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Investigating readiness in the Iranian steel industry through six sigma combined with fuzzy delphi and fuzzy DANP

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A B S T R A C T

In today's competitive world, Six Sigma can serve as a corporate strategy to improve quality and reduce costs. Six Sigma is a comprehensive and flexible system for achieving, maintaining and maximizing organizational success, through an improved performance of processes. However, this tool can only be successful in organizations which are already prepared for Six Sigma implementation. This study investigated the readiness of an Iranian company, Tabarestan Steel Co., in terms of Six Sigma projects. In doing so, the study proposed a model designed for assessing the readiness of Six Sigma in organizations. To this end, primarily Six Sigma readiness indicators were identified through Fuzzy Delphi, by recourse to the experts' opinions. Next the interrelationships between the indicators were examined through the Fuzzy DEMATEL method. The internal links between the indicators were determined after the examination, and the degree of importance and the weights of the indicators were decided. Ultimately, three highly important dimensions were discovered that had a significant function in Six Sigma implementation (leadership and perspective, corporate strategy, and focus on the customer).

1. Introduction

The economic conditions in which businesses compete today require organizations and management systems to urgently rely on tools that can improve quality and adapt productions/services to rapidly developing situations. Many leading theorists and managers have specifically focused on the issue of quality in such demanding circumstances. Managers are usually confronted with critical conditions such as a shortage of capital, the need to cut costs, and the need to sell more products; in fact, an organization has to be directed in a changing and unstable economic situation. As a qualitative method, the Six Sigma method can have a positive effect on quality, cost reduction, and customer satisfaction, as well as the current leadership of major organizations worldwide (Salehi Sedghiani & Roustai, 2005). Most of the organizations that have successfully implemented Six Sigma deployments have devised a six-year plan. However, companies can benefit from these projects shortly after the start of the project

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if appropriate arrangements are made (NikFarjam & Norosana, 2009). The implementation of Six Sigma will help improve and maintain quality, eliminate waste, and increase profits (Rajkumar, 2014). Organizations must primarily recognize sources of change and then identify the causes of their emergence, to achieve the desired quality and to be able to lead product quality changes in the right direction. Although these changes may be great in number, it would be more plausible to focus on the most important and determinant factors (Khobyari, 2003). A lack of readiness for the implementation of Six Sigma will result in a sense of disappointment in employees, resistance and opposition (individual, organizational or even political) at different levels, and a tension that could hinder the continuous improvement process (Antony, 2014). Chandra (2008) believes that one of the reasons behind the failure of Six Sigma programs is a lack of proper implementation (Zgardy et al., 2010). Obviously, a model that can assess companies' readiness for Six Sigma deployment can considerably help managers in their decisions. Six Sigma programs have been widely appreciated and conducted in Iranian companies. As the background shows (e.g. Kazazi & Saroukhani, 2005), the use of Six Sigma programs in the Iranian industrial culture has been very effective, although the dynamics, patterns and mechanisms of Six Sigma projects in such companies remain issues to be further investigated.

The purpose of this study is to probe into the implementation of Six Sigma in an empirical context, Tabarestan Steel Co., in Iran. Besides shedding a new light on the practical aspects of Six Sigma projects, the study can guide Iranian managers on how to make better and more informed decisions about effective deployment of Six Sigma programs, with a view of their organizational constraints. The findings can inspire improvements in the implementation of Six Sigma, and can practically help remove many concerns of senior executives of Tabarestan Steel Co. As mentioned above, an evaluative procedure before fully investing in Six Sigma projects can provide a blueprint of the situation and show how prepared a company is for such projects. This research seeks to (a). design a model for Six Sigma deployment in companies, through the data gathered from Tabarestan Steel Co.; and (b) ultimately formulate a general guideline for consultants and strategists who need to assess the readiness of a company prior to investment in and activation of Six Sigma projects.

2. Theoretical Foundations

2.1. The Notion of Six Sigma

Six Sigma is a systematic and powerful methodology that uses various tools to improve the quality of processes, products and services (Norosana et al., 2013). Experts dealing with Six Sigma have made efforts to achieve a comprehensive and complete definition of this approach. In this section, some of the most important definitions of the notion are reviewed (Azar et al., 2008). Fogel defines Six Sigma as a clever blend of organizational knowledge, coupled with efficient statistical techniques to improve an organization's efficiency/effectiveness and to meet the real needs of clients (Azar et al., 2008). Mattis contends that the Six Sigma approach tends to accelerate organizational processes that are directed toward goals. This methodology can be used to formulate a set of objectives in the organization (ibid.). (a) encouraging team thinking; (b) creating skills and expertise; (c) making decisions based on facts; (d) making continuous measurement of results and making comparisons with formal organizations; and (e) securing the commitment of senior management. Six Sigma focuses on achieving the goals and criteria and the use of management systems which have to successfully complete projects and sustain long-term profitability. From a technical perspective, Six Sigma concentrates on performance improvement through process data and the use of statistical methods of improvement (Snee, 2000). Six Sigma traditionally tries to reduce costs, and studies have demonstrated that it can also serve as a methodology for increasing profit (Sodhi & Sodhi, 2005), improving quality (Chen & Lyu, 2009), stimulating creativity (Biedry, 2001), and boosting organizational learning and facilitating innovation (Byrne et al., 2007; El Haouzi et al., 2009) (see also Krueger et al., 2013). Six Sigma, then, seeks to continuously enhance the improvement process (Lagrosen et al., 2011).

2.2. Studies Concerned with Six Sigma

Henderson and Evans (2000) in a research into the implementation of Six Sigma in General Electric, explored the Six Sigma concept, its benefits, and successful approaches to implementing Six Sigma, especially the operations of General Electric as a pioneering company which introduced the whole notion. Henderson and Evans concluded that the key to success of the Six Sigma was the support and involvement of senior management, organizational structure, training, tools, and relationships with human resource operations.

Hensley and Dobie (2005) evaluated Six Sigma in services, developing a model to help service organizations assess their readiness for Six Sigma programs and to offer suggestions for introducing Six Sigma processes. In their study, two main indicators of organizational readiness were primarily identified through an exploration of the literature, and then an organizational preparedness framework was devised. Chakravorty (2009) addressed the implementation of Six Sigma in the US network technology services, constructing an effective implementation model through the Six Sigma program in a network technology company. This model consists of six steps. (a) conduct a strategic analysis into customers and the market; (b) establish a high-level team aimed at moving toward a primary improvement; (c) identify general improvement tools; (d) display the process map and prioritize improvement opportunities; (e) develop a detailed plan for low-level improvement teams; and (f) make implementation, documentation and revision. The first four phases include strategic decisions that fit into a top-down approach in which management is primarily involved in decision-making. The last two steps involve tactical decisions and follow a bottom-up approach in which engineers and technicians are involved in decision-making from the outset.

