Management Strategies and Engineering Sciences 2024; 6(2):134-143

Evaluating the Efficiency of Sustainable Suppliers Based on Human and Environmental Indicators Using Data Envelopment Analysis and Gap Analysis (Case Study: Petrochemical Companies)

Somayeh Karamad[1], Hassan Dehghan Dehnavi [2]*, Hamid Babaei Meybodi[3], Mojdeh Rabbani[4]

1.PhD Student, Department of Industrial Management, Yazd Branch, Islamic Azad University, Yazd, Iran.
2.Associate Professor, Department of Industrial Management, Yazd Branch, Islamic Azad University, Yazd, Iran (Corresponding author).
3.Associate Professor, Department of Management, Meybod University, Meybod, Iran.
4.Assistant Professor, Department of Industrial Management, Yazd Branch, Islamic Azad University, Yazd, Iran.

*** Corresponding author email address**: hasanehghanehnavi@yahoo.com

Received: 2024-06-11 **Reviewed:** 2024-06-25 **Revised:** 2024-08-13 **Accepted:** 2024-08-24 **Published:** 2024-09-10

Abstract

Evaluating the efficiency of sustainable suppliers not only raises awareness among stakeholders but also enhances competition, promotes industry dynamism, and fosters the sustainable and balanced development of society. In the present study, human and environmental indicators were utilized, and optimal input and output criteria were selected based on expert opinions. Therefore, the selection of variables (inputs and outputs) in this research was assessed through a review of similar studies, interviews, and surveys with experts and specialists. All calculations were performed using DEA Solver software. The results revealed that out of 13 companies, 12 were efficient (efficiency score equal to one), and only one company was inefficient. Furthermore, "Movaledan Chemical Company," with an efficiency score of 1.66, was found to be more efficient compared to other companies, almost twice as efficient as "Pars Pak Kimia Company," which had the lowest efficiency score of 0.858. Pars Pak Kimia Company, with the lowest efficiency score (0.858), ranked last. In Data Envelopment Analysis (DEA), when calculating the efficiency of companies, several efficient units were used as benchmarks (or references) for each inefficient company. The benchmarks for Pars Pak Kimia Company were "Iran Petrochemical Trading Company" with a lambda coefficient of 0.262, "Chelik Alborz Company" with a lambda coefficient of 0.55, "Movaledan Chemical Company" with a lambda coefficient of 0.052, and "Farzam Chemical Group" with a lambda coefficient of 0.135. The results of the paired T-test indicate a significant difference at the 95% confidence level between the scores of this variable in the current and target states.

Keywords: *Efficiency, Data Envelopment Analysis, Human Indicators, Environmental Indicators, Sustainable Suppliers*

How to cite this article:

Karamad S, Dehghan Dehnavi H, Babaei Meybodi H, Rabbani M. (2024). Evaluating the Efficiency of Sustainable Suppliers Based on Human and Environmental Indicators Using Data Envelopment Analysis and Gap Analysis (Case Study: Petrochemical Companies). *Management Strategies and Engineering Sciences, 6*(2), 134-143.

1. Introduction

Energy productivity represents the greatest short-term opportunity for businesses and individuals to cope with the pressures of rising energy costs driven by current economic and geopolitical forces [1] while contributing to the creation of a more sustainable, affordable, reliable, and secure energy future for all [1-4].

Advancements in technologies, such as data and analytics, can yield significant cost savings in ways that were not feasible a decade ago [5]. These advancements have made energy productivity one of the fastest and most cost-effective measures for reducing energy costs while advancing global climate goals [6].

Business managers can take steps today to reduce their organizations' energy consumption and influence behavior change among individuals [7]. While there are several areas where efficiency improvements can be made, the greatest short-term potential lies in focusing on sustainability [8]. Currently, sustainability has become a global issue [9, 10], and it has transformed supply chain goals from traditional economic concerns of cost, quality, and time to multidimensional opportunities in economic, social, and environmental fields [11, 12].

On the other hand, manufacturing industries face many challenges in moving toward globalization [9], and this development must consider sustainability, utilizing advanced sustainable supply chain management approaches to meet the needs of future generations [13]. These factors have made the selection of sustainable suppliers a strategic decision in supply chain management. Selecting appropriate suppliers based on sustainability criteria (economic, environmental, and social) can help companies move toward sustainable development. In this regard, a positive relationship between sustainable supplier selection and supply chain management is required to pave the way for sustainable supply chain management (SSCM) [14, 15].

