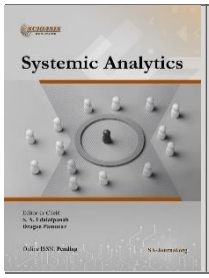

System Analytics

www.sa-journal.org

Syst. Anal. Vol. 2, No. 1 (2024) 14–26

Paper Type: Original Article

# Evaluation of Total Quality Management Enablers Using the DEMATEL-ISM Integration Method in the Steel Industry

**Seyyed Fatemeh Faghidian[1,*], Sara Mahmodi[2]**

[1] Department of Industrial Engineering, Science and Research Branch, Islamic Azad University, Tehran, Iran; f.faghidian@yahoo.com.

[2] Department of Industrial Engineering, Foulad Institute of Higher Industrial Education, Isfahan, Iran; sara1371mahmoodi@gmail.com.

**Citation:**

| | |
|---|---|
| *Received: 14 March 2023*<br>*Revised: April 2023*<br>*Accepted:02/05/2023* | Faghidian, S. F., & Mahmodi, S. (2024). Evaluation of total quality management enablers using the DEMATEL-ISM integration method in the steel industry. *System analytics,* 2(1), 14-26. |

## Abstract

Quality is an abstract concept that is included in production planning and management among industrial competitions, and its result in customer satisfaction and gaining market share has led to significant economic consequences for the organization. The present study sought to extract the enablers of Total Quality Management (TQM) in the steel industry, aiming to analyze the relationships between them using the DEMATEL-ISM integration method effectively, which can understand the complex correlations between the influencing factors and by using them and provide a hierarchical relational diagram of the effective factors. Thus, the importance of factors and quantifying the causal relationships among them were discussed. Eleven enablers were extracted, and their relationships were modeled at five levels. The first level includes the four enablers of resource management, standardization of processes and management, performance measurement, regular review of customer satisfaction, and conducting quality audits, and the fifth level includes commitment and management support. This study provided strong evidence to the management of steel industries to rationally develop strategies by considering the influence of enablers.

**Keywords:** Total quality management, Enablers, DEMATEL-ISM, Steel industry.

## 1 | Introduction

The intense competitive environment has accelerated business environment changes, making them more challenging. Total Quality Management (TQM) has been introduced as a superior strategy to achieve excellence and sustainable competitive advantage, and it has also followed a rapid expansion [1]. Due to its systematic approach to achieving the organization's strategic goals has become an essential factor for growth

Corresponding Author: f.faghidian@yahoo.com

https://doi.org/10.31181/sa2120246 0

and development in production and service organizations [2]. Here, some of its different applications are mentioned: the adaptation of quality management of Industry 4.0 [3]; integration of the two concepts of Environmental, Social, and Governance (ESG) and TQM, which promises a sustainable and progressive world [4]; its effective implementation for ISO certified construction companies [5]; its application in renewable energy projects and its integration with the concept of responsible managers' role [6], reduction of environmental impacts in the green supply chain [7]; its integration with the industry of intelligent transportation systems [1]; examining the performance of the organization considering TQM and social responsibility [8]; and the influence and power of TQM in organizations as a way to improve the quality of human resources [9].

What was stated is an example of comprehensive attention to this concept and its effective performance in planning, assurance, control, and quality improvement, turning it into a broad and open concept aiming to meet customer expectations. Despite many articles in this field, the successful implementation of TQA depends on its essential factors. This research seeks to identify and evaluate TQA enablers in the steel industry. Among Iran's industries, the steel industry has grown significantly, and steel companies have defined their values in terms of improving quality and employee participation in the decision-making process, customer orientation, and paying attention to the demands and needs of service recipients. In their significant goals, the establishment and maintenance of quality management systems based on ISO series standards and the promotion of quality management systems and service and customer satisfaction are defined. Since TQM is an organizational strategy that provides high-quality services and products to customers through quantitative and qualitative methods, identifying and evaluating TQM enablers can help realize the organization's goals.

Identifying the TQM enablers and screening them by the Delphi technique, the present study combined the Decision-Making Trial and Evaluation Laboratory (DEMATEL) and Interpretive Structural Modeling (ISM) to integrate the advantages of the two models as proper techniques in analyzing a large number of direct and indirect related factors [10]. Analyzing the integrated model is effective for complex systems from the view of mutual relations [11]. DEMATEL is a structured approach based on graph and matrix theory [12], and ISM is a structured approach that represents the relationships between factors through a hierarchical diagram [13].

Since most of the research on TQM enablers has been done with other decision-making methods, the use of this method is considered an innovation of this research, and it is also a promising part of case analysis for enablers, which can greatly help senior managers in formulating effective strategies in realizing the goals of the organization. Some research on the TQM enablers has been done in service industries and communication and information technology with few multi-criteria decision-making methods [14]–[17]. From their results, it can be concluded that using more comprehensive methods to analyze the results can bring more beneficial management consequences.

The article is organized as follows: Section 2 discusses the theoretical background, including examining the enablers' concepts. Section 3 of the research methodology is briefly described in DEMATEL-ISM. Section 4 includes research findings and model implementation results. After that, in the last part, the discussion and conclusions about the model's results are discussed.

## 2 | Review of Literature

In this section, the literature of this field is reviewed to extract the TQM enablers.

### 2.1 | TQM Enablers

Enabler means enabling or giving power, competence, or ability and is a variable that can create and maintain sustainability in TQM [15]. They provide results that motivate innovation and learning in the field under investigation. They increase performance and help the organization to achieve excellence [17]. TQM enablers

have been identified as a long-term commitment in the industry [18]. Previous studies have investigated the enablers of TQM implementation in different industries, and they can be considered responsible for obtaining better results and successful TQM implementation; therefore, they have high reliability [14]. With a critical review of the literature, the enablers can be grouped into five main categories, and the criteria of each of them are described and expressed in the following.

