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Identification and Prioritization of Key Factors Affecting Workforce Productivity Using Grey Delphi and Grey DEMATEL: A Case Study

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ABSTRACT

Enhancing workforce productivity is a critical challenge for industrial and engineering companies. This study aims to identify and prioritize key factors influencing workforce productivity using a structured multi-criteria decision-making approach. Initially, the Grey Delphi Method was employed to gather expert opinions and determine the most influential criteria, leading to the identification of six main criteria and twenty-two sub-criteria. Subsequently, the Grey DEMATEL technique was applied with inputs from four decision-makers to analyze causal relationships and rank these factors. The results indicate that managerial factors had the highest impact on workforce productivity, followed by socio-psychological factors and economic factors. Among the sub-criteria, leadership style, job satisfaction, and alignment between personal interests and job roles were identified as the most critical. These findings provide valuable insights for managers and policymakers, highlighting the need for leadership development, employee engagement, and tailored motivational strategies to enhance productivity. This study demonstrates the effectiveness of integrating Grey Delphi and Grey DEMATEL in decision-making processes, offering a systematic approach to optimizing workforce performance in complex organizational environments.

1. Introduction

In today's competitive business environment, workforce productivity has become one of the key factors driving organizational success and growth. Workforce productivity refers to the optimal utilization of employees' skills and abilities to achieve organizational goals. In industrial and engineering sectors, where the complexity and challenges are considerable, enhancing workforce

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productivity is even more critical. Identifying and managing the factors influencing workforce productivity can provide significant benefits. These factors can generally be categorized into managerial, socio-psychological, cultural, economic, individual, and environmental factors, each contributing differently to workforce productivity.

Numerous studies have examined the factors influencing workforce productivity. Several of these have emphasized the importance of leadership and management. For instance, transformational leadership has been shown to significantly impact employees' motivation and productivity [1-2]. The role of training and employee participation in decision-making has also been highlighted as critical for improving workforce performance [3]. Furthermore, research by Yukl [4] suggests that leadership style, particularly the ability of leaders to engage and empower employees, directly influences organizational productivity. Effective management strategies are essential for maximizing workforce productivity. Studies emphasize the significance of construction management expertise [5], supervision competence [5-6], well-defined work procedures [6], and efficient communication [6]. These insights underscore the importance of strong leadership, optimized resource management, and clear communication channels.

On the socio-psychological front, factors such as job security, fair treatment, and positive relationships between managers and employees have been identified as pivotal in improving employees' morale and productivity [7-8]. In addition, fostering a creative and innovative environment within the organization can lead to higher productivity by allowing employees to explore new ideas [9]. A sense of job satisfaction and organizational belonging also plays a role in employees' performance [10]. Worker motivation and commitment are consistently recognized as key productivity drivers. Research in the construction [5] and maintenance sectors [6] highlights the positive impact of financial incentives, job satisfaction, and recognition on enhancing worker motivation and overall productivity.

Cultural factors, including work ethics, adherence to rules and regulations, and team spirit, have also been shown to affect workforce productivity [11-12]. Hofstede's cultural dimensions theory emphasizes how different cultural attributes, such as individualism versus collectivism and uncertainty avoidance, impact productivity and organizational dynamics. Strong adherence to ethical principles and having a positive attitude towards the organization promote a disciplined and collaborative workforce, as evidenced by multiple cross-cultural studies [13].

Economic factors, such as appropriate compensation, benefits, and rewards, play a direct role in motivating employees and improving their productivity [14]. The equity theory by Adams [15] supports this by illustrating how fair pay and rewards align with higher employee satisfaction and performance. Additionally, the availability of facilities and appropriate benefits boosts overall organizational morale. Macroeconomic elements, including economic growth, inflation, and government policies, also influence workforce productivity. A study on construction labor productivity identified economic conditions as a major factor from the perspectives of both project managers and contractors [5].

Individual factors like the alignment between personal skills and job requirements, educational level, work experience, and physical and mental well-being have also been explored in numerous studies [16]. These studies highlight the necessity of matching employee skills with job tasks to improve job performance, emphasizing that a healthy and skilled workforce leads to higher productivity. Research on maintenance labor productivity in the UAE electricity sector identified

skill level as the most influential factor [6]. Similarly, studies on construction labor productivity emphasize the significance of experience and skills from the contractor's viewpoint [5]. These findings are consistent with research across various industries [5-6]. Physical and mental health play a crucial role in productivity. For instance, heat stress leads to significant reductions in labor productivity, with considerable economic implications [17]. A study on maintenance labor productivity in the UAE also identified health conditions as a highly influential factor [6].

Environmental factors, including the quality of work tools, physical conditions like lighting and ventilation, and health and safety measures, also influence workforce efficiency [18-19]. Ergonomics and workplace design are often overlooked but critical aspects that contribute to employees' comfort and ability to perform tasks effectively. Safe and comfortable working environments have been consistently linked to higher productivity and lower absenteeism rates. Access to essential tools, equipment, materials, and information is crucial for maintaining productivity. Research across different industries consistently identifies shortages of materials [5-6], equipment [6], and timely information [5] as major barriers to productivity. The work environment has a substantial impact on productivity, with factors such as safety measures [5-6], weather conditions [5-6], and workplace design [20] all contributing to productivity outcomes. Notably, heat stress is a particularly significant factor affecting labor efficiency [19].

Innovations in technology play a transformative role in productivity. The adoption of AI and data-driven methodologies in construction is a prominent example [20], offering enhanced automation, better decision-making, and improved efficiency. However, integrating AI also introduces challenges, including the need for workforce reskilling and upskilling.

Despite extensive research on workforce productivity, significant gaps remain in the literature. Many studies have primarily focused on Western contexts, with limited attention to the unique challenges faced by industries in developing countries, particularly in Iran. Moreover, few studies have comprehensively examined the multifaceted nature of productivity factors in industrial and engineering sectors, where managerial, social, cultural, and environmental dynamics interact.

A key limitation in previous research is the lack of studies utilizing integrated methodologies such as Grey Delphi and Grey DEMATEL to systematically identify, analyze, and rank these factors in localized industrial settings. This study addresses these gaps by employing a combination of Grey Delphi and Grey DEMATEL methods to determine and prioritize the key determinants of workforce productivity in a manufacturing and engineering company in Iran. The novelty of this research lies in its application of these methods in a non-Western, real-world industrial environment, offering new insights into workforce productivity factors within a developing economy.

By incorporating expert opinions and leveraging a structured linguistic approach to pairwise comparisons, this study provides a practical framework for improving workforce productivity in similar industries. Additionally, it contributes to the broader body of knowledge by demonstrating the effectiveness of integrating Grey Delphi and Grey DEMATEL in managing the complexities of workforce productivity in dynamic organizational contexts.

The remainder of the paper is structured as follows: Section 2 presents the research methodology, describing the Grey Delphi and Grey DEMATEL techniques used for identifying and prioritizing workforce productivity factors. Section 3 provides an overview of the case study, detailing the characteristics of one of the industrial and engineering companies in Iran where the study was

conducted. Section 4 explains the implementation of the proposed approach, including data collection, expert input, and analytical procedures. Section 5 interprets the results and discusses managerial implications, highlighting key findings and their practical relevance. Finally, Section 6 concludes the study by summarizing the key insights, discussing limitations, and offering suggestions for future research.

