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PRIORITIZING THE INDEXES OF INTELLECTUAL CAPITAL WITH THE FUZZY MODULATION AHP-TOPSIS METHOD (A STUDY ON SHAHID TONDGOOYAN PETROCHEMICAL COMPANY IN IRAN)

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ABSTRACT
Making decisions on the dimensions of intellectual capital and its influences on the performance of organizations is of significant importance. On one hand, the complexity of decision-making process and the movement of factors influential on the decision-making atmosphere from absolute to fuzzy data make the utilization of efficient models highly essential. Considering this, through utilizing the modulation of research science techniques in operations, with a fuzzy approach, this study identified and prioritized the indexes of intellectual capital in Shahid TondGooyan Petrochemical Company in Iran. The tool for the precise evaluation is the expert questionnaire which was developed in the form of five major indexes and twenty two subscales (postulating Chandra Sekhara et al model 2005) and allying the experts' opinions in the sample including seventeen individuals selected through purposive sampling. The analysis of the collected data using the fuzzy modulation hierarchical analysis AHP-TOPSIS method with SuperDecision software shows that the human capital is the most prioritized criterion of all. After that come structural capital, relational capital, customer capital, and finally innovation capital. The organization can based on the priorities mentioned above allocate its resources, whether financial or time resources, for the purpose of promoting the key elements of its intellectual capital.

KEYWORDS: intellectual capital, fuzzy logic, hierarchical analysis process, TOPSIS method.

1. INTRODUCTION

In a competitive age, the environments organizations are in characterize the increase in complexity, globalization and dynamism. Therefore, when establishing themselves, the organizations face new challenges that going out of them require more attention to the development and promotion of internal skills and capabilities. This can be done through the fundamentals of organizational knowledge and intellectual capital. Intellectual capital provides a qualitative viewpoint that has a close relationship with the measurement and identification of intangible assets developed by the organization (Claver, 2015). In different studies, intangible resources are known as a considerable resource to create value and to gain competitive advantage (Viktoria Goebel ,2015). It has been shown that intellectual capital has influences on the organization's performance and enables the organization to produce assets of higher value (Chandra Sekhara et al, 2015). Based on that, in many papers it is tried to emphasize on the strategic role of intangible assets like the staff capabilities, cultural values, long-term relationships between the enterprise and its stakeholders like clients, allies, providers and community as a whole in the unbearable and beneficial competition in order to make the management of intellectual capital a key issue in the managers' agenda (Castro *et al*, 2011).

Several (Mansion et al 2013, Darvish et al 2013, Nezhad Irani et al 2012) papers have studied how the management of intellectual capital improves the level of value creation of the business performance in an organization. Liliart et al (2003) considered the management of intellectual capital comprising of a multi-stage process. The starting point of the process is identifying the relative importance of the intellectual capital components and value creation factors. In this regard, Lozquist and Cojohnsiv (2000) divided the management of intellectual capital into two functions: control and development. Although they are compliments, control refers to the strategic activities designed to identify and prioritize the intangible resources. So, the identification and prioritization of the intellectual capital indexes for it to be managed is of high importance and necessity. This is much more important in the petrochemical companies which are the biggest producers of PET and PTA in Iran its duty is meet the changing needs of the final consumers of the chain value in petrochemical industry in food, medicine, packaging, textile and other related industries. In order to prevent the loss of efforts and costs one needs first to identify the importance of each dimension of the company's intellectual capital and then take measures to develop and manage them.

Meanwhile, the important point is that intellectual capital, being intangible, is hard to be measured. However, one should know that it is the development of quantitative indexes that can justify for the managers the utilization of intellectual capital in the organization (Costa and Menichini 2013). Therefore, the managers and experts recommend the fuzzy modulation AHP-TOPSIS method for the measurement of intellectual capital indexes.

Based on what was mentioned, in this study after doing some investigations with Delphi method, the model presented by Chandra Sekhara et al (2015) was adopted and due to the importance of the subject and lack of researches in this field, the indexes of intellectual capital were explained and prioritized and it is expected to theoretically:

- add to the knowledge and literature on intellectual capital
- introduce the intellectual capital in Shahid TondGooyan Petrochemical Company in Iran.