### 2.1.1 | Leadership-based enablers

Leadership-based enablers are defined as dividing power, assigning autonomy, and enforcing responsibilities to employees through implementing a series of leader behaviors [19]. Issues related to enablers are not only raised at the level of employees but the role of empowering leaders in improving the performance of organizations and employees has been investigated in many studies [20]–[22]. This type of enabler at the management level can increase productivity and subsequently improve the organization's performance by increasing employees' self-esteem [19].

When managers have enough confidence in the expertise of their employees, its effect can be seen well in employees' decisions [20]. Empowering leadership emphasizes the autonomy of employees [23]. Enforcing the authority of managers to lower levels and making the right decisions for employees gives higher-level managers more time and energy to deal with strategic issues, leading to the growth and prosperity of managers and employees, thus affecting the performance of leaders [20]. It is important to note that although empowering leadership behaviors cannot motivate employees to work harder, they can significantly motivate them to work smarter [24]. When employees are supported by management, it enables them to perform well in their jobs [25]. Based on what was said in this category, two TQM enablers are employed: creating commitment and management support [18], [26]–[33], leadership style, and change in organizational culture [18], [28], [32], [34]–[36].

### 2.1.2 | Resources and competency development-based enablers

Resources support the implementation of TQM programs, reflecting the organization's ability to use different and available resources and quality management tools [37]. The organization must train employees to use quality management methods and tools [5]. There is a deep and significant relationship between the factors of TQM technical and executive training in employee retention and satisfaction [29]. Also, employees must invest more resources to achieve defined goals [38], [39].

The development and attraction of employees committed to the organization's goals can be effective in implementing TQM. In this enabler, the effectiveness of human resources is discussed in terms of recruitment, training and development, communication, safety, and workforce satisfaction [40]. Many studies have been done about the recruitment process and its impact on organizational performance, and all of them emphasize that a good recruitment process leads to better adaptation of employees and their excellent performance and satisfaction [41]. Upgrading and improving available human resources is essential for companies to bring themselves the power to compete with others. Hence, the TQM implementation strategy can be crucial in human enablers [9]. TQM practices should be considered to allocate resources and continuously improve performance properly [42]. For this category, two enablers, resource management [18], [28], [34]–[36], [43] and personnel management [18], [28], [40] are considered.

### 2.1.3 | Process management-based enablers

This category plays a vital role in accepting new techniques such as process improvement, standardization, and knowledge development [31]. Quality must be built throughout the process - quality is not the result of random variation. It must focus on the process, which stems from the principle of prevention rather than correcting mistakes. In this case, the error dispersion of the production process is reduced to the minimum value [9]. Therefore, the responsibility for quality must be distributed among all departments and employees and in all methods [7]. With these explanations, two enablers have been considered for this category: the

implementation of the training program and the implementation of TQM training [18], [28], [30], [31] and the standardization of processes and management [18], [33]–[36], [40].

### 2.1.4 | Teamwork and participation-based enablers

Teamwork and empowering management, employees, and suppliers are among the factors that influence the successful implementation of TQM. The dynamic nature of work groups and the correct understanding of what happens in them is a challenge that can significantly contribute to the organization's excellence in the case of appropriate situations [44]. There is a direct and significant relationship between the performance of employees and TQM [45]. Information sharing facilitates problem-solving in teamwork [17]. Knowledge sharing affects the organization's employees in different ways and will lead to achieving the desired results for the organization [46]. Knowledge and participation will play an essential role in the creativity and excellence of employees' performance [46]. Therefore, two enablers have been considered for this category: teamwork development [18], [26], [28], [30] and employee relations [18], [29], [30], [40].

### 2.1.5 | Continuous improvement based enablers

As a philosophy, continuous quality improvement is necessary to gain a competitive advantage and ensure the success and better performance of the organization [47]. If an organization is not committed to continuous improvement due to lack of awareness of its basic concepts, TQM will not necessarily improve its performance and excellence [48]. Continuous improvement and customer satisfaction are closely related - through interaction with customers, not only will their needs be met, but beyond what customers want will be identified and provided by the company. As a result, it will guarantee the satisfaction and loyalty of customers to the company. Changing the direction of work to improve performance in the short term, maintain profits, and increase efficiency in the long time is a continuous improvement mechanism [49].

It should be noted that continuous improvement is a common task throughout the organization, including production line operators, sales and marketing officials who are in close contact with customers, and senior management. Gaining customer satisfaction leads to more market share [16]. Three criteria are considered for this category: regular review of customer satisfaction and quality audit [18], [28], [30], [33], [34] customer feedback [18], [27], [34], [50] and performance measurement [18], [26], [33], [36].

# 3 | Methodology

TQM enablers were extracted through comprehensive and critical literature. The Delphi technique is used to screen them, and to level the enablers, the combined method of DEMATEL-ISM is used. The statistical population of this study includes ten experts who are familiar with TQM concepts, have work experience of ten years or more, and have at least a bachelor's degree. In choosing them, they tried to have work experience in steel companies' Research and Development (R&D) departments. The tool for collecting information is a questionnaire. In the following, the methods employed in the study are described.

## 3.1 | Delphi Method

This method is based on the consensus of experts, and it is a structured process for classifying and collecting existing knowledge among experts in a research field. In this method, data is collected through a questionnaire, and controlled feedback is given on the answers. The Delphi technique is one of the most widely used methods to identify and screen decision-making indicators. It is a univariate analysis tool that facilitates communications among experts.