Establishing a business deal with suppliers to ensure profitability is a crucial strategic decision for manufacturing companies. Furthermore, supplier performance factors vary, creating complex decision-making opportunities for manufacturers. Thus, research to select the best suppliers that meet sustainability criteria set by manufacturers for developing sustainable supply chain management is essential. A decision-making framework supporting sustainable supplier selection is needed in developing countries for SSCM [16, 17].

Afshari (2022), in research titled "Sustainability Through Achieving Economic, Environmental, and Social Goals," states that social sustainability and its indicators are not well understood, making the monitoring of project design and implementation challenging. The study concluded that social sustainability pertains to the "production" and "demand" stages in energy supply chains, emphasizing common stakeholder analysis for employee-related social sustainability. The analysis highlighted the importance of internal stakeholders in achieving social sustainability, which is more strategic than tactical or operational. There is no consensus on the definition of social sustainability, nor is there agreement on how to measure it or the data needed for this purpose [18].

Coşkun (2022) investigated the economic, environmental, and social aspects of sustainable development for integrated supplier evaluation and assessed 69 companies. The study found that successful implementation of integrated sustainable supplier assessment and development can serve as a roadmap for chemical manufacturers to adopt sustainability practices and ensure continuous supply chain development [5]. Xing (2020) identified investments in pollution reduction, resource consumption, environmental design, green image, environmental management systems, and employee environmental training. The study ranked environmental design as the highest, followed by environmental management systems, green image, and resource consumption [19].

Chang (2020) demonstrated that internal greening is a prerequisite for green supply chain collaboration. Internal environmental management leads to greater performance gains than external environmental management, although environmental practices do not necessarily yield higher economic performance [13]. Wu (2020) concluded that quality and green management are essential for operational and environmental performance, presenting suitable criteria across five dimensions of the green supply chain: green design, green procurement, green transportation, green logistics, and reverse logistics. These dimensions encompass regulations, environmental and economic performance, customer and supplier collaboration, stakeholder pressure, green manufacturing, green packaging, inventory policies, logistics networks, service and technology quality, reduction activities, recycling, remanufacturing, reuse, and disposal [10].

Muñoz (2019), in research on trends and gaps in green management integration, found that market pressure moderates the relationship between actions and drivers of green supply chain management. Competitive pressure negatively moderates the relationship between actions and green drivers. The drivers analyzed include organizational support, government participation, and social capital, with green purchasing, customer collaboration, and green design having significant impacts, except for return on investment, which relates only to organizational support [12].

De Lima (2023), in a Delphi study on risk and uncertainty management in circular supply chains, conducted three rounds with stakeholders from 18 countries across five continents to analyze their perspectives. The study identified critical organizational, supply chain, and external risks and uncertainties, such as financial costs, lack of knowledge, operational and technological risks, quality, availability, and delivery of secondary resources, competition with linear-oriented companies, insufficient regulatory frameworks, and unstable prices for primary and secondary resources. Countermeasures include inter-company collaboration, circular product design, information sharing, flexibility, and financial risk management [8].

Supply chain management is fundamental to any supply chain, playing a crucial role in its successful survival in global competition [20]. Environmental issues have attracted significant attention from manufacturing organizations [21]. Humanity must account for the environmental and social impacts of economic growth in long-term planning [22]. A stable economic state requires maintaining population and material wealth at an optimal level with minimal product retention rates [23]. Human economy, a subset of a sustainable ecosystem, must also achieve stability in natural dimensions [24]. Herman Daly argued that endless growth-based economies are unsustainable and advocated for qualitative growth instead. His approach emphasizes reducing resource use through government regulation and market mechanisms, such as higher prices and better technology [25].

Social structures and living conditions should be considered primary elements in achieving sustainable development goals. Socially sustainable development enhances physical, intellectual, and social needs while promoting education, creativity, and human resource development. Urban planning should prioritize livable environments that connect public spaces to the social, spiritual, and physical well-being of residents. Urban quality and vibrancy are products of cultural vitality, social participation, environmental quality, and sustainable development [26].

Iran, a developing country with a vital petrochemical industry, plays a key role in meeting domestic and international demands and in economic and financial resource generation. Given that environmental factors and sustainability are crucial for industry development nationally and internationally, strategies for evaluating sustainable suppliers are essential. This study employs Data Envelopment Analysis (DEA) to examine supplier sustainability in refining and petrochemical industries, assessing economic, social, and environmental dimensions. The study also uses gap analysis to compare the current and desired states within these industries.