In methodology and experimentation, it is expected to:

- provide a comprehensive prioritization of intellectual capital in the society being studied based on fuzzy modulation hierarchical analysis AHP-TOPSIS method.

2. Theoretical framework

In 1969, John Kenneth Galbraith first used the term intellectual capital (Wenchang Fang and Ya-Hui Hsu 2009). Galbraith believed that intellectual capital was beyond "thinking as just thinking". In this sense, not only is the intellectual capital an intangible static asset, but also it is an ideology and a tool to reach one's goal (Benitez 2000).
Brooking (1996), Edvinsson and Malone (1997), Stewart (1997), Sveiby (1997) and Roos et al (1997) were the first to develop the concept of intellectual capital and played an important role in that (Viktoria Goebel 2015). Every one of them used different terms to understand the concept like intellectual capital, intangible resources. Stewart believes that intellectual capital is a set of knowledge and knowledge capabilities that the firm can use them to gain competitive advantages (Enrique Claver et al 2015). Edvinsson and Malone (1997) defined intellectual capital from the Accounting point of view and regard it the difference between the market value and the office value (Chandra Sekhara, et.al. 2015). In another definition, intellectual capital is the individual or group knowledge that that can be used to gain competitive advantage and increase the value of different kinds of capital (Eric C.K. Cheng, 2015).

As one can see, there are numerous definition provided of intellectual capital. Most of the definitions can be divided into two groups: in the first group, intellectual capital is considered the whole utilized knowledge by the organization to obtain the competitive advantage. Studies like Stewart (1997), Nahpait and Koushal (1998) and Yant (2004) can be assigned to this group.
From a wider point of view, intellectual capital also includes other intangible resources and activities. For example, European Commission (2006) states that intellectual capital is a combination of human, organizational and relational resources and the organization's activities and these resources include knowledge, skills, experiences, and abilities of the staff. R&D activities include the organizational procedures, trends, systems, databases, intellectual property rights of the company, all the resources related to relationships outside the company with the clients, providers, partners, etc. Researchers like Benitez (1999) and Mar (2006) have the same attitude on this matter (Cuadernos de Gestión, 2015).

To measure and manage the intellectual capital, different models are developed by researchers (Jorge Juan BojViudez. et al, 2015). In tripartite model, the intangible resources are divided into three groups: human capital, internal capital and external capital. Human capital is related to the staff competency and represents the implicit knowledge in their minds in the form of knowledge, skills, experiences, and abilities. The main goal of internal capital is to support the human capital to be converted to intellectual capital. In fact, as an infrastructure, it encourages the human resources to develop and use their knowledge; the knowledge remaining in the organization till the end of the working day, and by external capital we mean the knowledge obtained related to the environment outside the organization (Eric C.K. Cheng, 2015). Most of the intellectual capital models have tried to consider the three components (human, structural and relational capital) with some common characteristics for intellectual capital. In this study, a comprehensive model is adopted from Chandra Sekhara, et.al (2015) for the measurement of intellectual capital that includes Human Capital (HC), Structural Capital (SC), Relational Capital (RC), Innovation Capital (ICP), and Customer Capital (CC). They are operated with the Delphi method according to Table 1.

Table 1 : The main indexes and the relevant subscales

Symbol	Criteria	Subscales	Symbol
C1	Human Capital	Staff motivation	S11
		Staff technicality	S12
		Staff competency	S13
		Staff innovation	S14
		Staff experiences	S15
C2	Structural Capital	Organizational learning	S21
		Organizational structure	S22
		Informational system	S23
		Operational process	S24
		Cooperation culture	S25
C3	Relational Culture	Customer satisfaction	S31
		Relationships with providers and competitors	S32
		Brand value	S33
		Relationships with other organizations	S34
C4	Customer Capital	Customer royalty	S41
		Customization	S42
		Customer appropriacy	S43
		Marketing capability	S44
		Response rate to the customers	S45
C5	Innovation Capital	Innovational achievements	S51
		Innovational mechanism	S52
		Innovation culture	S53

3. MATERIALS AND METHODS

3.1 Method: this study is functional and the method is descriptive exploratory. It is descriptive inn that it objectively describes the condition in Shahid TondGooyan Petrochemical Company. In this study, the condition and situation are precisely defined and it is tried to provide objective report and results based on the current condition. On the other hand, it is exploratory because it tries to develop a model.