2. Research Methodology

This section outlines the comprehensive methodology used in this research to identify and prioritize the key factors affecting workforce productivity in a private industrial and engineering company in Iran. The methodology consists of multiple stages, including initial factor identification, expert evaluation, and the application of Grey Delphi and Grey DEMATEL methods for analysis. The overall research process is illustrated in ***Figure 1***.

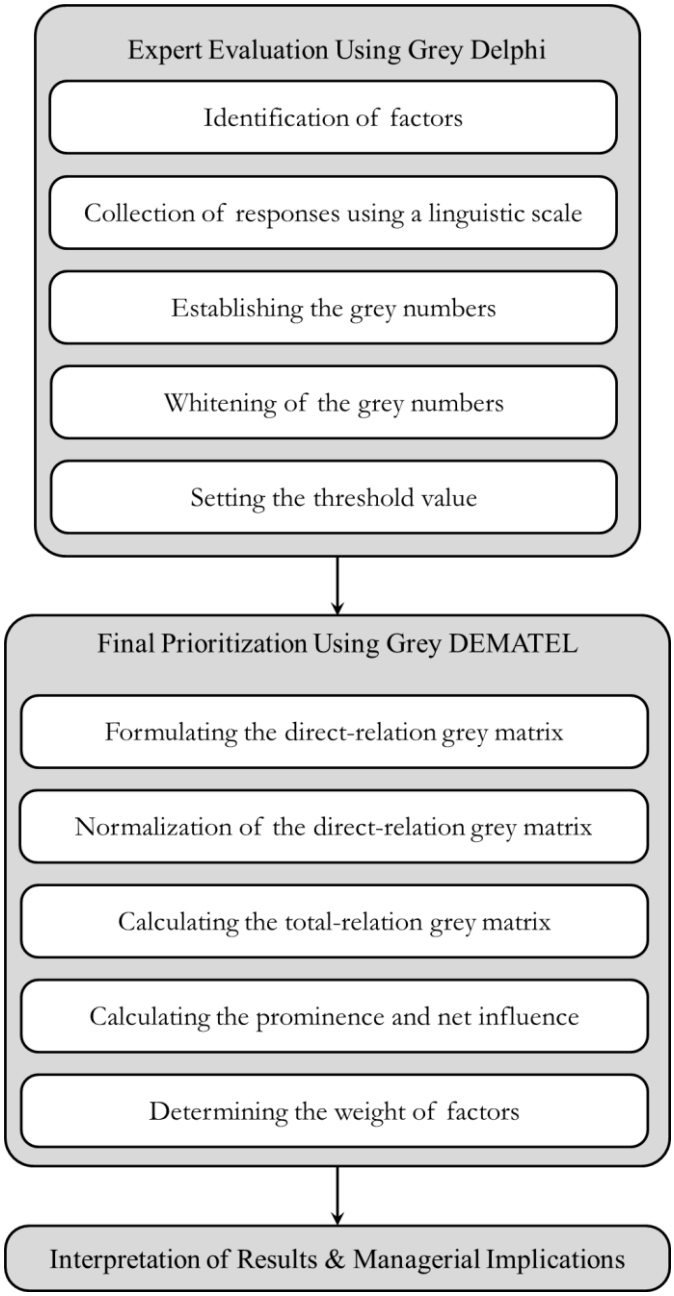

Figure. 1. Flowchart of the Research Methodology

3.1 Grey Numbers and Mathematical Operations

Grey numbers are an essential tool in decision-making processes under uncertainty. A grey number is expressed as an interval, typically represented as $\otimes G = [\underline{G}, \overline{G}]$, where $\underline{G}$ is the lower bound, and $\overline{G}$ is the upper bound. Grey numbers allow for a range of possible values instead of a single deterministic value, making them highly suitable for handling ambiguity and incomplete data.

Basic operations with grey numbers have been discussed extensively in various studies (e.g., [21]). The fundamental operations are expressed through ***Eqs. (1) to (4)***.

For two grey numbers $\otimes G_1 = \left[\underline{G_1}, \overline{G_1}\right]$ and $\otimes G_2 = \left[\underline{G_2}, \overline{G_2}\right]$:

$$\otimes G_1 + \otimes G_2 = \left[\underline{G_1} + \underline{G_2}, \overline{G_1} + \overline{G_2}\right] \quad \textbf{(1)}$$

$$\otimes G_1 - \otimes G_2 = \left[\underline{G_1} - \overline{G_2}, \overline{G_1} - \underline{G_2}\right] \quad \textbf{(2)}$$

$$\otimes G_1 \times \otimes G_2 = \left[min\left(\underline{G_1} \cdot \underline{G_2}, \underline{G_1} \cdot \overline{G_2}, \overline{G_1} \cdot \underline{G_2}, \overline{G_1} \cdot \overline{G_2}\right), max\left(\underline{G_1} \cdot \underline{G_2}, \underline{G_1} \cdot \overline{G_2}, \overline{G_1} \cdot \underline{G_2}, \overline{G_1} \cdot \overline{G_2}\right)\right] \quad \textbf{(3)}$$

Assuming $0 \notin \otimes G_2$:

$$\otimes G_1 \div \otimes G_2 = \left[min\left(\frac{\underline{G_1}}{\underline{G_2}}, \frac{\underline{G_1}}{\overline{G_2}}, \frac{\overline{G_1}}{\underline{G_2}}, \frac{\overline{G_1}}{\overline{G_2}}\right), max\left(\frac{\underline{G_1}}{\underline{G_2}}, \frac{\underline{G_1}}{\overline{G_2}}, \frac{\overline{G_1}}{\underline{G_2}}, \frac{\overline{G_1}}{\overline{G_2}}\right)\right] \quad \textbf{(4)}$$

3.2 Grey Delphi Method

The Grey Delphi method builds upon the Delphi technique, originally introduced by Dalkey and Helmer [22], by integrating it with grey set theory to address the limitations of the conventional Delphi approach. This method allows for reaching a consensus by incorporating expert opinions under conditions of uncertainty. The steps of the Grey Delphi method are as follows:

Step 1: Identification of factors

A comprehensive review of relevant literature identifies a list of factors associated with the problem under investigation [23]. These identified factors serve as the basis for designing a questionnaire to collect expert opinions.

Step 2: Collection of responses using a linguistic scale

Experts are invited to respond to the questionnaire using a predefined linguistic scale. Each linguistic term corresponds to a grey number, which allows for capturing the uncertainty in expert judgments. ***Table 1*** presents the linguistic terms along with their corresponding grey number.

Table 1. Linguistic terms and their corresponding grey numbers.

Linguistic terms	Very Low	Low	Medium	High	Very High
Grey numbers	[0,1]	[1,2]	[2,3]	[3,4]	[4,5]

Step 3: Establishing the grey numbers

The responses collected from experts are converted into corresponding grey numbers. The overall assessment of each factor is calculated as the average of the grey evaluations provided by all experts, as shown in ***Eq. (5)***.

$$\otimes G_i = \frac{\otimes G_i^1 + \otimes G_i^2 + \cdots + \otimes G_i^h + \cdots + \otimes G_i^k}{k} \quad \textbf{(5)}$$

Where $\otimes G_i$ represents the overall grey number for factor i, $\otimes G_i^h$ denotes the evaluation of expert h for factor i, and k is the number of experts.

Step 4: Whitening of the grey numbers

The grey numbers are transformed into crisp (white) values to facilitate further analysis. This whitening process can be achieved using ***Eq. (6)***.

$$G = \alpha \underline{G} + (1-\alpha)\overline{G}, \alpha \in [0,1] \quad \textbf{(6)}$$

In this equation, α is typically set to 0.5, and the resulting crisp value (G) represents the weighted mean of the lower ($\underline{G}$) and upper ($\overline{G}$) bounds of the grey number.

