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Analysis and Examination of Factors Affecting the Productivity of Mining and Mineral Industries Organizations for Performance Improvement and Productivity Enhancement Based on the Grounded Theory and Fuzzy DEMATEL Approach

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ABSTRACT

Organizations active in mining and mineral industries play an influential role in the economic growth and development of societies. Therefore, the present study was conducted with the aim of analyzing and examining the factors influencing the productivity of mining and mineral industries organizations to improve performance and enhance productivity based on the grounded theory and fuzzy DEMATEL approach. The present study is applied in terms of purpose and mixed-method in terms of implementation. The research population consisted of industry experts and specialists, as well as university faculty members in the field of mining and mineral industries at the Iranian Mineral Processing Research Center and its parent organization (IMIDRO). The sample size in the grounded theory and fuzzy DEMATEL sections was estimated at 30 and 40 individuals, respectively, selected through purposive sampling. To collect data, semi-structured interviews were used in the grounded theory section, and a researcher-developed pairwise-comparison questionnaire was used in the fuzzy DEMATEL section. In this study, to identify influential factors, open, axial, and selective coding methods were employed based on the grounded theory approach, and to determine the degree of influence and influenceability, the fuzzy DEMATEL method was used. The results of grounded theory indicated that the factors influencing the productivity of mining and mineral industries organizations for performance improvement and productivity enhancement consisted of 51 open codes, 25 axial codes, and 12 selective codes. The causal conditions included 10 open codes and 6 axial codes categorized into 3 selective codes: improvement of organizational structure and processes, technological infrastructure, and technology and innovation. The contextual conditions included 12 open codes and 4 axial codes in 2 selective codes: human resource empowerment and macro-level economic and policy factors. The intervening conditions included 12 open codes and 7 axial codes in 3 selective codes: leadership, management and policymaking, organizational risk and safety management, and supply chain and resources. Strategies included 9 open codes and 4 axial codes in 2 selective codes: operational management and productivity, and human capital development. The consequences included 8 open codes and 4 axial codes in 2 selective codes: economic and financial performance, and sustainability and social responsibility. Moreover, the results of fuzzy DEMATEL showed that the criterion of leadership, management, and policymaking, with a value of 7.1404, had the highest level of influence. After that, the criteria of economic and financial performance and improvement of organizational structure and processes ranked next, with values of 6.9473 and 6.9315, respectively. In addition, the technology and innovation criterion, with a value of 7.1678, had the highest degree of influenceability, followed by operational management and productivity and technological infrastructure, with values of 6.8736 and 6.8535, respectively. Furthermore, criteria C6, C10, C5, C11, and C1 were identified as causal variables, while criteria C4, C9, C12, C2, C8, C7, and C3 were classified as effect variables. According to the findings of this study, in order to enhance the productivity of mining and mineral industries organizations for performance improvement and productivity enhancement, conditions can be created to improve the identified codes and variables reported in this research.

Keywords: Organizational productivity, mining and mineral industries organization, performance improvement, productivity enhancement, grounded theory, fuzzy DEMATEL.

Introduction

The possession of natural resources such as mineral deposits not only helps the national economy overcome the challenge of securing raw materials for many industries, but also, by increasing income flows, can improve the level of welfare and living standards of people residing in mining host regions [1]. The mining and mineral industries sector is considered one of the most important economic sectors in any country and can serve as a powerful economic driver with an undeniable role in national economic development [2]. Today, the role of mining and mineral industries in the economy of any country is not limited to contributing to national income and economic growth; rather, this sector can also make a significant contribution to job creation and the reduction of poverty and unemployment. In other words, the mining and mineral industries sector directly contributes to economic growth and development through employment generation, creation of value added, compensation for labor and capital services, fostering entrepreneurial activities, and increasing tax revenues, and indirectly, through its linkages with other sectors and organizations, it provides the ground for increased production and employment in other organizations [3].

The macro-level policies of Iran in the mining and mineral industries sector include: geology and the preparation of basic data; identification and exploration of mineral resources and reserves and comprehensive geoscientific information dissemination; exploration, exploitation, processing, and production of mineral-based industrial products; the preservation of mineral reserves and the prevention of their destruction and environmental degradation; mineral development based on global competitiveness and spatial planning considerations; the value-added chain of mining and mineral industries; integrating low-grade and raw mineral materials into industrial processes; prioritizing strategic minerals with long value chains and broad application; and identifying bases and opportunities for mineral investment and export of mineral products [4]. Today, the mining industry is at a critical juncture in which operational excellence is increasingly defined not only by profitability, but also by commitment to and focus on the productivity of production factors. This transformation reflects a broader paradigm shift toward sustainable development and heightened awareness of the impact of the mining industry on the planet and its inhabitants [5]. Iran holds a special position among other countries in terms of diversity of mineral resources; its rich and varied mineral reserves, given the importance and breadth of their production chains from upstream activities (exploration and extraction) to downstream layers (mineral industries and inorganic chemistry), place it in a situation similar to the oil and gas industry and, potentially, through integration with the country's advantages in the oil and gas sector, can create strong synergies between these two advantages and turn them into a powerful engine for sustained national growth and development [6]. At present, Iran, with more than 68 types of non-oil mineral substances and reserves of about 43 billion tons, ranks among the top 15 countries in the world in terms of metallic and non-metallic minerals [6].

