Identifying the role of human resource management in increasing performance and implementation of six sigma projects using fuzzy cognitive maps

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C H R O N I C L E	A B S T R A C T
	Six Sigma is known as the best quality management system, which has been applied in different places with distinct tasks. Any implementation of Six Sigma project normally can succeed only when human resource management is applied within the organization, properly. In this paper, we illustrate the intense of relationships between the human resources management indices and Six Sigma project implementation indices for some selected Iranian manufacturing firms. By using the fuzzy cognitive maps (FCM), we are able to show the strength of relationships among various indices. This study helps quality and human resource managers learn how to manage the critical indices to achieve their determined goals and to increase Six Sigma project performance throw human resource management perspective.

1. Introduction

Human resource management is one of the most essential sources for business development. There are different definitions for human resource management (HRM). According to Armstrong (2003), HRM is a strategic and coherent approach to the management of an organization's most valued assets; the people working there whom individually and collectively contribute to the achievement of its objectives (Armstrong 2003). Storey (1989) believes that HRM could be regarded as a 'set of interrelated policies with an ideological and philosophical underpinning'. He suggests four aspects that constitute the meaningful version of HRM:

1. A particular constellation of beliefs and assumptions,
2. A strategic thrust informing decisions about people management,
3. The central involvement of line managers,
4. Reliance upon a set of 'levers' to shape the employment relationship.

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Many of the well-known firms, such as Motorola, General Electric, Honeywell, Raytheon, Sony, Caterpillar, and Johnson Controls, have successfully applied Six Sigma and reported remarkable improvements in market share, customer satisfaction, reliability, and performance of products and services with remarkable financial savings (Foster, 2007; Harry & Schroeder 2000; Pande & Holp, 2002; Snee, 1999). Not all organizations, however, have applied this methodology successfully (Gijo & Rao, 2005). Some of them reported that the best way to manage the change is through increased and sustained communication, motivation, and training (Antony, 2004; Brun 2011), which are the issues associated with HRM. The importance of HRM to Six Sigma implementation has been recognized in the literature (e.g., Breyfogle et al., 2001; Lee & Choi, 2006; Motwani et al., 2004). However, few studies have applied soft computing methods for examining the relationships between HRM and Six Sigma implementation for real-world case studies. This paper investigates the role of HRM practices in Six Sigma implementations. Prior studies have identified three HRM practice's employee involvement, employee training, and employee performance and recognition, which are important in modeling a quality culture and in influencing employees' attitudes toward quality (e.g., Bayo-Moriones & Bayo-Moriones & Merino-Dí az de Cerio,2001; Bou & Beltrán, 2005; Howard & Foster, 1999; Langbert, 2000).

During the past few years, Iran's Ministry of Industry, Mine and trade (IMIMT) plans to detect a good method for illustrating relationships between Six Sigma implementations and HRM in its supported firms, which enhanced their performance by applying Six Sigma continues improvement toolset in their firms and involved with HRM concepts. Soft computing systems play essential role for representing the relationships based on learning paradigm and experts' suggestions, which is an enrich source of knowledge. They also help decision makers extract the notions among various suggestions, unlike hard computing systems, which are based on optimization notion. In this paper, we use fuzzy cognitive maps (FCM) as a subset of the soft computing systems toolbox, which enables us to provide the strength of relationships between HRM indices and Six Sigma implementation's features.

In this study, we do not intend to get involved with various definitions of HRM, but we intend to infer to critical success factors (CSF) from human resources management perspective, which have influences in achieving prosperity in implementations and increasing performance of companies applied Six Sigma methodology in their continues improvement activities. Using collected questionnaires from 24 manufacturing plants which deployment Six Sigma, this study illustrates the effects of the three quality-oriented HRM practices on the implementations of Six Sigma methodology.

2. Literature review

The Six Sigma methodology was born in Motorola and it is strongly oriented to measurement, and in particular to the adoption of statistical techniques. It has been widely used method and it is now encompassed in a comprehensive framework advocating the adoption of some basics quantitative tools for the resolution of the most common problems, which characterize the organizations (Brun 2011). After enounced Six Sigma, many companies have been familiar with total quality management (TQM) and well known it's PDCA cycle (plan, do, control and act). Näslund (2008) showed Six Sigma essentially repackaged version of the TQM and this method seems to follow the fad (product) life cycle. The literature offers similar and rather general CSF for these methods, e.g. top management support and the importance of communication and information and by inspecting a lot of papers he suggested that all CSF were similar in the two mentioned methods.