Step 5: Setting the threshold value

The final step involves selecting or rejecting factors based on a threshold value (λ). If the computed crisp value for a factor is greater than or equal to the threshold ($G \geq \lambda$), the factor is accepted; otherwise, it is rejected.

These steps collectively define the framework of the Grey Delphi method, which provides a structured and systematic approach to decision-making under uncertainty. In this study, the Grey Delphi method is utilized to screen and refine the identified factors, ensuring a more accurate and consensus-based selection.

3.3 The Grey DEMATEL Method

The Grey DEMATEL method was employed in this study to assess the interdependencies and cause-effect relationships among the screened factors. This technique is particularly well-suited for analyzing complex systems with interconnected factors, especially under uncertain conditions. The steps of the Grey DEMATEL method are as follows:

Step 1: Formulating the direct-relation grey matrix

Each of the q decision-makers provides pairwise comparisons of the factors based on their impact on one another, using linguistic terms defined in ***Table 2***. The initial grey matrix for each decision-maker is represented in ***Eq. (7)***.

Table 2. Linguistic variables and their corresponding grey numbers.

Linguistic variables	No Influence	Very Low Influence	Low Influence	High Influence	Very High Influence
Grey numbers	[0,0]	[0,1]	[1,2]	[2,3]	[3,4]

$$\otimes A^p = \begin{bmatrix} [0,0] & \otimes a_{12}^p & \cdots & \otimes a_{1n}^p \\ \otimes a_{21}^p & [0,0] & \cdots & \otimes a_{2n}^p \\ \vdots & \vdots & \ddots & \vdots \\ \otimes a_{n1}^p & \otimes a_{n2}^p & \cdots & [0,0] \end{bmatrix} \quad i,j = 1,2,\dots,n;\ \ p = 1,2,\cdots q \tag{7}$$

Where $\otimes A^p$ denotes the initial grey matrix for decision-maker p, and $\otimes a_{ij}^p$ represents the impact of factor i on factor j from the perspective of decision-maker p.

The results of the pairwise comparisons are then used to construct the direct-relation grey matrix, denoted as $\otimes A$. This matrix represents the direct influence of each factor on the others.

$$\otimes A = \frac{\otimes A^1 + \otimes A^2 + \cdots + \otimes A^p + \cdots + \otimes A^q}{q} \tag{8}$$

Step 2: Normalization of the direct-relation grey matrix

The direct-relation grey matrix is normalized using ***Eqs. (9) and (10)*** to ensure that all values are appropriately scaled. This normalization is essential for establishing a standardized measure of influence.

$$\otimes N = \otimes s \times \otimes A \tag{9}$$

$$\otimes s = \left[\underline{s}, \overline{s}\right] = \frac{1}{\underset{1 \le i \le n}{max} \sum_{j=1}^{n} \otimes a_{ij}} \tag{10}$$

Step 3: Calculating the total-relation grey matrix

The total-relation grey matrix ($\otimes T$) is calculated to capture both the direct and indirect influences of factors.

$$\otimes T = (\otimes N)(\otimes I\ - \otimes N)^{-1} \tag{11}$$

where $\otimes I$ denotes the identity matrix of order

Step 4: Calculating the prominence and net influence

The causal parameter is calculated using ***Eqs. (12) and (13)***.

$$\otimes R_i = \sum_{j=1}^{n} t_{ij} \ \ , i = 1,2,\dots,n \tag{12}$$

$$\otimes D_j = \sum_{i=1}^{n} t_{ij} \ \ , j = 1,2,\dots,n \tag{13}$$

The value of $\otimes R_i$ in each row indicates the combined direct and indirect impacts of factor i on the other factors, while $\otimes D_j$ represents the total direct and indirect influences received by factor j from the other factors (i.e., the extent to which factor j is affected).

Step 5: Determining the weight of factors

Following the calculation of $\otimes R_i$ and $\otimes D_j$, a whitening process is applied to the values to determine the weights of each factor. The weight of each factor (W_i) is computed using ***Eq. (14)***.

$$W_i = [(R_i + D_i)^2 + (R_i - D_i)^2]^{\frac{1}{2}} \quad , i = 1,2,\dots,n \tag{14}$$

Next, the weight of each factor is normalized using ***Eq. (15)***.

$$\bar{W}_i = \frac{W_i}{\sum_{j=1}^{n} W_j} \quad , i = 1,2,\dots,n \tag{15}$$

3. Overview of the Case Study: An Industrial and Engineering Company in Iran

This study focuses on a private industrial and engineering company in Iran that specializes in the design, engineering, and maintenance of energy and industrial infrastructure. Established with the mission of delivering high-quality services in power generation and energy distribution, the company plays a critical role in the country's energy sector. Its operations span various areas, including power plant maintenance, industrial project management, and automation solutions for energy systems.

With a workforce composed of highly skilled professionals and engineers, the company places strong emphasis on continuous improvement, technological innovation, and workforce productivity to maintain its competitive edge in a rapidly evolving market.

Key characteristics of the company include:

- **Sector Focus:** Energy and industrial services.
- **Workforce:** A large and diverse team engaged in engineering, project management, and technical services.
- **Organizational Structure:** A hierarchical management framework with a strong emphasis on leadership, collaboration, and productivity optimization.

Given its role in a capital-intensive industry, optimizing workforce productivity is crucial for ensuring operational efficiency, reducing downtime, and maintaining project timelines. These factors make it an ideal subject for analyzing the key determinants of workforce productivity in an industrial and engineering setting.

4. Implementation of the Proposed Approach

In this study, the proposed approach for identifying and prioritizing the factors affecting workforce productivity was implemented in the case study company using the Grey Delphi and Grey DEMATEL methods. As outlined in the methodology section, the process began with the identification of relevant factors from a comprehensive review of the literature. This review resulted in a list of 40 factors considered influential in workforce productivity, which were then subjected to expert evaluation [23]. A total of 10 experts from the case study company were invited to provide

their opinions using a predefined linguistic scale. The scale included terms such as 'Very Low,' 'Low,' 'Medium,' 'High,' and 'Very High,' each corresponding to specific grey numbers as shown in ***Table 1***. The experts' responses were recorded and summarized in ***Table 3***.

Table 3. Linguistic ratings provided by the 10 experts for each factor.

