Using Approach of Fuzzy Prospect Theory to Analyze Key Competencies of Safety, Health and Environment Management

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Abstract
In Yazd Alloy Steel Factory, to reduce occupational accidents, considering safety, health and environment matters have been important more than before. In this study, we have investigated and explained key competencies of safety, health and environment officers in the alloy steel factory by using the proposed safety competency model by Chang and colleagues. Therefore, there were distributed and gathered the prepared questionnaires among 10 safety, health and environment managers and educational officers in the factory to identify priority of the proposed components of the model. To analyze data and determine priorities, there was used from Fuzzy Multi Criteria Decision Method (MCDM) based on prospect theory known as fuzzy TODIM[1]. The research results can help the factory managers to develop training programs and enhance skills of safety, health and environment employees. According to the research results, recognize ability of social and psychological risks, safety and health project management and recognize ability of environmental risks components were considered in planning priorities respectively.

Keywords: competency; safety, health and environment management; prospect theory; fuzzy TODIM

Introduction

It is clear that industry structure is a bed that can contain wide range of accidents, injuries, financial losses and casualties (Conchie et al, 2013). According to Heynz (2006), health and safety are not random, and macro planning, compliance with standards and instituting safety culture is essential to ensure optimal level of occupational health and safety in an organization (Geminiani et al, 2013). By focusing on organizational environment, it can be found that factors such as efficiency of accident reporting systems, occupational accident management and learning them, investment on safety systems, managerial and supervision approaches and consciousness of human force are known as infrastructures of organization's safety culture (Mearns et al 2013). Therefore, many experts believe that competent managers and supervisors about safety issues, as main component for implementing organization safety culture, can help employees to improve their behaviors

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for dealing with safety issues and institutionalize skills for preventing accidents' occurrence; as a result, it can be minimized accidents and their causalities (Conchie et al, 2013). In fact, employees' occupational safety and health is a subject that has been studied by authors in recent years. There have been provided several different models to examine safety of organizational persons and factors affecting on occupational health. Hale (1995) considered three factors that affect safety of organization's persons: industry experts, modifier factors and controller factors (Hale, 1995). To support Hale's model, Wu (2010) developed safety performance measure based on occupational health and safety, after pervasive studies. This scale includes nine factors: inspection and search; legal duties; emergency procedures and modify damages; management and financial affairs; cultural changes; recognizing and analyzing problem; develop and implement solutions; knowledge management; and education and communication (Wu, 2011). After studying safety models by considering available models, it is necessary that there are recognized and defined persons' occupational safety and health competencies, and safety performance competency of organizational persons should be reviewed and confirmed by considering competency concept (Chang et al, 2012). In recent years, important role of steel industry in the country development cannot be denied as a development indicator. By considering the matter as well as due to sensitiveness of observing safety issues in the country's steel industry, the present research attempts to provide effective solutions for improving managers' safety performance in Yazd Alloy Steel Factory and decreasing human causalities and financial damages, by identifying key components of competency of safety, health and environment managers and supervisors of the factory. It is hoped that there are collected more effective training programs to improve safety culture based on the extracted key competencies from the research.

Research History

This part of the study, the concepts of competency, safety and review of the literature is dedicated. This section of the present article includes defining competency concepts, safety and reviewing the research history. Finally, there have been introduced defining the used safety competency model in the research and prospect theory.

Theoretical History

Competency includes those individual abilities that help a person to complete tasks in hand successfully. Each competency is a mix of knowledge, skills, attitudes and abilities; it is a method that causes being put in practice people skills (Mashhoodi, 2010). In general, competency emphasize on those features of employees that affect effectiveness of individual occupational performance in organization. Therefore, managerial competency refers to organization managers' skills, capabilities and knowledge that will lead to their occupational success (Gholipour et al, 2012). Actually, managerial and supervisory competency development, which it is considered in context of human resource management, is main key to achieve organization to strategic goals, because managers and supervisors are main source to get competitive advantage, and managerial competency reflects behaviors related with human values and it is effective to form organizational dimensions (Chong, 2011). This matter causes competencies to be reviewed continually and improved as necessary (Martina et al, 2012). In general, organization survival and

development is a subject that all industries try to its implementation; and safety is an issue that can accomplish this goal (Wanwena et al, 2011). Safety in organization is a factor to minimize occupational accidents (Merchant, 2012). Safety culture consists a set of individual and group behavioral values, attitudes, competencies and patterns that show organization's commitment level, available skills and managers' style to create and maintain a healthy and safe environment (Biggs et al, 2013). Due to competency levels, issues related to labor relations, human resource (HR) information systems, salary and fringe benefits, health and safety, using technology and organizational development are emphasized in technical competency level, and corporate managers and supervisors should upgrade their qualifications to implement safety culture (Alavi & Moghaddam, 2006). As organization human force plays main role to occur occupational accidents and can create a health and safe space in organization (Herrero et al, 2013) as well as by considering the matter that occupational health and safety issues are competency components, it is necessary that competency management guides organization's people partnership and commitment toward creating safety culture as an instrument to develop human resources (Ramllal, 2006). Therefore, the present study attempts to examine the officers' safety competency in Yazd Alloy Steel Factory.