Many of researchers emphasized on the role of HRM in quality management (QM) activities. Zu (2009) named some of HRM indices in Six Sigma implementation projects under the name of

'infrastructure QM', such as 'top management support', 'workforce management' and 'customer relationship' these notions have been adapted from HRM practices.

The notion of 'customer relationship' is associated with Six Sigma projects implementations. It contains both inner-customer and outer-customer and without correct managements systems to manage two mentioned categories where Six Sigma projects cannot achieve its determined objectives (Zu, 2008; Pande & Holp, 2002; Eckes, 2003).

Brun (2011) statistically showed the frequency of the various CSF, which outs of a sample, contains 18 papers tried to analyze the reasons behind the success of real life applications of Six Sigma, which is depicted in Fig. 1. As we can observe, the HRM related factors for example 'Management involvement', 'Linking six sigma to customer', 'Training' and 'Linking six sigma to human resource', have more frequency in the selected papers and also these notions adapted from HRM practices.
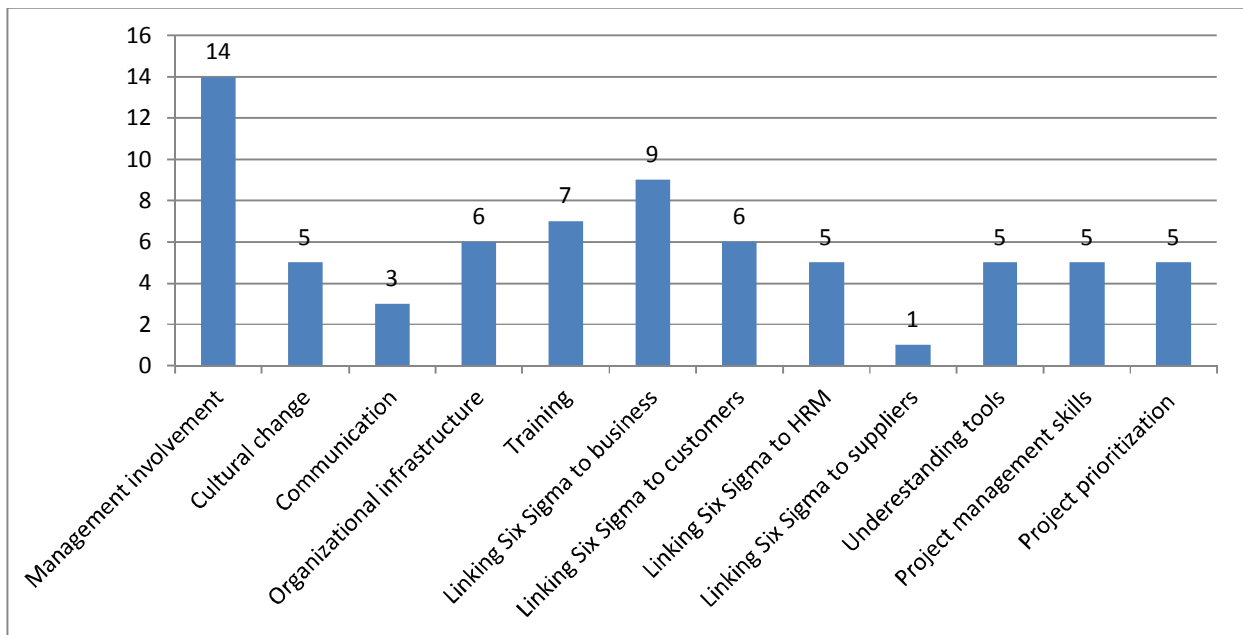

Fig. 1. The frequency of CSF in the literature (Brun, 2011)