2. Methodology

The present study is considered an applied research type in terms of its objective. In terms of type, it is classified as descriptive-analytical research. Methodologically, it is a survey research where efforts are made to investigate the relationships between variables through a process that includes stages such as decision-making about the research hypothesis, selecting the research population, data collection method, and data organization and analysis. This study aims to evaluate the efficiency of sustainable suppliers and identify the causes of poor performance in inefficient centers. Therefore, to determine the level of efficiency, we need to derive the empirical production function or the efficiency frontier based on observed data.

Two fundamental methods used to approximate the production function in economics are parametric methods and non-parametric methods. The SBM model was used to determine the efficiency of the units. The SBM model, as formulated in Equation (1), can be transformed into the following linear programming problem by introducing a positive scalar variable t:

$$\min_{t,\lambda,s^-,s^+} \quad \tau = t - \frac{1}{m}\sum_{i=1}^{m} ts_i^- / x_{i0}$$
$$1 = t + \frac{1}{s}\sum_{i=1}^{S} ts_r^+ / y_{r0}$$
$$x_0 = X\lambda + S^-$$
$$y_0 = Y\lambda - S^+$$
$$\lambda \geq 0, S^- \geq 0, S^+ \geq 0, t \geq 0$$

If:

$$S^- = ts^-, S^+ = ts^+, \Lambda = t\lambda$$

Then:

$$\min_{t,\lambda,s^-,s^+} \quad \tau = t - \frac{1}{m}\sum_{i=1}^{m} S_i^- / x_{i0}$$
$$1 = t + \frac{1}{s}\sum_{i=1}^{S} S_r^+ / y_{r0}$$
$$tx_0 = X\Lambda + S^-$$
$$ty_0 = Y\Lambda - S^+$$
$$\Lambda \geq 0, S^- \geq 0, S^+ \geq 0, t \geq 0$$

To evaluate the efficiency of petrochemical companies that produce various products, the input-oriented SBM model with variable returns to scale was used. This model was chosen because these companies have more control over their inputs. All calculations related to Data Envelopment Analysis (DEA) were performed using the DEA Solver software.

DEA software is categorized into two types. The first category includes operations research software like LINGO and GAMS, where DEA models must be implemented through coding in their environments to calculate the optimal parameter values and efficiency scores. The second category includes software such as Dea Frontier, DeaMax, DeaP, and Dea Solver, which do not require coding. These tools allow users to specify the input and output variables for each Decision-Making Unit (DMU) and the desired model, automatically analyzing the data and providing various outputs. These outputs include efficiency scores for each DMU, unit rankings, identification of reference units for inefficient units, calculation of model parameters, determination of optimal input and output values, and recommendations for improving inefficient units.

Thus, to ensure accurate model calculations and utilize the diverse outputs, this study employed the Dea Solver software. In Dea Solver, problem-solving is conducted in two forms: the primal (multiplicative) and the dual. In the dual form, the λ values are used to identify the reference set of inefficient units, and the slack values are used to compute the optimal output values for inefficient units.

3. Findings

The selection of variables (inputs and outputs) in this study was based on similar research, interviews, and surveys with experts and specialists, as presented in Figure 1.