Human resources play a crucial role in organizations, and organizations and their various projects are conceived, implemented, and operated by people. Therefore, individuals play a highly significant role in projects, and effective human resource management has a decisive impact on the success of any organization [7]. The motivation of human resources has a substantial effect on the performance and productivity of various projects; thus, success in improving project performance requires a precise understanding of job demands, individual needs, and the proper deployment of human resources in appropriate positions [8]. Increasing competition and the drive for survival have compelled many organizations to concentrate their activities on core products and key competencies, a process that necessitates investment in research and the creation of technological innovations to enable performance improvement and productivity enhancement [9]. Human resources, work, performance, production, productivity, and industry are closely interconnected concepts, and when discussing the performance and productivity of human resources, the human being is considered either as an operator or as an active workforce [10]. In recent years, there has been growing interest in mining policy in the use of system dynamics modeling to address the complexity of numerous issues in the sector, with system dynamics aimed at helping to analyze and solve problems and challenges, and several studies have accordingly sought to identify the factors influencing them [11].

Various factors in the supply chain of organizations related to mining and mineral industries, by creating joint relationships with customer needs and aligning operations, can enhance their performance in terms of efficiency, productivity, profitability, and competitiveness, and these organizations perform better when they develop integrated configurations of interconnected elements within their supply chain [12]. Examining the components of economic growth in leading developed and developing countries shows that the contribution of improved labor and capital productivity to economic growth has been substantial and in some cases has surpassed the contribution of factor accumulation. Economists argue that productivity improvement paves the way for economic growth and better living standards for individuals [13]. Contemporary organizations require performance improvement and productivity enhancement in order to survive and progress in a competitive environment. Performance improvement refers to the continuous increase and enhancement of performance, while productivity pertains to the effective and optimal use of various resources and inputs such as labor, capital, materials, energy, and information, emphasizing both efficiency and effectiveness; efficiency refers to doing things correctly and is measured by the ratio of actual output to standard output, whereas effectiveness refers to the degree to which achieved outputs conform to intended goals [14]. Improving performance and enhancing productivity constitute the main keys to competitiveness, upgrading the business environment, and ensuring organizational access to sustainable growth and development. Therefore, the use of diverse tools, techniques, methods, and activities to improve organizational performance and productivity is of great importance, and studies have been carried out in this field [15].

A review of prior research indicates that, first, relatively few studies have examined the factors influencing organizational productivity specifically for performance improvement and productivity enhancement in the mining and mineral industries sector, and second, no research was found that identified the influencing and influenced factors in this context. For example, in a study on the factors affecting capital productivity in the mining sector, Agheli and Hosseini concluded that per capita capital, the mineral price index, energy use efficiency, and the share of private ownership had a significant impact on capital productivity in mining; thus, increasing energy efficiency, reducing per capita capital, and increasing mineral prices raise average capital productivity [16]. In another study on labor productivity in mines, Agheli reported that the share of skilled workers, private ownership of mines, per capita capital, and wages and salaries had a positive effect on labor productivity in mines; therefore, raising labor productivity in mines requires designing compensation and reward systems proportionate to workers' value added, using labor-saving technologies (advanced mining equipment) for the extraction of deep and high-risk deposits, privatizing non-strategic mines, increasing labor's share of the profits and sales of mineral products, and taking into account substitution and complementarity relationships among labor, energy, and capital in the extraction and processing of mineral materials [17]. In a separate study on designing a dynamic balanced scorecard as an industrial safety management system in metallurgical mining, Mayo-Alvarez, Del Aguila-Arcentales, and Alvarez-Risco found that key influencing factors included a dynamic balanced scorecard (with components such as dynamic simulation for organizational learning and strategic improvement in safety performance measurement), soft systems methodology and systems thinking (with components such as resolving complex human and organizational problems in the mining environment and improving coordination and comprehensive decision-making across units), and industrial safety (with components such as fostering a preventive safety culture, reducing accidents and downtime and increasing employee motivation, leadership commitment in safety, and occupational disease management in the mining workforce) [18]. In another study on the productivity of a copper mine, De Solminihac, González, and Cerda reported that the decline in labor productivity is attributable to four factors: real mining wages, electricity prices, copper prices, and ore grade [19]. In addition, in an empirical study on energy prices, energy productivity, and capital productivity and their policy implications, Gamtessa and Elani concluded that increases in energy prices, the energy–capital ratio, and the energy–output ratio affect capital productivity and may sometimes generate price shocks [20].