   In addition, Six Sigma involves with using a comprehensive set of structured procedures named DMAIC, contains define, measure, analyze, improve and control phases. The DMAIC cycle comes into play to meet the customer's needs consistently and perfectly enables us to have continues improvement in our activities (see Fig. 2). The people how's involved in Six Sigma continues improvement projects have different names, such as champion, master black belt (MBB), black belt (BB) and green belt (GB). The mentioned categories for members of Six Sigma improvement teams depends on experience, organizational hierarchy position and training (Pande & Holp, 2002; Eckes, 2003). Also, HRM is concerned with people and the way they are managed, and is recognized as one of the important sources of competitive advantage (Schuler and MacMillan, 1984). From the resource-based view of the firm, HRM contributes to sustained competitive advantage by facilitating the development of other organizational capabilities (Saá-Pérez & García-Falcón, 2002). The HRM system supports an organization's QM effort by reinforcing employee relationships and group consciousness of the need for customer satisfaction, raising employee competence, and helping to achieve culture change by involving members in quality decision making (Yang, 2006).
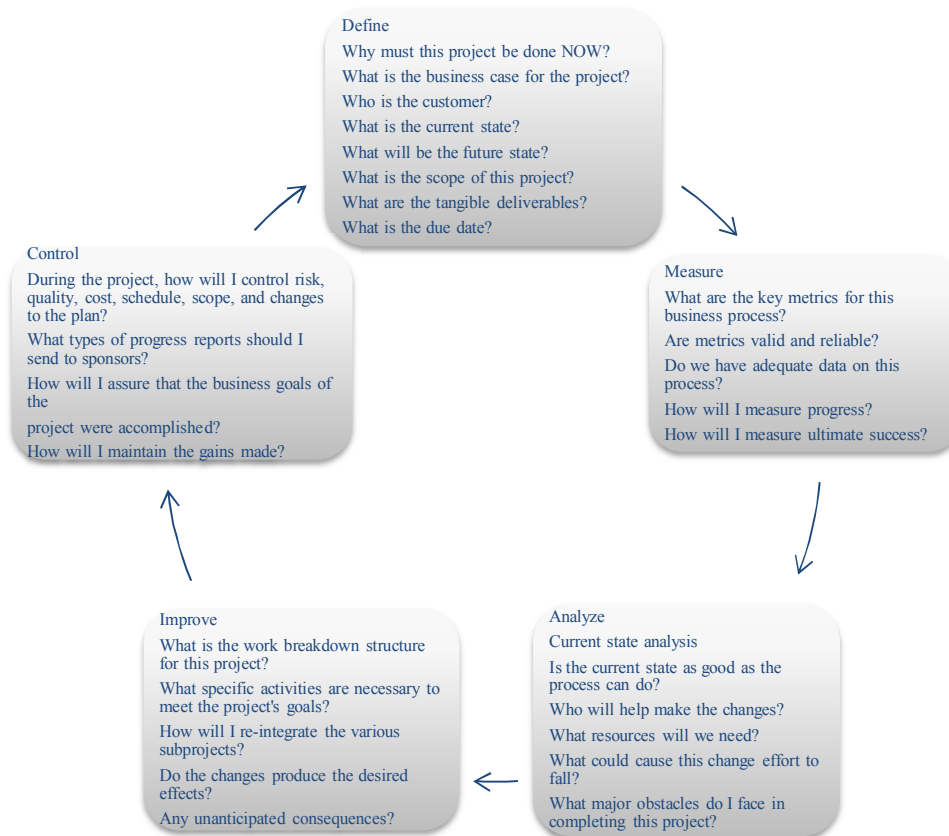
Fig. 2. DMAIC structured improvement cycle

The existing body of literature examining the relationship of HRM and QM provides a theoretical background to investigate HRM and Six Sigma. Prior studies have examined various HRM dimensions such as human resource planning, recruiting and selection, work design and analysis, training and education, job rotation, leadership development, performance appraisal, incentive compensation, benefits and profit sharing, employee development, employee security and health, communication, and the use of teams (e.g., Dean & Bowen, 1994; Bayo-Moriones & Merino-Díaz de Cerio, 2001; Bou & Beltran, 2005; Flynn et al., 1995; Mayer, 2002; Yang, 2006). Among them, dimensions related to such practices as employee involvement, employee training, and employee performance recognition are suggested to have a particularly important impact on QM implementation (Bayo-Moriones & Merino-Díaz de Cerio, 2001; Bou & Beltran, 2005; Flynn et al., 1995; Kaynak, 2003). Enhancing Six Sigma implementation through human resource management employee involvement is necessary for continuous improvement because ultimately people make quality happen (Rahman & Bullock 2005).