Lee et al. (2011) investigated Six-Sigma readiness through a self-assessment model for Chinese companies. They suggested that the main challenge for a successful Six Sigma implementation was readiness. Through this method, organizations could learn about their potentials and flaws in the implementation of Six Sigma. Lagrosen et al. (2011), investigating organizational learning and assessment of Six Sigma deployment preparedness, concluded that organizational learning could provide a framework for assessing the readiness of Six Sigma in an IT organization through a hybrid model they proposed. Probing into preparedness in the Lean Six Sigma (LSS) process in the Higher Education, Antony (2014) described the key factors for implementing Six Sigma. Anthony observed that a number of papers focused on Six Sigma literature to detect the importance of key success factors. The key factors were the essential components that increased the likelihood of success of any initial improvement project before the organization invested its resources. A lack of preparedness would lead to a sense of disappointment in employees, resistance and opposition (individual or organizational or political), and distress which could impede the path to continuous improvement. Finally, Antony concluded that LSS could be a powerful method for controlling process inefficiency in the higher education. Performance Innovation LLC has been working on a team of consultants for over 20 years to provide consultation and training concerned with management and process improvement. With the introduction of Six Sigma, along with leading industry engineering and development of leadership indicators, they help to improve the process. The company operates in the field of pure Six Sigma, leadership improvement, process management, and strategic management. The Six Sigma Readiness Assessment Tool is an effect product; Table 1 reports a summary of the variables for Six Sigma preparation, as observed in various studies in the literature. The items in Table 1 represent the measures that senior managers/directors and chief executives/leaders in an organization must take prior to Six Sigma implementation.

3. Research Methodology

This research was an applied, quantitative study based on the framework of analytic survey. The first statistical population of this research included academic experts with knowledge in field of Six Sigma. Twelve of them were selected through purposeful sampling. The second statistical population was composed of experts in the field of the steel industry (Tabarestan Steel Company). The census method was used to select a sample because of the low community size (12 individuals). The participants were senior managers, middle managers, and professional employees.

3.1. Delphi Fuzzy

In this study, the method proposed by Liu and Chen (2007) was used to implement the fuzzy Delphi analysis process. The process of this method involved the following steps.

Collet experts' opinions. First, the experts were asked to scrutinize the parameters influencing a given decision in terms of importance, using a qualitatively or, if possible, quantitatively scale (Very Important = 9; Important = 7; Relatively Important = 5; Minimally Important = 3; Not Important = 1).

Calculate fuzzy numbers. To calculate fuzzy numbers, α_{ij} values were considered, based on the opinions expressed by the experts (Ataei, 2010). Fuzzy numbers at this stage could be calculated based on different membership functions such as the triangular or trapezoidal state. Considering the high application and simplicity of the triangular method, a fuzzy number was defined through the following relations (Liu and Chen, 2007).

$$\alpha_{ij} = \left(\alpha ij\,,\ dij\,,\ gij\right) \tag{1}$$

$$\alpha_{ij} = \text{Min}\,(\text{b}_{ijk}), k = 1,2,.....,n \tag{2}$$

$$d_{ij} = (\prod_{k=1}^{n} b_{ijk}), k = 1,2,.....,n \tag{3}$$

$$g_{ij} = Max\,(b_{ijk}), k = 1,2,.....,n \tag{4}$$

where b_{ijk} is the relative importance of parameter i with respect to parameter j, K is experts' points of, α_{ij} and g_{ij} are the upper and lower limits of the queries, and d_{ij} is the geometric mean of the opinions of the respondents. The components of the fuzzy number were defined according to this format. α_{ij}, g_{ij}, $d_{ij.}$ The values of these components always fell within this range [9, 1.9].

Create a fuzzy inverse matrix. At this stage, according to the fuzzy numbers obtained in the previous step, the fuzzy pair matrix between the various parameters was described through the following relation (Liu and Chen, 2007). Partial fuzzy weight calculation parameters were used to calculate the relative weights of the parameters of the following relations.

$$A_{ij} = [a_{ij}], a_{ij} \times a_{ji} \approx 1, \forall_{i,j} = 1,2,3,..... \tag{5}$$

$$Z_i = [a_{ij} \otimes ....\otimes a_{ij}]^{-1} \tag{6}$$

$$W_i = Z_i\,(Z_i \oplus ....\oplus Z_n) \tag{7}$$

$$W_i = (\prod_{k=1}^{3n} W_{ij}) \tag{8}$$

where ⊗ is the symbol of the multiplication of fuzzy numbers, and ⊕ is the symbol of the sum of fuzzy numbers, and is a vector of a row representing the fuzzy weight of parameter i.

Calculate non-fuzzy weight parameters. In this step, in order to defuzzify the parameters, the geometric mean of the components of the fuzzy weights of the parameters was obtained; as such, the weights of the parameters were formulated as definite numbers (see Liu and Chen, 2007).

3.2. DEMATEL fuzzy method

The DEMATEL technique is a method for complex problems first introduced by American scientists between 1926 and 1972; this technique was built based on the theory of graph that was able to solve problems with a simple method. However, there was a problem with the DEMATEL technique, as it relied on a fuzzy DEMATEL technique, which made decisions in conditions of uncertainty. Fuzzy

DEMATEL makes it easy to make decisions in terms of environmental uncertainty through language variables. This technique can be easily applied to such fields as production, organization management, information systems, and environmental uncertainty (Zhou & et al. 2011). Furthermore, this technique can solve all problems that organizations confront in group decision-making under fuzzy conditions (Reyes et al., 2011). This method involves the following steps.

Create a matrix of direct relationships between system factors. Experts, using the linguistic variables, expressed their views about the mutual impact of the main factors on each other. By converting linguistic estimates into fuzzy numbers, the primary direct relation matrix $A = [a_{ij}]$ was created, in which A is the nonnegative matrix N × N, and the frame a_{ij} is a triangular fuzzy number representing the direct impact of factor i on factor j. When $i = j$, the diameter components of the matrix are zero (Cheng et al., 2009) ,

$$A = \begin{bmatrix} a_{11} & a_{1j} & a_{1n} \\ a_{i1} & a_{ij} & a_{in} \\ a_{n1} & a_{nj} & a_{nn} \end{bmatrix} \tag{9}$$

Gather the data and merge respondents' opinions. In this step, to determine the effect of each criterion on another, the symbol $0_{ij} = (1_{ij}, m_{ij}, u_{ij})$ was used to represent the respondents' comments on the effect of factor i on factor j. Where $i = j$ in the matrix, the number was zero. For every respondent, a matrix $n * n$ b, a with fuzzy frame, was defined as $O^{\sim p} = [O^{\sim p}{}_{ij}]$, where p is the number of respondents and n is the number of factors under investigation. As a result, $O^{\sim 1}$, $O^{\sim 2}$, $O^{\sim 3}$, ..., $O^{\sim p}$ were the matrices of responder p.

