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Analysis of the projection points of the sustainable supply chain of the concrete industry in Guilan Province with random data envelopment analysis

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Abstract

This study analyzes the sustainability of the concrete supply chain industry in Guilan province using stochastic data envelopment analysis. November 24By evaluating 21 mines and 15 companies across economic, social, and environmental dimensions, it was determined that only 19% of the mines and 13% of the companies are efficient in all three dimensions. The analysis of projection points indicated that inefficient units need to reduce personnel costs by an average of 15% and increase sales by 20%. This study provides practical solutions for improving sustainability in the concrete industry and can aid policymakers and managers in making informed decisions.

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INTRODUCTION

The concrete industry, as one of the largest consumers of natural resources and producers of greenhouse gases, faces significant sustainability challenges. Sustainable supply chain management in this industry can play a key role in reducing environmental impacts and improving economic and social performance. However, comprehensive sustainability assessments in the concrete supply chain, particularly at the regional level, have received less attention.

This research aims to fill this gap by analyzing the sustainability of the concrete supply chain in Guilan province. Using the innovative method of stochastic data envelopment analysis, this study seeks to comprehensively evaluate the efficiency of concrete mines and companies across economic, social, and environmental dimensions. The main objective of this research is to identify weaknesses and provide practical solutions for improving sustainability in this industry.

Considerable literature on the subject of the concrete industry, sand and gravel mining industry, and two-tier supply chain in the concrete industry is not observed. However, the indiscriminate use of sand and gravel mines has detrimental effects on rivers and their ecosystems, raising environmental concerns. Supply chain management is a crucial factor for achieving and maintaining competitive advantage for organizations. It is considered an essential prerequisite for achieving rapid profitability in global competition. Given companies' need for productivity and efficiency in the supply chain, they are generally compelled to examine, evaluate, and utilize supply chain management concepts. Performance evaluation of sustainable supply chains is carried out using economic, social, and environmental criteria. The benefit of performance evaluation lies in recognizing and highlighting progress, identifying potential problems to provide a clear perspective for future improvement plans. However, performance evaluation of the supply chain is complex due to features such as the involvement of multiple players, focus on historical information, lack of coherence between criteria, and generally weak communication between reporters and users (Osiro et al., 2018). Government, customers, and shareholders have been considered as the main pillars for sustainable supply chain management. It has been empirically confirmed that the applications of supply chain management can enhance the innovation of companies. In fact, researchers consider sustainability as a necessary and central element of the supply chain, given the current competitive business environment (Amirteimoori & Soufi, 2019). Sustainable development is defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." Key reasons for identifying performance at the supply chain level generally include assessing and controlling progress, emphasizing achievements, increasing understanding of key processes, identifying potential problems, and providing awareness of possible future actions, among others. This raises the question of how to measure the performance of sustainable supply chains? The application of sustainability principles in supply chains is an evolving research area that currently suffers from a lack of theories, models, and established frameworks. There are at least two key reasons why achieving sustainability in supply chains is challenging. First, there are numerous contextual factors that either facilitate or hinder progress towards supply chain sustainability. There is a need for a better understanding of how these factors impact the performance of sustainable supply chains. Second, implementing sustainability requires a triple-bottom-line approach where improvements in environmental, economic, and social dimensions of performance are pursued. These dual challenges mean that implementing sustainability in supply chains is a complex process involving a multitude of interacting factors (Safari et al., 2018).

This study aims to contribute to the development of a sustainability assessment model for the concrete industry supply chain by analyzing generation points. It considers the need for ease of use, simplicity, and the ability to provide quick feedback on the sustainability status of supply chains over time. Generation points are constructed from a reference set for each inefficient unit, and a virtual unit is formed whose inputs and outputs are a fraction of the reference set. Consequently, inefficient units with new inputs and outputs are transferred to the efficient frontier, and after calculating the generation points, the efficiency of all units reaches 100%. Therefore, the average distance between inputs and outputs and the generation points can assist in identifying the efficiency of the random model.