Teamwork and group problem solving are important parts of quality management (QM), which permits decentralized decision making by allowing employees to make decisions on their own (Dean and Bowen 1994; Flynn Schroeder and Sakakibara 1994). Teamwork contributes to employee involvement by creating collaboration between management and employees that allows non managerial employees to make important contributions to quality improvement (Dean & Bowen, 1994). In addition, cross-functional teams create synergy by involving different functions to achieve the outcomes of the whole organization. Employee training is the cornerstone of QM implementation (Juran, 1993). The QM-related training includes training in small group problem solving, communication, statistical tools, and other relevant areas, in addition to classroom and on-site training about specific tasks, with the purpose of transforming employees into creative problem

solvers (Flynn et al., 1994; Kaynak, 2003). Through training, employees also can better understand the QM policies implemented by the organization and become more inspired to take part in the quality improvement effort (Joseph, 1999). Employee performance and recognition involves the methods implemented by organizations to provide appropriate compensation, promotion, and recognition policies for their employees. The traditional employee performance appraisal approach emphasizes the impact of individual differences, but the quality-oriented performance appraisal practice requires group performance, quality-based incentives, and compensation based on breadth of skills (Dean & Bowen, 1994; Flynn et al., 1994). Maintaining an effective quality culture requires recognizing and rewarding continuous quality improvement activities and quality customer services, including both formal and informal, and financial and nonfinancial rewards for individuals and teams that contribute to the quality improvement effort (Blackburn & Rosen, 1993).

The QM research has shown that the three quality-oriented HRM practices identified previously contribute to quality improvement by helping firms develop a competent, committed work force for continuous improvement (Flynn et al., 1994). Kaynak (2003) found that organizations use quality data better by training their employees in quality tools and by encouraging them to participate in decision-making processes, teamwork, and employee recognition. Similarly, Sila and Ebrahimpour (2005) found that it is critical for designing high-quality products and services and to manage processes for quality that firms build organizational competencies through effective HRM practices and focused on employee training and satisfaction. Nair (2006) conducted a meta-analysis of 26 QM studies and found that people management practices were highly correlated to aggregate business performance, financial performance, and operational performance. In addition, people management significantly interacts with other QM practices to affect customer service and product quality.

3. Method of Research

A cognitive map (CM) is a directed digraph for showing causality between concepts in complex foundations, first introduced by Axlord (1976) in political complications.
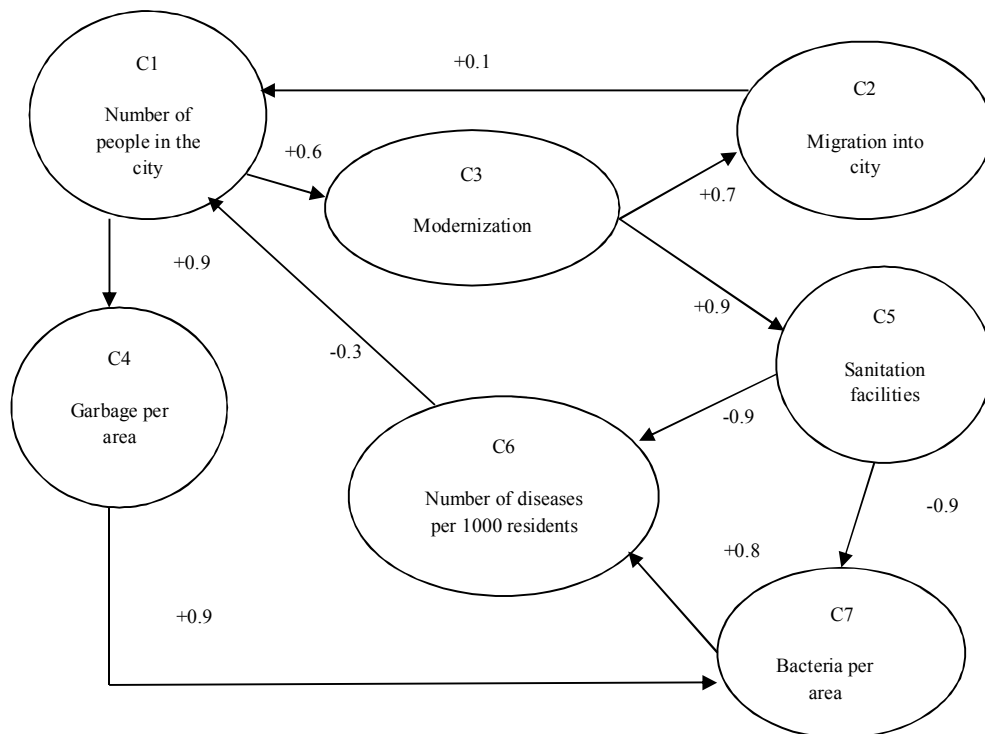