The mining and mineral industries sector can, through the provision of raw materials for production, job creation, value added, and tax revenues, create and accelerate conditions for national growth and development. This is feasible through appropriate policymaking in the sector and evaluation of its impacts and consequences on other economic sectors. In other words, performance improvement and productivity enhancement in the mining and mineral industries sector constitute one of the main pillars of economic development in countries, and Iran is among the most important countries in terms of possessing rich mineral reserves. Therefore, the main rationale for conducting this study lies in improving performance and enhancing productivity in socio-economic and political phenomena in the mining and mineral industries sector, enabling relevant organizations operating in competitive environments to adopt appropriate strategies in the face of industry challenges. Mining and mineral industries face a set of diverse resources that must be transformed into a range of products and services, and given the scarcity and high cost of resources, the optimal use of resources to realize organizational objectives is now felt more strongly than ever. For this reason, entry into the domain of performance improvement and productivity enhancement is of particular importance and guides organizations in the mining and mineral industries sector along the path of success and flourishing. Furthermore, leveraging the latent potential of this sector can increase national income and reduce unemployment, thereby decreasing Iran's dependence on oil revenues and, in addition, reducing the country's reliance on imports of raw materials and gradually fostering national self-sufficiency. Another important point is that improving performance and enhancing productivity in the mining and mineral industries sector require identifying the factors influencing these outcomes so that, in the next step, effective and practical programs can be designed for this purpose. In light of the above, the present study was conducted with the aim of analyzing and examining the factors affecting the productivity of mining and mineral industries organizations for performance improvement and productivity enhancement, based on the grounded theory and fuzzy DEMATEL approaches.

Methodology

The present study is applied in terms of purpose and qualitative in terms of implementation. The research population consisted of industry experts and specialists, as well as university instructors in the field of mining and mineral industries at the Iranian Mineral Processing Research Center and its parent organization (IMIDRO). The sample size in the grounded theory and fuzzy DEMATEL sections was estimated at 30 and 40 individuals, respectively, selected through purposive sampling. In the grounded theory section, interviews with 30 experts and specialists were conducted until theoretical saturation was reached. Theoretical saturation occurs when further interviews no longer provide new data to the researcher and recurring statements appear in the experts' responses. At this stage, the researcher discontinues further interviews and proceeds with data analysis. In the fuzzy DEMATEL section, 40 experts and specialists were included and, similar to the grounded theory section, were selected using purposive sampling. In purposive sampling, participants are selected based on key and specific criteria, which included having educational qualifications in management, mining engineering, or mineral industries (at least a master's degree for the grounded theory section and at least a bachelor's degree for the fuzzy DEMATEL section), a minimum of 10 years of educational and research experience, practical and theoretical experience in mining and mineral industries, and familiarity with the domain of the study.

The implementation stages of the present research were as follows: First, with the assistance of professors and based on theoretical foundations, interview questions were designed to identify the factors affecting the productivity of mining and mineral industries organizations for performance improvement and productivity enhancement. Then, sampling was conducted among experts and specialists, and interviews continued until new participants were unable to contribute any new findings to prior results, achieving theoretical saturation. Based on the interview analysis, a questionnaire was designed, and thereafter, additional experts and specialists were surveyed to determine the influencing and influenced factors related to the productivity of mining and mineral industries organizations for performance improvement and productivity enhancement. Purposive sampling was used to select participants in both sections—identifying influential factors and determining influencing and influenced factors—and the importance and necessity of the research were clearly and thoroughly explained to participants in both sections. Ethical principles and considerations regarding participation were described to all participants, and they were assured that all mentioned considerations would be fully observed. At the end of each section, participants were thanked and appreciated for their contribution to the research.

In addition to the demographic information form, this study included two other instruments: in the grounded theory section, semi-structured interviews were used, and in the fuzzy DEMATEL section, a researcher-developed questionnaire was employed. Interviews are typically conducted in a simple manner with the aim of collecting data; in semi-structured interviews, general principles of the interview are predetermined, but the interviewer may influence aspects such as the sequence of topics or the duration of the interview. To this end, the interviewer used a list of questions and, based on interviewees' responses, asked additional questions to deepen understanding of their perspectives. Interviews were conducted in person, and prior to interviewing, discussions were held regarding the time, location, and conditions of the interview (including audio recording to prevent accidental loss of information), and participants' consent was obtained. Interviews were conducted at the scheduled time and place, and in addition to taking notes on key points, interviews were recorded. After each interview, audio files were reviewed, and any unrecorded information was documented. The process of selecting participants and interviewing continued until new interviewees were unable to provide additional information beyond what had already been obtained from previous experts, thus indicating saturation. The validity of the interviews was confirmed using six strategies: triangulation of data collection methods and sources, participant verification, prolonged engagement of the researcher with the phenomenon, additional researcher review, participatory research processes, and examination of researcher assumptions. Reliability was obtained through inter-coder agreement, yielding a coefficient of 0.88.