3.2 Statistical sample: the statistical sample in this study comprises of all the experienced experts in Shahid TondGooyan Petrochemical Company. Due to some reasons and as the hierarchical analysis process AHP-TOPSIS method is used to survey experts, it is essential for the statistical sample to be composed of knowledgeable experts in their fields. For this purpose, purposive sampling was used and 17 experts were identified. It is worth mentioning that although the number of the experts in the previous studies varied between 10 to 1685 individuals, the recommended number is 10 to 20 in case there is homogeneity among the members (Powell 2003; Okali Paloski 2004).

3.3 Data gathering: The data in this study are gathered through library and field methods. To write the literature review (theoretical framework and background) and choose the research criteria and indexes with the library method, there were used magazines, conference articles and scientific websites; wit the field method, the main data of the research were gathered to investigate the research questions, through distributing questionnaires among the experts with the Delphi method. The questionnaire used is an expert one and is a pairwise comparisons type. The questions of the questionnaire were first prepared based on Chandra Sekhara et al model scales and subscales and the adapted with the Delphi method to the statistical sample. So, the subscales underwent some changes and obviously after that the validity of the questionnaire content was confirmed by the experts. As the research process is based on a theoretical framework, the validity is clear and as the derivation many factors relies on a large number of theses and articles, the predicted validity seems to have been fulfilled.

To measure the stability, in addition to using the calculations related to the inconsistency rate of each expert's response, the inconsistency rate of the ideas of the experts was calculated too. The results obtained confirm the stability of the questionnaire.

4. RESULTS

In the recent years, several studies have used MCDA techniques to measure the intellectual capital. In this study, to prioritize the intellectual capital factors the AHP-TOPSIS was used. AHP is an organized method to cope with making complicated decisions that provides a logical and comprehensive framework for the structure of a decision-making problem representing the quantity of its elements, their relationship with the general goals and evaluating the other option (R. K. Jaiswala 2015).

Also TOPSIS (the rating method with regard to the positive ideal solution) is known as a classic method of MCDM that was developed by Hwang and Yoon to solve the multivariate decision-making issues based on the ideal determination. The options chosen have the least distance to the positive ideal and the most distance to the negative ideal (Hwang C. L. and Yoon K., 1981).

In this approach, AHP is used to determine the weight of the indexes and TOPSIS is used to determine the general rating of IC indexes (Chandra Sekhara, et al, 2015).
The analysis trend is as follows:

1. the pairwise comparison of the main scale based on the goal and determining the weight of the main sale
2. the pairwise comparison of the subscales of every scale and determining the weight of the subscales in every cluster
3. multiplying the weight of the subscales with the relevant scale and determining the final weight of the subscales
4. determining the final priority of the scales and subscales with TOPSIS with the calculation of positive ideal and negative ideal

For the purpose of the pairwise comparison of the elements Saaty nine-point scale was used which developed by Thomas Saaty the provider of the hierarchical analysis theory. The scales and subscales are shown in Table 1.
It is worth mentioning that in this study to make the measurements quantitative, the fuzzy approach is used. So, when gathering the experts' opinions, expressive and common fuzzys in the pairwise comparison questionnaire are used. Fuzzy logic is the one that replaces the conclusion methods in human brain and to express ambiguity in the form of a number, introduces a function for the membership in one group, that assigns a number between zero and one to very element. This number represents the level of the element's membership in the set. Zero indicates that the element is totally outside the set while one means the element is completely in the set (Ahmadifard, 2013). In this study, the Saaty fuzzy range is used based in Table 2.