Criteria	**Experts**									
	E_1	E_2	E_3	E_4	E_5	E_6	E_7	E_8	E_9	E_{10}
Job rotation	L	M	L	M	M	M	L	M	M	M
Sense of belonging to the organization	H	H	H	H	M	VH	H	H	M	VH
Job promotion system based on merit	M	M	H	M	H	M	H	M	H	M
Motivational incentives in the workplace	H	H	H	VH	H	H	VH	H	H	VH
Work ethic	H	H	H	VH	H	H	VH	H	H	VH
Alignment between personal skills and job requirements	H	H	H	VH	H	H	VH	H	H	VH
Use of internet and intranet within departments	M	M	H	M	H	H	L	H	H	L
Educational level	M	H	H	H	M	H	H	H	M	H
Alignment between personal interests and job roles	H	H	H	H	H	VH	H	H	H	H
Sense of job security	H	H	H	VH	H	H	VH	H	H	VH
Work experience	H	H	M	H	H	M	H	M	M	H
Quality of raw materials	H	M	H	M	H	H	L	H	H	VH
Positive organizational outlook	H	H	H	VH	H	H	H	H	H	VH
Adequate monetary rewards	H	H	H	VH	H	H	VH	H	H	VH
Job satisfaction	H	H	H	VH	H	H	VH	H	H	VH
Access to updated work tools and equipment	H	H	H	VH	H	H	VH	H	H	VH
Manager-employee relations	VH	H	VH	H	VH	H	VH	H	VH	H
Performance-based wage system	H	H	H	H	H	H	H	H	H	H
Calm and joyful work environment	M	M	H	M	H	H	VH	M	M	H
Workplace health and safety	H	H	H	VH	H	H	VH	H	H	VH
On-the-job training	H	H	H	H	M	H	VH	H	M	VH
Physical and mental well-being	H	M	H	VH	VH	H	VH	M	H	VH
Automation system for administrative and financial tasks	M	M	M	H	M	M	H	M	M	H
Perception of fair working conditions	H	H	M	H	M	H	M	H	M	H
Suitable physical work conditions (e.g., lighting, ventilation)	H	H	H	H	H	H	H	H	H	H
Teamwork spirit	H	H	H	H	H	H	H	H	M	VH
Ergonomics	M	L	M	H	H	M	L	M	M	M
Adherence to ethical principles	H	M	H	H	H	H	H	H	M	H
Competitive spirit	L	H	M	H	H	H	L	M	M	H
Adherence to rules and regulations	M	H	M	H	H	H	H	M	M	VH
Environment for creativity and innovation	M	M	M	VH	H	M	L	H	M	H
Presence of a competent supervisor	H	H	VH	H	H	VH	H	H	VH	H
Quality of work life	H	M	H	VH	M	H	VH	M	M	VH
Maintenance system for equipment and machinery	H	M	H	H	H	H	H	M	H	H
Welfare facilities	H	H	H	H	H	H	H	H	H	H
Employee participation in decision-making	H	H	H	M	H	M	VH	H	H	VH
Salary and wage level	VH	VH	H	VH	H	VH	VH	H	H	VH
Leadership style	H	VH	H	VH	H	H	VH	H	H	VH
Adequate non-monetary rewards	H	H	H	H	M	H	M	M	H	H
Friendly atmosphere among employees	H	M	M	H	H	H	H	M	H	VH

The collected responses were then converted into grey numbers to account for the uncertainty in expert judgments. The corresponding grey numbers are displayed in ***Table 4***.

Table 4. Corresponding grey numbers for the linguistic ratings provided in Table 3.

Criteria	**Experts**									
	E_1	E_1	E_1	E_1	E_1	E_1	E_1	E_1	E_1	E_1
Job rotation	[1,2]	[2,3]	[1,2]	[2,3]	[2,3]	[2,3]	[1,2]	[2,3]	[2,3]	[2,3]
Sense of belonging to the organization	[3,4]	[3,4]	[3,4]	[3,4]	[2,3]	[4,5]	[3,4]	[3,4]	[2,3]	[4,5]
Job promotion system based on merit	[2,3]	[2,3]	[3,4]	[2,3]	[3,4]	[2,3]	[3,4]	[2,3]	[3,4]	[2,3]
Motivational incentives in the workplace	[3,4]	[3,4]	[3,4]	[4,5]	[3,4]	[3,4]	[4,5]	[3,4]	[3,4]	[4,5]
Work ethic	[3,4]	[3,4]	[3,4]	[4,5]	[3,4]	[3,4]	[4,5]	[3,4]	[3,4]	[4,5]
Alignment between personal skills and job requirements	[3,4]	[3,4]	[3,4]	[4,5]	[3,4]	[3,4]	[4,5]	[3,4]	[3,4]	[4,5]
Use of internet and intranet within departments	[2,3]	[2,3]	[3,4]	[2,3]	[3,4]	[3,4]	[1,2]	[3,4]	[3,4]	[1,2]
Educational level	[2,3]	[3,4]	[3,4]	[3,4]	[2,3]	[3,4]	[3,4]	[3,4]	[2,3]	[3,4]
Alignment between personal interests and job roles	[3,4]	[3,4]	[3,4]	[3,4]	[3,4]	[4,5]	[3,4]	[3,4]	[3,4]	[3,4]
Sense of job security	[3,4]	[3,4]	[3,4]	[4,5]	[3,4]	[3,4]	[4,5]	[3,4]	[3,4]	[4,5]
Work experience	[3,4]	[3,4]	[2,3]	[3,4]	[3,4]	[2,3]	[3,4]	[2,3]	[2,3]	[3,4]
Quality of raw materials	[3,4]	[2,3]	[3,4]	[2,3]	[3,4]	[3,4]	[1,2]	[3,4]	[3,4]	[4,5]
Positive organizational outlook	[3,4]	[3,4]	[3,4]	[4,5]	[3,4]	[3,4]	[3,4]	[3,4]	[3,4]	[4,5]
Adequate monetary rewards	[3,4]	[3,4]	[3,4]	[4,5]	[3,4]	[3,4]	[4,5]	[3,4]	[3,4]	[4,5]
Job satisfaction	[3,4]	[3,4]	[3,4]	[4,5]	[3,4]	[3,4]	[4,5]	[3,4]	[3,4]	[4,5]
Access to updated work tools and equipment	[3,4]	[3,4]	[3,4]	[4,5]	[3,4]	[3,4]	[4,5]	[3,4]	[3,4]	[4,5]
Manager-employee relations	[4,5]	[3,4]	[4,5]	[3,4]	[4,5]	[3,4]	[4,5]	[3,4]	[4,5]	[3,4]
Performance-based wage system	[3,4]	[3,4]	[3,4]	[3,4]	[3,4]	[3,4]	[3,4]	[3,4]	[3,4]	[3,4]
Calm and joyful work environment	[2,3]	[2,3]	[3,4]	[2,3]	[3,4]	[3,4]	[4,5]	[2,3]	[2,3]	[3,4]
Workplace health and safety	[3,4]	[3,4]	[3,4]	[4,5]	[3,4]	[3,4]	[4,5]	[3,4]	[3,4]	[4,5]
On-the-job training	[3,4]	[3,4]	[3,4]	[3,4]	[2,3]	[3,4]	[4,5]	[3,4]	[2,3]	[4,5]
Physical and mental well-being	[3,4]	[3,4]	[3,4]	[3,4]	[2,3]	[4,5]	[3,4]	[3,4]	[2,3]	[4,5]
Automation system for administrative and financial tasks	[2,3]	[2,3]	[3,4]	[2,3]	[3,4]	[2,3]	[3,4]	[2,3]	[3,4]	[2,3]
Perception of fair working conditions	[3,4]	[3,4]	[3,4]	[4,5]	[3,4]	[3,4]	[4,5]	[3,4]	[3,4]	[4,5]
Suitable physical work conditions (e.g., lighting, ventilation)	[3,4]	[3,4]	[3,4]	[4,5]	[3,4]	[3,4]	[4,5]	[3,4]	[3,4]	[4,5]
Teamwork spirit	[3,4]	[3,4]	[3,4]	[4,5]	[3,4]	[3,4]	[4,5]	[3,4]	[3,4]	[4,5]
Ergonomics	[2,3]	[2,3]	[3,4]	[2,3]	[3,4]	[3,4]	[1,2]	[3,4]	[3,4]	[1,2]
Adherence to ethical principles	[2,3]	[3,4]	[3,4]	[3,4]	[2,3]	[3,4]	[3,4]	[3,4]	[2,3]	[3,4]
Competitive spirit	[3,4]	[3,4]	[3,4]	[3,4]	[3,4]	[4,5]	[3,4]	[3,4]	[3,4]	[3,4]
Adherence to rules and regulations	[3,4]	[3,4]	[3,4]	[4,5]	[3,4]	[3,4]	[4,5]	[3,4]	[3,4]	[4,5]
Environment for creativity and innovation	[3,4]	[3,4]	[2,3]	[3,4]	[3,4]	[2,3]	[3,4]	[2,3]	[2,3]	[3,4]
Presence of a competent supervisor	[3,4]	[2,3]	[3,4]	[2,3]	[3,4]	[3,4]	[1,2]	[3,4]	[3,4]	[4,5]
Quality of work life	[3,4]	[3,4]	[3,4]	[4,5]	[3,4]	[3,4]	[3,4]	[3,4]	[3,4]	[4,5]
Maintenance system for equipment and machinery	[3,4]	[3,4]	[3,4]	[4,5]	[3,4]	[3,4]	[4,5]	[3,4]	[3,4]	[4,5]
Welfare facilities	[3,4]	[3,4]	[3,4]	[4,5]	[3,4]	[3,4]	[4,5]	[3,4]	[3,4]	[4,5]
Employee participation in decision-making	[3,4]	[3,4]	[3,4]	[2,3]	[3,4]	[2,3]	[4,5]	[3,4]	[3,4]	[4,5]
Salary and wage level	[4,5]	[3,4]	[4,5]	[3,4]	[4,5]	[3,4]	[4,5]	[3,4]	[4,5]	[3,4]
Leadership style	[3,4]	[3,4]	[3,4]	[3,4]	[3,4]	[3,4]	[3,4]	[3,4]	[3,4]	[3,4]
Adequate non-monetary rewards	[2,3]	[2,3]	[3,4]	[2,3]	[3,4]	[3,4]	[4,5]	[2,3]	[2,3]	[3,4]
Friendly atmosphere among employees	[3,4]	[3,4]	[3,4]	[4,5]	[3,4]	[3,4]	[4,5]	[3,4]	[3,4]	[4,5]