A questionnaire is a tool for obtaining specific information regarding a defined issue, such that the information—after analysis and interpretation—allows for a more accurate assessment of the issue. Respondents record their answers within a range of predetermined options. The researcher-designed questionnaire in the present study was developed based on semi-structured interviews. Each item included five response options: very low (score 1), low (score 2), moderate (score 3), high (score 4), and very high (score 5). The total questionnaire score was calculated from the sum of all items, and each component's score was obtained from the sum of its respective items; higher scores indicated a greater presence of that characteristic. The validity of the researcher-made questionnaire was confirmed by experts, and the overall reliability, as well as the reliability of each component, was obtained using Cronbach's alpha, which exceeded 0.70.

In this study, open, axial, and selective coding processes based on the grounded theory approach were used to identify influential factors, and the fuzzy DEMATEL method was used to determine influencing and influenced factors. Grounded theory is a method for identifying influential factors that uses an inductive approach—meaning that theory development proceeds from the specific to the general. This method employs a series of systematic procedures to construct a theory about the phenomenon under study. In this method, coding is conducted based on six categories: causal conditions, contextual conditions, intervening conditions, core phenomenon, strategies, and consequences. Coding was performed using MAXQDA software version 20. Furthermore, fuzzy DEMATEL is a method used to determine influencing and influenced factors employing multi-criteria decision-making techniques. It provides a comprehensive approach for analyzing and forming a structured model based on causal relationships among variables. DEMATEL is a decision-making method based on pairwise comparisons and expert judgment to systematically structure system elements and was originally developed to analyze highly complex global problems. This method examines causal relationships among decision-making criteria using a fuzzy inference approach and transforms causal relationships between components and variables into a comprehensible structural model using graph theory. The eight steps of fuzzy DEMATEL include: forming an expert panel, selecting a fuzzy linguistic scale, establishing the initial direct-relation matrix, calculating the normalized direct-relation matrix, calculating the total-relation matrix, forming the row and column sums in the total-relation matrix, defuzzifying values, and plotting the influence–influenceability diagram and determining the threshold value and sub-factor table.

Findings and Results

This study consisted of two parts: grounded theory and fuzzy DEMATEL. The sample in the grounded theory section included 30 experts and specialists, and the results of their demographic information are presented in Table 1.

Table 1

Demographic characteristics of the grounded theory sample

Row	Gender	Education Level	Field and Specialization	Experience (years)
1	Male	PhD	Mining Engineering – Mineral Processing	23
2	Male	PhD	Mining Engineering – Mineral Processing	21
3	Male	PhD	Mining Engineering – Mineral Processing	16
4	Male	PhD	Industrial Engineering – Industries	20
5	Male	PhD	Economic Geology	23
6	Female	PhD	Geology – Paleontology	20
7	Male	PhD	Analytical Chemistry	22
8	Female	PhD	Analytical Chemistry	15
9	Male	PhD	Pure Chemistry	18
10	Male	PhD	Physical Chemistry	17
11	Female	PhD	Financial Management	22
12	Female	PhD	Environmental Management	15
13	Male	Master's	Industrial Engineering – Industries	20
14	Male	Master's	Industrial Engineering – Systems	17
15	Male	Master's	Industrial Engineering – Systems	15

16	Male	Master’s	Industrial Management – Production	20
17	Male	Master’s	Industrial Management – Production	19
18	Male	Master’s	Mining Engineering – Mineral Processing	25
19	Male	Master’s	Mining Engineering – Mineral Processing	19
20	Male	Master’s	Mining Engineering – Extraction	16
21	Male	Master’s	Mining Engineering – Exploration	22
22	Male	Master’s	Analytical Chemistry	22
23	Male	Master’s	Business Management	28
24	Male	Master’s	Business Management	15
25	Male	Master’s	Public Management	29
26	Female	Master’s	Executive Management	15
27	Male	Master’s	Electrical Engineering – Electronics	25
28	Female	Master’s	Computer Engineering – Hardware	23
29	Female	Master’s	Computer Engineering – Software	15
30	Male	Master’s	Extractive Metallurgical Engineering	16

According to the results of Table 1, most of the grounded theory sample were male (23 individuals, equal to 76.67%) and held a master’s degree (18 individuals, equal to 60%). In addition, their fields of study, specializations, and years of experience are shown in the table. The results of open, axial, and selective coding to identify the factors influencing the productivity of mining and mineral industries organizations for performance improvement and productivity enhancement based on the grounded theory approach are presented in Table 2.

Table 2.

