in the form of descriptors such as good, average, and weak could alleviate this issue to some extent. It is acknowledged that individuals may harbor divergent opinions regarding qualitative variables like low or high. Experts possess varying mindsets due to their distinct characteristics, and the analysis of variables could yield inconclusive results if responses are influenced by disparate mentalities. However, experts would likely provide responses with a more uniform mindset if they are tasked with defining the range of qualitative variables.[28] Therefore, qualitative variables are defined as TFNs in the form of good, average, and weak options. The most likely values defined through TFNs were considered as (5,7,9), (3,5,7), and (1,3,5) for good, average, and weak options, respectively.

Verbal indices and fuzzy equations associated with the 5-hour spectrum, are presented in Table 1.

Fuzzy Calculations

In each phase of the fuzzy test, the fuzzy average for the fuzzy triangular numbers of A1, A2, ..., An is defined in equation 2:

$$AM = (A1, A2, \ldots An)/n \quad (2)$$

In the formula of Ai (ai, bi, ci), the TFN is related to the ith individual, and AM is the fuzzy average of each of the questions. After calculating the fuzzy average for each of the questions of the questionnaire, the difference from the population average at each stage is calculated for each expert using by equation 3:

$$(Am1 - Ai1, Bm1, Cm1 - Ci1) \quad (3)$$

Where, Am1, Bm1, and Cm1 are respectively the lower, middle, and upper bounds of the average TFNs of each of the questions, and Ai1, Bi1, and Ci1 are respectively the lower, middle, and upper bounds of the ith individual. In the subsequent stage, each expert is presented with the population average from the preceding stage, along with the deviation of their individual opinion from this population average. Subsequently, each expert proceeds to revise their opinion in light of this information or maintain their initial stance on the relevant deviation. Following this, a fuzzy average is recalculated for the updated stage, and the average deviation between the two stages is computed for each question. If the average deviation, determined by the following formula, falls below 0.15, it indicates a substantial consensus has been attained regarding the given question. This iterative process persists until a satisfactory level of consensus is achieved (equation 4).

$$(1) S(Ni, Nj) = \lceil (a1+2a2+a3)-(b1+2b2+b3) \rceil / 4(B2-B1) \quad (4)$$

Where B2 and B1 are respectively the maximum and the minimum bounds between the averages of two steps. Further, a1, a2, and a3 are the lower, middle, and upper bounds of the average of each question in the previous stage, and b1, b2, and b3 are respectively the lower, middle, and upper bounds related to the average of the new stage.[28]

Fuzzy Analytical Hierarchy Process

The fuzzy AHP is implemented as follows:

1. A new questionnaire has been prepared for the relevant criteria and indicators after determining the indicators using the fuzzy Delphi method, and the professional experts were asked to express their opinion. By collecting the questionnaires, there would be matrices equal to the number of these questionnaires.
2. At this stage, the compatibility of the matrices was examined using the Leung and Kao technique.

The equation 5 is used to unify the relevant matrices in:

$$(1) \overline{ri} = \left[\overline{ai}1 * \ldots * \overline{ai}n\right] {}^{1}\!/_{n} \quad (5)$$

The weight of each criterion and index is calculated by the use of the following relation, in equation 6:

$$(1) \tilde{w}_{1=\tilde{r}_1} * (\tilde{r}_1 * \ldots \tilde{r}_n)^{-1} \quad (6)$$

3. The total weight of each index is obtained by multiplying the weight of each criterion by the weight of each index, using by equation 7:

$$(1) OW = W_f * Wf_i \quad (7)$$

4. Calculation of the best nonfuzzy performance value: At this stage, after calculating the total weight of the criteria, the best nonfuzzy performance (BNP) is calculated using the following formula. Using this formula, triangular numbers are converted into normal numbers so that numbers can be comparable, in Equation 8:

$$(1) BNP = \left[(u-l)+(m-l)\right]/3+l \quad (8)$$

5. Finally, the indicators are ranked using the results obtained in the previous stage.

Results

In this section, the outcomes of the fuzzy computations carried out for the execution of the fuzzy Delphi algorithm are delineated in Tables 2 to 5. In accordance with the elucidations furnished for the Delphi method algorithm, as well as the descriptions expounded in the research methodology section, the Delphi implementation is terminated, and factors categorized as ‘good’ (with their average score falling within the range of triangular numbers of 5, 7, 9) are identified as influential financial factors in EMA when the average disparity among experts’ perspectives regarding the mentioned factors in the questionnaire is determined to be less than 0.15 over two consecutive stages of the fuzzy Delphi method