Multi Criteria Decision-Making (MCDM) based on Prospect Theory

In decision-making matters, there are used various methods of preference elicitation to determine optimal choice among multiple options. However, these methods are more or less accuracy (Lahdelma & Salminen, 2009). There have been provided some approaches to help decision makers in such matters that different decision makers choose numerous choices based on multi criteria. Among them, researchers have interested prospect theory because of its high descriptive power (Gomes & Rangel, 2009; Wakker, 2002). Main idea in the prospect theory is that choices are evaluated by different functions and by considering a reference point (Lahdelma & Salminen, 2009). Various researches have confirmed that prospect theory is consistent with decision makers' behavior (Gomes & Rangel, 2009; Wakker, 2002). Prospect theory also makes possible predicting and describing those behaviors that violate some aspects of rationality (Kahneman & Tversky, 1979).

Empirical History

Given importance of occupational health and safety issues has led to carry out many studies on this subject. In their research, Ismail and colleagues identified factors affecting implementation of safety management systems. To do this study, there were extracted factors affecting the system implementation according to experts' opinion and reviewing safety literature; then there was developed a proper questionnaire. Results indicated that awareness of organization's human force about safety matters and people sensitiveness about them play an important role to implement safety management system in an organization successfully, in addition to appropriate designing industrial machineries and equipments as well as improve working procedures (Ismail et al, 2012). By considering employees' role to success organization and institutionalize safety concept, Dearmond et al studied individuals' safety performance in organization structure. By using statistical analysis, they found that individual's perception about importance of safety in organization

and his/her involvement to prevent occupational accidents have a negative correlation with frequency of occupational accidents (Dearmond et al, 2011). Kiani et al studied safety training, the understood organizational support about safety and the related events with safety. Their research findings indicate that reducing the related events with safety is realized by improving employees' perception from organizational support, and it will minimize occupational accidents (Kiani et al, 2010). As increasing awareness of organizational people about safety matters and understanding its sensitiveness requires competence supervisors in organizations, Chang et al introduced competency model for safety of organization's employees and studied correlation between competency and performance. This study results indicated that employees' safety competency model includes five factors: occupation, age, occupational office, education and working conditions of employees. The results also showed that there is a significant positive correlation between employees' competency and safe operations (Chang et al, 2012). Conchie et al carried out a study to investigate involvement of supervisors in leading employees to follow safety procedures and identify obstacles in the process. The research findings indicate that factors such as overlapping organizational roles, formal approaches in organization and individual features of work force are factors that prevent supervisors' partnership in safety programs. According to the research findings, organization should held training programs to promote supervisors' abilities, and develop supervisors' competencies in leading employees to follow safe procedures by supporting them because there is a significant positive correlation between supervisors' safe behaviors, such as sharing achievable values through safe behaviors, and monitor safety issues with employees' safe behaviors (Conchie et al 2013). By reviewing previous researches, the present study attempts to examine qualification and staff attention at Yazd Alloy Steel Factory and prioritize to elements affecting safety competency of supervisors, according to the proposed model by Chang et al (2012) and staff attention to safety issues in the factory. It should be noted that in this study, there are prioritized safety competency components with emphasis on prospect theory as one of methods in multiple criteria decision making. As there are examined a wide range of decision-making in complex environments, using instruments to extract accurate information from heart of available ambiguities is very effective to overcome such conditions. Fuzzy theory is an instrument to decrease these complexities on process (Kelemenis et al. , 2011). Its application can be seen in the present research.

Safety Competency Model

In this research, the proposed model by Chang et al (2012) has been used to determine safety key competencies. This model has been developed based on managerial skills and technical skills in five dimensions consisting 28 components. This model is as the Fig. 1.