Make the initial decision matrix (O). From the simple average, the comments of all individuals with triangular fuzzy dimensions were $O_{ij} = (l_{ij}, m_{ij}, u_{ij})$ (Jassbi et al., 2010).

$$\tilde{O}_{ij} = \frac{1}{p} \sum_{p=1}^{p} \tilde{a}_{ij}^{p} \tag{10}$$

$$\tilde{O} = \begin{bmatrix} \tilde{o}_{11} & \tilde{o}_{12} & \tilde{o}_{13} & . & . & \tilde{o}_{1n} \\ \tilde{o}_{21} & \tilde{o}_{22} & \tilde{o}_{23} & . & . & \tilde{o}_{2n} \\ \tilde{o}_{31} & \tilde{o}_{32} & \tilde{o}_{33} & . & . & \tilde{o}_{3n} \\ . & . & . & . & . & . \\ . & . & . & . & . & . \\ \tilde{o}_{m1} & \tilde{o}_{m2} & \tilde{o}_{m3} & . & . & \tilde{o}_{mn} \end{bmatrix} \tag{11}$$

Calculate the normalized matrix. To create the normalized matrix, the following relations were utilized (Zhou et al., 2011).

$$Z_h^{\sim} = k \times O_h^{\sim} \qquad h = l, m, u$$

$$k = \min\left[\frac{1}{Max \sum_{j=1}^{n} |\tilde{o}_{ij}|}, \frac{1}{Max \sum_{i=1}^{n} |\tilde{o}_{ij}|}\right] \tag{12}$$

$$i, j \in \{1, 2, 3, ..., n\}$$

$$\tilde{z}=\begin{bmatrix}\tilde{z}_{11} & \tilde{z}_{12} & \tilde{z}_{13} & . & . & \tilde{z}_{1n}\\ \tilde{z}_{21} & \tilde{z}_{22} & \tilde{z}_{23} & . & . & \tilde{z}_{2n}\\ \tilde{z}_{31} & \tilde{z}_{32} & \tilde{z}_{33} & . & . & \tilde{z}_{3n}\\ . & . & . & . & . & .\\ . & . & . & . & . & .\\ \tilde{z}_{m1} & \tilde{z}_{m2} & \tilde{z}_{m3} & . & . & \tilde{z}_{mn}\end{bmatrix} \tag{13}$$

Create matrix V. Matrix V was calculated for every fuzzy limit (l''_{ij}, m''_{ij}, u''_{ij}) via.

$$l''_{ij}=\tilde{z}_l\times(I-\tilde{z}_l)^{-1} \tag{14}$$

$$m''_{ij}=\tilde{z}_m\times(I-\tilde{z}_m)^{-1} \tag{15}$$

$$u''_{ij}=\tilde{z}_u\times(I-\tilde{z}_u)^{-1} \tag{16}$$

Finally, each of the lower, middle, and upper triangles were bound together, as a result of which matrix $V^{\sim}$ was formulated.

$$\tilde{V}=\begin{bmatrix}\tilde{v}_{11} & \tilde{v}_{12} & \tilde{v}_{13} & . & . & \tilde{v}_{1n}\\ \tilde{v}_{21} & \tilde{v}_{22} & \tilde{v}_{23} & . & . & \tilde{v}_{2n}\\ \tilde{v}_{31} & \tilde{v}_{32} & \tilde{v}_{33} & . & . & \tilde{v}_{3n}\\ . & . & . & . & . & .\\ . & . & . & . & . & .\\ \tilde{v}_{m1} & \tilde{v}_{m2} & \tilde{v}_{m3} & . & . & \tilde{v}_{mn}\end{bmatrix} \tag{17}$$

Fuzzify non-fuzzy numbers. For this purpose, *i* and *j* were used, according to the following relations.

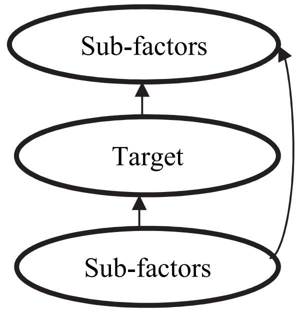
$$v=\frac{(l+4m+u)}{6} \tag{18}$$

As a result of which we have.

$$V=\begin{bmatrix}v_{11} & v_{12} & v_{13} & . & . & v_{1n}\\ v_{21} & v_{22} & v_{23} & . & . & v_{2n}\\ v_{31} & v_{32} & v_{33} & . & . & v_{3n}\\ . & . & . & . & . & .\\ . & . & . & . & . & .\\ v_{m1} & v_{m2} & v_{m3} & . & . & v_{mn}\end{bmatrix} \tag{19}$$

3.3. Fuzzy ANP method

The ANP Analytic network process proposed by Saaty (2004) deals with multi-criteria decision-making problems in which there is an interaction and interdependence among decision-making criteria (or opinions, sub-criteria). In the ANP technique, to demonstrate the existing dependencies of decision-making levels, a supermatrix is normally constructed. In this study, a grid and a supermatrix were used (see Fig. 1).



$$w = \begin{bmatrix} 0 & 0 & 0 \\ w_{21} & w_{22} & 0 \\ 0 & w_{32} & 1 \end{bmatrix}$$

Fig 1. The grid used in this research and its supermatrix

The first level of the network included the goals, and the second level addressed the main factors which had Zornian affiliations and were placed at the third level. In the supermatrix W, *W21* was the relative weight of the main factors with respect to the target node *W22*. The internal weight between the main *W32* factors was the weight of the subframes relative to their respective principal factors. The matrix T was the output of the DEMATEL method; after normalization, it was considered to be the matrix W22. To calculate *W21* and *W3,* pairwise comparisons were made. To calculate fuzzy numbers, α_{ij} values were considered. Expert opinions were processed directly (Ataei, 2010). Fuzzy numbers at this stage could be calculated based on different membership functions such as triangular or trapezoidal formats. Given the high application and simplicity of working with the triangular method, a fuzzy number was defined through the following relations (Liu & Chen, 2007).

$$\alpha_{ij} = \left(\alpha ij\, ,\ dij\, ,\ gij\right) \tag{20}$$

$$\alpha_{ij} = \text{Min}\ (\text{b}_{ijk}), k = 1,2,.....,n \tag{21}$$

$$d_{ij} = (\prod_{k=1}^{n} b_{ijk}), k = 1,2,.....,n \tag{22}$$

$$g_{ij} = Max\ (b_{ijk}), k = 1,2,.....,n \tag{23}$$

In the development analysis method, for each row of the pairwise comparison matrix, the S_k value, which was itself a triangular number, was calculated via.

$$S_k = \sum_{j=1}^{n} M_{kj} * \left[\sum_{i=1}^{m} \sum_{j=1}^{n} M_{ij} \right]^{-1}, \tag{24}$$

where *k* is the row number, while *i* and *j* indicate the options and indicators, respectively. In general, in the development analysis method, after the calculation of S_k, have to be obtained, the magnitude of items with respect to each other must be computed. If M_1 and M_2 are two triangular fuzzy numbers, the magnitude of M_1 over M_2, shown by $V(M_1 \geq M_2)$, is decided as follows.

$$\begin{Bmatrix} V\ (m_1 \geq m_2) = 1 \\ if m_1 \geq m_2 \\ V\ (m_1 \geq m_2 = hgt\,(m_1 \cap m_2) \\ otherwise \end{Bmatrix} \tag{25}$$

we have,

$$hgt(M_1 \cap M_2) = \frac{u_1 - l_2}{(u_1 - l_2) + (m_2 - m_1)} \tag{26}$$

The formula could also be computed through the equation below. The size of a triangular fuzzy number which is larger than of another triangular fuzzy number *k* is verified through Eq. (28).