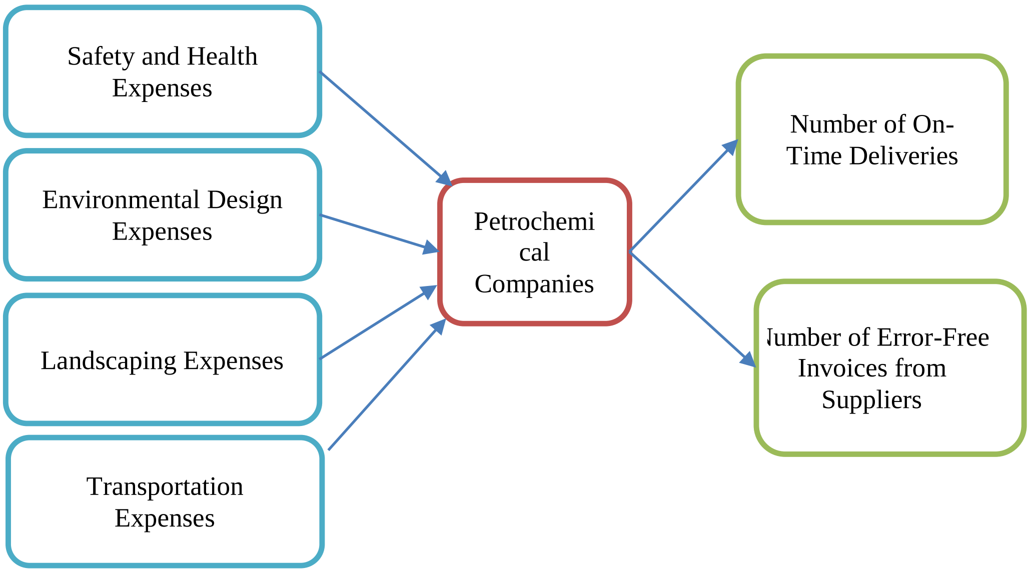

Figure 1. Input and Output Variables

Through a review of the literature and research background, inputs and outputs for petrochemical companies were identified, and the descriptive statistics for these variables were calculated, as shown in Table 1.

Table 1. Descriptive Statistics of Input and Output Variables

Variable	Safety and Health Expenses (Input Variable)	Environmental Design Expenses (Input Variable)	Landscaping Expenses (Input Variable)	Transportation Expenses (Input Variable)	Number of On-Time Deliveries (Output Variable)	Number of Error-Free Invoices from Suppliers (Output Variable)

Maximum	90.1	141.1	426.7	1014.9	334.5	385.5
Minimum	27.2	32.3	205.7	431.8	199.5	52.5
Mean	57.8	88.3	303.0	605.1	277.8	177.6
Standard Deviation	20.6	32.0	60.8	160.3	46.4	81.7

All calculations were conducted using DEA Solver software, as shown in Table 2. Companies with an efficiency score of one are efficient, while those with a score less than one are inefficient.

Table 2. Efficiency Results for Petrochemical Companies and Classification of Efficient and Inefficient Companies

Classification	Petrochemical Companies	Rank	Efficiency
Efficient	National Iranian Oil Company	1	1
Efficient	Shazand Petrochemical Company	1	1
Efficient	Esfahan Petrochemical Company	1	1
Efficient	Farabi Petrochemical Company	1	1
Efficient	Iran Petrochemical Trading Company	1	1
Efficient	Chelik Alborz Company	1	1
Efficient	Aland Chemical Group	1	1
Efficient	Movaledan Chemical Company	1	1
Efficient	Carbonic Acid Chemical Company	1	1
Efficient	Nima Chemical Industry	1	1
Efficient	Gipa Company	1	1
Efficient	Farzam Chemical Group	1	1
Inefficient	Pars Pak Kimia Company	2	0.846

The findings in Table 2 show that out of 13 companies, 12 are efficient (with an efficiency score of one), and only one company is inefficient. To rank the companies with an efficiency score of one, the super-efficiency method (Andersen-Petersen) was used. In this method, the efficiency constraint is removed, allowing the efficiency score to be greater than one. The results from the Andersen-Petersen method are reported in Table 3.

Table 3. Efficiency Scores of Companies (Andersen-Petersen Model)

Petrochemical Companies	Rank	Efficiency
Movaledan Chemical Company	1	1.6634
Nima Chemical Industry	2	1.4615
Aland Chemical Group	3	1.3214
Gipa Company	4	1.2606
National Iranian Oil Company	5	1.1764
Chelik Alborz Company	6	1.1656
Carbonic Acid Chemical Company	7	1.1128
Shazand Petrochemical Company	8	1.1107
Iran Petrochemical Trading Company	9	1.0720
Farzam Chemical Group	10	1.0702
Farabi Petrochemical Company	11	1.0398

Esfahan Petrochemical Company	12	1.0295
Pars Pak Kimia Company	13	0.8587

As shown, "Movaledan Chemical Company" has the highest efficiency score of 1.66, nearly twice the efficiency score of "Pars Pak Kimia Company" (0.858). "Pars Pak Kimia Company" has the lowest efficiency score and ranks last.