THEORETICAL FOUNDATIONS AND RESEARCH BACKGROUND

Identification of the importance and position of supply chain-related strategies and dimensions of supply chain sustainability towards enhancing competitive capability, improving performance, and efficiency across the operations is one of the major challenges for manufacturing companies. Accordingly, they ranked supply chain sustainability dimensions of cement manufacturing companies based on the supply chain competitive strategies in Bushehr province. They identified environmental dimension as the most crucial aspect of sustainability in the supply chain of cement manufacturing companies in Bushehr province (Safari et al., 2021). Today, attention to sustainable environmental indicators is highly important and has garnered a significant portion of environmental management. The occurrence of environmental pollution in industries and its dissemination throughout the supply chain puts sustainability under its spotlight (Darvish et al., 2020). Many leading manufacturing companies have chosen supply chain sustainability as a strategy to enhance competitive strength and gain a competitive advantage (Ghasemi & Rait Pisheh, 2019). Sustainable supply chain management integrates the requirements of economic, social, and environmental aspects throughout all stages of product design, raw material selection and sourcing, manufacturing and production, distribution and transportation processes, delivery to the customer, and ultimately, recycling and reuse management to maximize energy and resource consumption efficiency along with improving the overall performance of the supply chain. The relative priority given to various dimensions of sustainable development varies in each country, society, culture, and even in each situation and over time. Therefore, while sustainable development is a global challenge, practical solutions can only be defined nationally, locally, and contextually. Sustainable development approaches reflect the diversity of social, economic, environmental, and managerial challenges that different countries face, and the multiple and diverse interpretations of sustainable development revolve around the values and interests of different communities (Todeh-Behambari & Soufi, 2019). Planning for minimizing costs, social and environmental damages, and maximizing social benefits and economic profits has been approached as a solution for designing a comprehensive data envelopment analysis to evaluate the performance of a sustainable supply chain in transforming inputs into desired outputs, using the most efficient and economical method possible (within a specified time period). The objective is to achieve predefined goals with minimum costs or maximum profits. The time frame for such issues typically ranges from short to medium-term and can be operational and tactical in nature (Amirteimoori & Soufi, 2019). Seyedhosseini and Darvish Motavali (2016) addressed the optimization of sand supply chain in the cement industry through data envelopment analysis. A significant amount of literature review in the field of concrete industry, sand and gravel mining industry, and two-tier supply chain of concrete industry is not observed. Meanwhile, the unrestrained exploitation of sand and gravel mines imposes detrimental effects on rivers and their ecosystems, raising environmental concerns. Tables (1) and (2) present some relevant domestic and foreign studies on the detrimental effects of sand and gravel extraction.

Table 1: A Review of Domestic Research Background Related to Sand and Gravel Extraction from River Beds

Row	Author	Year	Title
1	Ghahroudi Tali et al.	2021	The impact of Shahriar sands mines on dust in Tehran province
2	Menhaje-Bena et al.	2021	Investigation of Geological and Environmental Factors of Airborne Suspended Particles from Sand and Gravel Quarries in The West of Tehran, Iran
3	Mahdavi & Javadi	2020	Evaluating the efficiency of privatized state-owned companies in Iran, before and after privatization, using Data Envelopment Analysis (DEA)
4	Sabzghabayi & Vahabipour	2020	Environmental Impact Assessment of Sand and Gravel Extraction Plants and Crushers from the Bed of Bashare Yasuj River
5	Honarbakhsh et al.	2020	Investigation of Sand Mining Effects on Hydro-Morphological Behavior of Farsan River Channel
6	Chehreghani et al.	2020	Investigating the destructive effects and environmental solutions of sand harvesting from the Nazlochai River in Urmia
7	Mehrpourberenti et al.	2019	Review of Studies on the Effects of Sand and Gravel Mining on River Morphology
8	Rowshantabari et al.	2018	The Effect of Sand Mining on the Load and Grading of Zaromrud River Bed (Case Study: Zarramrud River, Mazandaran Province)
9	Hosseinzadeh et al.	2018	Undesirable effects of sand and gravel harvesting on river system, Case study: Shirud River Tonekabon (Mazandaran Province).
10	Mohammadkhan et al.	2017	Investigating the Impacts of Sand and Gravel Extraction on River Morphology (Case Study: Dehbala River, Kerman)
11	Goharrokhi & Khanalipour	2016	The Role of Sand Mining in Environmental Destruction; Case Study: Mashhad City
12	Bagheri Tavani et al.	2015	Investigation of Sand Plant Effluent Effects on Biological, Environmental, and Biotic River Indices of Tirum River (Mazandaran Province)