Given that the level of disagreement among experts regarding all the questions during the two stages of Delphi method implementation is less than 0.15 (as indicated in Table 5), it can be inferred that a satisfactory consensus has been reached among the experts. Consequently, the implementation of the Delphi method is ceased, and the results are expounded upon. Subsequently, in accordance with the explanations provided in the research methodology section, the factors classified as ‘good’ in the final (second) stage of Delphi method implementation (with their average score falling within the range of triangular numbers of 5, 7, 9 as delineated in Table 5) were recognized as the experts’ chosen factors influencing EMA. Hence, it can be deduced that the objective of the research, aimed at identifying potential factors impacting EMA, has been fulfilled, and the principal question of the research has been addressed.

Then, the recognized factors were ranked by applying the fuzzy AHP. Regarding the results obtained from ranking the prospective factors affecting EMA, the factors

Table 2. Subject Matters and Concepts Stated Implicitly in the Questionnaire of Prospective Factors Identification

Item	Intended Subject or Concept	Item	Intended Subject or Concept
1	Socially responsible investment (SRI)	11	Investing in fixed assets
2	Green innovation	12	Designing tools for predicting environmental effects
3	Planning to improve cleaner production techniques	13	Recycling and recovery of materials and energy
4	Planning and management of green supply chain	14	Research and development expenses
5	Investing in environment renewal projects	15	Risk and debt management
6	Production process design	16	Environmental budgeting
7	Green Design	17	Designing strategic plans
8	Product pricing	18	Accounting innovation
9	Pollution forecast	19	Energy efficiency
10	Evaluating the environmental investment	20	Budgeting

Table 3. Experts' Opinions Average Obtained From the First and Second Stages of the Questionnaire

Factor	Code- Criterion	Average Fuzzy Opinions of the First Stage			Result	Average Fuzzy Opinions of the Second Stage			Result	Average Fuzzy Difference of First and Second Questionnaires
		Upper Bound	Middle Bound	Lower Bound		Upper Bound	Middle Bound	Lower Bound		
Prospective factors affecting the EMA	Socially responsible investment (SRI)	8.06	6.06	4.06	Good	8.29	6.29	4.29	Good	-0.06
	Accounting innovation	7.35	5.35	3.35	Average	7.29	5.29	3.29	Average	0.01
	Planning to improve cleaner production techniques	8.12	6.12	4.12	Good	8.29	6.29	4.29	Good	-0.04
	Planning and management of green supply chain	7.59	5.59	3.59	Average	8.06	6.06	4.06	Good	-0.11
	Investing in environment renewal projects	7.41	5.41	3.41	Average	8.00	6.00	4.00	Good	-0.13
	Production process design	7.47	5.47	3.47	Average	7.71	5.71	3.71	Average	-0.06
	Green design	7.76	5.76	3.76	Average	8.06	6.06	4.06	Good	-0.07
	Product pricing	7.82	5.82	3.82	Average	7.71	5.71	3.71	Average	0.03
	Pollution forecast	7.59	5.59	3.59	Average	7.29	5.29	3.29	Average	0.08
	Evaluating environmental (green) investment	8.00	6.00	4.00	Good	8.06	6.06	4.06	Good	-0.01
	Investing in fixed assets	7.59	5.59	3.59	Average	7.41	5.41	3.41	Average	0.05
	Designing tools for predicting environmental effects	7.59	5.59	3.59	Average	8.06	6.06	4.06	Good	-0.11
	Recycling and recovery of materials and energy	7.35	5.35	3.35	Average	7.35	5.35	3.35	Average	0.00
	Research and development expenses	8.00	6.00	4.00	Good	8.18	6.18	4.18	Good	-0.04
	Risk and debt management	7.41	5.41	3.41	Average	7.35	5.35	3.35	Average	0.01
	Environmental budgeting	7.59	5.59	3.59	Average	8.06	6.06	4.06	Good	-0.11
	Designing strategic plans	6.76	4.76	2.76	Average	7.00	5.00	3.00	Average	-0.06
	Green innovation	7.65	5.65	3.65	Average	8.06	6.06	4.06	Good	-0.09
	Energy efficiency	7.82	5.82	3.82	Average	7.71	5.71	3.71	Average	0.03
	Budgeting	8.00	6.00	4.00	Good	8.12	6.12	4.12	Good	-0.03