## 3.2 | DEMATEL-ISM Integration Method

The DEMATEL technique is used to discover causal and logical correlations between factors in complex systems based on expert judgment. ISM is a similar method that expresses the structured model of agents in terms of visual multilevel structural relationships [51]. Both techniques are used for deep analysis of problems

and have been used separately in past studies. Since both have their focus when used independently, they may not provide a comprehensive and accurate answer to the mechanisms affecting system performance. Therefore, their combined method that provides more accurate results is used [10]–[13], [51], [52]. More developed models have also been introduced to combine them [53], [54]. According to its requirements and assumptions, the model presented by Wang et al. [55] was used in the present study. According to this method, the output of the DEMATEL method will be used as the input of the ISM method. The technique is described below:

I. Establishing the direct correlation matrix M: using the 5-point Likert scale (0 to 4). The pairwise influence of the criteria on each other is measured. Then, the arithmetic mean of the scores of all the expert questionnaires is calculated for each pair of mutual elements to build the M matrix. n represents the number of factors, and $a_{ij}$ shows the degree of influence of factor i on factor j.

$$M=\begin{pmatrix} a1n & \cdots & ann \\ \vdots & \ddots & \vdots \\ an1 & \cdots & ann \end{pmatrix}. \quad \textbf{(1)}$$

II. Calculating the normalized direct relation matrix N: For this purpose, the coefficient k is multiplied by the matrix M.

$$N= K* M =\left(\frac{1}{\max\sum_{j=1}^{n} x_{ij}}\right)*M, \qquad 1\leq x\leq n. \quad \textbf{(2)}$$

III. Calculating the full correlation matrix T: considering I as a matrix of the same order as the matrix N.

$$T=N\,(I-N)^{-1}. \quad \textbf{(3)}$$

IV. Calculating the degree of influence ($D_i$), degree of being influenced ($C_i$), degree of centrality ($M_i$), and degree of cause ($R_i$): for each factor in the complete correlation matrix, the named degrees are calculated according to the following formula:

$$D_i=\sum_{j=1}^{n} t_{ij}, \quad (i=1,2,\ldots\ldots,n),$$

$$C_i=\sum_{j=1}^{n} t_{ji}, \quad (i=1,2,\ldots\ldots,n),$$

$$M_i=D_i + C_i,$$

$$R_i= D_i - C_i. \quad \textbf{(4)}$$

V. Calculating the overall influence matrix H: if I is considered an identity matrix, the matrix H is calculated as follows:

$$H= T + I. \quad \textbf{(5)}$$

VI. Determining the reachability matrix K: This step requires the introduction of the threshold value $\lambda$, whose value is determined based on the opinion of experts. Its introduction aims to remove influence relations with a low degree of influence, simplify the system structure, and facilitate the division of the hierarchical structure [51].

$$K_{ij}=\begin{cases} 1, & h_{ij} \geq \lambda \ (i, j=1,2,3,\ldots\ldots,n), \\ 0, & h_{ij} < \lambda \ (i, j=1,2,3,\ldots\ldots,n). \end{cases} \quad \textbf{(6)}$$

VII. Hierarchical division: based on the reachability matrix, the set of input (prerequisite) and output (achievement) criteria is calculated for each criterion. Then, the common factors are determined. At this stage, the criterion has the highest level: the output set (reachability) equals the common set. After identifying this variable or variables, their rows and columns are removed from the table, and the operation is repeated on other criteria.

# 4 | Findings

After extracting the enablers of TQM to match and localize them with the field of research, a questionnaire was designed and provided to the experts to rate each indicator based on a five-point Likert scale (0 to 4). It should be noted that experts have confirmed the validity of the questionnaire, and its final value has been confirmed with Cronbach's alpha 0.735. After completing the questionnaires once, the average scores for each index were determined, and if the average score was less than three, the index was eliminated. All scores were above three in these calculations, so no indicator was removed. This result was not far from the expectation because the indicators were extracted with a critical background review. *Table 1* shows the indicators and their average scores.

**Table 1. The results of the Delphi technique.**

| Code | Indicators | Mean Scores |
|---|---|---|
| C1 | Management commitment and support | 4.1 |
| C2 | Regular customer satisfaction reviews and audits | 3.5 |
| C3 | Personnel management | 3.6 |
| C4 | Employee relations | 3.7 |
| C5 | Implementation of training program and implementation of TQM training | 3.5 |
| C6 | Performance evaluation | 3.8 |
| C7 | Development of teamwork | 3.9 |
| C8 | Changes in organizational culture | 3.8 |
| C9 | Standardization of processes and management | 3.8 |
| C10 | Resource management | 3.3 |
| C11 | Customer feedback | 3.4 |

## 4.1 | DEMATEL-ISM Method Results

First, ten selected experts were asked to determine the impact of each criterion on the other based on a 5-point Likert scale (0 to 4) through the questionnaire provided to them. Then, their opinions were merged with the arithmetic mean method. In this way, the direct correlation matrix (M) is formed, and after normalizing it, to calculate the complete correlation matrix by considering the matrix (I), the matrix T was calculated with the following values:

**Table 2. Complete correlation matrix T.**

| | C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 | C9 | C10 | C11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| C1 | 0.082 | 0.278 | 0.210 | 0.213 | 0.185 | 0.287 | 0.212 | 0.188 | 0.254 | 0.218 | 0.238 |
| C2 | 0.043 | 0.075 | 0.121 | 0.056 | 0.054 | 0.148 | 0.070 | 0.049 | 0.143 | 0.077 | 0.074 |
| C3 | 0.098 | 0.230 | 0.090 | 0.137 | 0.127 | 0.240 | 0.178 | 0.157 | 0.184 | 0.146 | 0.183 |
| C4 | 0.076 | 0.210 | 0.121 | 0.062 | 0.083 | 0.170 | 0.115 | 0.140 | 0.139 | 0.098 | 0.147 |
| C5 | 0.094 | 0.252 | 0.173 | 0.160 | 0.076 | 0.237 | 0.133 | 0.143 | 0.180 | 0.180 | 0.197 |
| C6 | 0.081 | 0.216 | 0.151 | 0.129 | 0.166 | 0.127 | 0.126 | 0.137 | 0.151 | 0.138 | 0.164 |
| C7 | 0.101 | 0.217 | 0.135 | 0.164 | 0.120 | 0.225 | 0.075 | 0.105 | 0.178 | 0.136 | 0.145 |
| C8 | 0.097 | 0.186 | 0.096 | 0.089 | 0.073 | 0.185 | 0.112 | 0.061 | 0.148 | 0.119 | 0.140 |
| C9 | 0.097 | 0.179 | 0.096 | 0.110 | 0.066 | 0.189 | 0.086 | 0.111 | 0.082 | 0.115 | 0.113 |
| C10 | 0.064 | 0.151 | 0.053 | 0.066 | 0.058 | 0.124 | 0.067 | 0.067 | 0.125 | 0.046 | 0.058 |
| C11 | 0.069 | 0.173 | 0.078 | 0.077 | 0.085 | 0.154 | 0.064 | 0.095 | 0.125 | 0.131 | 0.061 |

You can draw the following *Fig. 1* by calculating the values of the correlation vector and the superiority vector that are announced in *Table 3*.

Table 3. Importance and effectiveness of criteria.

| | D | R | D+R | D-R | Criterion Type |
|---|---|---|---|---|---|
| C1 | 2.364 | 0.904 | 3.267 | 1.460 | Cause |
| C2 | 0.910 | 2.169 | 3.079 | -1.258 | Effect |
| C3 | 1.771 | 1.323 | 3.094 | 0.447 | Cause |
| C4 | 1.362 | 1.262 | 2.624 | 0.100 | Cause |
| C5 | 1.825 | 1.094 | 2.919 | 0.731 | Cause |
| C6 | 1.585 | 2.086 | 3.671 | -0.501 | Effect |
| C7 | 1.602 | 1.237 | 2.839 | 0.364 | Cause |
| C8 | 1.306 | 1.253 | 2.559 | 0.054 | Cause |
| C9 | 1.245 | 1.710 | 2.955 | -0.465 | Effect |
| C10 | 0.878 | 1.405 | 2.283 | -0.527 | Effect |
| C11 | 1.114 | 1.520 | 2.634 | -0.406 | Effect |

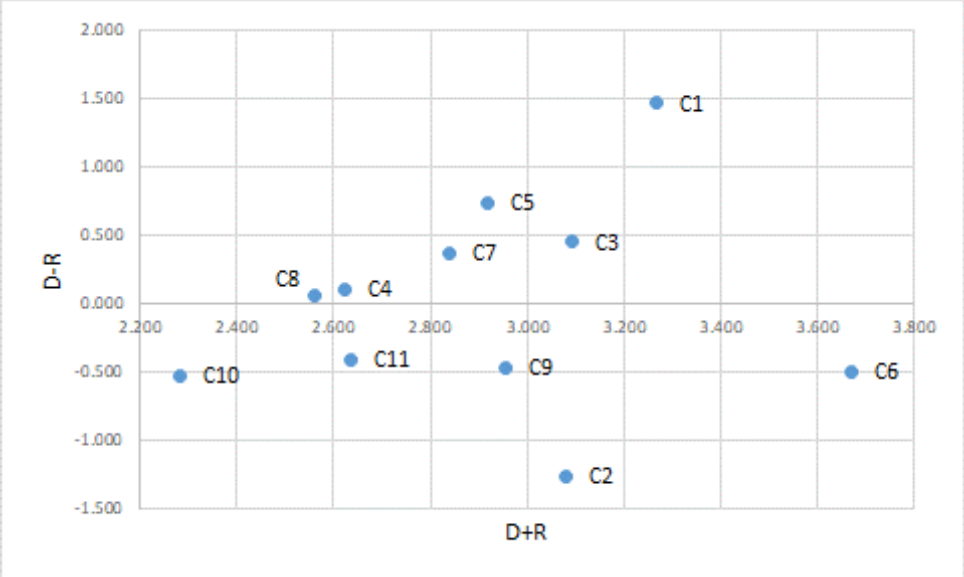


Fig. 1. Causal diagram of factors.

The DEMATEL method has been carried out up to this point according to the conventional procedure. Then, the ISM method was implemented, the input of which was the output of the DEMATEL method, and in this way, the effective levels were obtained using the DEMATEL relationships.

After completing the fifth and sixth steps, in this step, levels are determined with the hierarchy system. Table 4 determines the first level's criteria, including criteria C10, C9, C6, and C2.

Table 4. Level 1 criteria.

| Criterion | Output | Input | Subscription | Level |
|---|---|---|---|---|
| C1 | C1-C2-C3-C4-C5-C6-C7-C8-C9-C10-C11 | C1 | C1 | |
| C2 | C2-C3-C5-C6-C8-C9-C10-C11 | C1-C2-C3-C4-C5-C6-C7-C8-C9-C10-C11 | C2-C3-C5-C6-C8-C9-C10-C11 | 1 |
| C3 | C2-C3-C4-C5-C6-C7-C8-C9-C10-C11 | C1-C2-C3-C4-C5-C6-C7-C8-C9-C11 | C2-C3-C4-C5-C6-C7-C8-C9-C11 | |
| C4 | C2-C3-C4-C5-C6-C8-C9-C10-C11 | C1-C3-C4-C5-C6-C7 | C3-C4-C5-C6 | |
| C5 | C2-C3-C4-C5-C6-C7-C8-C9-C10-C11 | C1-C2-C3-C4-C5-C6-C7-C8-C9-C11 | C2-C3-C4-C5-C6-C7-C8-C9-C11 | |