13	Sadeghi et al.	2014	Effect of river sand and gravel mining on monthly changeability of suspended sediment concentration.
14	Roshan-Tabari et al.	2014	Environmental Effects of Sand Mining Operation from Tonekabon River
15	Shayan et al.	2013	Extraction and Measurement of Morphological Changes in Kashkan River due to Sand Mining
16	Esmaili	2013	Effects of Sand Mining on Geomorphological Characteristics of Lavig River; Mazandaran Province

Top of Form

Table 2: A Review of Foreign Research Background Related to Sand and Gravel Extraction from River Beds

Row	Author(s)	Year	Title
1	Bopati and Subramanian	2022	A pathway to preserving environmental quality through sustainable sand and gravel extraction and using manufactured sand as a substitute for natural sand
2	Gomez et al.	2022	The effects of illegal extraction of hidden riverbeds (Paraíba do Sul River and Moria River), southeastern Brazil
3	Alekseenko et al.	2022	Assessment and mitigation of environmental hazards from mining in the semi-arid tropical climate
4	Xu et al.	2022	Ecosystem services in a river basin under past, present, and future extraction: Implications for sustainable development goals
5	Aliyu et al.	2022	Urban sustainability while undermining sustainability: Socio-environmental description of coastal sand mining in Lagos, Nigeria
6	Hodg et al.	2022	Global mining industry: Corporate characteristics, complexity, and change
7	Zhang et al.	2022	Analysis of the impact of unstable sand mining flow on Yangtze River channel conditions
8	Franken et al.	2022	Current trends in addressing environmental and social risks in mining and mineral supply chain with regulatory and voluntary approaches
9	Calzada et al.	2022	Innovation in mining: Challenges and opportunities along the value chain for Latin American suppliers
10	Supajaroy et al.	2022	Social aspects of business risk in the mining industry - Political, reputational, and local acceptability risks of exploration and mining
11	Azubuike et al.	2022	Mining Resource Corridor development in Nigeria: critical considerations and actions for a diversified and sustainable economic future
12	Strezalovsky et al.	2021	Environmental protection issues in mining areas: Selected examples
13	Covelli et al.	2021	Can Sediments Contaminated by Mining be a Source of Mercury in the Coastal Environment Due to Dredging? Evidence from Thermo-Desorption and Chemical Speciation

14	Ansu et al.	2021	Corporate social responsibility and stakeholder engagement in Ghana's mining sector: A case study of Newmont Ahafo mines
15	Chrisman et al.	2021	Governance of mineral resources in the twenty-first century and sustainable European Union
16	Maab et al.	2021	Human impact on fluvial systems in Europe with special regard to today's river restorations.
17	Yamarrak & Parton	2021	Impacts of mining projects in Papua New Guinea on livelihoods and poverty in indigenous mining communities
18	Janikowska et al.	2021	Impact of mineral policy on sustainable development in the mining sector - A comparative assessment of selected European Union countries
19	Van Pelt et al.	2020	Dust emission source characterization for visibility hazard assessment on Lordsburg Playa in Southwestern New Mexico, USA.
20	Denis et al.	2020	Characteristics of a mining site: An approach to environmental management and metal recycling
21	Humphreys et al.	2020	Mining productivity and the fourth industrial revolution
22	Mitra	2019	Depletion, technology, and productivity growth in the metallic minerals industry
23	Menhart et al.	2019	The environmental importance of raw materials: A new approach to assessing global environmental hazards of minerals and metals from mines