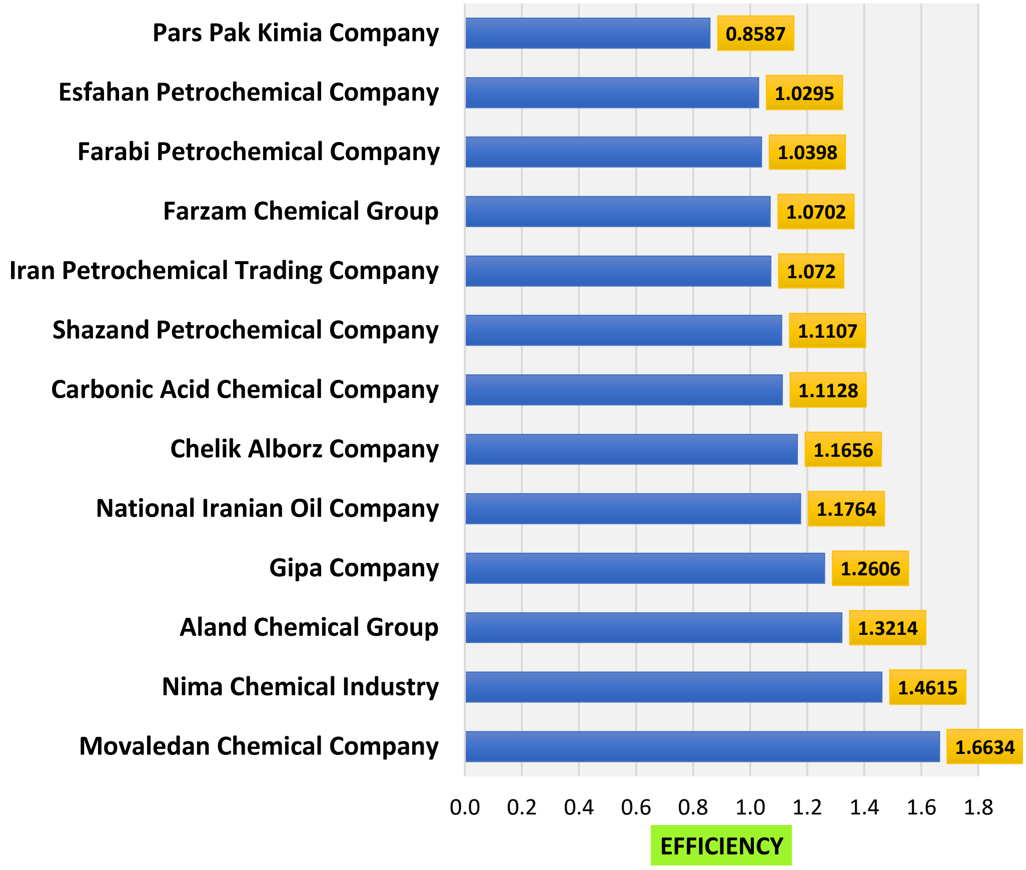

Figure 2. Efficiency Ranking of Petrochemical Companies (Andersen-Petersen Model)

In Data Envelopment Analysis, when calculating the efficiency of companies, efficient units are used as benchmarks (or references) for each inefficient unit. The reference units for companies with lower efficiency scores are listed in the table below. For example, the reference units for "Pars Pak Kimia Company" are "Iran Petrochemical Trading Company" with a lambda coefficient of 0.262, "Chelik Alborz Company" with a lambda coefficient of 0.55, "Movaledan Chemical Company" with a lambda coefficient of 0.052, and "Farzam Chemical Group" with a lambda coefficient of 0.135. The higher the lambda coefficient, the more significant the role of the company as a benchmark.

Table 4. Reference Units for Petrochemical Companies

Companies	Reference Units
Esfahan Petrochemical Company	Esfahan Petrochemical Company (1), Carbonic Acid Chemical Company (0.464), Farzam Chemical Group (0.19)
Farabi Petrochemical Company	Farabi Petrochemical Company (1), Farzam Chemical Group (0.22)
Iran Petrochemical Trading Company	Iran Petrochemical Trading Company (1), Movaledan Chemical Company (0.219), Farzam Chemical Group (0.037)
Farzam Chemical Group	Farzam Chemical Group (1), Carbonic Acid Chemical Company (0.027)

Pars Pak Kimia Company	Iran Petrochemical Trading Company (0.262), Chelik Alborz Company (0.55), Movaledan Chemical Company (0.052), Farzam Chemical Group (0.135)

The Shapiro-Wilk test was used to assess the normality of variables.

Table 5. Normality Test Results (Shapiro-Wilk Test)

Variables	Shapiro Statistic	Sig	Status	Test Type
Safety and Health Expenses	0.921	0.262	Normal	Parametric
Environmental Design Expenses	0.957	0.705	Normal	Parametric
Landscaping Expenses	0.978	0.966	Normal	Parametric
Transportation Expenses	0.866	0.101	Normal	Parametric
Number of On-Time Deliveries	0.894	0.112	Normal	Parametric
Number of Error-Free Invoices	0.926	0.301	Normal	Parametric

As shown in Table 5, the significance level (sig) for all variables is greater than 0.05. Therefore, the null hypothesis is accepted, indicating that the variables' distribution is normal.