| | | | | |
|---|---|---|---|---|
| C6 | C2-C3-C4-C5-C6-C7-C8-C9-C10-C11 | C1-C2-C3-C4-C5-C6-C7-C8-C9-C10-C11 | C2-C3-C4-C5-C6-C7-C8-C9-C10-C11 | 1 |
| C7 | C2-C3-C4-C5-C6-C7-C8-C9-C10-C11 | C1-C3-C5-C6-C7 | C3-C5-C6-C7 | |
| C8 | C2-C3-C5-C6-C8-C9-C10-C11 | C1-C2-C3-C4-C5-C6-C7-C8-C9-C11 | C2-C3-C5-C6-C8-C9-C11 | |
| C9 | C2-C3-C5-C6-C8-C9-C10-C11 | C1-C2-C3-C4-C5-C6-C7-C8-C9-C10-C11 | C2-C3-C5-C6-C8-C9-C10-C11 | 1 |
| C10 | C2-C6-C9-C10 | C1-C2-C3-C4-C5-C6-C7-C8-C9-C10-C11 | C2-C6-C9-C10- | 1 |
| C11 | C2-C3-C5-C6-C8-C9-C10-C11 | C1-C2-C3-C4-C5-C6-C7-C8-C9-C11 | C2-C3-C5-C6-C8-C9-C11 | |

It is enough to delete the rows and columns of these four criteria and perform the calculations to determine the output and input again to determine the criteria of the second level. *Table 5* illustrates the criteria of the second level, which includes C11, C8, C5, C3.

**Table 5. Level 2 criteria.**

| Criterion | Output | Input | Subscription | Level |
|---|---|---|---|---|
| C1 | C1-C3-C4-C5-C7-C8-C11 | C1 | C1 | |
| C3 | C3-C4-C5-C7-C8-C11 | C1-C3-C4-C5-C7-C8-C11 | C3-C4-C5-C7-C8-C11 | 2 |
| C4 | C3-C4-C5-C8-C11 | C1-C3-C4-C5-C7 | C3-C4-C5 | |
| C5 | C3-C4-C5-C7-C8-C11 | C1-C3-C4-C5-C7-C8-C11 | C3-C4-C5-C7-C8-C11 | 2 |
| C7 | C3-C4-C5-C7-C8-C11 | C1-C3-C5-C7 | C3-C5-C7 | |
| C8 | C3-C5-C8-C11 | C1-C3-C4-C5-C7-C8-C11 | C3-C5-C8-C11 | 2 |
| C11 | C3-C5-C8-C11 | C1-C3-C4-C5-C7-C8-C11 | C3-C5-C8-C11 | 2 |

The previous procedure is repeated, and *Table 6* shows the third criteria level, including C4.

**Table 6. Level 3 criteria.**

| Criterion | Output | Input | Subscription | Level |
|---|---|---|---|---|
| C1 | C1-C4-C7 | C1 | C1 | |
| C4 | C4 | C1-C4-C7 | C4 | 3 |
| C7 | C4-C7 | C1-C7 | C7 | |

The fourth and fifth-level criteria are extracted from *Table 7*. According to the results obtained, the research model is shown below (Fig. 2).

**Table 7. Level 4-5 criteria.**

| Criterion | Output | Input | Subscription | Level |
|---|---|---|---|---|
| C1 | C1-C7 | C1 | C1 | 5 |
| C7 | C7 | C1-C7 | C7 | 4 |