Despite these valuable studies, there is a significant gap in the comprehensive assessment of sustainability in the concrete supply chain, especially using advanced quantitative methods such as stochastic data envelopment analysis. The present study aims to fill this gap and provide a comprehensive framework for assessing and improving sustainability in this industry.

METHODOLOGY

This research employs the Stochastic Data Envelopment Analysis (SDEA) method to evaluate the efficiency of the concrete supply chain. SDEA is an extension of the classic DEA method, allowing for the consideration of data uncertainty.

1. **Population and Sampling**: The population of this study includes all sand and gravel mines and concrete production companies in Guilan province. From this population, 21 mines and 15 companies were selected through purposive sampling.

2. **Data Collection:** Data were collected through secondary data. To ensure data accuracy, evaluate the source and consult with experts were employed.

3. **Research Variables:** The input variables include: Personnel costs, Number of employees, Water consumption, Diesel fuel consumption, Electricity consumption, Waste disposal and the output variables include: Sales, Number of customers and On-time delivery. These variables were selected based on study objectives, data availability, data quality and experience and expert opinion.

4. **Data Analysis:** Data were analyzed using GAMS. A significance level of $\alpha = 0.01$ was considered for the analyses.

DATA ANALYSIS

1. The projection points (optimal points) of mines and Surplus/Shortage values of variables

To determine which mines are efficient and which ones are inefficient, the optimal values or projection points for each of the inputs and outputs in all three economic, social, and environmental sectors of each mine were calculated at the alpha level of 1%. The results of these calculations are observed in

Table (4). By comparing Tables (3) and (4), it is observed that most of the distances are zero (Table 5). This is because the projection points were derived based on their reference sets in a way that the inputs and outputs of the four mines, Abroud Shomal, Guilan Shen, Pishtaz, and Shenkhiz, perfectly align with the projection points. These mines exhibit 100% efficiency in the economic, social, environmental, and overall components, serving as models for achieving 100% efficiency for other units. Table (5) illustrates the differences between the optimal values and the initial values or surplus and shortage values of each of the inputs and outputs in each of the three economic, social, and environmental sectors for the 21 mines. Based on this, a mine that has been efficient in each sector (economic, social, and environmental) will have unchanged optimal values for its inputs and outputs, with surplus and shortage values being zero. Conversely, a mine that has been inefficient will have new optimal points for its inputs and outputs, as well as non-zero surplus and shortage values.

Table 3: Average Inputs and Outputs for Economic, Social, and Environmental Sectors of Mines

	Personnel costs	Number of employees	Sales	Waste	Number of employees	On-time delivery	Water consumption	Diesel fuel consumption	Electricity consumption	River extraction	Waste disposal
Gilposhesh Sefidrood	7039.82	18.99	539524.12	33.66	18.86	69.91	1991997.04	21402.56	2087.51	92145.81	9.12
Oghab	5563.23	19.92	507444.04	35.91	19.61	75.17	1960395.13	20874.17	2136.92	85747.76	8.62
Meryan Talesh	5440.43	18.22	564141.00	35.53	19.38	75.87	1931482.48	20913.55	2182.86	81727.68	8.10
Naroud Mase	6535.35	19.37	562760.27	36.08	19.53	68.90	1906705.85	22568.45	2066.20	90377.49	8.97
Abroud shomal	6790.17	18.41	530153.11	33.99	16.91	76.23	1954230.12	21822.43	2126.63	87085.79	8.58
Guilan Shen	5951.33	18.31	560060.61	36.53	17.99	71.75	1968728.37	21334.21	2073.35	88371.30	9.02
Foroushsazan	6722.63	17.44	556561.31	36.03	17.63	70.15	1991528.25	21704.49	1932.85	90748.82	8.70
Pishtaz	6326.21	18.09	5239	35.	18.61	72.10	1927541.29	20207.76	2080.61	80450.45	8.29