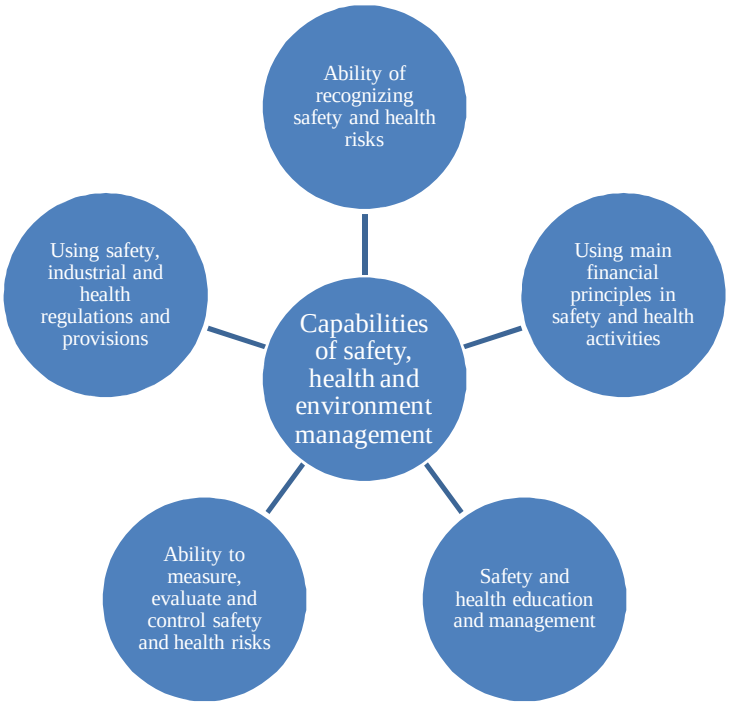

Fig. 1: safety capability model (Chang et al, 2012)

Research Methodology

The present research is applicable objectively; it is a measuring research based on the method of data collecting. In the research, there was designed its questionnaire by using the provided competency model by Chang et al firstly, in order to achieve its goal and implementation; then there was used from content justifiability and experts verification to examine its justifiability. There were distributed and collected the mentioned questionnaires between 10 experts of safety field including safety, health and environment managers and education personnel in Yazd Alloy Steel Factory, in order to identify key competencies of safety management in the factory. Fuzzy TODIM method based on prospect theory was used to its analysis. This method has been introduced in the following.

Fuzzy TODIM Method (Fuzzy Multi Criteria Decision-Making based on Prospect Theory)

In this section, there is introduced definition of triangular fuzzy numbers, confirming method of triangular fuzzy numbers and calculating fuzzy distances between the numbers. Then data will be analyzed based on fuzzy TODIM.

Definition 1

Triangular Fuzzy Number: a triangular fuzzy number $\tilde{\mathbf{A}}$ can be defined with an arranged triple (a, b, c). Membership function is defined as follows:

$$f_{\tilde{A}}(x) = \begin{cases} 0 & x < a \\ \dfrac{x-a}{b-a} & a \le x \le b \\ \dfrac{c-x}{c-b} & b \le x \le c \\ 0 & x \ge c \end{cases}$$

Definition 2

Consider triangular fuzzy number$\tilde{A}(a_1, a_2, a_3)$. In the research, certain amount is calculated by equation 1 (Sanayei et al, 2010).

$$m(\tilde{A}) = \frac{a_1 + a_2 + a_3}{3}$$

Definition 3

Consider triangular fuzzy numbers $\tilde{\mathbf{A}}(\boldsymbol{a_1}, \boldsymbol{a_2}, \boldsymbol{a_3})$ and $\tilde{\mathbf{B}}(\boldsymbol{b_1}, \boldsymbol{b_2}, \boldsymbol{b_3})$. Distance between these two numbers is calculated by equation 2 (Awasthi et al, 2011).

$$d(\tilde{a}, \tilde{b}) = \sqrt{\frac{1}{3}[(b_3 - a_3)^2 + (b_2 - a_2)^2 + (b_1 - a_1)^2]} \qquad (2)$$

Consider A matrix as the following, which it includes decision option and criteria:

A_1،. . . ، A_n are possible options, C_1 ،. . . ، C_m are research criteria and $\tilde{x}_{ij}$ id fuzzy numbers that indicate importance level of A_i option in direction with C_j. Weight vector of $W = (w_1, w_j, \dots, w_m)$ indicates importance of each component, as which $\sum_{j=1}^{m} w_j = 1$

Fuzzy TODIM method, as the developed type of fuzzy TODIM contains the following steps (Krohling, de Souza, 2012):

First Step: criteria are divided to positive and negative criteria usually. Fuzzy normal matrix is shown by $\tilde{R} = [\tilde{r}_{ij}]_{n*m}$ fuzzy normal amount is calculated by equation 3.