The average grey values were calculated for each factor, as shown in ***Table 5***. This step facilitated a more comprehensive understanding of the overall evaluation of each factor by aggregating the experts' input. To enable further analysis, the grey numbers were converted into crisp (white) values through a whitening process, as described in the methodology. This transformation made it easier to proceed with the subsequent steps of the analysis. The whitening results provided a clearer representation of each factor's importance, enabling a more accurate prioritization.

Finally, a threshold value of 3.5, as recommended by previous studies (e.g., [24]), was applied to determine which factors should be considered for the next phase. Factors with a white value greater than or equal to the threshold were accepted, while those below the threshold were rejected. The final set of accepted factors is presented in ***Table 5***, which shows that out of the initial 40 factors, 22 were deemed significant enough to be retained for further analysis.

The retained factors were organized into six primary categories, which are detailed in ***Table 6***, where the final list of criteria and their corresponding sub-criteria is presented.

Table 5. Results of expert evaluation using the Grey Delphi method.

Factors	Grey weight	Crisp weight	Decision
Job rotation	[1.7,2.7]	2.2	Reject
Sense of belonging to the organization	[3,4]	3.5	Accept
Job promotion system based on merit	[2.4,3.4]	2.9	Reject
Motivational incentives in the workplace	[3.3,4.3]	3.8	Accept
Work ethic	[3.3,4.3]	3.8	Accept
Alignment between personal skills and job requirements	[3.3,4.3]	3.8	Accept
Use of internet and intranet within departments	[2.3,3.3]	2.8	Reject
Educational level	[2.7,3.7]	3.2	Reject
Alignment between personal interests and job roles	[3.1,4.1]	3.6	Accept
Sense of job security	[3.3,4.3]	3.8	Accept
Work experience	[2.6,3.6]	3.1	Reject
Quality of raw materials	[2.7,3.7]	3.2	Reject
Positive organizational outlook	[3.2,4.2]	3.7	Accept
Adequate monetary rewards	[3.3,4.3]	3.8	Accept
Job satisfaction	[3.3,4.3]	3.8	Accept
Access to updated work tools and equipment	[3.3,4.3]	3.8	Accept
Manager-employee relations	[3.5,4.5]	4	Accept
Performance-based wage system	[3,4]	3.5	Accept
Calm and joyful work environment	[2.6,3.6]	3.1	Reject
Workplace health and safety	[3.3,4.3]	3.8	Accept
On-the-job training	[3,4]	3.5	Accept
Physical and mental well-being	[3.2,4.2]	3.7	Accept
Automation system for administrative and financial tasks	[2.3,3.3]	2.8	Reject
Perception of fair working conditions	[2.6,3.6]	3.1	Reject
Suitable physical work conditions (e.g., lighting, ventilation)	[3,4]	3.5	Accept
Teamwork spirit	[3,4]	3.5	Accept
Ergonomics	[2,3]	2.5	Reject
Adherence to ethical principles	[2.8,3.8]	3.3	Reject
Competitive spirit	[2.3,3.3]	2.8	Reject
Adherence to rules and regulations	[2.7,3.7]	3.2	Reject
Environment for creativity and innovation	[2.4,3.4]	2.9	Reject
Presence of a competent supervisor	[3.3,4.3]	3.8	Accept
Quality of work life	[2.9,3.9]	3.4	Reject
Maintenance system for equipment and machinery	[2.8,3.8]	3.3	Reject
Welfare facilities	[3,4]	3.5	Accept
Employee participation in decision-making	[3,4]	3.5	Accept
Salary and wage level	[3.6,4.6]	4.1	Accept
Leadership style	[3.4,4.4]	3.9	Accept
Adequate non-monetary rewards	[2.7,3.7]	3.2	Reject
Friendly atmosphere among employees	[2.8,3.8]	3.3	Reject

Table 6. Final list of 22 sub-criteria along with their corresponding criteria.

Criteria (Code)	Sub-criteria (Code)
Economic factors (C1)	Adequate monetary rewards (C11) Performance-based wage system (C12) Welfare facilities (C13) Salary and wage level (C14)
Cultural factors (C2)	Work ethic (C21) Positive organizational outlook (C22) Teamwork spirit (C23)
Managerial factors (C3)	Motivational incentives in the workplace (C31) On-the-job training (C32) Presence of a competent supervisor (C33) Employee participation in decision-making (C34) Leadership style (C35)
Individual factors (C4)	Alignment between personal skills and job requirements (C41) Alignment between personal interests and job roles (C42) Physical and mental well-being (C43)
Socio-psychological factors (C5)	Sense of belonging to the organization (C51) Sense of job security (C52) Job satisfaction (C53) Manager-employee relations (C54)
Environmental factors (C6)	Access to updated work tools and equipment (C61) Workplace health and safety (C62) Suitable physical work conditions (C63)

In the following, the Grey DEMATEL method was employed to determine the weights and priorities of the accepted sub-criteria and criteria. This method evaluates the relationships and influences among both criteria and sub-criteria to develop a structural model. In this stage, four decision-makers (DMs) provided pairwise comparisons using a linguistic scale based on the spectrum defined in ***Table 2***. These comparisons were then converted into grey numbers to account for uncertainties and aggregated into an initial direct-relation matrix, presented in ***Table 7***.