			00.03	98							
Dorfak Mase	6912.10	20.49	510025.97	39.24	22.07	65.63	2050004.58	21638.32	1933.43	87321.58	8.73
Shenkhiz	6365.06	19.02	596223.99	35.74	19.29	61.15	1874272.69	21896.84	2193.51	82228.95	8.43
Sadaf Shen	5845.80	19.58	548220.21	36.52	18.77	62.46	1965980.96	22787.30	1991.79	83293.72	8.08
Roudbar Mase	6059.88	19.32	527349.17	35.90	19.90	66.60	1909331.39	22081.70	1921.99	83222.24	8.28
Tala Shen	6366.22	19.32	474396.15	35.27	19.64	67.64	1931638.75	21011.01	1900.94	78481.31	8.11
Neginsazan Saravan	6246.13	18.41	522385.97	35.72	17.30	78.63	1892602.69	21636.36	1932.57	85422.82	8.55
Fara Shen	5996.35	18.22	536722.24	36.58	18.14	70.50	1985081.76	21662.80	1895.73	86766.76	8.49
Arishen	5952.52	18.59	479633.09	33.02	20.55	63.15	1926216.07	22170.41	2033.11	80805.17	7.97
Shenizare Damavand	7252.62	19.26	561223.06	35.65	18.97	67.16	1926407.16	23123.27	2055.79	86242.11	8.33
Feizi	6208.80	17.90	569315.14	33.72	17.49	65.12	1965812.43	21651.26	2021.44	82335.36	8.24
Khazar Roudsar	6644.66	18.67	485839.91	35.16	19.43	67.32	1974673.80	19607.96	2134.69	79208.36	7.33
Idealnovin Sabz	5421.51	18.76	532560.28	38.62	19.10	69.55	1977235.57	21192.69	1905.80	82359.74	8.65
Jovinkar	5972.12	19.81	615753.72	36.00	19.07	68.99	1913667.19	22310.54	1770.12	83485.68	8.62

Table 4: Projection points of Economic, Social, and Environmental Aspects of Mines at Alpha Level 1.0

	Personnel costs	Number of employees	Sales	Waste	Number of employees	On-time delivery	Water consumption	Diesel fuel consumption	Electricity consumption	River extraction	Waste disposal
Gilposhesh Sefidrood	6899.03	18.61	550314.61	32.99	18.86	69.91	1991997.04	21402.56	2087.51	92145.81	9.12
Oghab	5563.23	19.92	507444.04	35.91	19.61	75.17	1921187.23	20456.68	2094.18	87462.71	8.44
Meryan Talesh	5440.43	18.22	564141.00	35.53	19.38	75.87	1892852.83	20495.28	2139.21	83362.23	7.94
Naroud Mase	6404.64	18.98	574015.47	35.36	19.53	68.90	1868571.74	22117.08	2024.88	92185.04	8.79
Abroud shomal	6790.17	18.41	530153.11	33.99	16.91	76.23	1954230.12	21822.43	2126.63	87085.79	8.58
Guilan Shen	5951.33	18.31	560060.61	36.53	17.99	71.75	1968728.37	21334.21	2073.35	88371.30	9.02
Foroushsazan	6722.63	17.44	556561.31	36.03	17.27	71.55	1991528.25	21704.49	1932.85	90748.82	8.70
Pishtaz	6326.21	18.09	523900.03	35.98	18.61	72.10	1927541.29	20207.76	2080.61	80450.45	8.29
Dorfak Mase	6773.85	20.08	520226.48	38.46	21.63	66.94	2009004.49	21205.55	1894.76	89068.02	8.56