Table 4. Selected Factors Resulting From the Experts' Final Consensus

Code- Criterion	Final Result
Socially responsible investment (SRI)	Accepted
Planning to improve cleaner production techniques	Accepted
Green supply chain management	Accepted
Investing in environment renewal projects	Accepted
Evaluating environmental (green) investment	Accepted
Designing tools for predicting environmental effects	Accepted
Research and development expenses	Accepted
Environmental budgeting	Accepted
Green innovation	Accepted
Budgeting	Accepted
Green design	Accepted

Table 5. Priority of Criteria

Indicator	V	Weight	Rank
Planning to improve cleaner production techniques	1.19	0.152	1
Green design	0.96	0.135	2
Green supply chain management	0.94	0.127	3
Operational budgeting	0.86	0.114	4
Research and development expenses	0.74	0.094	5
Green innovation	0.69	0.087	6
Designing tools for predicting environmental effects	0.57	0.077	7
Evaluating environmental (green) investment	0.51	0.061	8
Investing in environment renewal projects	0.49	0.058	9
Environmental budgeting	0.37	0.051	10
Socially Responsible Investment (SRI)	0.29	0.044	11
Total	7.61	1	

of planning to improve the cleaner production methods and socially responsible investment (SRI) respectively have the most and the least effect on EMA.

Conclusions and Suggestions

The recognized prospective factors affecting management accounting in this research revealed that EMA in organizations is limited and scattered in reactive and preventive stages, except in the case of applying EMA to save costs and improve efficiency. The findings reveal the identification of 11 items from a pool of 20 proposed factors associated with prospective considerations. These selected factors were prioritized as follows: planning for enhancing cleaner production techniques, green design initiatives, management of green supply chains, operational budgeting practices, allocation of resources for research and development, fostering green innovation, development of tools for predicting environmental impacts, assessment of environmental (green) investments, investment in renewable environmental projects, implementation of environmental budgeting strategies, and engagement in socially responsible investment endeavors.

The results indicate that organizations demonstrate a notable emphasis on the advancement of cleaner production techniques, which emerged as the most significant aspect in this study. Concurrently, the utilization of EMA appears to escalate, particularly in terms of integrated tools and for purposes of control and monitoring. Hence, it is recommended to decision-makers and officials within the studied industries to consistently implement cleaner production techniques, which serve as proactive environmental measures throughout the stages of process, product, and service development. This endeavor aims to bolster overall productivity within the production unit, yielding economic benefits while mitigating social risks to both human populations and the environment. By accentuating specific and innovative criteria within the production process to curtail costs and mitigate adverse environmental impacts, the adoption of cleaner production methods integrates financial and environmental considerations into the decision-making framework. Consequently, this approach facilitates constructive modifications in the company's production processes by selecting the most suitable production design options.

The second most important and effective factor identified in this research was green design. While the cost of product design typically represents a minor fraction of the overall product development expenditure, decisions made during this phase significantly influence the selection of raw materials, adoption of production and distribution methodologies, and provision of production services by the business unit. Thus, meticulous attention to product design yields consequential benefits within the production unit. To attain a green product, transitioning from traditional product design approaches to green design becomes imperative. This shift in approach necessitates a corresponding shift in attitude towards production, entailing the adoption of environmentally-friendly design principles.

Ranked as the third most crucial factor according to expert perspectives, green supply chain management entails the incorporation of environmentally sustainable practices into conventional supply chain operations, aimed at fostering sustainable development. Altering traditional supply chain management approaches becomes imperative to enhance the organization's social responsibility quotient. Supply chain greening involves integrating environmental criteria or considerations throughout the supply chain continuum. Consequently, it is recommended that polluting companies and industries adopt operational budgeting practices and exercise sound judgment in allocating resources for research and development expenses, thereby facilitating more environmentally conscious investments in green innovation. This would decrease the environmental costs and harmful effects significantly. Green process innovation is effective on the financial and environmental performance of oil, gas, and petrochemical, as well as the metal and chemical industries; but it affects their economic performance only in oil, gas, and petrochemical industries.