Table 2 : Linguistics variables scale with triangular fuzzy numbers; Lee et al 2008: 101

Value	The comparison of i against j	Fuzzy numbers			Inverse fuzzy numbers		
		l	m	u	l	m	u
1	Equally Preferred	1	1	1	1	1	1
2	Middle	1	2	3	0.333	0.5	1
3	Moderately Preferred	2	3	4	0.25	0.333	0.5
4	Middle	3	4	5	0.2	0.25	0.333
5	Strongly Preferred	4	5	6	0.166	0.2	0.25
6	Middle	5	6	7	0.142	0.16	0.2
7	very strongly Preferred	6	7	8	0.125	0.142	0.166
8	Middle	7	8	9	0.111	0.125	0.142
9	Extremely Preferred	9	9	9	0.111	0.111	0.111

4.1 Determining the priority the human capital factors based on the goal

In the first step, the main subscales are compared based on the goal pairwise. The pairwise comparison is very simple and all the elements of every cluster should be compared two by two. So, if there are n elements in a cluster, there will be $\frac{n(n-1)}{2}$ comparisons. As there are five scales, the number of the comparisons is:

$$\frac{n(n-1)}{2} = \frac{5(5-1)}{2} = 10$$

The experts' viewpoint is made quantitative using the fuzzy scale which is done according to Table 2. Therefore, ten pairwise comparisons of the five main scales based on seventeen experts' viewpoint in a fuzzy mode are presented in Table 3.

Table 3 : The pairwise comparison of the main factors of assessing intellectual capital

C5	C4	C3	C2	C1	
(2.17, 2.75, 3.4)	(1.81, 2.29, 2.76)	(1.19, 1.49, 1.81)	(1.02, 1.26, 1.56)	(1, 1, 1)	C1
(1.64, 2, 2.39)	(1.62, 1.92, 2.22)	(1.07, 1.31, 1.59)	(1, 1, 1)	(0.64, 0.79, 0.98)	C2
(1.17, 1.48, 1.87)	(1.73, 2.17, 2.65)	(1, 1, 1)	(0.63, 0.76, 0.93)	(0.55, 0.67, 0.84)	C3
(1.08, 1.33, 1.67)	(1, 1, 1)	(0.38, 0.46, 0.58)	(0.45, 0.52, 0.62)	(0.36, 0.44, 0.55)	C4
(1, 1, 1)	(0.93, 0.75, 0.93)	(0.53, 0.67, 0.85)	(0.42, 0.5, 0.61)	(0.29, 0.36, 0.46)	C5

After forming the matrix of the pairwise comparisons, the special vector is calculated. First, the fuzzy sum of every line is calculated.

$$\sum_{j=1}^{n} M_{g_1}^{j}$$

The fuzzy extension of the internal factors fuzzy sum is as follows.

Therefore, the fuzzy extension of the preferences in each of the main scales is as follows:

Then, the fuzzy sum of the total elements of the preference column is calculated as follows:

$$\sum_{i=1}^{n}\sum_{j=1}^{n} M_g^j$$

The total of elements of the preference column of the main scales is as follows:

$$\sum_{i=1}^{5}\sum_{j=1}^{5} M_g^j = (24.69, 28.93, 34.26)$$

To make the preferences of each scale normal, the total of the scale values must be divided by the total of all the preferences (column elements). As the values are fuzzy, the fuzzy sum of every line is multiplied by the total reverse. The total reverse should be calculated.

Therefore, the results of normalizing the values obtained are as follows:

Each of the values obtained, the fuzzy and normalized weight are related to the main scales. There are numerous ways for the defuzzification of the values obtained one of which is to calculate the feasibility and also use the crisp number. In this study, the feasibility levels are calculated.

The defuzzification of the values: there are many ways such as Minkovski method for defuzzification. In this study, the center of mass method calculations were used for defuzzification.

$$x_{\max}^1 = \frac{l+m+u}{3}; \quad x_{\max}^2 = \frac{l+2m+u}{4}; \quad x_{\max}^3 = \frac{l+4m+u}{6}$$