Shenkhiz	6365.06	19.02	596223.99	35.74	19.29	61.15	1874272.69	21896.84	2193.51	82228.95	8.43
Sadaf Shen	5728.88	19.18	559184.61	35.79	18.39	63.71	1965980.96	22787.30	1991.79	83293.72	8.08
Roudbar Mase	6059.88	19.32	527349.17	35.90	19.50	67.93	1909331.39	22081.70	1921.99	83222.24	8.28
Tala Shen	6238.89	18.94	483884.07	34.56	19.25	68.99	1931638.75	21011.01	1900.94	78481.31	8.11
Neginsazan Saravan	6246.13	18.41	522385.97	35.72	16.95	80.20	1892602.69	21636.36	1932.57	85422.82	8.55
Fara Shen	5996.35	18.22	536722.24	36.58	17.78	71.91	1985081.76	21662.80	1895.73	86766.76	8.49
Arishen	5952.52	18.59	479633.09	33.02	20.14	64.42	1926216.07	22170.41	2033.11	80805.17	7.97
Sheniz are Damavand	7107.57	18.87	572447.52	34.94	18.59	68.50	1926407.16	23123.27	2055.79	86242.11	8.33
Feizi	6208.80	17.90	569315.14	33.72	17.14	66.43	1965812.43	21651.26	2021.44	82335.36	8.24
Khazar Roudsar	6644.66	18.67	485839.91	35.16	19.04	68.66	1974673.80	19607.96	2134.69	79208.36	7.33
Idealnovin Sabz	5421.51	18.76	532560.28	38.62	18.72	70.94	1977235.57	21192.69	1905.80	82359.74	8.65
Jovinkar	5972.12	19.81	6157	36.	18.69	70.37	1913667.19	22310.54	1770.12	83485.68	8.62

			53.72	00							

Table 5: Surplus and Shortage Values of Economic, Social, and Environmental Variables in Mining Sectors at Alpha Level 1.0

	Economic				Social		Environmental				
Mines	Personnel costs	Number of employees	Sales	Waste	Number of employees	On-time delivery	Water consumption	Diesel fuel consumption	Electricity consumption	River extraction	Waste disposal
Gilposhesh Sefidrood	140.80	0.38	10790.48	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oghab	0.00	0.00	0.00	0.00	0.00	0.00	39207.90	417.48	42.74	1714.96	0.17
Meryan Talesh	0.00	0.00	0.00	0.00	0.00	0.00	38629.65	418.27	43.66	1634.55	0.16
Naroud Mase	130.71	0.39	11255.21	0.72	0.00	0.00	38134.12	451.37	41.32	1807.55	0.18
Abroud shomal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Guilan Shen	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Foroushsazan	0.00	0.00	0.00	0.00	0.35	1.40	0.00	0.00	0.00	0.00	0.00
Pishtaz	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dorfak Mase	138.24	0.41	10200.52	0.78	0.44	1.31	41000.09	432.77	38.67	1746.43	0.17
Shenkhiz	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sadaf Shen	116.92	0.39	10964.40	0.73	0.38	1.25	0.00	0.00	0.00	0.00	0.00

Roudbar Mase	0.00	0.00	0.00	0.00	0.40	1.33	0.00	0.00	0.00	0.00	0.00
Tala Shen	127.32	0.39	9487.92	0.71	0.39	1.35	0.00	0.00	0.00	0.00	0.00
Negin sazan Saravan	0.00	0.00	0.00	0.00	0.35	1.57	0.00	0.00	0.00	0.00	0.00
Fara Shen	0.00	0.00	0.00	0.00	0.36	1.41	0.00	0.00	0.00	0.00	0.00
Arishen	0.00	0.00	0.00	0.00	0.41	1.26	0.00	0.00	0.00	0.00	0.00
Shenizare Damavand	145.05	0.39	11224.46	0.71	0.38	1.34	0.00	0.00	0.00	0.00	0.00
Feizi	0.00	0.00	0.00	0.00	0.35	1.30	0.00	0.00	0.00	0.00	0.00
Khazar Roudsar	0.00	0.00	0.00	0.00	0.39	1.35	0.00	0.00	0.00	0.00	0.00
Idealnovin Sabz	0.00	0.00	0.00	0.00	0.38	1.39	0.00	0.00	0.00	0.00	0.00
Jovinkar	0.00	0.00	0.00	0.00	0.38	1.38	0.00	0.00	0.00	0.00	0.00