Table 7. Initial direct-relation matrix

(7a) Initial direct-relation matrix for economic sub-criteria

	C_{11}	C_{12}	C_{13}	C_{14}
C_{11}	[0,0]	[2,3]	[1,2]	[3,4]
C_{12}	[0.5,1.5]	[0,0]	[1.5,2.5]	[2,3]
C_{13}	[0.5,1.5]	[0.5,1.5]	[0,0]	[1.5,2.5]
C_{14}	[1.5,2.5]	[2,3]	[1,2]	[0,0]

(7b) Initial direct-relation matrix for cultural sub-criteria

	C_{21}	C_{22}	C_{23}
C_{21}	[0,0]	[2,3]	[3,4]
C_{22}	[1,2]	[0,0]	[2,3]
C_{23}	[0.5,1.5]	[1.5,2.5]	[0,0]

(7c) Initial direct-relation matrix for managerial sub-criteria

	C_{31}	C_{32}	C_{33}	C_{34}	C_{35}
C_{31}	[0,0]	[2,3]	[2,3]	[1.5,2.5]	[2.5,3.5]
C_{32}	[1,2]	[0,0]	[2,3]	[1,2]	[1,2]
C_{33}	[0.5,1.5]	[2,3]	[0,0]	[2.5,3.5]	[2.5,3.5]
C_{34}	[2,3]	[1.5,2.5]	[1.5,2.5]	[0,0]	[2,3]
C_{35}	[3,4]	[1.5,2.5]	[1.5,2.5]	[2.5,3.5]	[0,0]

(7d) Initial direct-relation matrix for individual sub-criteria

	C_{41}	C_{42}	C_{43}
C_{41}	[0,0]	[2.5,3.5]	[1.5,2.5]
C_{42}	[1.5,2.5]	[0,0]	[2.5,3.5]
C_{43}	[0.5,1.5]	[2,3]	[0,0]

(7e) Initial direct-relation matrix for socio-psychological sub-criteria

	C_{51}	C_{52}	C_{53}	C_{54}
C_{51}	[0,0]	[2,3]	[3,4]	[1.5,2.5]
C_{52}	[1.5,2.5]	[0,0]	[2,3]	[0.5,1.5]
C_{53}	[1.5,2.5]	[2,3]	[0,0]	[2.5,3.5]
C_{54}	[2,3]	[1,2]	[3,4]	[0,0]

(7f) Initial direct-relation matrix for environmental sub-criteria

	C_{61}	C_{62}	C_{63}
C_{61}	[0,0]	[2,3]	[2,3]
C_{62}	[1,2]	[0,0]	[3,4]
C_{63}	[1,2]	[2,3]	[0,0]

(7g) Initial direct-relation matrix for main criteria

	C_1	C_2	C_3	C_4	C_5	C_6
C_1	[0,0]	[1,2]	[2,3]	[2,3]	[2,3]	[0.5,1.5]
C_2	[2,3]	[0,0]	[2,3]	[1,2]	[2,3]	[0.5,1.5]
C_3	[2.5,3.5]	[2,3]	[0,0]	[2.5,3.5]	[3,4]	[1.5,2.5]
C_4	[1.5,2.5]	[0.5,1.5]	[2.5,3.5]	[0,0]	[1.5,2.5]	[1,2]
C_5	[2,3]	[1.5,2.5]	[3,4]	[2,3]	[0,0]	[2,3]
C_6	[0.5,1.5]	[0.5,1.5]	[1.5,2.5]	[1,2]	[2,3]	[0,0]

To ensure the comparability of influence values, the direct-relation matrix was normalized. This step adjusts the matrix so that the values reflect a consistent scale of influence across all factors. As shown in ***Table 8***, the normalized direct-relation matrix is presented.

Table 8. Normalized direct-relation matrix

(8a) Normalized direct-relation matrix for economic sub-criteria

	C_{11}	C_{12}	C_{13}	C_{14}
C_{11}	[0,0]	[0.333,0.333]	[0.167,0.222]	[0.444,0.5]
C_{12}	[0.083,0.167]	[0,0]	[0.25,0.278]	[0.333,0.333]
C_{13}	[0.083,0.167]	[0.083,0.167]	[0,0]	[0.25,0.278]
C_{14}	[0.25,0.278]	[0.333,0.333]	[0.167,0.222]	[0,0]

(8b) Normalized direct-relation matrix for cultural sub-criteria

	C_{21}	C_{22}	C_{23}
C_{21}	[0,0]	[0.4,0.429]	[0.571,0.6]
C_{22}	[0.2,0.286]	[0,0]	[0.4,0.429]
C_{23}	[0.1,0.214]	[0.3,0.357]	[0,0]

(8c) Normalized direct-relation matrix for managerial sub-criteria

	C_{31}	C_{32}	C_{33}	C_{34}	C_{35}
C_{31}	[0,0]	[0.235,0.24]	[0.235,0.24]	[0.176,0.2]	[0.28, 0.294]
C_{32}	[0.118,0.16]	[0,0]	[0.235,0.24]	[0.118,0.16]	[0.118,0.16]
C_{33}	[0.059,0.12]	[0.235,0.24]	[0,0]	[0.28, 0.294]	[0.28, 0.294]
C_{34}	[0.235,0.24]	[0.176,0.2]	[0.176,0.2]	[0,0]	[0.235,0.24]
C_{35}	[0.32,0.352]	[0.176,0.2]	[0.176,0.2]	[0.28, 0.294]	[0,0]

(8d) Normalized direct-relation matrix for individual sub-criteria

	C_{41}	C_{42}	C_{43}
C_{41}	[0,0]	[0.583,0.625]	[0.375,0.417]
C_{42}	[0.375,0.417]	[0,0]	[0.583,0.625]
C_{43}	[0.125,0.25]	[0.5,0.5]	[0,0]

(8e) Normalized direct-relation matrix for socio-psychological sub-criteria

	C_{51}	C_{52}	C_{53}	C_{54}
C_{51}	[0,0]	[0.308,0.316]	[0.421,0.462]	[0.231,0.263]
C_{52}	[0.231,0.263]	[0,0]	[0.308,0.316]	[0.077,0.158]
C_{53}	[0.231,0.263]	[0.308,0.316]	[0,0]	[0.369, 0.385]
C_{54}	[0.308,0.316]	[0.154,0.211]	[0.421,0.462]	[0,0]

(8f) Normalized direct-relation matrix for environmental sub-criteria

	C_{61}	C_{62}	C_{63}
C_{61}	[0,0]	[0.5,0.5]	[0.5,0.5]
C_{62}	[0.25,0.333]	[0,0]	[0.667, 0.75]
C_{63}	[0.25,0.333]	[0.5,0.5]	[0,0]

(8g) Normalized direct-relation matrix for main criteria

	C_1	C_2	C_3	C_4	C_5	C_6
C_1	[0,0]	[0.087,0.121]	[0.174,0.182]	[0.174,0.182]	[0.174,0.182]	[0.043,0.091]
C_2	[0.174,0.182]	[0,0]	[0.174,0.182]	[0.087,0.121]	[0.174,0.182]	[0.043,0.091]
C_3	[0.212,0.217]	[0.174,0.182]	[0,0]	[0.212,0.217]	[0.242, 0.261]	[0.130,0.152]
C_4	[0.130,0.152]	[0.043,0.091]	[0.212,0.217]	[0,0]	[0.130,0.152]	[0.087,0.121]
C_5	[0.174,0.182]	[0.130,0.152]	[0.242,0.261]	[0.174,0.182]	[0,0]	[0.174,0.181]
C_6	[0.043,0.091]	[0.043,0.091]	[0.130,0.152]	[0.087,0.121]	[0.174,0.182]	[0,0]

Using the normalized matrix, the total-relation matrix was calculated. This matrix reflects both direct and indirect influences between factors, offering a comprehensive view of how each factor interacts with the others, as shown in ***Table 9***.