Fig. 3. A classic form of the fuzzy cognitive maps (FCM)

A fuzzy cognitive Map (FCM) is a graphical representation, consisting of nodes indicating the most relevant factors of a decisional environment; and the links between these nodes representing the relationships between those factors. FCM is a modeling methodology for complex decision systems originated from the combination of fuzzy logic and neural networks. A FCM explains the behavior of a system in terms of concepts; each concept representing an entity, a state, available, or a characteristic of the system. FCMs have been applied in simulation, modeling of organizational strategies, support for strategic problem formulation and decision analysis, knowledge bases construction, managerial problems diagnosis, failure modes effects analysis, requirements analysis, systems requirements specification, urban design support, relationship management in airlines Services and web-mining inference amplification (Rodriguez-Repiso et al., 2007). For making FCM framework for current study we needs define concepts as node, we use C_i for concept i (for i=1, 2,…, 6) defined as below.

Table 1
The descriptions of concepts in the proposed fuzzy cognitive map

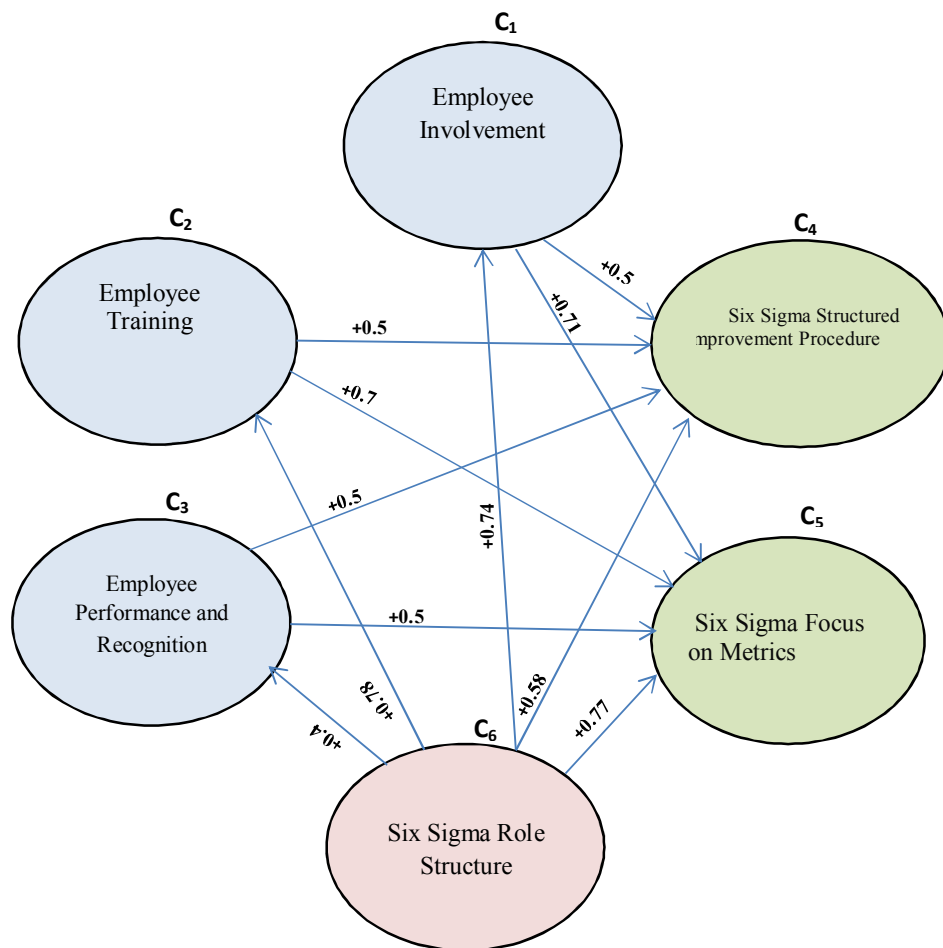| Concept	Abbreviation	Concept	Abbreviation
HRM practice concept		Use of Six Sigma methodology concept	
• employee involvement	C_1	• Six Sigma structured improvement procedure	C_4
• employee training	C_2	• Six Sigma focus on metrics	C_5
• employee performance and recognition	C_3	• Six Sigma role structure concept	C_6