$$V(M_1 \geq M_2,...,M_K) = V(M_1 \geq M_2),...,V(M_1 \geq M_K) \tag{27}$$

To make the weights of the indicators in the pairwise comparison matrix, relation 28 was used.

$$W'(x_i) = Min\{V(S_i \geq S_k)\}, \qquad k = 1,2,...,n. \qquad k \neq i \tag{28}$$

The weight vector of the indices was then formulated as follows,

$$W'(x_i) = [W'(c_1), W'(c_2),...,W'(c_n)]^T, \tag{29}$$

which is the vector of abnormal coefficients of the fuzzy analytic hierarchical process. Based on the following equation, the abnormal results obtained from the relation above are normalized. The normalized results were obtained through the following equation.

$$W_i = \frac{w_i'}{\sum w_i'} \tag{30}$$

where Factors is the vector of the abnormal coefficients of the fuzzy hierarchy process. Through the following relation, the results were obtained with a view to the above normal relation. The normalized results were calculated via.

$$w_c = BW \tag{31}$$

The complete solution to the network analysis process, and even the hierarchical analysis process, can only be used in a real and precise method when the number of criteria and options are limited.

4. Findings

The findings of the statistical and analytic procedures are divided into three parts, which are reported in the following sub-sections.

4.1. Part 1. Delphi Fuzzy Findings

In this sub-section, the indicators extracted from the literature were processed through the fuzzy Delphi, which involved four stages. In the first stage, according to the options shared, the difference between the two stages was less than the threshold value (0.1), in which case, the polling process was terminated (Cheng & Lin, 2002). The indicators were used for finalization and the final indicators were also found (see Table 1).

Table 1
Indicators extracted from the literature & their initial and finalized list

Readiness variables	1	2	3	4	5	6	7	8	9	10	11	12	first fuzzy number (MIN)	second fuzzy number (GEOMEAN)	third fuzzy number (MAX)	defuzzied [1]Number	First round	second round	third round	Forth round
1.	3	4	4	4	4	3	4	4	4	3	4	3	3	3.634241	4	2.90856	√			
2.	4	3	3	2	3	3	3	3	3	4	3	3	2	3.042777	4	1.760694	√			
3.	4	4	3	3	4	4	4	3	3	4	4	3	3	3.548152	4	2.887038	√			
4.	3	4	4	4	4	4	4	3	3	3	4	4	3	3.634241	4	2.90856	√			
5.	3	4	4	5	3	3	4	4	4	4	4	3	3	3.702453	5	2.675613	√			
6.	4	3	3	3	3	4	3	4	4	3	3	4	3	3.382043	4	2.845511				
7.	4	3	4	3	3	3	4	3	4	4	3	4	3	3.464102	4	2.866025				
8.	3	4	3	4	4	5	3	4	4	4	4	4	3	3.792287	5	2.698072				
9.	3	4	4	4	4	3	3	4	3	4	4	3	3	3.548152	4	2.887038	√			
10.	4	4	3	4	3	5	5	4	3	3	4	3	3	3.682594	5	2.670649				
11.	3	3	3	3	4	4	3	3	3	3	3	4	3	3.22371	4	2.805927				
12.	3	3	4	3	3	3	4	4	3	4	3	4	3	3.382043	4	2.845511				
13.	4	4	4	3	4	4	4	4	5	4	3	4	3	3.884299	5	2.721075	√			
14.	4	3	3	4	3	2	3	3	3	4	4	3	2	3.192223	4	1.798056				
15.	4	4	3	3	4	5	4	4	5	3	3	3	3	3.682594	5	2.670649	√			
16.	3	3	3	4	4	3	2	4	3	4	3	3	2	3.192223	4	1.798056	√			
17.	3	4	4	4	3	4	3	3	4	4	4	4	3	3.634241	4	2.90856	√			
18.	4	4	4	4	3	3	4	3	3	3	4	3	3	3.464102	4	2.866025				
19.	4	4	3	3	4	4	5	4	5	3	4	3	3	3.771946	5	2.692986	√			
20.	3	3	3	3	4	3	3	4	3	4	3	4	3	3.301927	4	2.825482				
21.	3	3	3	4	3	4	4	4	4	3	3	4	3	3.464102	4	2.866025				
22.	4	4	4	4	4	5	4	3	3	3	4	4	3	3.792287	5	2.698072	√			
23.	3	4	3	4	3	3	4	3	4	3	3	3	3	3.301927	4	2.825482				
24.	4	3	3	3	4	4	4	4	3	4	4	3	3	3.548152	4	2.887038	√			
25.	3	3	4	3	3	3	3	3	4	4	4	4	3	3.382043	4	2.845511				
26.	3	4	3	3	3	3	3	4	3	3	4	3	3	3.22371	4	2.805927				
27.	4	4	3	4	4	3	3	3	3	4	3	4	3	3.464102	4	2.866025				
28.	3	4	4	3	4	4	4	4	3	4	4	4	3	3.722419	4	2.930605	√			
29.	3	3	3	3	3	4	3	4	4	4	3	4	3	3.382043	4	2.845511	√			
30.	3	3	4	4	3	3	4	5	4	3	3	3	3	3.445521	5	2.61138				
31.	4	3	3	4	3	4	4	3	3	4	4	4	3	3.548152	4	2.887038	√			
32.	4	4	4	4	4	4	4	4	4	4	4	3	3	3.905246	4	2.976312				
33.	4	3	4	3	4	3	3	4	4	3	4	3	3	3.464102	4	2.866025	√			
34.	3	4	4	3	3	4	3	4	4	4	3	4	3	3.548152	4	2.887038	√			
35.	4	4	3	4	3	4	4	3	3	4	3	4	3	3.548152	4	2.887038	√			
36.	3	4	3	3	3	3	4	3	4	3	4	4	3	3.382043	4	2.845511				
37.	4	3	4	4	4	4	4	3	4	3	4	3	3	3.634241	4	2.90856	√			
38.	3	3	3	4	3	4	3	4	3	4	4	3	3	3.382043	4	2.845511	√			
39.	4	4	3	4	3	4	3	4	4	4	3	4	3	3.634241	4	2.90856	√			
40.	3	4	4	3	4	4	3	3	4	4	3	4	3	3.548152	4	2.887038	√			
41.	4	4	4	4	3	3	4	3	3	3	4	4	3	3.548152	4	2.887038	√			
42.	3	3	4	3	3	4	3	4	3	3	3	3	3	3.22371	4	2.805927				
43.	4	3	3	3	4	3	3	4	4	4	4	3	3	3.464102	4	2.866025	√			
44.	3	3	4	4	3	4	4	3	4	3	3	4	3	3.464102	4	2.866025				
45.	3	4	4	4	4	3	4	3	4	4	4	3	3	3.634241	4	2.90856				
46.	3	3	3	4	3	4	4	4	3	3	4	4	3	3.464102	4	2.866025				
47.	4	3	3	3	4	3	3	3	3	4	3	3	3	3.22371	4	2.805927				
48.	4	4	4	3	4	4	3	4	4	4	3	4	3	3.722419	4	2.930605				
49.	4	4	4	4	4	3	4	3	3	5	4	4	3	3.792287	5	2.698072				
50.	3	4	3	4	3	4	3	4	4	3	4	3	3	3.464102	4	2.866025				
51.	4	3	4	4	3	4	4	3	3	4	4	3	3	3.548152	4	2.887038				
52.	3	3	3	3	4	4	4	4	4	4	3	4	3	3.548152	4	2.887038				
53.	4	4	4	3	3	3	4	4	4	4	3	4	3	3.634241	4	2.90856	√			
54.	3	3	3	4	3	4	3	3	5	3	3	4	3	3.363902	5	2.590975	√			
55.	3	4	4	3	4	4	4	4	3	3	4	3	3	3.548152	4	2.887038				
56.	4	4	3	4	4	3	3	3	4	3	4	3	3	3.464102	4	2.866025				
57.	3	4	4	3	4	4	3	4	4	4	3	3	3	3.548152	4	2.887038				
58.	4	3	3	4	3	4	4	4	4	4	4	4	3	3.722419	4	2.930605	√			
59.	3	4	3	4	4	3	4	4	3	3	4	4	3	3.548152	4	2.887038	√			
60.	3	3	4	3	4	3	4	3	3	3	3	3	3	3.22371	4	2.805927	√			
61.	4	3	3	3	3	4	3	3	3	4	4	4	3	3.382043	4	2.845511	√			
62.	4	4	4	4	3	3	3	4	4	4	4	3	3	3.634241	4	2.90856				
63.	4	4	3	4	4	4	4	4	4	3	5	3	3	3.792287	5	2.698072		√		
64.	3	4	4	4	4	3	4	3	3	3	3	4	3	3.464102	4	2.866025		√		
65.	3	3	3	3	3	3	4	3	3	4	4	4	3	3.301927	4	2.825482		√		
66.	3	3	4	3	4	4	3	4	4	3	4	3	3	3.464102	4	2.866025				
67.	4	4	3	3	3	4	3	3	4	4	4	4	3	3.548152	4	2.887038				
68.	4	4	3	4	4	3	4	4	3	3	3	3	3	3.464102	4	2.866025		√		
69.	3	4	4	4	3	3	4	3	3	4	3	5	3	3.52912	5	2.63228		√		
70.	3	3	3	3	4	4	3	4	4	3	3	3	3	3.301927	4	2.825482		√		
71.	3	3	3	4	3	4	3	3	3	4	4	5	3	3.445521	5	2.61138				
72.	4	4	4	3	4	3	3	4	4	4	4	4	3	3.722419	4	2.930605				
73.	4	3	4	3	3	4	4	4	3	3	3	3	3	3.382043	4	2.845511				
74.	3	4	4	4	4	4	4	3	4	4	3	4	3	3.722419	4	2.930605		√		
75.	3	4	4	4	5	4	4	4	4	3	4	4	3	3.884299	5	2.721075		√		