A paired t-test was used to compare the current state with target values. The statistical hypotheses at a 95% confidence level are defined as follows.

Table 6. Paired T-Test Results

Statistical Outcome	p	t	Mean	Variables
Null hypothesis rejected - Significant difference between current state and target values	0.001	-9.139	227.84	Number of On-Time Deliveries - Current
			285.61	Number of On-Time Deliveries - Target
Null hypothesis rejected - Significant difference between current state and target values	0.001	-9.895	177.57	Number of Error-Free Invoices - Current
			184.80	Number of Error-Free Invoices - Target

Table 6 shows the mean number of on-time deliveries and error-free invoices from suppliers for the current and target states. The mean number of on-time deliveries is 227.84, while the target is 285.61. The paired t-test results indicate a significant difference at the 95% confidence level ($P < 0.05$), with the number of on-time deliveries being lower than the target values.

Other findings indicate that the mean number of error-free invoices from suppliers is 177.57, while the target is 184.80. The paired t-test results show a significant difference at the 95% confidence level ($P < 0.05$), with the number of error-free invoices from suppliers being lower than the target values.

4. Discussion and Conclusion

The industrialization of human societies, while providing prosperity, welfare, and advancement for people, has also caused environmental problems, human health issues, resource depletion, environmental pollution, ecological imbalance, and work safety hazards. This issue is recognized as a major obstacle to the growth and development of nations and is even considered a hindrance to development. Moving toward a supply chain approach enables higher productivity levels to meet societal needs, improve local and global environmental quality, and enhance environmental protection, simultaneously focusing on the environment, quality, and profitability.

Green supply chain management integrates supply chain management with environmental requirements at all stages, including product design, raw material selection and procurement, production, delivery to the customer, and post-consumption recycling and reuse, aiming to maximize energy and resource efficiency while enhancing the overall performance of the supply chain. Given the significant importance of sustainable suppliers and their considerable impact on the efficiency of petrochemical companies, Data Envelopment Analysis (DEA) and gap analysis were employed as innovative methods to continuously improve the efficiency of sustainable suppliers.

The study findings indicate that out of 13 companies, 12 are efficient (efficiency score equal to one), and only one company is inefficient. "Movaledan Chemical Company" has an efficiency score of 1.66, almost twice the efficiency score of "Pars Pak Kimia Company" (0.858), which ranks last. Afshari (2022) concluded that social sustainability pertains to the "production" and "demand" stages in energy supply chains and emphasizes employee-related social sustainability through common stakeholder analysis [18]. The analysis highlighted the importance of internal stakeholders in achieving social sustainability, which is more strategic than tactical or operational. There is no consensus on the definitions of social sustainability, nor is there agreement on how to measure it or the required data.

Coşkun (2022) assessed 69 companies to evaluate and develop integrated sustainable suppliers and found that successfully implementing this approach can serve as a roadmap for chemical manufacturers to adopt sustainable practices and ensure continuous supply chain development. Xing (2020) identified investments aimed at pollution reduction, resource consumption, environmental design, green image, environmental management systems, and environmental training for employees [19]. Chang (2020) showed that internal greening is a prerequisite for collaboration in a green supply chain, with internal environmental management yielding higher performance gains than external management, though environmental practices do not necessarily lead to higher economic performance [13].

Wu (2020) found that appropriate criteria for operational and environmental performance in green supply chains encompass five dimensions: green design, green procurement, green transportation, green logistics, and reverse logistics. Green design involves regulatory criteria, environmental and economic performance; green procurement includes customer-supplier collaboration, stakeholder pressure, and quality regulations; green transportation covers green manufacturing, packaging, and inventory policies; green logistics includes logistics network organization, service quality, and technology quality; and reverse logistics involves reduction activities, recycling, remanufacturing, reuse, and disposal [10].

Muñoz (2019), in a study on trends and gaps in green management integration, found that market pressure moderates the relationship between actions and drivers of green supply chain management, while competitive pressure negatively moderates this relationship. Key drivers examined include organizational support, government participation, and social capital, with green purchasing, customer collaboration, and green design significantly affecting green management drivers, except for return on investment, which only relates to organizational support [12].

De Lima (2023), in a Delphi study on risk and uncertainty management in circular supply chains, conducted three rounds with industrial, governmental, non-governmental, and academic stakeholders from 18 countries across five continents. The results identified critical risks and uncertainties, including uncertain financial costs, lack of knowledge and expertise, operational and technological risks, uncertain quality and availability of secondary resources, market competition with linear companies, insufficient regulatory frameworks, and volatile prices for primary and secondary resources. Appropriate countermeasures include inter-company collaboration, circular product design, information sharing, flexibility, and financial risk management [8].