$$r_{ij}^k = \frac{max(r_{ij}^3) - r_{ij}^k}{max(r_{ij}^3)_i - min(r_{ij}^1)_i} \qquad k = 1,2,3 \qquad \text{For positive criteria}$$

$$r_{ij}^{k} = \frac{r_{ij}^{k} - min\left(r_{ij}^{1}\right)}{max\left(r_{ij}^{3}\right)_i - min\left(r_{ij}^{1}\right)_i} \qquad k = 1,2,3 \qquad \text{For negative criteria}$$

Second Step: Calculating dominance scope of each option in $\tilde{A}_i$ in comparison to option $\tilde{A}_j$ by using equations 4 and 5

$$\delta\left(\tilde{A}_i, \tilde{A}_j\right) = \sum_{c=1}^{m} \varphi_c \left(\tilde{A}_i, \tilde{A}_j\right) \qquad \forall(i, j) \qquad (4)$$

Where

$$\varphi_c(A_i, A_j) = \begin{cases} \sqrt{\frac{w_c}{\sum_{c=1}^{m} w_c}} . d(\tilde{x}_{ic}, \tilde{x}_{jc}) & if\ (m(\tilde{x}_{ic}) - m(\tilde{x}_{jc})) > 0 \\ 0 & if\ (m(\tilde{x}_{ic}) - m(\tilde{x}_{jc})) = 0 \\ \frac{-1}{\theta} \sqrt{\frac{\sum_{c=1}^{m} w_c}{w_c}} . d\left(\tilde{x}_{ic}, \tilde{x}_{jc}\right) & if\ (m(\tilde{x}_{ic}) - m(\tilde{x}_{jc})) < 0 \end{cases} \qquad (5)$$

Expression $\varphi_c(A_i, A_j)$ indicates C criterion proportion from function $\delta\left(\tilde{A}_i, \tilde{A}_j\right)$ when i option is compared to j option. Parameter θ represents character of mutation toward answers completely opposite in comparison with answers agrees completely. In case of risk aversion$\theta > 1$. Kahneman and Torski (1979) identified $\theta = 2.25$ experimentally, which it is consistent with experimental data. In addition, they showed that θ value is between 2 and 2.5. Expressions $m(\tilde{x}_{ic})$ and $m(\tilde{x}_{jc})$ show final volume of $\tilde{x}_{ic}$ and $\tilde{x}_{jc}$ fuzzy numbers. Expression $d(\tilde{x}_{ic}, \tilde{x}_{jc})$ shows distance between $\tilde{x}_{ic}$ and $\tilde{x}_{jc}$ fuzzy numbers. There is possible to occure three cases:

1. $(m(\tilde{x}_{ic}) - m(\tilde{x}_{jc})) > 0$ shows profit
2. $(m(\tilde{x}_{ic}) - m(\tilde{x}_{jc})) = 0$
3. $(m(\tilde{x}_{ic}) - m(\tilde{x}_{jc})) < 0$ shows loss

Final dominance scope matrix is gained by summing up minor dominance scope matrix for each criterion.

Third Step: Calculating total value option i is achieved through normalizing final dominance scope matrix by using Equation 6.

$$\varepsilon_i = \frac{\sum \delta(i,j) - \min \sum \delta(i,j)}{\max \sum \delta(i,j) - \min \sum \delta(i,j)} \qquad (6)$$

Options' priority will be identified by arranging amount of ε_i. The best option has more ε_i.

Collecting Data

In the research, there was designed a questionnaire contains five aspects of safety competency and its related 28 components, in order to collect data in consistent with the mentioned safety competency model in the research literature. This questionnaire was distributed between 10 experts by considering to their accessibility. They were safety, health and environment managers and safety education officers in Yazd Alloy Steel Factory.

Data Analysis

This research examines and explains competency priority among safety, health and environment supervisors in Yazd Alloy Steel Factory. In the research, decision matrix consists 28 competency components, as options and 10 decision-maker experts as decision criteria. According to Table 1, there were used triangular fuzzy numbers to change certain data to fuzzy numbers. Fuzzy information was non-scaled after being fuzzy the research data in accordance with equation 3. After forming fuzzy normal matrix phase in accordance with fuzzy TODIM method, there was calculated minor dominance field of safety competency components in comparison with each other and based on the identified criterion (decision-maker expert in the research) with respect to equation 3. Then, there was achieved final dominance scope by calculating total relative dominance for each component in comparison to other components according to specific criteria and with respect to equation 5. Finally, priority of each component is achieved by normalizing final matrix of dominance scope according to equation 6. Table 2 shows final results of data analysis including priorities for each component.