Results of open, axial, and selective coding for identifying factors influencing the productivity of mining and mineral industries organizations for performance improvement and productivity enhancement based on the grounded theory approach

Category	Selective Code	Axial Code	Open Code
Causal conditions	Improvement of organizational structure and processes	Organizational structure and agility Communication and interactions	Organizational structure Managerial and leadership styles Organizational interactions Innovation and technology
	Technological infrastructure	Technology development Supportive infrastructure	Technological problems and constraints Physical and logistical development Safety and environmental infrastructure
	Technology and innovation	Technological ideas Technological Challenges	New productivity technologies Technology production and upgrading Digital barriers
Contextual conditions	Human resource empowerment	Training and Skills Development Motivation and organizational culture	In-house training Specialized training course Skills and competency enhancement Training and evaluation system Soft skills training Employee motivation Meritocracy and organizational justice Cultural and social values
	Macroeconomic and policy factors	Macroeconomic and political environment Financing and investment	Economic fluctuations and recession Sanctions and macro policies Financial and support resources Financial challenges
Intervening conditions	Leadership, management, and policymaking	Leadership and organizational structure Role of government and regulations	Managerial approaches Strategic alignment Regulation and policymaking
	Organizational risk and safety management	Risk identification and assessment	Identification of operational risks

		Risk reduction and management programs Safety culture and risk acceptance	Risk assessment and prioritization Formulation of safety policies and procedures Continuous monitoring and control of risks Promotion of organizational safety culture Stress management and mental health in dealing with risk
	Supply chain and resources	Supply chain integration Logistics management	Supplier management Customer management Operations optimization
Strategies	Operational management and productivity	Production planning and management Performance management	Production and productivity planning Higher efficiency in extraction and processing Evaluation and control Supply chain management
	Human capital development	Training and skills Employee health and motivation	Specialized and technical training Human resource quality Mental health Strengthening positive organizational behavior Organizational motivation
Consequences	Economic and financial performance	Financial structures Regional investment	Financing Financial productivity Infrastructure development Regional effects
	Sustainability and social responsibility	Environment and safety Corporate social responsibility	Environmental protection Industrial safety Social projects Institutional participation

According to the results of Table 2, the factors influencing the productivity of mining and mineral industries organizations for performance improvement and productivity enhancement consisted of 51 open codes, 25 axial codes, and 12 selective codes. Specifically, the causal conditions included 10 open codes and 6 axial codes in 3 selective codes (improvement of organizational structure and processes, technological infrastructure, and technology and innovation); the contextual conditions included 12 open codes and 4 axial codes in 2 selective codes (human resource empowerment and macroeconomic and policy factors); the intervening conditions included 12 open codes and 7 axial codes in 3 selective codes (leadership, management and policymaking, organizational risk and safety management, and supply chain and resources); the strategies included 9 open codes and 4 axial codes in 2 selective codes (operational management and productivity and human capital development); and the consequences included 8 open codes and 4 axial codes in 2 selective codes (economic and financial performance and sustainability and social responsibility).

Furthermore, the sample in the fuzzy DEMATEL section consisted of 40 experts and specialists, and the results of their demographic information are presented in Table 3.

Table 3

Demographic characteristics of the fuzzy DEMATEL sample

Variable	Level	Frequency	Percentage	Cumulative percentage
Gender	Male	34	85.00	85.00
	Female	6	15.00	100.00
Age	31–40 years	12	30.00	30.00
	41–50 years	17	42.50	72.50
	Above 50 years	11	27.50	100.00
Education	Bachelor’s	5	12.50	12.50
	Master’s	22	55.00	67.50

PhD	13	32.50	100.00

According to the results of Table 3, most of the fuzzy DEMATEL sample were male (34 individuals, equal to 85%), aged 41–50 years (17 individuals, equal to 42.50%), and held a master's degree (22 individuals, equal to 55%). The results of the identified selective codes and their abbreviations for the factors influencing the productivity of mining and mineral industries organizations for performance improvement and productivity enhancement are presented in Table 4.

Table 4

Identified selective codes and abbreviations for factors influencing the productivity of mining and mineral industries organizations for performance improvement and productivity enhancement

Selective code	Abbreviation	Selective code	Abbreviation
Improvement of organizational structure and processes	C1	Organizational risk and safety management	C7
Technological infrastructure	C2	Supply chain and resources	C8
Technology and innovation	C3	Operational management and productivity	C9
Human resource empowerment	C4	Human capital development	C10
Macroeconomic and policy factors	C5	Economic and financial performance	C11
Leadership, management, and policymaking	C6	Sustainability and social responsibility	C12

For the fuzzy DEMATEL procedure, first, the arithmetic mean of the fuzzy DEMATEL matrix was calculated; to obtain a collective perspective and reduce individual biases, fuzzy judgments were aggregated using the arithmetic averaging method, and the maximum value was derived. Then, the fuzzy DEMATEL matrix was scaled using standard normalization formulas to enable more precise calculations in subsequent steps. In the next stage, the direct influence matrix was constructed in fuzzy form. In this matrix, each element represented the degree of direct influence of one criterion on another and served as the basis for the total-relation matrix. The results of the defuzzified matrix and the threshold value for the factors influencing the productivity of mining and mineral industries organizations for performance improvement and productivity enhancement are presented in Table 5.