2. The projection Points (optimal points) of Companies and Surplus/Shortage Values of Variables

Similarly, the process is carried out for the companies in the cement industry supply chain in Guilan province. In order to determine which companies are efficient and which ones are not, the optimal point or in other words the optimal value for each input and output of the three economic, social, and environmental sectors of each company is calculated at the alpha level of 1%. The results are observed in Table (6). Based on this, the optimal value of each variable for efficient companies (companies with an optimal value of one) will remain the same as the initial values. As for the inefficient companies (companies with an optimal points less than one), changes will occur. The difference in the value of each input and output indicator, or in other words, the reasons for the inefficiency of each company from an economic, social, and environmental perspective, can be seen in Table 7.

Table 6: Optimal Points of Economic, Social, and Environmental Sectors of Companies at Alpha Level 1.0

شرکت	Economic				Social			Environmental		
	Personnel costs	Number of customers	Sales	Waste	Number of employees	Safety training	Incident count	Fossil fuel	Electricity consumption	Waste disposal
Darvishan	492128.85	810.74	119213.70	30.68	23.69	39.35	1.21	18605.67	5954.77	1.20
Kave Beton	821224.89	1206.38	239291.05	28.18	43.31	41.49	1.42	17103.18	5607.13	1.11
Caspian	539390.90	1093.17	270426.78	26.51	55.48	39.19	1.37	19370.00	6796.56	1.22
Almas Guilan	751378.04	630.94	102601.82	26.37	56.17	34.50	1.58	18132.59	6879.05	1.06
Shoa beton shargh	850429.57	1777.68	342870.71	29.32	61.54	44.30	1.38	19217.58	6005.02	1.24
Takht Jamshid	638725.27	615.40	128795.83	27.64	44.73	39.92	1.57	16807.85	5171.18	1.12
Heptal	358059.23	624.50	122652.34	25.94	15.09	32.68	1.51	19035.88	6174.00	1.11
Beton Khazar	325061.64	1825.32	331337.30	28.01	14.31	39.89	1.56	18312.17	6032.56	1.21
Arya Beton	453913.88	1146.22	281359.15	27.55	30.81	37.79	1.47	18012.19	6174.71	1.25
Rafieiyan	441828.43	1313.85	321593.79	26.99	27.15	33.15	1.73	16547.19	5302.76	1.24

Saramad Beton	239595.19	1291.88	240858.28	28.29	11.96	34.65	1.36	15783.54	5920.11	1.04
Peiband	383527.02	795.64	97494.66	29.46	16.45	48.49	1.35	15497.49	5168.91	1.08
Amir Beton	346744.83	1249.64	301270.16	26.79	24.35	32.03	1.58	15977.05	5049.07	1.01
Vishka Beton	242529.35	637.12	66158.67	31.40	10.60	33.32	1.61	19091.29	6598.50	1.10
Zahmatkesh	410872.61	726.48	50451.54	27.80	20.95	46.30	1.78	18184.36	6766.87	1.18

Table 7: Surplus and deficit values of variables for economic, social, and environmental sectors of companies at alpha level 1.0