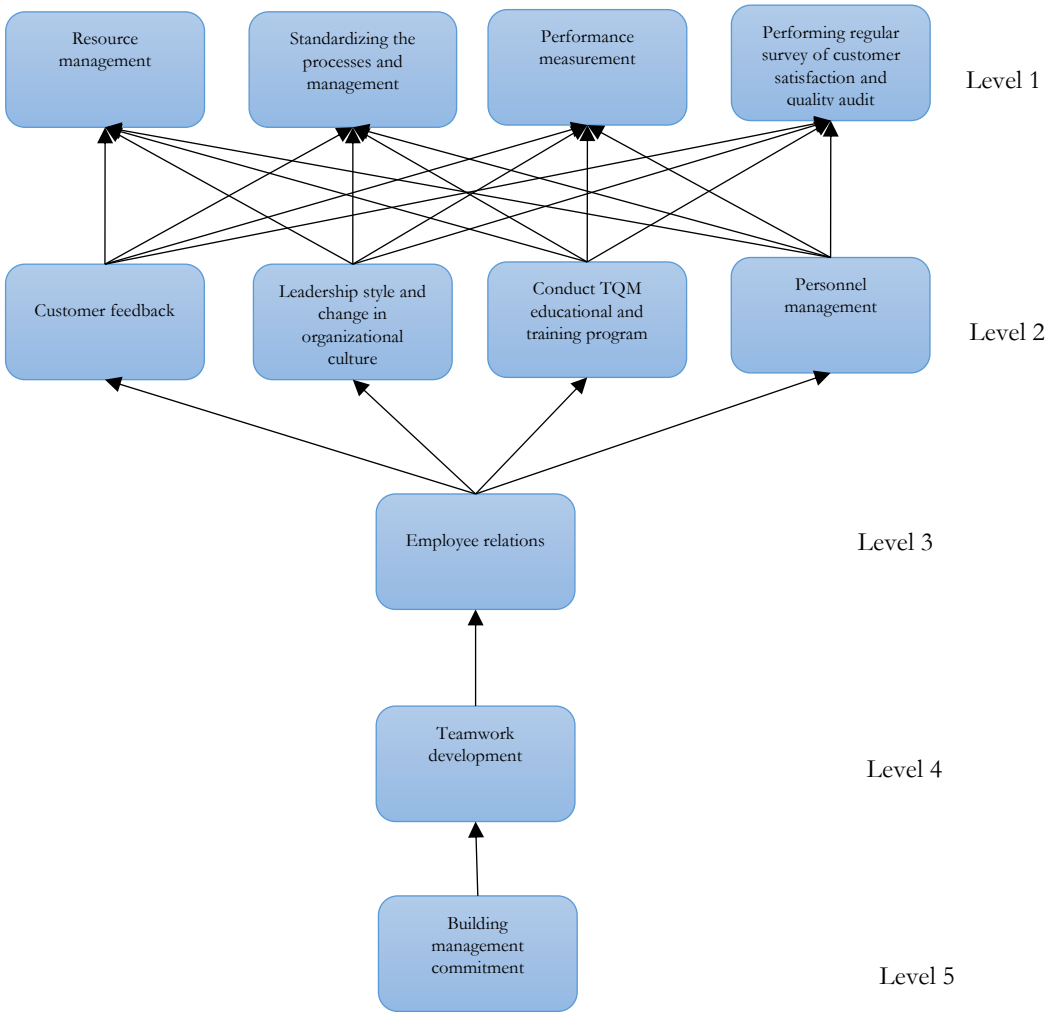


**Fig. 2. Hierarchical model of factors.**

## 5 | Discussion and Conclusion

Eleven TQM enablers appropriate to the industry investigated were extracted from this study's literature. ISM was employed to understand the contextual relations among the enablers correctly. The results show the importance of C1 and its presence in the fifth level as the most influential level in the hierarchical model. Empowered leadership by developing teamwork in a way that gives employees the power to make and implement decisions, increases their commitment and dependence on the organization and encourages them to make the right decisions. This way, we can expect work groups with less error deviation throughout the production stages and customer interaction. The effect of this procedure can be seen at the other levels in changing organizational culture and customer satisfaction. Establishing comprehensive quality management and the involvement of expert employees and resource management so that creative and motivated employees are involved in its implementation can help the organization excel, satisfy the customer, and lead to more market share and profit. It should be noted that this process should be continuously implemented and followed up in the organization. Management should maintain the quality of work performance of its organization at the desired level by providing implementation strategies.

Calculating the value of M according to its definition showed that C6, C1, C3, and C2 interact most with other system elements. The basic concept of TQM is continuous improvement, and its evaluation is through system performance measurement. This measurement includes management performance, employee satisfaction, and customer satisfaction. By calculating the value of $R<0$, the effective criteria are C8, C4, C7, C5, C3, and C1, which conforms to the TQM executive philosophy, and other criteria are also considered effective and ineffective.

The results of MICMAC analysis show that the enabler C6 is connected, and the enablers C8, C10, C11, C9, and C2 are dependent. After that, enablers C1, C5, C7, C3, and C4 are considered independent system factors. These results are consistent with the concepts of TQM enablers. Based on the results, it can be stated that the strong driving force of TQM implementation is the enabler of management, and paying attention to it can significantly affect the organization's performance.

Since the basis of this method is the subjective judgment of experts and the use of their empirical knowledge, it is suggested to use the mathematics of uncertainty and fuzzy methods in future research and compare the results with the present study. Considering the complexity of relations, using other integrated decision-making methods can be recommended for future research.

## Author Contribution

S. F. F. conceptualization, methodology, writing-creating the initial design, and Validation. S. M. investigation, formal analysis, writing, and editing. All authors have read and agreed to the published version of the manuscript.

## Funding

The authors declare that no external funding or support was received for the research.

## Data Availability

All data supporting the reported findings in this research paper are provided within the manuscript.

## Conflicts of Interest

The authors declare no conflict of interest concerning the reported research findings.

## References

[1] Akhmatova, M. S., Deniskina, A., Akhmatova, D. M., & Prykina, L. (2022). Integrating quality management systems (TQM) in the digital age of intelligent transportation systems industry 4.0. *Transportation research procedia*, *63*, 1512–1520.

[2] Nasim, K., Sikander, A., & Tian, X. (2020). Twenty years of research on total quality management in higher education: a systematic literature review. *Higher education quarterly*, *74*(1), 75–97.

[3] Souza, F. F., Corsi, A., Pagani, R. N., Balbinotti, G., & Kovaleski, J. L. (2022). Total quality management 4.0: adapting quality management to Industry 4.0. *The TQM journal*, *34*(4), 749–769.

[4] Lim, W. M., Ciasullo, M. V., Douglas, A., & Kumar, S. (2022). Environmental social governance (ESG) and total quality management (TQM): a multi-study meta-systematic review. *Total quality management & business excellence*, 1–23.

[5] Budayan, C., & Okudan, O. (2022). Roadmap for the implementation of total quality management (TQM) in ISO 9001-certified construction companies: evidence from Turkey. *Ain shams engineering journal*, *13*(6), 101788. https://doi.org/10.1016/j.asej.2022.101788

[6] Hussain, T., Wang, D., & Benqian, L. (2023). Examining the role of responsible management, CSR, and TQM in enhancing renewable energy projects: an empirical analysis. *Acta ecologica sinica*. https://doi.org/10.1016/j.chnaes.2023.06.010

[7] Akhmatova, M. S., Deniskina, A., Akhmatova, D.-M., & Kapustkina, A. (2022). Green SCM and TQM for reducing environmental impacts and enhancing performance in the aviation spares supply chain. *Transportation research procedia*, *63*, 1505–1511.