Based on the research findings, inefficient companies should model efficient ones, optimally utilizing their resources to enhance efficiency. The following recommendations are proposed to improve performance: Inefficient companies should reduce inputs to the obtained levels and redefine their processes and procedures using expert opinions to reach the efficiency frontier. Further investigation into inefficient companies could help develop more effective productivity and efficiency improvement plans. Even efficient companies should have plans to enhance productivity and efficiency.

Since this study focused on evaluating production efficiency, future research could investigate profitability and productivity growth to complement this study and reveal other performance aspects. Companies operating under increasing returns to scale should expand their activities, while those under decreasing returns to scale should revise their structures to move toward long-term cost minimization. To ensure more reliable results, it is suggested that managers calculate the cost elasticity of production factors using econometric methods in addition to DEA.

Given the high importance of companies in service delivery and their significant impact on the national financial market, authorities should annually measure company efficiency and productivity in various Iranian cities, especially provincial capitals, to promote sustainable growth through practical solutions. Future research could integrate various DEA techniques to comprehensively evaluate company performance, as the choice of input and output variables significantly influences DEA results. Thus, selecting more effective parameters based on existing studies is recommended. Additionally, since this study used an input-oriented model, evaluating efficiency using an output-oriented model is suggested. DEA models typically offer only one of the two approaches (input-oriented or output-oriented) for inefficient branches. To overcome this limitation, a model incorporating both approaches is recommended.

Authors' Contributions

Authors equally contributed to this article.

Acknowledgments

Authors thank all participants who participate in this study.

Declaration of Interest

The authors report no conflict of interest.

Funding

According to the authors, this article has no financial support.

Ethical Considerations

All procedures performed in this study were under the ethical standards.

References

[1] E. Saygili, E. Uye Akcan, and Y. Ozturkoglu, "An Exploratory Analysis of Sustainability Indicators in Turkish Small-and Medium-Sized Industrial Enterprises," *Sustainability,* vol. 15, no. 3, p. 2063, 2023, doi: 10.3390/su15032063.

[2] G. Xu, M. Yang, S. Li, M. Jiang, and H. Rehman, "Evaluating the effect of renewable energy investment on renewable energy development in China with panel threshold model," *Energy Policy,* vol. 187, p. 114029, 2024, doi: 10.1016/j.enpol.2024.114029.

[3] E. E. O. Opoku, A. O. Acheampong, K. E. Dogah, and I. Koomson, "Energy innovation investment and renewable energy in OECD countries," *Energy Strategy Reviews,* vol. 54, p. 101462, 2024, doi: 10.1016/j.esr.2024.101462.

[4] H. Liu, "Life Cycle Assessment and Model Optimization for Sustainable Energy Cross-Border E-Commerce," *Eai Endorsed Transactions on Energy Web,* vol. 11, 2024, doi: 10.4108/ew.5493.

[5] S. S. Coşkun, M. Kumru, and N. M. Kan, "An integrated framework for sustainable supplier development through supplier evaluation based on sustainability indicators," *Journal of Cleaner Production,* vol. 335, p. 130287, 2022, doi: 10.1016/j.jclepro.2021.130287.

[6] F. Alamroshan, M. La'li, and M. Yahyaei, "The green-agile supplier selection problem for the medical devices: a hybrid fuzzy decision-making approach," *Environmental Science and Pollution Research,* vol. 29, no. 5, pp. 6793-6811, 2022, doi: 10.1007/s11356-021-14690-z.

[7] M. L. Tseng, S. X. Li, C. W. R. Lin, and A. S. Chiu, "Validating green building social sustainability indicators in China using the fuzzy delphi method," *Journal of Industrial and Production Engineering,* vol. 40, no. 1, pp. 35-53, 2023, doi: 10.1080/21681015.2022.2070934.

[8] F. A. De Lima and S. Seuring, "A Delphi study examining risk and uncertainty management in circular supply chains," *International Journal of Production Economics,* 2023, doi: 10.1016/j.ijpe.2023.108810.

[9] M. L. Tseng, M. S. Islam, N. Karia, F. A. Fauzi, and S. Afrin, "A literature review on green supply chain management: Trends and future challenges," *Resources, Conservation and Recycling,* pp. 63-46, 2019, doi: 10.1016/j.resconrec.2018.10.009.