Fig. 4. A sample of relationship in Six Sigma projects implementation

For determining the strength between two concepts of i and j denoted by W_{ij}, we should first define sign of the strength between two concepts. If increase in one concept increases the amount of another concept, we say there is a positive relationship between two concepts. When increase in the amount of one concept decreases the amount of another concept, consequently we say there is a negative relationship between two concepts. If there is not any logical or empirical relationship between two concepts, we conclude there is not any relationship between mentioned concepts. For example, in Six Sigma improvements activities, an increase in the amounts of 'employee training' activities increases 'Six Sigma structured improvement procedure' (see Fig 4), so we conclude there is a positive relationship between 'employee training' and 'Six Sigma structured improvement procedure' (Rodriguez-Repiso et al., 2007; Kosko, 1986).
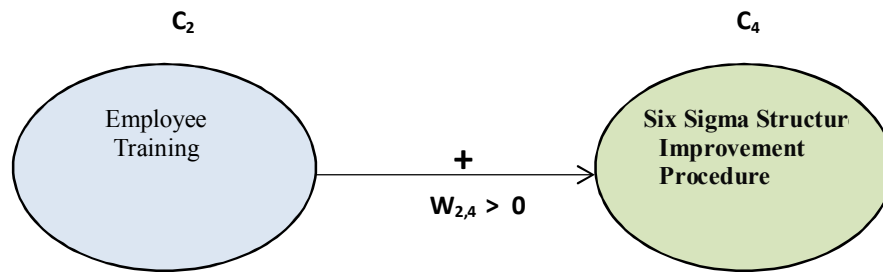

Fig. 4. A sample of relationship in Six Sigma projects implementation

According above mentioned subjects, we concluded amounts of this relationships in FCM can be positive or negative or zero defined as below:

$$\begin{cases} W_{ij} > 0 & \text{Positive relationship} \\ W_{ij} < 0 & \text{Negative relationship} \\ W_{ij} = 0 & \text{No relationship} \end{cases} \qquad (1)$$

For obtaining the amount of these relationships we use Rodriguez-Repiso methodology, which is based on four matrix consist of initial matrix of concepts (IMC), fuzzified matrix of concepts (FMC), strength of relationships matrix of concepts (SRMC) and final matrix of concepts (FMS). In first step, we compose initial matrix of concepts (IMC) by collecting 24 questionnaires, which is prepared by champions of Six Sigma teams from 24 manufacturing plants. In this questionnaire, we asked them to assign how six factors rolled in six sigma projects (see Table 2).

Table 2
Data's collected from 24 manufactory plants (IMC)

Plant	p1	p2	p3	p4	p5	p6	p7	p8	p9	p10	p11	p12	p13	p14	p15	p16	p17	p18	p19	p20	p21	p22	p23	p24
C1	VH	H	M	VH	VH	VH	H	VH	VH	M	H	VH	VH	VH	VH	M	H	H	L	M	VH	VH	VH	VH
C2	VH	H	H	H	H	H	VH	M	H	VH	VH	M	M	VH	H	M	M	M	H	VH	M	M	H	VL
C3	M	L	H	L	L	H	L	L	VL	L	L	L	L	L	VH	VH	H	H	VH	VL	M	H	VH	M
C4	M	H	VH	L	M	L	H	L	H	M	L	H	VH	H	H	VH	H	M	L	H	L	M	L	M
C5	VH	H	H	VH	H	H	M	H	VH	H	VH	M	H	VH	VH	H	M	L	M	VL	M	M	VL	H
C6	H	H	M	VH	VH	VL	H	VH	H	VH	VH	H	H	VH	H	L	M	M	M	H	M	H	M	VH

In Table 2, VH means very high influences; H represents high influence; M shows medium influence; L means very low influences; and VL is used for very low influences.