[1] Min+((GEOMEAN+MAX)/4)

The final indicators are summarized in Table 2 as follows,

Table 2
Final indicators

Dimension	Indicators
Leadership and Perspectives	Providing support
	Providing guidance and reward
	Empowering employees
	Encouraging employees to focus on important matters and rely on Six Sigma and the strategic design
	Perception and acceptance of the senior manager
	Making sure of the commitment of chief executive officer
	Setting goals at each stage and identifying the responsible employee
	Developing an object-oriented approach
	Prioritizing customers, shareholders and employees
	Making sure of employees' understanding of the Six Sigma benefit value for the customer
	Fostering belief and commitment in employees to attain the prospect
	Adopting change
Management commitment and resources	Having familiarity with the Six Sigma process
	Linking the Six Sigma principles to the goals of the company
	Applying benchmarks to demonstrate the benefits of implementing Six Sigma projects to shareholders
	Performing active leadership
	Recording continuous improvement of market share (over the last few years)
	Having the ability to cover sufficient financial support for an improvement project
	Motivating staff through the HR system
Focus on customer	Meeting customers' expectations and focusing on them
	Evaluating company's customer orientation, employee development plan, training programs, job description and annual development plans
Choosing the right people	Understanding/implementing the Six Sigma logic by project members
	Using criteria to select the right people to instruct and implement the project
	Assigning flexible/open minded people as project members
	Making sure of project members' understanding of Six Sigma tools
Manage and improve the process	Using reciprocity for improvement outcomes
	Using the SPC tool (process maps, control charts, pareto graphs)
	Collecting data for key process functions
	Certifying the accuracy of collected data
	Keeping costs under control
	Investing in employee training and encouraging problem-solving
	Assigning a team to solve problems
Company strategy	Participating in a specifically defined strategy
	Making sure of employees' perception that strategy is the key to company success
	Keeping stability in corporate strategy
	Devising a well-specified corporate strategy for every member
	Considering the improvement process in formulating strategies
	Setting criteria for measuring the extent to which a company's strategy is achieved
	Completing small projects Before starting larger ones

The final indicators presented in Table 2 indicate that the Tabarestan Steel Co. had to use these indicators to be able to adopt and implement Six Sigma projects.

4.2. DEMATEL fuzzy findings

This section is presented step-by-step according to the explanations provided. Due to constraint of space, only one sample analysis is presented. The rest of the information is reported in tables (see table 3).

Table 3
List of the criteria

Row	Symbol	Criteria
1	C_1	Leadership and Perspectives
2	C_2	Management commitment and resources
3	C_3	Focus on customer
4	C_4	Choosing the right people
5	C_5	Manage and improve the process
6	C_6	company strategy

To verify the criteria used in the 12 expert opinions, Table 4 shows the paired comparison of each expert. In this matrix, $\tilde{x}_{\mathrm{ij}} = (l_{ij}, m_{ij}, u_{ij})$ are fuzzy triangular numbers, and $\tilde{x}_{ii} = (i = 1,2,3, \ldots, n)$ are considered to be fuzzy numbers (0,0,0). Accordingly, expert opinions were collected and combined through the relations mentioned in methodology section.