Table 5

Results of the Defuzzified Matrix and Threshold Value for Factors Affecting the Productivity of Mining and Mineral Industries Organizations for Performance Improvement and Productivity Enhancement

DI FUZZY	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
C1	0.5184	0.5992	0.6260	0.5987	0.5621	0.5841	0.5866	0.5721	0.6010	0.5709	0.5774	0.5350
C2	0.5652	0.5088	0.6060	0.5690	0.5419	0.5568	0.5649	0.5545	0.5759	0.5386	0.5576	0.5108
C3	0.5554	0.5726	0.5201	0.5591	0.5316	0.5458	0.5560	0.5448	0.5691	0.5348	0.5490	0.5090
C4	0.5764	0.5818	0.6102	0.5164	0.5491	0.5755	0.5759	0.5640	0.5881	0.5623	0.5678	0.5327
C5	0.5700	0.5851	0.6119	0.5800	0.4910	0.5697	0.5719	0.5684	0.5854	0.5571	0.5693	0.5307
C6	0.6044	0.6147	0.6412	0.6158	0.5815	0.5307	0.6020	0.5936	0.6168	0.5844	0.5965	0.5587
C7	0.5340	0.5417	0.5687	0.5389	0.5144	0.5295	0.4761	0.5226	0.5446	0.5186	0.5257	0.4992
C8	0.5335	0.5480	0.5719	0.5383	0.5211	0.5340	0.5371	0.4711	0.5532	0.5184	0.5368	0.4963
C9	0.5744	0.5867	0.6157	0.5856	0.5555	0.5708	0.5769	0.5709	0.5230	0.5619	0.5750	0.5332
C10	0.5799	0.5928	0.6219	0.5954	0.5567	0.5835	0.5806	0.5679	0.5937	0.4999	0.5731	0.5379
C11	0.5848	0.5990	0.6256	0.5912	0.5714	0.5872	0.5832	0.5813	0.5991	0.5684	0.5155	0.5406
C12	0.5163	0.5231	0.5486	0.5272	0.4978	0.5159	0.5212	0.5098	0.5237	0.5018	0.5098	0.4268

The results of calculating the D and R indices for the factors influencing the productivity of mining and mineral industries organizations for performance improvement and productivity enhancement are presented in Table 6.

Table 6

Results of Calculating the D and R Indices for Factors Influencing the Productivity of Mining and Mineral Industries Organizations for Performance Improvement and Productivity Enhancement

DI FUZZY	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	D values
C1	0.5184	0.5992	0.6260	0.5987	0.5621	0.5841	0.5866	0.5721	0.6010	0.5709	0.5774	0.5350	**6.9315**
C2	0.5652	0.5088	0.6060	0.5690	0.5419	0.5568	0.5649	0.5545	0.5759	0.5386	0.5576	0.5108	**6.6499**
C3	0.5554	0.5726	0.5201	0.5591	0.5316	0.5458	0.5560	0.5448	0.5691	0.5348	0.5490	0.5090	**6.5473**
C4	0.5764	0.5818	0.6102	0.5164	0.5491	0.5755	0.5759	0.5640	0.5881	0.5623	0.5678	0.5327	**6.8002**
C5	0.5700	0.5851	0.6119	0.5800	0.4910	0.5697	0.5719	0.5684	0.5854	0.5571	0.5693	0.5307	**6.7907**
C6	0.6044	0.6147	0.6412	0.6158	0.5815	0.5307	0.6020	0.5936	0.6168	0.5844	0.5965	0.5587	**7.1404**
C7	0.5340	0.5417	0.5687	0.5389	0.5144	0.5295	0.4761	0.5226	0.5446	0.5186	0.5257	0.4992	**6.3139**
C8	0.5335	0.5480	0.5719	0.5383	0.5211	0.5340	0.5371	0.4711	0.5532	0.5184	0.5368	0.4963	**6.3597**
C9	0.5744	0.5867	0.6157	0.5856	0.5555	0.5708	0.5769	0.5709	0.5230	0.5619	0.5750	0.5332	**6.8297**
C10	0.5799	0.5928	0.6219	0.5954	0.5567	0.5835	0.5806	0.5679	0.5937	0.4999	0.5731	0.5379	**6.8833**
C11	0.5848	0.5990	0.6256	0.5912	0.5714	0.5872	0.5832	0.5813	0.5991	0.5684	0.5155	0.5406	**6.9473**
C12	0.5163	0.5231	0.5486	0.5272	0.4978	0.5159	0.5212	0.5098	0.5237	0.5018	0.5098	0.4268	**6.1222**
R values	**6.7128**	**6.8535**	**7.1678**	**6.8156**	**6.4741**	**6.6835**	**6.7324**	**6.6210**	**6.8736**	**6.5170**	**6.6536**	**6.2109**	

The influence and influenceability results for the factors affecting the productivity of mining and mineral industries organizations for performance improvement and productivity enhancement are presented in Table 7 and Figure 1.