Table 3
Fuzzified matrix of concepts (FMC)

	p1	p2	p3	p4	p5	p6	p7	p8	p9	p10	p11	p12
C1	1	0.67	0.33	1	1	1	0.67	1	1	0.33	0.67	1
C2	1	0.75	0.75	0.75	0.75	0.75	1	0.5	0.75	1	1	0.5
C3	0.5	0.25	0.75	0.25	0.25	0.75	0.25	0.25	0	0.25	0.25	0.25
C4	0.33	0.67	1	0	0.33	0	0.67	0	0.67	0.33	0	0.67
C5	1	0.75	0.75	1	0.75	0.75	0.5	0.75	1	0.75	1	0.5
C6	0.75	0.75	0.5	1	1	0	0.75	1	0.75	1	1	0.75

	p13	p14	p15	p16	p17	p18	p19	p20	p21	p22	p23	p24
C1	1	1	1	0.33	0.67	0.67	0	0.33	1	1	1	1
C2	0.5	1	0.75	0.5	0.5	0.5	0.75	1	0.5	0.5	0.75	0
C3	0.25	0.25	1	1	0.75	0.75	1	0	0.5	0.75	1	0.5
C4	1	0.67	0.67	1	0.67	0.33	0	0.67	0	0.33	0	0.33
C5	0.75	1	1	0.75	0.5	0.25	0.5	0	0.5	0.5	0	0.75
C6	0.75	1	0.75	0.25	0.5	0.5	0.5	0.75	0.5	0.75	0.5	1

Each elements in row i and column j is opinions of jth person about i^{th} concepts denoted by $O_{i,j}$, also we show row i in corresponding matrix with V_i (Rodriguez-Repiso et al., 2007; Alizadeh et al., 2008). Next, we compose fuzzified matrix of concepts (FMC) by using the data from Table 2, and translates this matrix into a fuzzy matrix by using Likert scale (VH=9, H=7, M=5, L=3, VL=1) and Eq. (2). Every rows illustrates intense of each concepts by different people contributing in Six Sigma improvements teams (Alizadeh et al., 2008). $Max(O_{iq}) \Rightarrow X_i(O_{iq})=1$ and $Min(O_{ip}) \Rightarrow X_i(O_{ip})=1$; for p,q=1, 2, 3,…, 24; i=1,2,…,6

$$X_i(O_{ij}) = \frac{O_{iq} - Min(O_{ip})}{Max(O_{iq}) - Min(O_{ip})} \tag{2}$$

In some cases similar to this study, it is difficult to assign a certain number (score) for each question between 0 and 100. For facilitating doing this work, we change Rodriguez-Repiso algorithms by using linguistically variables standby numerical scale, without losing main FCM concepts (Rodriguez-Repiso et al., 2007; Kosko, 1986).

In the third step, we need to compute adjacency of two concepts C_i and C_j by using two kinds of formulations. If two concepts C_i and C_j have a direct and a positive relationship we use $X_1(V_j) - X_2(V_j)$ for distance between two concepts, otherwise, f two concepts have reverse relationship, we use $X_1(V_j) - (1 - X_2(V_j))$. Subsequently, we define two types of formulations to compute distance by using absolute assign for two mentioned formulations: $d_j = | X_1(V_j) - X_2(V_j)) |$ for direct relations and $d_j = | X_1(V_j) - (1 - X_2(V_j)) |$ for diverse relationships. According to above subjects another variable should be define as AD determined as follow,

$$AD = \frac{\sum_{j=1}^{m} d_j}{m} \tag{3}$$

where the adjacency of two concepts rows is defined with S as $S = 1 - AD$ (4).

Table 4
Strength of relationships matrix of concepts (SRMC)

Concept	C1	C2	C3	C4	C5	C6
C1	-	0.64	0.52	0.51	0.71	0.74
C2	0.64	-	0.58	0.57	0.78	0.78
C3	0.52	0.58	-	0.59	0.59	0.49
C4	0.51	0.57	0.59	-	0.60	0.58
C5	0.71	0.78	0.59	0.60	-	0.77
C6	0.74	0.78	0.49	0.58	0.77	-

Some of computed values between concepts (see Table 4) might be impossible or irreligious in Six Sigma activities and do not existence in empirical activates should be ignored also mathematics computes acquires this deleted relationships. With this work obtained final matrix of concepts (FMS).