Table 4
Average of expert opinions

	C_1	C_2	C_3	C_4	C_5	C_6
C_1	(0.0000,0.0000,0.0000)	(3.0000,3.7224,4.0000)	(3.0000,3.7224,4.0000)	(2.0000,3.1166,4.0000)	(2.0000,3.4303,4.0000)	(3.0000,3.4641,4.0000)
C_2	(2.0000,2.2134,3.0000)	(0.0000,0.0000,0.0000)	(3.0000,3.4641,4.0000)	(2.0000,2.8563,4.0000)	(3.0000,3.2237,4.0000)	(3.0000,3.5482,4.0000)
C_3	(3.0000,3.0728,4.0000)	(3.0000,3.0728,4.0000)	(0.0000,0.0000,0.0000)	(2.0000,2.9417,4.0000)	(2.0000,3.1302,4.0000)	(2.0000,3.2697,4.0000)
C_4	(2.0000,2.0687,3.0000)	(2.0000,2.0687,3.0000)	(3.0000,3.1473,4.0000)	(0.0000,0.0000,0.0000)	(2.0000,2.0687,3.0000)	(3.0000,3.5482,4.0000)
C_5	(3.0000,3.0728,4.0000)	(3.0000,3.0728,4.0000)	(3.0000,3.0728,4.0000)	(2.0000,2.0687,3.0000)	(0.0000,0.0000,0.0000)	(3.0000,3.3019,4.0000)
C_6	(3.0000,3.0728,4.0000)	(3.0000,3.1473,4.0000)	(4.0000,4.0000,4.0000)	(3.0000,3.0728,4.0000)	(3.0000,3.0728,4.0000)	(0.0000,0.0000,0.0000)

Based on the relations mentioned, the views were integrated in the normalization section in the fuzzy metamaterial and matrix. Table 5 shows the normalized matrix.

Table 5
Normalized Matrix

	C1	C2	C3	C4	C5	C6
C1	(0.0000,0.0000,0.0000)	(0.1500,0.1861,0.2000)	(0.1500,0.1861,0.2000)	(0.1000,0.1558,0.2000)	(0.1000,0.1715,0.2000)	(0.1500,0.1732,0.2000)
C2	(0.1000,0.1107,0.1500)	(0.0000,0.0000,0.0000)	(0.1500,0.1732,0.2000)	(0.1000,0.1428,0.2000)	(0.1500,0.1612,0.2000)	(0.1500,0.1774,0.2000)
C3	(0.1500,0.1536,0.2000)	(0.1500,0.1536,0.2000)	(0.0000,0.0000,0.0000)	(0.1000,0.1471,0.2000)	(0.1000,0.1565,0.2000)	(0.1000,0.1635,0.2000)
C4	(0.1000,0.1034,0.1500)	(0.1000,0.1034,0.1500)	(0.1500,0.1574,0.2000)	(0.0000,0.0000,0.0000)	(0.1000,0.1034,0.1500)	(0.1500,0.1774,0.2000)
C5	(0.1500,0.1536,0.2000)	(0.1500,0.1536,0.2000)	(0.1500,0.1536,0.2000)	(0.1000,0.1034,0.1500)	(0.0000,0.0000,0.0000)	(0.1500,0.1651,0.2000)
C6	(0.1500,0.1536,0.2000)	(0.1500,0.1574,0.2000)	(0.2000,0.2000,0.2000)	(0.1500,0.1536,0.2000)	(0.1500,0.1536,0.2000)	(0.0000,0.0000,0.0000)

After calculating the above matrix, the total fuzzy relations were normalized according to the relations mentioned in the fuzzy demultiplex section. Table 6 shows the matrix V.

Table 6
Total relationships matrix

	C_1	C_2	C_3	C_4	C_5	C_6
C_1	(0.2270,0.4437,3.6667)	(0.3737,0.6438,4.0000)	(0.4021,0.7078,4.1667)	(0.2859,0.5920,4.0000)	(0.3028,0.6292,4.0000)	(0.3686,0.6889,4.1667)
C_2	(0.3203,0.4957,3.6389)	(0.2440,0.4318,3.6667)	(0.4029,0.6375,3.9931)	(0.2864,0.5313,3.8333)	(0.3430,0.5677,3.8333)	(0.3693,0.6321,3.9931)
C_3	(0.3400,0.5333,3.8333)	(0.3554,0.5716,4.0000)	(0.2503,0.4966,4.0000)	(0.2701,0.5404,4.0000)	(0.2863,0.5703,4.0000)	(0.3128,0.6285,4.1667)
C_4	(0.3033,0.4360,3.3333)	(0.3171,0.4675,3.4783)	(0.3838,0.5596,3.6594)	(0.1819,0.3521,3.3478)	(0.2873,0.4646,3.4783)	(0.3518,0.5665,3.6594)
C_5	(0.3737,0.5163,3.6944)	(0.3907,0.5534,3.8551)	(0.4204,0.6081,4.0142)	(0.2988,0.4888,3.8188)	(0.2257,0.4168,3.6884)	(0.3854,0.6076,4.0142)
C_6	(0.4016,0.5528,3.8333)	(0.4199,0.5954,4.0000)	(0.4915,0.6878,4.1667)	(0.3620,0.5655,4.0000)	(0.3811,0.5891,4.0000)	(0.2838,0.5114,4.0000)

To be able to apply the relations obtained from the fuzzy DEMATEL to the fuzzy network analysis process, the entire interface matrix was defuzzified. Therefore, the matrix primarily defined the relationships and was finally normalized within a column (see Table 7). Table 8 illustrates the relationships within the frame of the normalized matrix.

Table 7

Abnormalized diaphragmatic relationships matrix

	C_1	C_2	C_3	C_4	C_5	C_6
C_1	0.9447	1.1582	1.2333	1.1090	1.1366	1.2152
C_2	0.9903	0.9397	1.1577	1.0408	1.0745	1.1485
C_3	1.0511	1.1070	1.0395	1.0720	1.0946	1.1656
C_4	0.8968	0.9442	1.0469	0.8230	0.9373	1.0462
C_5	1.0222	1.0766	1.1445	1.0121	0.9302	1.1383
C_6	1.0744	1.1336	1.2349	1.1040	1.1229	1.0549

Table 8

Normalized diaphragmatic relationships matrix

	C_1	C_2	C_3	C_4	C_5	C_6
C_1	0.15799	0.18213	0.17987	0.18001	0.18052	0.17953
C_2	0.16562	0.14777	0.16884	0.16894	0.17066	0.16968
C_3	0.17578	0.17408	0.15160	0.17400	0.17385	0.17220
C_4	0.14998	0.14848	0.15268	0.13358	0.14887	0.15456
C_5	0.17095	0.16930	0.16691	0.16428	0.14774	0.16817
C_6	0.17968	0.17826	0.18010	0.17919	0.17835	0.15585

4.3. Fuzzy Analytic Network Process Findings

4.3.1. Create a comparative matrix

This section is divided into seven sub-parts, including weighting and dimensioning information. The sub-components were analyzed according to the method of fuzzy network analysis process, and were further developed to analyze the identification of the effective factors. In this section, due to constraints of space, only one sample is presented. After the questionnaire was designed, copies of it were submitted to the 12 industry experts who participated in the study. Next, confirmation and the criteria for analysis were considered. At this stage, the comparison was paired with the relative importance of all the questionnaires. Accordingly, the matrix of paired comparisons was created, and the importance coefficient of the main indicators of performance evaluation, as well as the pairwise matrix of the coefficient of significance of indices relative to the index, were computed .

4.3.2. Calculation of triangular fuzzy numbers

Given the relative importance of the calculated values in the previous step, triangular fuzzy numbers were calculated to integrate all expert opinions.