Table 9. Total-relation matrix, including direct and indirect influences.

(9a) Total-relation matrix for economic sub-criteria

	C_{11}	C_{12}	C_{13}	C_{14}
C_{11}	[0.432,0.85]	[0.931,1.332]	[0.670,1.133]	[1.194,1.581]
C_{12}	[0.365,0.82]	[0.434,0.853]	[0.553,0.975]	[0.799,1.253]
C_{13}	[0.281,0.707]	[0.391,0.858]	[0.242,0.630]	[0.581,1.053]
C_{14}	[0.527,0.944]	[0.776,1.179]	[0.559,1.002]	[0.662,1.091]

(9b) Total-relation matrix for cultural sub-criteria

	C_{21}	C_{22}	C_{23}
C_{21}	[0.279,0.679]	[0.843,1.254]	[1.105,1.497]
C_{22}	[0.349,0.749]	[0.367,0.74]	[0.756,1.173]
C_{23}	[0.233,0.627]	[0.494,0.89]	[0.337,0.74]

(9c) Total-relation matrix for managerial sub-criteria

	C_{31}	C_{32}	C_{33}	C_{34}	C_{35}
C_{31}	[1.015,1.616]	[1.239,1.854]	[1.239,1.854]	[1.278,1.900]	[1.404,2.004]
C_{32}	[0.767,1.400]	[0.698,1.302]	[0.888,1.496]	[0.858,1.498]	[0.888,1.539]
C_{33}	[1.023,1.667]	[1.166,1.785]	[0.976,1.591]	[1.288,1.885]	[1.322,1.93]
C_{34}	[1.108,1.704]	[1.094,1.716]	[1.094,1.716]	[1.014,1.617]	[1.251,1.86]
C_{35}	[1.353,1.928]	[1.264,1.891]	[1.264,1.891]	[1.422,2.017]	[1.253,1.856]

(9d) Total-relation matrix for individual sub-criteria

	C_{41}	C_{42}	C_{43}
C_{41}	[1.395,2.743]	[2.830,4.183]	[2.667,4]
C_{42}	[1.579,2.972]	[2.320,3.734]	[2.667,4]
C_{43}	[1.088,2.422]	[2.014,3.413]	[1.667,3]

(9e) Total-relation matrix for socio-psychological sub-criteria

	C_{51}	C_{52}	C_{53}	C_{54}
C_{51}	[1.487,2.359]	[1.777,2.635]	[2.459,3.307]	[1.657,2.518]
C_{52}	[1.192,2.064]	[1.049,1.887]	[1.678,2.606]	[1.078,1.959]
C_{53}	[1.587,2.470]	[1.669,2.528]	[2.008,2.882]	[1.652,2.479]
C_{54}	[1.681,2.535]	[1.632,2.504]	[2.403,3.227]	[1.438,2.252]

(9f) Total-relation matrix for environmental sub-criteria

	C_{61}	C_{62}	C_{63}
C_{61}	[1.857,3.8]	[3.429,5.4]	[4,6]
C_{62}	[2,4]	[3,5]	[4,6]
C_{63}	[1.714,3.6]	[2.857,4.8]	[3,5]

(9g) Total-relation matrix for main criteria

	C_1	C_2	C_3	C_4	C_5	C_6
C_1	[0.368,0.606]	[0.333,0.596]	[0.597,0.849]	[0.522,0.764]	[0.571,0.826]	[0.297,0.572]
C_2	[0.52,0.762]	[0.257,0.49]	[0.597,0.845]	[0.455,0.719]	[0.575,0.828]	[0.295,0.571]
C_3	[0.692,0.934]	[0.499,0.764]	[0.629,0.872]	[0.698,0.938]	[0.804,1.039]	[0.465,0.741]
C_4	[0.461,0.716]	[0.285,0.556]	[0.601,0.846]	[0.353,0.59]	[0.518,0.783]	[0.319,0.579]
C_5	[0.622,0.874]	[0.443,0.712]	[0.79,1.0228]	[0.63,0.879]	[0.556,0.803]	[0.475,0.733]
C_6	[0.321,0.603]	[0.236,0.502]	[0.454,0.727]	[0.361,0.629]	[0.47,0.73]	[0.197,0.42]

In the following step, the values of $\otimes R_i$ are determined by summing the elements of each row in the total-relation grey matrix, while $\otimes D_j$ is calculated by summing the elements in the columns. After whitening these values using ***Eq. (6)***, the weights of the criteria are then computed. The values of $\otimes R_i$, $\otimes D_j$, and the corresponding weights of each criterion are presented in ***Table 10***.

Table 10. Values of $\otimes R_i$, $\otimes D_j$, and weights.

(10a) Values of $\otimes R_i$, $\otimes D_j$, and weights for economic sub-criteria

	$\otimes R_i$	$\otimes D_j$	Weight	Normal Weight
C_{11}	[3.228,4.896]	[1.605,3.321]	6.718	0.259
C_{12}	[2.151,3.901]	[2.532,4.223]	6.413	0.247
C_{13}	[1.496,3.248]	[2.023,3.739]	5.278	0.204
C_{14}	[2.523,4.216]	[3.236,4.978]	7.512	0.290

(10b) Values of $\otimes R_i$, $\otimes D_j$, and weights for cultural sub-criteria

	$\otimes R_i$	$\otimes D_j$	Weight	Normal Weight
C_{21}	[2.227,3.431]	[0.860,2.0545]	4.500	0.334
C_{22}	[1.471,2.662]	[1.703,2.884]	4.366	0.324
C_{23}	[1.064,2.257]	[2.198,3.41]	4.609	0.342

(10c) Values of $\otimes R_i$, $\otimes D_j$, and weights for managerial sub-criteria

	$\otimes R_i$	$\otimes D_j$	Weight	Normal Weight
C_{31}	[6.175,9.228]	[5.267,8.314]	14.520	0.202
C_{32}	[4.099,7.234]	[5.462,8.548]	12.742	0.177
C_{33}	[5.775,8.859]	[5.462,8.548]	14.325	0.200
C_{34}	[5.562,8.613]	[5.86,8.917]	14.479	0.202
C_{35}	[6.557,9.583]	[6.118,9.189]	15.729	0.219

(10d) Values of $\otimes R_i$, $\otimes D_j$, and weights for individual sub-criteria

	$\otimes R_i$	$\otimes D_j$	Weight	Normal Weight
C_{41}	[6.891,10.927]	[4.061,8.138]	15.269	0.311
C_{42}	[6.565,10.706]	[7.163,11.33]	17.893	0.364
C_{43}	[4.769,8.835]	[7,11]	15.954	0.325

(10e) Values of $\otimes R_i$, $\otimes D_j$, and weights for socio-psychological sub-criteria

	$\otimes R_i$	$\otimes D_j$	Weight	Normal Weight
C_{51}	[7.38,10.819]	[5.948,9.428]	16.846	0.252
C_{52}	[4.997,8.516]	[6.126,9.554]	14.636	0.219
C_{53}	[6.915,10.359]	[8.549,12.022]	18.994	0.284
C_{54}	[7.154,10.518]	[5.824,9.208]	16.405	0.245

(10f) Values of $\otimes R_i$, $\otimes D_j$, and weights for environmental sub-criteria

	$\otimes R_i$	$\otimes D_j$	Weight	Normal Weight
C_{61}	[9.286,15.2]	[5.571,11.4]	21.066	0.301
C_{62}	[9,15]	[9.286,15.2]	24.244	0.346
C_{63}	[7.571,13.4]	[11,17]	24.737	0.353

(10g) Values of $\otimes R_i$, $\otimes D_j$, and weights for main criteria

	$\otimes R_i$	$\otimes D_j$	Weight	Normal Weight
C_1	[2.687,4.212]	[2.984,4.496]	7.195	0.164
C_2	[2.699,4.22]	[2.052,3.619]	6.326	0.145
C_3	[3.788,5.289]	[3.668,5.166]	8.956	0.205
C_4	[2.536,4.07]	[3.019,4.519]	7.087	0.162
C_5	[3.516,5.023]	[3.495,5.009]	8.522	0.195
C_6	[2.038,3.611]	[2.046,3.615]	5.655	0.129

The final results, including the weights and rankings, are presented in ***Table 11***.