[10] R. Wu, B. Huo, Y. Yu, and Z. Zhang, "Quality and green management for operational and environmental performance: relational capital in supply chain management," *International Journal of Logistics Research and Applications,* pp. 1-22, 2020. [Online]. Available: https://come.tju.edu.cn/info/1632/7141.htm.

[11] T. D. Mastos *et al.*, "Introducing an application of an industry 4.0 solution for circular supply chain management," *Journal of Cleaner Production,* vol. 300, p. 126886, 2021, doi: 10.1016/j.jclepro.2021.126886.

[12] A. Muñoz-Villamizar, J. Santos, P. Grau, and E. Viles, "Trends and gaps for integrating lean and green management in the agri-food sector," *British Food Journal,* 2019, doi: 10.1108/BFJ-06-2018-0359.

[13] T. W. Chang, Y. L. Yeh, and H. X. Li, "How to shape an organization's sustainable green management performance: the mediation effect of environmental corporate social responsibility," *Sustainability,* vol. 12, no. 21, p. 9198, 2020, doi: 10.3390/su12219198.

[14] S. Han, J. P. Ulhøi, and H. Song, "Digital trust in supply chain finance: the role of innovative fintech service provision," *Journal of Enterprise Information Management,* 2024, doi: 10.1108/JEIM-07-2022-0238.

[15] G. Kabra and A. Ramesh, "Analyzing drivers and barriers of coordination in humanitarian supply chain management under fuzzy environment," *Benchmarking: An International Journal,* vol. 22, no. 4, pp. 559-587, 2015, doi: 10.1108/BIJ-05-2014-0041.

[16] M. Nishat Faisal, D. K. Banwet, and R. Shankar, "Supply chain risk mitigation: modeling the enablers," *Business Process Management Journal,* vol. 12, no. 4, pp. 535-552, 2006, doi: 10.1108/14637150610678113.

[17] O. Olawale, F. A. Ajayi, C. A. Udeh, and O. A. Odejide, "Risk management and HR practices in supply chains: Preparing for the Future," *Magna Scientia Advanced Research and Reviews,* vol. 10, no. 2, pp. 238-255, 2024, doi: 10.30574/msarr.2024.10.2.0065.

[18] H. Afshari, S. Agnihotri, C. Searcy, and M. Y. Jaber, "Social sustainability indicators: A comprehensive review with application in the energy sector," *Sustainable Production and Consumption,* 2022, doi: 10.1016/j.spc.2022.02.018.

[19] C. Xing, Y. Zhang, and Y. Wang, "Do banks value green management in China? The perspective of the green credit Policy," *Finance Research Letters,* vol. 35, p. 101601, 2020, doi: 10.1016/j.frl.2020.101601.

[20] C. W. Craighead, D. J. Ketchen Jr, and J. L. Darby, "Pandemics and supply chain management research: toward a

theoretical toolbox," *Decision Sciences,* vol. 51, no. 4, pp. 838-866, 2020, doi: 10.1111/deci.12468.
[21] J. Jemai, B. Do Chung, and B. Sarkar, "Environmental effect for a complex green supply-chain management to control waste: A sustainable approach," *Journal of Cleaner Production,* vol. 277, p. 122919, 2020, doi: 10.1016/j.jclepro.2020.122919.
[22] A. Tuni, A. Rentizelas, and D. Chinese, "An integrative approach to assess environmental and economic sustainability in multi-tier supply chains," *Production Planning & Control,* vol. 31, no. 11-12, pp. 861-882, 2020, doi: 10.1080/09537287.2019.1695922.
[23] L. Pari, A. Suardi, W. Stefanoni, F. Latterini, and N. Palmieri, "Environmental and economic assessment of castor oil supply chain: a case study," *Sustainability,* vol. 12, no. 16, p. 6339, 2020, doi: 10.3390/su12166339.
[24] K. Das, "Planning environmental and economic sustainability in closed-loop supply chains," *Operations and Supply Chain Management: An International Journal,* vol. 13, no. 1, pp. 64-81, 2020, doi: 10.31387/oscm0400253.
[25] I. Perevozova *et al.*, "Integration of the supply chain management and development of the marketing system," *International Journal of Supply Chain Management,* vol. 9, no. 3, pp. 496-507, 2020. [Online]. Available: https://www.coursesidekick.com/management/56685.
[26] M. Mahmoudi and I. Parviziomran, "Reusable packaging in supply chains: A review of environmental and economic impacts, logistics system designs, and operations management," *International Journal of Production Economics,* vol. 228, p. 107730, 2020, doi: 10.1016/j.ijpe.2020.107730.