[8] Tsou, Y. H., Huang, Y. F., Liu, S. C., & Do, M. H. (2021). The effects of total quality management and corporate social responsibility on firm performance: a future research Agenda. *The journal of Asian finance, economics and business*, *8*(4), 277–287.

[9] Arifin, S., Darmawan, D., Hartanto, C. F. B., & Rahman, A. (2022). Human resources based on total quality management. *Journal of social science studies (JOS3)*, *2*(1), 17–20.

[10] Trivedi, A., Jakhar, S. K., & Sinha, D. (2021). Analyzing barriers to inland waterways as a sustainable transportation mode in India: a DEMATEL-ISM based approach. *Journal of cleaner production*, *295*, 126301. https://doi.org/10.1016/j.jclepro.2021.126301

[11] Yu, S., Geng, X., He, J., & Sun, Y. (2023). Evolution analysis of product service ecosystem based on interval Pythagorean fuzzy DEMATEL-ISM-SD combination model. *Journal of cleaner production*, *421*, 138501. https://doi.org/10.1016/j.jclepro.2023.138501

[12] Huo, T., Cong, X., Cheng, C., Cai, W., & Zuo, J. (2023). What is the driving mechanism for the carbon emissions in the building sector? an integrated DEMATEL-ISM model. *Energy*, *274*, 127399. https://doi.org/10.1016/j.energy.2023.127399

[13] Shen, J., Li, F., Shi, D., Li, H., & Yu, X. (2018). Factors affecting the economics of distributed natural gas-combined cooling, heating and power systems in China: a systematic analysis based on the integrated decision making trial and evaluation laboratory-interpretative structural modeling (DEMATEL-ISM). *Energies*, *11*(9), 2318. https://doi.org/10.3390/en11092318

[14] Talib, F., Asjad, M., Attri, R., Siddiquee, A. N., & Khan, Z. A. (2019). Ranking model of total quality management enablers in healthcare establishments using the best-worst method. *The TQM journal*, *31*(5), 790–814. https://doi.org/10.1108/TQM-04-2019-0118

[15] Khanam, S., Siddiqui, J., & Talib, F. (2015). Modelling the TQM enablers and IT resources in the ICT industry: an ISM-MICMAC approach. *International journal of information systems and management*, *1*(3), 195–218.

[16] Prakash, C., Barua, M. K., & Balon, V. (2015). Prioritizing TQM enablers to improve Indian airlines performance under fuzzy environment. *Industrial engineering journal*, *8*(8), 28–34.

[17] Khanam, S., Siddiqui, J., & Talib, F. (2016). A DEMATEL approach for prioritizing the TQM enablers and IT resources in the Indian ICT industry. *International journal of applied management sciences and engineering (IJAMSE)*, *3*(1), 11–29.

[18] Talib, F., & Rahman, Z. (2010). Critical success factors of TQM in service organizations: a proposed model. *Services marketing quarterly*, *31*(3), 363–380.

[19] Peng, J., Nie, Q., & Chen, X. (2023). Managing hospitality employee cyberloafing: the role of empowering leadership. *International journal of hospitality management*, *108*, 103349. https://doi.org/10.1016/j.ijhm.2022.103349

[20] Lin, M., Ling, Q., Zhang, L., Cui, X., & Zhang, Z. (2022). The effects of manager role stress on job thriving of both employees and managers through empowering leadership. *Tourism management*, *92*, 104545. https://doi.org/10.1016/j.tourman.2022.104545

[21] Sievers, F., Reil, H., Rimbeck, M., Stumpf-Wollersheim, J., & Leyer, M. (2021). Empowering employees in industrial organizations with IoT in their daily operations. *Computers in industry*, *129*, 103445. https://doi.org/10.1016/j.compind.2021.103445

[22] Peng, J., Yang, X., & Huan, T. C. (2022). The effects of empowering leadership on employee adaptiveness in luxury hotel services: evidence from a mixed-methods research. *International journal of hospitality management*, *101*, 103113. https://doi.org/10.1016/j.ijhm.2021.103113

[23] Lee, A., Willis, S., & Tian, A. W. (2018). Empowering leadership: a meta-analytic examination of incremental contribution, mediation, and moderation. *Journal of organizational behavior*, *39*(3), 306–325.

[24] Rapp, A., Ahearne, M., Mathieu, J., & Schillewaert, N. (2006). The impact of knowledge and empowerment on working smart and working hard: the moderating role of experience. *International journal of research in marketing*, *23*(3), 279–293.

[25] Paillé, P., & Francoeur, V. (2022). Enabling employees to perform the required green tasks through support and empowerment. *Journal of business research*, *140*, 420–429.

[26] Hazilah Abd. Manaf, N. (2005). Quality management in Malaysian public health care. *International journal of health care quality assurance*, *18*(3), 204–216.

[27] Wang, C. H., Chen, K. Y., & Chen, S. C. (2012). Total quality management, market orientation and hotel performance: the moderating effects of external environmental factors. *International journal of hospitality management*, *31*(1), 119–129.

[28] Mohammad Mosadeghrad, A. (2014). Essentials of total quality management: a meta-analysis. *International journal of health care quality assurance*, *27*(6), 544–558.

[29] Ali, K. A. M., & Alolayyan, M. N. (2013). The impact of total quality management (TQM) on the hospital's performance: an empirical research. *International journal of services and operations management*, *15*(4), 482–506.

[30] Sweis, R. J., Al-Mansour, A., Tarawneh, M., & Al-Dweik, G. (2013). The impact of total quality management practices on employee empowerment in the healthcare sector in Saudi Arabia: a study of King Khalid Hospital. *International journal of productivity and quality management*, *12*(3), 271–286.