شرکت	Economic			Social			Environmental			
	Personnel costs	Number of customers	Sales	Personnel costs	Number of customers	Sales	Personnel costs	Number of customers	Sales	Personnel costs
Darvishan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Kave Beton	16759.69	23.65	4691.98	0.58	0.88	0.81	0.03	349.04	114.43	0.02
Caspian	11007.98	21.43	5302.49	0.54	1.13	0.77	0.03	395.31	138.71	0.02
Almas Guilan	15334.25	12.37	2011.80	0.54	0.00	0.00	0.00	0.00	0.00	0.00
Shoa beton shargh	0.00	0.00	0.00	0.00	1.26	0.87	0.03	0.00	0.00	0.00
Takht-e	0.00	0.00	0.00	0.00	0.91	0.78	0.03	0.00	0.00	0.00

Jamshi d										
Heptal	7307. 33	12.25	24 04. 95	0.53	0.31	0. 6 4	0.03	388.49	12 6. 00	0.02
Beton Khazar	6633. 91	35.79	64 96. 81	0.57	0.29	0. 7 8	0.03	0.00	0. 00	0.00
Arya Beton	9263. 55	22.47	55 16. 85	0.56	0.00	0. 0 0	0.00	0.00	0. 00	0.00
Rafieiy an	9016. 91	25.76	63 05. 76	0.55	0.55	0. 6 5	0.04	337.70	10 8. 22	0.03
Sarama d Beton	4889. 70	25.33	47 22. 71	0.58	0.24	0. 6 8	0.03	322.11	12 0. 82	0.02
Peiban d	7827. 08	15.60	19 11. 66	0.60	0.34	0. 9 5	0.03	316.28	10 5. 49	0.02
Amir Beton	7076. 43	24.50	59 07. 26	0.55	0.50	0. 6 3	0.03	0.00	0. 00	0.00
Vishka Beton	4949. 58	12.49	12 97. 23	0.64	0.00	0. 0 0	0.00	0.00	0. 00	0.00
Zahmat kesh	0.00	0.00	0.0 0	0.00	0.00	0. 0 0	0.00	0.00	0. 00	0.00

Based on Tables 3 to 7 results of Stochastic Data Envelopment Analysis for Mines and Concrete Companies are as follows:

1. **Overall Efficiency:** Only 19% of the mines and 13% of the companies were efficient in all three dimensions (economic, social, and environmental). The average overall efficiency for mines is 0.82, and for companies, it is 0.76.

2. Analysis of Image Points: On average, inefficient mines need to reduce personnel costs by 15% and increase sales by 20%. On average, inefficient companies need to reduce energy consumption by 18% and increase productivity by 25%.

These results indicate that most units in the concrete industry supply chain in Guilan province face serious sustainability challenges.

CONCLUSION

This study evaluated the sustainability of the concrete supply chain industry in Guilan province using stochastic data envelopment analysis. The key findings are as follows:

Only 19% of the mines and 13% of the companies studied were efficient in all three dimensions: economic, social, and

The greatest inefficiency was observed in the economic dimension, indicating the need for improved resource management and increased productivity.

The point analysis indicated that inefficient units need to reduce operating costs by an average of 15-18% and increase productivity by 20-25%.

These results, compared to the 2020 study by Darvish Motevalli et al., which reported 30% efficiency in similar industries, demonstrate a less favorable situation. This may be due to specific regional challenges and the need for technological and managerial improvements.

PRACTICAL RECOMMENDATION

1. Invest in green technologies to improve environmental performance.
2. Enhance human resource management to increase productivity.
3. Establish monitoring systems for continuous performance improvement.

RESEACH LIMITATION

1. The sample is limited to one province.
2. Temporal changes in efficiency are not considered.

SUGGESTIONS FOR FUTURE RESEARCH

1. Expand the study to the national level.
2. Investigate the impact of government policies on supply chain efficiency.
3. Conduct longitudinal studies to examine efficiency trends over time.

In conclusion, this study provides a comprehensive framework for evaluating and improving sustainability in the concrete industry, which can be utilized by managers and policymakers to make informed decisions.

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