Table 7

Influence and Influenceability Results for Factors Affecting the Productivity of Mining and Mineral Industries Organizations for Performance Improvement and Productivity Enhancement

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
D+R	13.644	13.503	13.715	13.616	13.265	13.824	13.046	12.981	13.703	13.400	13.601	12.333
D−R	0.219	−0.204	−0.621	−0.015	0.317	0.457	−0.419	−0.261	−0.044	0.366	0.294	−0.089

Figure 1

Influence and Influenceability Results for Factors Affecting the Productivity of Mining and Mineral Industries Organizations for Performance Improvement and Productivity Enhancement

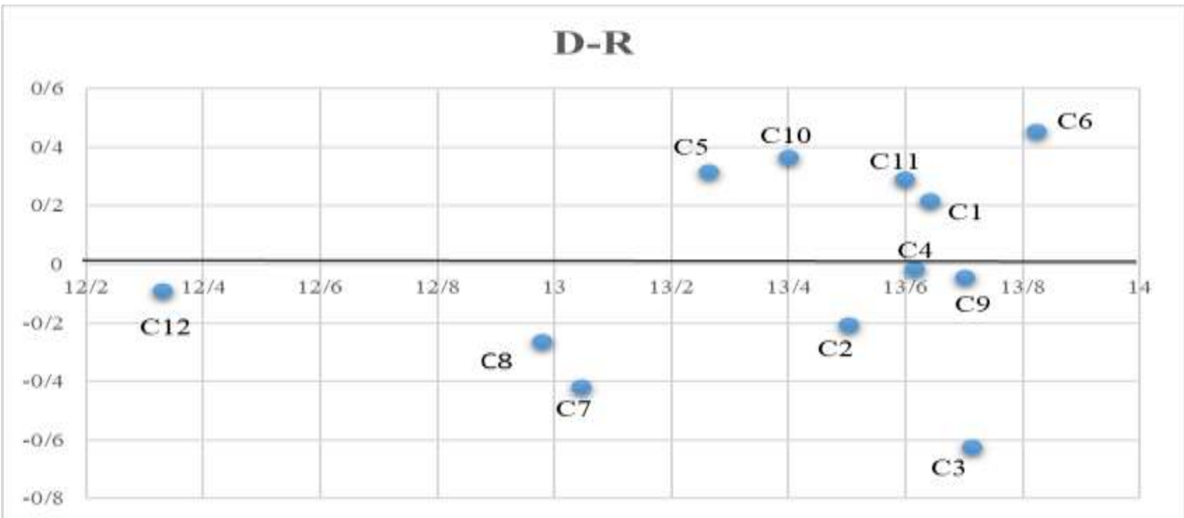

Table 8

Final Results of Factors Influencing the Productivity of Mining and Mineral Industries Organizations Based on the Fuzzy DEMATEL Method

Index	Ranking of Criteria Based on Abbreviation and Score	Index	Ranking of Criteria Based on Abbreviation and Score

D (Degree of influence)	C6: 7.1404; C11: 6.9473; C1: 6.9315; C10: 6.8833; C9: 6.8297; C4: 6.8002; C5: 6.7907; C2: 6.6499; C3: 6.5473; C8: 6.3597; C7: 6.3139; C12: 6.1222	R (Degree of influenceability)	C3: 7.1678; C9: 6.8736; C2: 6.8535; C4: 6.8156; C7: 6.7324; C1: 6.7128; C6: 6.6835; C11: 6.6536; C8: 6.6210; C10: 6.5170; C5: 6.4741; C12: 6.2109
D+R (Interaction of the factor with other factors)	C6: 13.824; C3: 13.715; C9: 13.703; C1: 13.644; C4: 13.616; C11: 13.601; C2: 13.503; C10: 13.400; C5: 13.265; C7: 13.046; C8: 12.981; C12: 12.333	D−R (Causal or Effect Variable)	*Causal:* C6: 0.457; C10: 0.366; C5: 0.317; C11: 0.294; C1: 0.219 *Effect:* C4: −0.015; C9: −0.044; C12: −0.089; C2: −0.204; C8: −0.261; C7: −0.419; C3: −0.621

According to the results of Table 7 and Figure 1, the variables *improvement of organizational structure and processes*, *human resource empowerment*, *macroeconomic and policy factors*, *leadership, management and policymaking*, *human capital development*, and *economic and financial performance* were identified as influencing factors. The variables *technological infrastructure*, *technology and innovation*, *organizational risk and safety management*, *supply chain and resources*, *operational management and productivity*, and *sustainability and social responsibility* were identified as influenced factors. In addition, Table 8 presents the final results of the fuzzy DEMATEL analysis, showing—based on the D, R, D+R, and D−R indices and each criterion's abbreviation and score—the priority ranking of factors from highest to lowest in terms of influence, influenceability, interaction level, and classification as causal or effect variables.