Table 5
Final matrix of concepts (FMS)

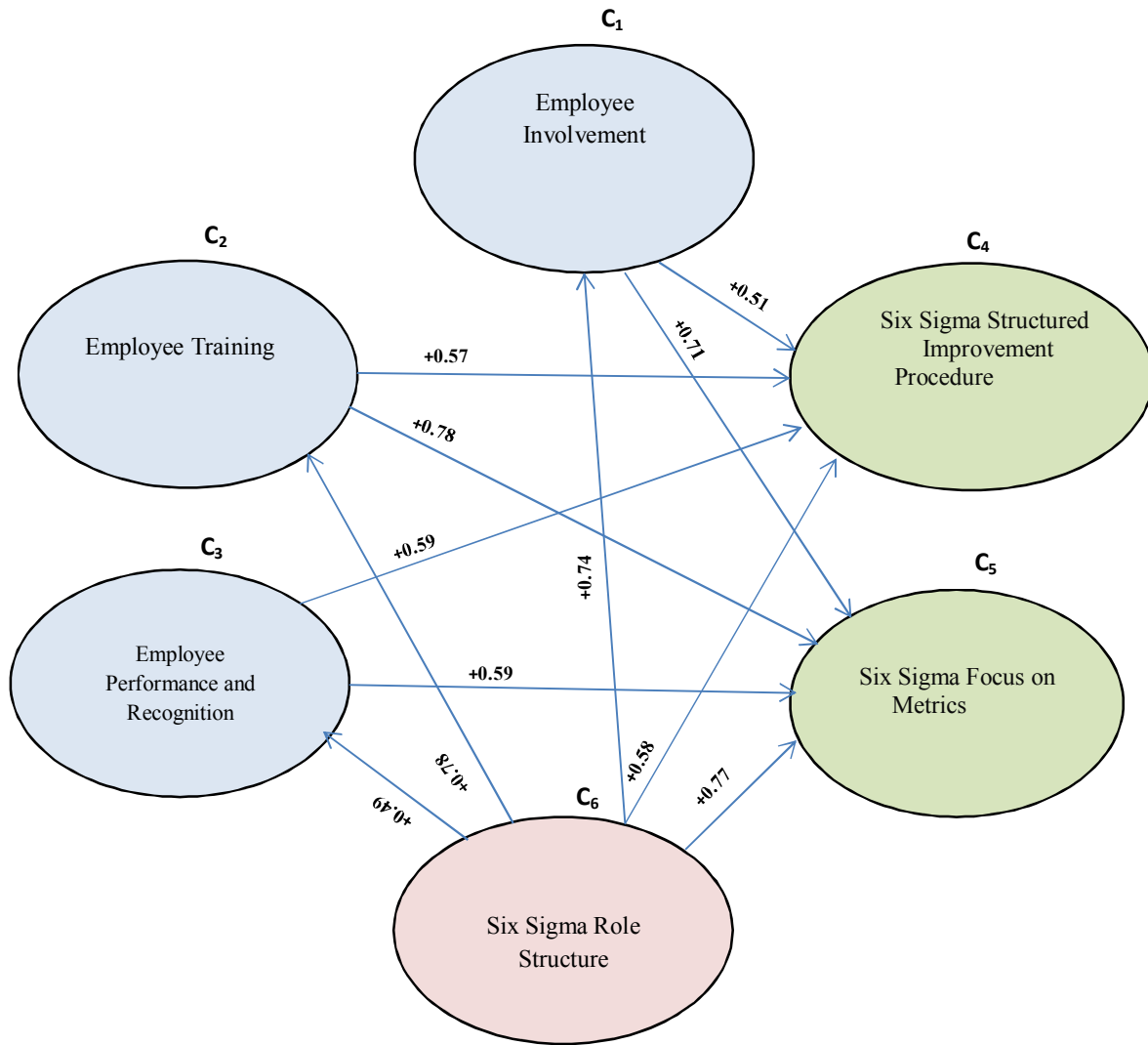| Concept	C_1	C_2	C_3	C_4	C_5	C_6
C_1	-	-	-	0.51	0.71	-
C_2	-	-	-	0.57	0.78	-
C_3	-	-	-	0.59	0.59	-
C_4	-	-	-	-	-	-
C_5	-	-	-	-	-	-
C_6	0.74	0.78	0.49	0.58	0.77	-

Fig. 5. A fuzzy cognitive map of impacts between HRM and Six Sigma

4. Conclusions

In this paper, we have presented an empirical investigation to illustrate the intense of relationships between the human resources management indices and Six Sigma project implementation indices in some selected Iranian manufacturing firms. By using the fuzzy cognitive maps (FCM), we were able to show the strength of relationships among various indices. This study helps quality and human resource managers learn how to manage the critical indices to achieve their determined goals and to increase Six Sigma project performance throw human resource management perspective. According to the results of this survey, the maximum correlation is between 'Employee Training- Six Sigma Focus on Metrics' and 'Six Sigma Role Structure-Employee Training'.

Acknowledgement

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