Table 9

Matrix of Triangular Fuzzy Numbers

	company strategy	Manage and improve the process	Choosing the right people	Focus on customer	Management commitment and resources	Leadership and Perspectives
Leadership and Perspectives	(1 ,1,1)	(9,5.614,3)	(1 ,6.3568 ,9)	(0.25 ,8,4.025)	(8,3.949,0.333)	(8,2.039,0.333)
Management commitment and resources	(0.333,0.178,0.111)	(1,1,1)	(5.0642,0.5 ,8)	(5,2.506,0.333)	(1 ,6,2.271)	(0.167, 0.779, 4)
Focus on customer	(0.157,0.111 ,1)	(0.125 ,2,0.197)	(1,1,1)	(0.149 ,0.196 ,0.5)	(2,0.235,0.125)	(0.111 ,2,0.202)
Choosing the right people	(4,0.248,0.125)	(3,0.399,0.2)	(8,5.110,2)	(1,1,1)	(1.135,0.333 ,4)	(7,0.413,0.143)
Manage and improve the process	(3,0.253,0.125)	(1,0.439,0.166)	(4.264,0.5 ,8)	(0.25 ,3,0.882)	(1 ,1,1)	(5,0.466,0.111)
company strategy	(3,0.49,0.125)	(6,1.284,0.25)	(9,4.937,0.5)	(7,2.42,0.149)	(9,2.142,0.2)	(1 ,1 ,1)

The triangular fuzzy set was defined via. ãij = (αij,βij, δij) where $\tilde{a}_{ij}$ is the set of triangular fuzzy numbers, α_{ij} is the least value of criterion *j* for dimension *i*, β_{ij} is the geometric mean of criterion *j* for dimension *i*, and δ_{ij} is the highest criterion value of dimension *j* for dimension *i*. The information includes the numbers in parentheses, which are respectively least value of criterion *j* for dimension *i*, the geometric mean of criterion *j* for dimension *i*, and the highest value of criterion *j* for the dimension *I* (see Table 9).

5.3.3. coefficients of each of the pairwise matrices

At this stage, using the definitions of the fuzzy network analysis process, the coefficients of each of the pairwise matrices were calculated.

$$\left[\sum_{i=1}^{m}\sum_{j=1}^{n} M_{ij}\right] = (18.825\ ,64.651\ ,131.833)^{-1} = (0.0075, 0.0154, 0.0531)$$

$$S_1 = (5.916, 22.9838, 43) * (0.0075, 0.0154, 0.0531) = (0.4437, 0.3539, 2.2833)$$
$$S_2 = (3.111, 11.8182, 24.333) * (0.0075, 0.0154, 0.0531) = (0.02333, 0.1820, 1.2920)$$
$$S_3 = (1.621, 1.978, 8.5) * (0.0075, 0.0154, 0.0531) = (0.0121, 0.0304, 0.4513)$$
$$S_4 = (3.801, 8.305, 27) * (0.0075, 0.0154, 0.0531) = (0.0285, 0.1278, 1.4337)$$
$$S_5 = (2.152, 7.304, 21) * (0.0075, 0.0154, 0.0531) = (0.01614, 0.1124, 1.1151)$$
$$S_6 = (2.224, 12.273, 35) * (0.0075, 0.0154, 0.0531) = (0.01668, 0.1890, 1.8585)$$

5.3.4. The magnitude of each element on other elements

The magnitude of each element on other elements was calculated (see table 10).

Table 10
The magnitude of each element on other elements was calculated

S_1	S_2	S_3	S_4	S_5	S_6
$s_1 \geq s_2$= 1	$s_2 \geq s_1$= 0.8315	$s_3 \geq s_1$=0.0229	$s_4 \geq s_1$=0.8140	$s_5 \geq s_1$=0.7354	$s_6 \geq s_1$=0.8956
$s_1 \geq s_3$= 1	$s_2 \geq s_3$= 1	$s_3 \geq s_2$=0.7362	$s_4 \geq s_2$=0.9629	$s_5 \geq s_2$=0.94	$s_6 \geq s_2$=1
$s_1 \geq s_4$= 1	$s_2 \geq s_4$= 1	$s_3 \geq s_4$=0.8127	$s_4 \geq s_3$=1	$s_5 \geq s_3$=1	$s_6 \geq s_3$=1
$s_1 \geq s_5$= 1	$s_2 \geq s_5$=1	$s_3 \geq s_5$=0.8414	$s_4 \geq s_5$=1	$s_5 \geq s_4$=0.9862	$s_6 \geq s_4$=1
$s_1 \geq s_6$= 1	$s_2 \geq s_6$=0.9945	$s_3 \geq s_6$=0.7326	$s_4 \geq s_6$=0.9585	$s_5 \geq s_6$=0.9348	$s_6 \geq s_5$=1

After determining the magnitude of each element with respect to other elements, the magnitude of S_i items was computed.

$$Min\ V\ (S_1 \geq S_2, S_3, S_4, S_5, S_6) = 1 \qquad Min\ V\ (S_4 \geq S_1, S_2, S_3, S_5, S_6) = 0.8140$$
$$Min\ V\ (S_2 \geq S_1, S_3, S_4, S_5, S_6) = 0.8315 \qquad Min\ V\ (S_5 \geq S_1, S_2, S_3, S_4, S_6) = 0.7354$$
$$Min\ V\ (S_3 \geq S_1, S_2, S_4, S_5, S_6) = 0.0229 \qquad Min\ V\ (S_6 \geq S_1, S_2, S_3, S_4, S_5) = 0.8956$$

These numbers represent the non-normal weights of the indicators C_1-C_6, and the following values of the normalized weights are given.

$$W = [0.2325, 0.1933, 0.0053, 0.1893, 0.1710, 0.2083]$$

Next the dependence between the criteria calculated through the fuzzy DEMATEL method was considered in this section (see Table 11).

Table 11
Normalized diaphragmatic relationships matrix

	C_1	C_2	C_3	C_4	C_5	C_6
C_1	0.15799	0.18213	0.17987	0.18001	0.18052	0.17953
C_2	0.16562	0.14777	0.16884	0.16894	0.17066	0.16968
C_3	0.17578	0.17408	0.15160	0.17400	0.17385	0.17220
C_4	0.14998	0.14848	0.15268	0.13358	0.14887	0.15456
C_5	0.17095	0.16930	0.16691	0.16428	0.14774	0.16817
C_6	0.17968	0.17826	0.18010	0.17919	0.17835	0.15585

Criteria were obtained by taking into account dependence by combining the results through the relation $W\varepsilon = B \times W$.

	C1	C2	C3	C4	C5	C6				Finally Weight	Rank
Leadership and perspectives	0.15799	0.18213	0.17987	0.18001	0.18052	0.17953		0.2325		0.175692	1
Management commitment and resources	0.16562	0.14777	0.16884	0.16894	0.17066	0.16968	×	0.1933	=	0.165062	4
Focus on customer	0.17578	0.17408	0.15160	0.17400	0.17385	0.17220		0.0053		0.169647	3
Choosing the right people	0.14998	0.14848	0.15268	0.13358	0.14887	0.15456		0.1893		0.150953	6
Manage and improve the process	0.17095	0.16930	0.16691	0.16428	0.14774	0.16817		0.1710		0.164685	5
company strategy	0.17968	0.17826	0.18010	0.17919	0.17835	0.15585		0.2083		0.173662	2

Table 12 shows the total weights of indicators calculated based on the relationships mentioned above and the processes, along with final weights.