Table 1: trianglar fuzzy numbers

Vocal sentence	Positive numbers	triangle fuzzy numbers
Very important	9	(7, 9, 9)
Important	7	(5, 7, 9)
Important relatively	5	(3, 5, 7)
Low importance	3	(1, 3, 5)
Unimportant	1	(1, 1, 3)

Table 2: final results of analyzing data and each component's priority

Safety capability aspects	necessary capabilities to take charge of safety and health	ε_i	priority
Ability of recognizing safety and health risks	Ability to recognize physical risks	0.793	11
	Ability to recognize chemical risks	0.793	12
	Ability to recognize environmental risks	0.889	3
	Ability to recognize social and mental risks	1	1
	Ability to recognize ergonomic risks	0.683	20
Ability to measure, evaluate and control safety and health risks	Ability of measuring and supervising safety and health risks	0.751	15
	Ability of controlling safety and health risks through engineering technical criteria	0.795	10
	Ability of controlling safety and health risks through managerial criteria	0.805	9
	Ability of evaluating and testing personal protection facilities	0.531	26
	Ability of using and keeping personal protection facilities	0.641	21
Ability of education and	Ability of effective information extraction about safety and health	0.618	22

	Ability of using procedures of safety and health education	0.824	6
	Recognizing approaches of emergency response to events	0.811	8
	Investigation and auditory	0.843	4
	Ability of using individuals' capability in safety and health management	0.821	7
	Management of safety and health project	0.892	2
	Conducting risk management	0.776	13
	Developing safety and health management systems	0.832	5
Using main financial principles in safety and health activities	Using main financial principles (profit and cost) in safety and health activities	0.552	25
	Using statistical principles to recognize the most common risks	0.472	27
	Ability for using principles of safety and health leadership	0.718	16
	Recognizing and creating criterion of safety and health culture	0.713	17
	Recognizing and creating criterion of safety and health performance	0.583	24
Using safety, industrial and health regulations and provisions	Using work safety and health regulations (identifying high risk jobs)	0.766	14
	Creating and implementing work investigation regulation	0.61	23
	Ability of implementing regulation for protecting the wounded workers	0.693	19
	Ability of identifying work standards	0.696	18
	Ability of implementing work insurance law	0	28

Research Findings

According to the research results, component of ability to identify social and psychological risks factors were considered as the first priority in comparison with other competency factors. Components of safety and health project management and ability to identify environmental risks were positioned in the second and third respectively. Table 2 shows other priorities. The research results were presented by safety, health, and environment experts, which they were approved.

Conclusion and Recommendations

Many problems of decision-making are occurred in complex environments that uncertainty, incomplete knowledge and ambiguity are their features. For this reason, nature of each decision-making process is mixed with uncertainty. Solving decision-making complex processes are very difficult due to uncertainty, risk and inherent complexities in multi criteria decision-making process. In dealing with uncertainty complexity, it is very useful to use tools that can give correct information about all available data. It is very difficult to

examine data with uncertainty and individuals' comments by analyzing common multi criteria decision-making processes. Gomes and Lima (1992) introduced a method under name fuzzy TODIM to deal with such difficulties. In addition, information ambiguity affects decision-making process. The ambiguity arises from using verbal phrases such as very good, good, average etc. Therefore, fuzzy logic is a mean to reduce impact of such ambiguities on decision-making process. In this research, data uncertainty and ambiguity has influenced decision-making process. Some uncertainties in the collected data are related to the research limitations, especially limitation to select experts, non-availability many experts and lack of denying human errors in individuals' performance to choose options. In addition, data ambiguity is inevitable because of verbal expressions to rate the research components. Accordingly, to overcome these limitations, there has been used the integrated fuzzy logic model and multi criteria decision-making based on prospect in the research to analyze data. The research results have been confirmed by previous studies. In the previous studies, it has been cleared that factors such as poor awareness of top managers about safety, lack of training, poor awareness of project managers about safety, lack of entering resources to enhance safety and lack of awareness about operations' safety risks are effective in poor performance of safety management. Results of the carried out researches about studying necessary competencies to take charge safety, health and environment positions indicate that ability to train safety, health and environment, inspection ability, communication ability, leadership ability and ability to train safety and health were very important; ability to use financial principles and statistical techniques are the lowest competency. The research results can help authorities for planning to enhance skills and competencies of safety, health and environment officers. It also can help them to develop strategic and operational plans to increase safety for reducing risks. The research main limitation was unavailability of many experts. This research results can be used to develop effective operational programs, develop strategies to enhance safety and select the most suitable strategy. In addition, the model results can be integrated with performance develop model to select appropriate educational programs. It is also recommended that similar researches are carried out in other factories that safety is an effective factor for their performance, in order to compare their results with the research results.

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