Discussion and Conclusion

The mining and mineral industries sector plays a significant role in improving organizational performance and national development. Accordingly, the present study was conducted to analyze and examine the factors influencing the productivity of mining and mineral industries organizations to enhance performance and increase productivity based on grounded theory and the fuzzy DEMATEL approach.

The findings showed that the factors affecting the productivity of mining and mineral industries organizations consisted of 51 open codes, 25 axial codes, and 12 selective codes. The causal conditions included three selective codes: improvement of organizational structure and processes, technological infrastructure, and technology and innovation. The contextual conditions included two selective codes: human resource empowerment and macroeconomic and policy factors. The intervening conditions consisted of three selective codes: leadership, management and policymaking; organizational risk and safety management; and supply chain and resources. Strategies included two selective codes: operational management and productivity, and human capital development. The outcomes included two selective codes: economic and financial performance, and sustainability and social responsibility. The results of the fuzzy DEMATEL analysis further showed that improvement of organizational structure and processes, human resource empowerment, macroeconomic and policy factors, leadership, management and policymaking, human capital development, and economic and financial performance were influencing variables, while technological infrastructure, technology and innovation, organizational risk and safety management, supply chain and resources, operational management and productivity, and sustainability and social responsibility were influenced variables. These findings were in line with the results of previous studies [16-20].

In interpreting and explaining these findings, it can be argued that enhancing productivity in mining and mineral industries organizations requires identifying the causal conditions that influence productivity and designing appropriate programs based on these conditions. For this purpose, organizations can focus on improving organizational structure and processes, technological infrastructure, and technology and innovation through organizational structure modification, managerial and leadership styles, organizational interactions, technological development and innovation, addressing technological limitations, physical and logistical development, safety and environmental infrastructure, advanced productivity technologies, technology production and upgrading, and overcoming digital barriers.

The contextual conditions included human resource empowerment and macroeconomic and policy factors. To improve these conditions, organizations can design programs to adjust in-house training, conduct specialized training courses, strengthen skills and competencies, enhance the training and evaluation system, develop soft skills training, increase employee motivation, promote meritocracy and organizational justice, reinforce cultural and social values, manage economic fluctuations and recessions, navigate sanctions and macro policies, strengthen financial resources and support systems, and address financial challenges.

The intervening conditions included leadership, management and policymaking, organizational risk and safety management, and supply chain and resources. Addressing these requires designing programs related to managerial approaches, strategic alignment, regulatory and policy frameworks, identification of operational risks, risk assessment and prioritization, development of safety policies and procedures, continuous monitoring and control of risks, promoting safety culture within the organization, managing stress and mental health in high-risk environments, supplier management, customer management, and operations optimization.

Strategies included operational management and productivity and human capital development. Enhancing performance and productivity in mining and mineral industries requires planning in areas such as production planning and productivity, increasing efficiency in extraction and processing, performance evaluation and control, supply chain management, technical and specialized training, improving the quality of human resources, strengthening mental health, promoting positive organizational behavior, and enhancing organizational motivation.

The outcomes of organizational productivity in mining and mineral industries included economic and financial performance and sustainability and social responsibility. Achieving these outcomes requires planning in areas such as financing, financial productivity, infrastructure development, regional impacts, environmental protection, industrial safety, social projects, and institutional participation.

Furthermore, the influencing variables identified included improvement of organizational structure and processes, human resource empowerment, macroeconomic and policy factors, leadership, management and policymaking, human capital development, and economic and financial performance. The influenced variables included technological infrastructure, technology and innovation, organizational risk and safety management, supply chain and resources, operational management and productivity, and sustainability and social responsibility. Therefore, improving performance and enhancing productivity in mining and mineral industries organizations require identifying the influencing factors and then designing and implementing programs to improve them. Moreover, the influenced factors will grow and evolve as a result of improvements in organizational performance and productivity.

The main limitations of this study included the relatively small sample size for the fuzzy DEMATEL section, the use of purposive sampling, and the restriction of the research sample to experts and specialists in the mining and mineral industries sector at the Iranian Mineral Processing Research Center and its parent organization (IMIDRO). Therefore, it is recommended that future studies examine organizational performance and productivity in the mining and mineral industries sector from various angles and employ other sampling methods. Another practical suggestion is for policymakers and planners in the mining and mineral industries sector to use the questionnaire developed in this study to assess the current state of organizational productivity, identify strengths and weaknesses, enhance strengths, and design and implement actionable programs to address weaknesses. Based on the findings of this study, it is possible to create the necessary conditions for improving the codes identified to enhance the productivity of mining and mineral industries organizations.

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Authors' Contributions

All authors equally contributed to this study.

Declaration of Interest

The authors of this article declared no conflict of interest.

Ethical Considerations

The study protocol adhered to the principles outlined in the Helsinki Declaration, which provides guidelines for ethical research involving human participants. Written consent was obtained from all participants in the study.

Transparency of Data

In accordance with the principles of transparency and open research, we declare that all data and materials used in this study are available upon request.

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