Recognizing the significance of environmental effects is one of the most important issues and concerns in the environmental assessment process of plans and projects, which mainly depends on its multi-criteria nature. According to the experts' opinions in this research, management accounting can help companies in this case by designing tools to predict environmental effects.

Green investment encompasses financial allocations aimed at enhancing environmentally sustainable business practices and safeguarding natural resources. Initially, companies may incur substantial costs in adopting green technologies, with initial returns potentially modest. Such investments typically involve a diversified portfolio comprising shares of companies committed to environmental stewardship. These companies either operate directly within environmentally conscious sectors or prioritize environmental protection and the mitigation of ecological footprints in their operational processes. Investment avenues include green stocks, bonds, mutual funds, exchange-traded funds (ETFs), and other securities. Recognizing the benefits of green investment for both companies and investors, as well as its positive impact on the environment, stock exchanges and relevant regulatory bodies are encouraged to incentivize investment in green stocks by incorporating ethical and social criteria into their frameworks.

The fields of green or renewable energies have emerged as primary focal points for green investors. In contemporary times, numerous companies are transitioning to renewable energy sources, thereby diminishing reliance on environmentally detrimental fuels. Notably, fossil fuels are being supplanted in electricity generation, exemplifying this shift. Given projections indicating imminent and severe climate changes, coupled with the imperative to combat global warming, investments in such enterprises stand to yield significant returns. Nations such as China, alongside major industries worldwide, are increasingly integrating renewable energies into their operational frameworks. Solar energy, hydroelectric power, wind energy, geothermal energy, hydropower, and wave energy constitute subcategories within the realm of renewable energies.

The final crucial factor delineated by experts in this research is SRI. SRI represents an investment approach centered on companies that not only generate favorable social impacts but also demonstrate adequate financial efficacy.

Hence, it is recommended that the surveyed industry and other enterprises undertake measures to mitigate their environmental risks through targeted initiatives pertinent to their respective sectors, enhance resource efficiency, and minimize waste generation. Additionally, companies can enhance their social impact by fostering a conducive work environment for employees and fostering constructive engagements with society. Such efforts are instrumental in fostering corporate and environmental sustainability, while concurrently yielding economic dividends and fulfilling social responsibilities.

Practical Suggestions

Considering the impact of oil, gas, and petrochemical industry activities on the environment, it is suggested to create the space required for the increase of social trust as well as to improve the relationship with other communities to present an appropriate public perception of the oil industry. Additionally, it is recommended that regulatory bodies such as compilers of accounting and auditing standards, stock exchange organizations, national tax administrations, and other relevant entities within the financial and economic sectors of the country devise and enforce requirements, laws, standards, as well as policies and regulations pertaining to social responsibilities. These measures should be aligned with the findings of the present research to facilitate the implementation of EMA, particularly within industries with significant environmental impact.

In light of the aforementioned considerations, it is advised that environmental authorities and legislative bodies take proactive steps to promote a healthy environment. This may involve enforcing existing environmental laws, enacting new legislation where necessary, and imposing legal penalties on companies found to be polluting. Such measures are essential for fostering environmental stewardship and ensuring compliance with regulatory standards, thereby safeguarding the well-being of ecosystems and communities.

Based on the factors identified in this research, it is recommended that companies prioritize enhancements to their costing systems and EMA reporting within their business units.

Given the restricted breadth of prior research on the determinants influencing EMA, particularly the absence of comprehensive studies in this domain within Iran, the factors delineated in this study were put forth by pertinent experts. They furnish a broad and exhaustive panorama of the determinants influencing EMA, along with other overarching strategies germane to the advancement of EMA practices in Iran. These factors merit consideration by relevant institutions, company executives, professional bodies, and regulatory agencies involved in environmental preservation and conservation efforts. They can inform initiatives aimed at enhancing management accounting systems, fostering the development of management accounting practices, and bolstering monitoring mechanisms for more efficacious outcomes.

Future Suggestions

Future researchers are suggested to repeat the present research by applying other techniques such as phenomenology.

The results can be used as a tool to measure the level of application of considerations in industries.

In light of the present research endeavor, future researchers are encouraged to conduct analogous studies across diverse polluting industries. Such endeavors hold promise in aiding industries to align with environmental objectives by delineating pertinent environmental criteria and considerations. Moreover, it is recommended that researchers delve into the challenges encountered in EMA. This would offer valuable insights for enhancing environmental accounting practices and fostering sustainability within industries.

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