[31] Alolayyan, M. N. F., Mohd Ali, K. A., Idris, F., & Ibrehem, A. S. (2011). Advance mathematical model to study and analyse the effects of total quality management (TQM) and operational flexibility on hospital performance. *Total quality management & business excellence*, *22*(12), 1371–1393.

[32] Adjei, E., & Mensah, M. (2016). Adopting total quality management to enhance service delivery in medical records: exploring the case of the Korle-Bu Teaching Hospital in Ghana. *Records management journal*, *26*(2), 140–169.

[33] Duggirala, M., Rajendran, C., & Anantharaman, R. N. (2008). Patient-perceived dimensions of total quality service in healthcare. *Benchmarking: an international journal*, *15*(5), 560–583.

[34] Sadeh, E. (2017). Interrelationships among quality enablers, service quality, patients' satisfaction and loyalty in hospitals. *The TQM journal*, *29*(1), 101–117.

[35] Moreno-Rodri, J. M., Cabrerizo, F. J., Pérez, I. J., Marti, M. A. (2013). A consensus support model based on linguistic information for the initial-self assessment of the EFQM in health care organizations. *Expert systems with applications*, *40*(8), 2792–2798.

[36] Baidoun, S. D., Salem, M. Z., & Omran, O. A. (2018). Assessment of TQM implementation level in Palestinian healthcare organizations: the case of Gaza Strip hospitals. *The TQM journal*, *30*(2), 98–115.

[37] Wardhani, V., Utarini, A., van Dijk, J. P., Post, D., & Groothoff, J. W. (2009). Determinants of quality management systems implementation in hospitals. *Health policy*, *89*(3), 239–251.

[38] Sharma, P. N., & Kirkman, B. L. (2015). Leveraging leaders: a literature review and future lines of inquiry for empowering leadership research. *Group & organization management*, *40*(2), 193–237.

[39] Cheong, M., Spain, S. M., Yammarino, F. J., & Yun, S. (2016). Two faces of empowering leadership: enabling and burdening. *The leadership quarterly*, *27*(4), 602–616.

[40] Sabella, A. R., Kashou, R., & Omran, O. (2015). Assessing quality of management practices in Palestinian hospitals. *International journal of organizational analysis*, *23*(2), 213–232.

[41] Pandey, P., Agrawal, N., Saharan, T., & Raut, R. D. (2021). Impact of human resource management practices on TQM: an ISM-DEMATEL approach. *The TQM journal*, *34*(1), 199–228.

[42] Sweis, R. J., Elhawa, N. A., & Sweis, N. J. (2019). Total quality management practices and their impact on performance: case study of Royal Jordanian Airlines. *International journal of business excellence*, *17*(2), 245–263.

[43] Stewart, A. (2003). An investigation of the suitability of the EFQM excellence model for a pharmacy department within an NHS Trust. *International journal of health care quality assurance*, *16*(2), 65–76.

[44] Kanjanakan, P., Wang, P. Q., & Kim, P. B. (2023). The empowering, the empowered, and the empowerment disparity: a multilevel analysis of the integrated model of employee empowerment. *Tourism management*, *94*, 104635. https://doi.org/10.1016/j.tourman.2022.104635

[45] Kamble, S., Gunasekaran, A., & Dhone, N. C. (2020). Industry 4.0 and lean manufacturing practices for sustainable organisational performance in Indian manufacturing companies. *International journal of production research*, *58*(5), 1319–1337.

[46] Saffar, N., & Obeidat, A. (2020). The effect of total quality management practices on employee performance: the moderating role of knowledge sharing. *Management science letters*, *10*(1), 77–90.

[47] Jimoh, R., Oyewobi, L., Isa, R., & Waziri, I. (2019). Total quality management practices and organizational performance: the mediating roles of strategies for continuous improvement. *International journal of construction management*, *19*(2), 162–177.

[48] Oliveira, G. S., Corrêa, J. E., Balestrassi, P. P., Martins, R. A., & Turrioni, J. B. (2019). Investigation of TQM implementation: empirical study in Brazilian ISO 9001-registered SMEs. *Total quality management & business excellence*, *30*(5–6), 641–659.

[49] Van Aartsengel, A., & Kurtoglu, S. (2013). *A guide to continuous improvement transformation: concepts, processes, implementation*. Springer Science & Business Media.

[50] Kristianto, Y., Ajmal, M. M., & Sandhu, M. (2012). Adopting TQM approach to achieve customer satisfaction: a flour milling company case study. *The TQM journal*, *24*(1), 29–46.

[51] Chen, Y., Zhou, R., & Zhou, Y. (2022). Analysis of critical factors for the entrepreneurship in industries of the future based on DEMATEL-ISM approach. *Sustainability*, *14*(24), 16812. https://doi.org/10.3390/su142416812

[52] Xiahou, X., Wu, Y., Duan, T., Lin, P., Li, F., Qu, X., … Liu, J. (2022). Analyzing critical factors for the smart construction site development: a DEMATEL-ISM based approach. *Buildings*, *12*(2), 116. https://doi.org/10.3390/buildings12020116

[53] Feng, X., Li, E., Li, J., & Wei, C. (2023). Critical influencing factors of employees' green behavior: three-stage hybrid fuzzy DEMATEL--ISM--MICMAC approach. *Environment, development and sustainability*, 1–29. https://link.springer.com/article/10.1007/s10668-023-03364-0

[54] Chen, P., Cai, B., Wu, M., & Zhao, Y. (2022). Obstacle analysis of application of blockchain technology in power data trading based on improved DEMATEL--ISM method under fuzzy environment. *Energy reports*, *8*, 4589–4607.

[55] Wang, L., Cao, Q., & Zhou, L. (2018). Research on the influencing factors in coal mine production safety based on the combination of DEMATEL and ISM. *Safety science*, *103*, 51–61.