The findings presented in ***Table 11*** indicate that the 'Managerial factors' (C3) carried the highest weight among all criteria. The 'Socio-psychological factors' (C5) were ranked second in importance, while the 'Economic factors' (C1), 'Individual factors' (C4), 'Cultural factors' (C2), and 'Environmental factors' (C6) were ranked in third to sixth place, respectively.

Furthermore, among the sub-criteria, 'Alignment between personal interests and job roles' (C42) held the highest weight. 'Job satisfaction' (C53) and 'Physical and mental well-being' (C43) were ranked as the second and third most important sub-criteria, respectively.

- **Managerial factors (C3):** The 'Leadership style' (C35) was the highest priority, followed by 'Motivational incentives in the workplace' (C31), 'Employee participation in decision-making' (C34), 'Presence of a competent supervisor' (C33), and 'On-the-job training' (C32).
- **Socio-psychological factors (C5):** 'Job satisfaction' (C53) ranked highest, followed by 'Sense of belonging to the organization' (C51), 'Manager-employee relations' (C54), and 'Sense of job security' (C52).
- **Economic factors (C1):** 'Salary and wage level' (C14) took the top spot, followed by 'Adequate monetary rewards' (C11), 'Performance-based wage system' (C12), and 'Welfare facilities' (C13).
- **Individual factors (C4):** 'Alignment between personal interests and job roles' (C42) ranked highest, followed by 'Physical and mental well-being' (C43), and 'Alignment between personal skills and job requirements' (C41).
- **Cultural factors (C2):** 'Teamwork spirit' (C23) was the highest priority, followed by 'Work ethic' (C21), and 'Positive organizational outlook' (C22).
- **Environmental factors (C6):** 'Suitable physical work conditions' (C63) were given the highest priority, followed by 'Workplace health and safety' (C62), and 'Access to updated work tools and equipment' (C61).

Table 11. Final weights and rankings based on the Grey DEMATEL method.

Criteria	Local Weight	Sub-criteria	Local Weight	Global Weight	Rank
Economic factors (C1)	0.164	Adequate monetary rewards (C11)	0.259	0.043	15
		Performance-based wage system (C12)	0.247	0.041	19
		Welfare facilities (C13)	0.204	0.033	22
		Salary and wage level (C14)	0.290	0.048	9
Cultural factors (C2)	0.145	Work ethic (C21)	0.334	0.048	7
		Positive organizational outlook (C22)	0.324	0.047	10
		Teamwork spirit (C23)	0.342	0.049	5
Managerial factors (C3)	0.205	Motivational incentives in the workplace (C31)	0.202	0.041	16
		On-the-job training (C32)	0.177	0.036	21
		Presence of a competent supervisor (C33)	0.200	0.041	18
		Employee participation in decision-making (C34)	0.202	0.041	17
		Leadership style (C35)	0.219	0.045	12
Individual factors (C4)	0.162	Alignment between personal skills and job requirements (C41)	0.311	0.050	4
		Alignment between personal interests and job roles (C42)	0.364	0.059	1
		Physical and mental well-being (C43)	0.325	0.053	3
Socio-psychological factors (C5)	0.195	Sense of belonging to the organization (C51)	0.252	0.049	6
		Sense of job security (C52)	0.219	0.043	14
		Job satisfaction (C53)	0.284	0.055	2
		Manager-employee relations (C54)	0.245	0.048	8
Environmental factors (C6)	0.129	Access to updated work tools and equipment (C61)	0.301	0.039	20
		Workplace health and safety (C62)	0.346	0.045	13
		Suitable physical work conditions (C63)	0.353	0.046	11

5. Interpretation of Results & Managerial Implications

This section provides a detailed analysis of the results obtained using the Grey Delphi and Grey DEMATEL methods, followed by the managerial implications for enhancing workforce productivity in industrial and engineering companies.

The findings of this study indicate that managerial factors (C3) carried the highest weight among all the criteria affecting workforce productivity. Within this category, leadership style (C35)

emerged as the most significant sub-criterion, highlighting the critical role of leadership approaches in motivating and guiding employees. For managers, this suggests that focusing on leadership development, improving motivational strategies, and increasing employee participation in decision-making processes are essential for driving workforce productivity.

Socio-psychological factors (C5) were ranked second in importance, with job satisfaction (C53) and sense of belonging to the organization (C51) being key sub-criteria. These results emphasize that fostering a healthy and supportive work environment, along with ensuring employee satisfaction, is pivotal in enhancing workforce productivity. Managers should prioritize creating an environment that promotes job security, social support, and a positive work atmosphere to retain and motivate their employees.

Economic factors (C1) and individual factors (C4) also played significant roles, particularly the importance of competitive wages and aligning employees' personal interests with their job roles. This insight is crucial for managers, suggesting that providing competitive compensation, performance-based rewards, and ensuring alignment between personal interests and job responsibilities can substantially improve employee performance and satisfaction.

In conclusion, the results underscore the importance of adopting a comprehensive and balanced approach to workforce management. Addressing factors such as leadership style, socio-psychological well-being, and economic incentives will help companies create a productive, engaged, and satisfied workforce.

6. Conclusions

This study successfully identified and prioritized the key factors affecting workforce productivity using the Grey Delphi and Grey DEMATEL methods. The results indicate that managerial factors, especially leadership style and employee motivation, along with socio-psychological factors such as job satisfaction and sense of belonging, play the most significant roles in enhancing workforce productivity. Economic factors (e.g., salary and benefits) and individual factors (e.g., alignment between personal interests and job roles) also contribute significantly to productivity. These findings provide valuable insights for managers, enabling them to design targeted strategies that can improve workforce performance and organizational efficiency.

This study has some limitations. The sample is limited to a single private industrial and engineering company in Iran, which may restrict the generalizability of the findings to other contexts or countries. Additionally, the study relied on inputs from a limited number of decision-makers, which may affect the robustness of the results. Moreover, the study focused primarily on certain factors and did not extensively consider environmental or cultural factors, which could also influence workforce productivity.

Future research could extend this study to other industries and companies to assess whether the identified factors have a similar impact on workforce productivity across different sectors. Additionally, comparing the findings with those of companies in other countries or regions would provide a broader understanding of how cultural, economic, and managerial differences shape workforce productivity. Further studies could also incorporate a larger sample of decision-makers to increase the reliability of the results. Exploring additional factors, such as environmental and

technological influences, could offer a more holistic view of the factors impacting workforce performance.

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