Table 12
Final weights

Dimension	Weight	Rank	Indicators	The weight of the following component	Rank below component in component	The final weight	The final rank
Leadership and Perspectives	0.175692	1	Providing support	0.11221	1	0.0197	22
			Providing guidance and reward	0.09312	3	0.0164	26
			Empowering employees	0.08091	8	0.0142	32
			Encouraging employees to focus on important matters and rely on Six Sigma and the strategic design	0.07098	11	0.0125	35
			The perception and acceptance of the senior manager	0.08212	6	0.0144	30
			Making sure of the commitment of chief executive officer	0.09321	2	0.0164	26
			Setting goals at each stage and identifying the responsible employee	0.09212	4	0.0162	27
			Developing an object-oriented approach	0.08921	5	0.0157	28
			Prioritizing customers, shareholders and employees	0.07676	9	0.0135	33
			Making sure of employees' understanding of the Six Sigma benefit value for the customer	0.06325	12	0.0111	36
			Fostering belief and commitment in employees to attain the prospect	0.07123	10	0.0125	35
			Adopting change	0.08111	7	0.0143	31
Management commitment and resources	0.165062	4	Having familiarity with the Six Sigma process	0.15612	3	0.0258	14
			Linking the Six Sigma principles to the goals of the company	0.14213	4	0.0235	16
			Applying benchmarks to demonstrate the benefits of implementing Six Sigma projects to shareholders	0.09332	7	0.0154	29
			Performing active leadership	0.12238	6	0.0202	21
			Recording continuous improvement of market share (over the last few years)	0.13123	5	0.0217	19
			Having the ability to cover sufficient financial support for an improvement project	0.17231	2	0.0284	10
			Motivating staff through the HR system	0.18324	1	0.0302	7
Focus on customer	0.169647	3	Meeting customers' expectations and focusing on them	0.46123	2	0.0782	2
			Evaluating company's customer orientation, employee development plan, training programs, job description and annual development plans	0.54009	1	0.0916	1
Choosing the right people	0.15095	6	Understanding/implementing the Six Sigma logic by project members	0.12125	4	0.0183	25
			Using criteria to select the right people to instruct and implement the project	0.30793	1	0.0465	3
			Assigning flexible/open minded people as project members	0.29169	2	0.0440	4
			Making sure of project members' understanding of Six Sigma tools	0.27968	3	0.0422	5
Manage and improve the process	0.16468	5	Using reciprocity for improvement outcomes	0.18112	1	0.0298	8
			Using the SPC tool (process maps, control charts, pareto graphs)	0.16213	4	0.0267	12
			Collecting data for key process functions	0.11502	6	0.0189	24
			Certifying the accuracy of collected data	0.13518	5	0.0223	17
			Keeping costs under control	0.08123	7	0.0134	34
			Investing in employee training and encouraging problem-solving	0.16216	3	0.0267	12
			Assigning a team to solve problems	0.16324	2	0.0269	11
company strategy	0.173662	2	Participating in a specifically defined strategy	0.17812	1	0.0309	6
			Making sure of employees' perception that strategy is the key to company success	0.15219	3	0.0264	13
			Keeping stability in corporate strategy	0.14421	4	0.0250	15
			Devising a well-specified corporate strategy for every member	0.16428	2	0.0285	9
			Considering the improvement process in formulating strategies	0.12303	6	0.0214	20
			Setting criteria for measuring the extent to which a company's strategy is achieved	0.11021	7	0.0191	23
			Completing small projects before starting larger ones	0.12812	5	0.0222	18

6. Conclusion

This study has investigated the readiness of an Iranian steel industry company for the implementation of Six Sigma projects. Six Sigma is a methodology that helps minimize error in work. It is a statistical measure that enhances accuracy in production, services and processes, while serving as a measurement tool. It also be applied as a business strategy, because it lowers the costs of high quality. The use of the effective and simple techniques proposed in the Six Sigma methodology paves the way for improving the optimal production processes, such as the general process map (SIPOC), defect detection tables, and various measures of process capability measurement, identifying the strengths and weaknesses in organizational processes. This study tried to identify and categorize the factors affecting the implementation and function of recovery programs in the steel industry. In addition, contrary to some of the studies focused on barriers, this study included specific notions of improvement such as innovation, pollution reduction, or quality management. Improvement was regarded as a comprehensive concept in this research, as a factor that could reduce time and cost or increase the quality of all projects. Researchers in recent years have frequently relied on the multi-criteria decision-making approach, considering its specific features. Some researchers who tried to categorize the affected components used the analytical tool of multi-criteria decision making, and some have demonstrated that this framework works properly. In this research, attempt was made to provide a conceptual framework for identifying influential factors by examining the elements important for successful implementation of Six Sigma in the organization. Through further statistical analysis, the fuzzy Delphi was used to identify and prioritize the specified indicators (given the high accuracy of fuzzy methods). Moreover, to conduct a better fuzzy analysis of the fuzzy analysis process, the fuzzy DEMATEL method was employed (to specify the interconnection between the indicators). By detecting the interconnection between the indicators, the indicators were prioritized, and the multiple dimensions of the Six Sigma were also taken into account. This study contributes to the line of academic research that examines more precisely the various dimensions of Six Sigma. Broadly speaking, the model proposed in this study has revealed the importance and role of the key elements to Six Sigma success and some of the critical areas that managers need to focus on when implementing the Six Sigma project in an organization. For example, senior management support has a direct impact on the link that Six Sigma can have with human resource management, education, cultural change, and other factors. Therefore, it is imperative that senior management accept Six Sigma concepts for a successful implementation of Six Sigma. Managers should also be willing to allocate sufficient resources to adapt organizational processes, structures and policies to frame and implement the Six Sigma approach. The findings of this study will help develop the knowledge of Six Sigma, as it aims to provide a model for managers and planners of organizations by providing empirical evidence through an analytic model arising from the conditions of Iranian organizations. It is necessary to take into account the circumstances, the amount of resources, and organizational priorities for the compilation and implementation of Six Sigma projects.

In general, the study had some limitations, such as sample size, limited access to steel companies, and perceptional differences exhibited by the respondents in their answers to questionnaire items. These factors should be further controlled to ensure the changeability and consideration of possible external variations for a better validation of the model and the generalizability of the results and the sample size. Researchers interested in this topic can use the following suggestions for further research. they can probe into methods such as in-depth interviews with experts and the theory of diography. Some studies can collect data from manufacturing industries and optimize the proposed model through the data gathered. An interesting topic for further investigation is the factors contributing to the success of Six Sigma in the steel industry and the effect of these factors on various performance dimensions of companies. Another area of search can focus on the effect of other quality management approaches such as ISO on the proposed model.

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