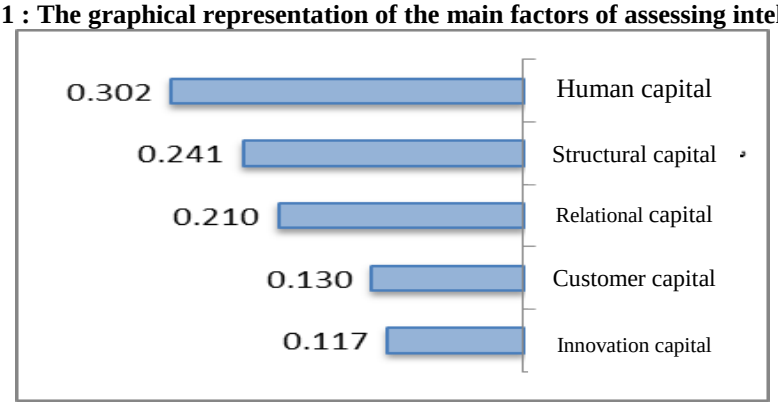
Crisp number = $Z^* = \max\{ x_{\max}^1, x_{\max}^2, x_{\max}^3 \}$

It must be mentioned that the weights calculated are non-fuzzy but they must be normalized.

Table 4 : The defuzzification of final weight values of the main scales

	X1max	X2max	X3max	Deffuzy	Normal
Human capital	0.313	0.311	0.309	0.313	0.302
Structural capital	0.249	0.248	0.246	0.249	0.241
Relational culture	0.218	0.216	0.214	0.218	0.210
Customer capital	0.135	0.133	0.132	0.135	0.130
Innovation capital	0.121	0.119	0.117	0.121	0.117

Figure 1 : The graphical representation of the main factors of assessing intellectual capital



W_1= ٠,٣٠٢ ٠,٢٤١ ٠,٢١٠ ٠,١٣٠ ٠,١١٧

Based on what was mentioned, the special vector for the main scales will be W_1. The inconsistency rate of the comparisons is 0.014 which is less than 0.1 and therefore the comparisons can be trusted.

4.3 Determining the priority of the research subscales

In the second step, FAHP technique was used and the subscales related to every group of the intellectual capital were compared pairwise. The pairwise comparison in every cluster is done separately and the procedure is like the one in the first step and the results are shown here.

Table 5 : The fuzzy values of human capital subscales

Human Capital Subscales	**Deffuzy**	**Normal**
Staff motivation	0.177	0.172
Staff technicality	0.193	0.188
Staff competence	0.256	0.249
Staff innovation	0.153	0.148
Staff experience	0.250	0.243

Based on the special vector obtained, the staff competency being 0.250 is of highest priority and the staff experience being 0.220 is the second. The inconsistency rate of the comparisons is 0.020 at the threshold of 0.1.

Table 6 : The fuzzy values of structural capital subscales (C2)

	X1max	X2max	X3max	Deffuzy	Normal
Organizational learning	0.250	0.248	0.246	0.250	0.244
Organization's structure	0.224	0.222	0.221	0.224	0.219
Informational system	0.239	0.237	0.235	0.239	0.234
Operational process	0.157	0.156	0.155	0.157	0.154
Cooperation culture	0.154	0.152	0.150	0.154	0.150

Based on the special vector obtained, the organizational learning being 0.244 is of highest priority and the informational system being 0.234 is the second. The inconsistency rate of the comparisons is 0.065 at the threshold of 0.1.

Table 7 :The fuzzy values of relational culture subscales (C3)

Crisp	X1max	X2max	X3max	Deffuzy	Normal
Customer satisfaction	0.242	0.241	0.239	0.242	0.237
Relationship with providers and competitors	0.392	0.391	0.389	0.392	0.385
Brand value	0.175	0.175	0.174	0.175	0.172
Relationship with other organizations	0.210	0.209	0.207	0.210	0.206

Based on the special vector obtained, the providers and competitors being 0.385 is of highest priority and the customer satisfaction being 0.237 is the second. The inconsistency rate of the comparisons is 0.055 at the threshold of 0.1.

Table 8 :The fuzzy values of customer capital subscales (C4)

	X1max	X2max	X3max	Deffuzy	Normal
Customer loyalty	0.200	0.198	0.196	0.200	0.192
Customization	0.263	0.261	0.260	0.263	0.253
Customer appropriacy	0.269	0.267	0.265	0.269	0.259
Marketing capability	0.126	0.125	0.124	0.126	0.121
Response rate to the customers	0.183	0.181	0.178	0.183	0.176

Based on the special vector obtained, customer appropriacy being 0.259 is of highest priority and the customization being 0.253 is the second. The inconsistency rate of the comparisons is 0.050 at the threshold of 0.1.

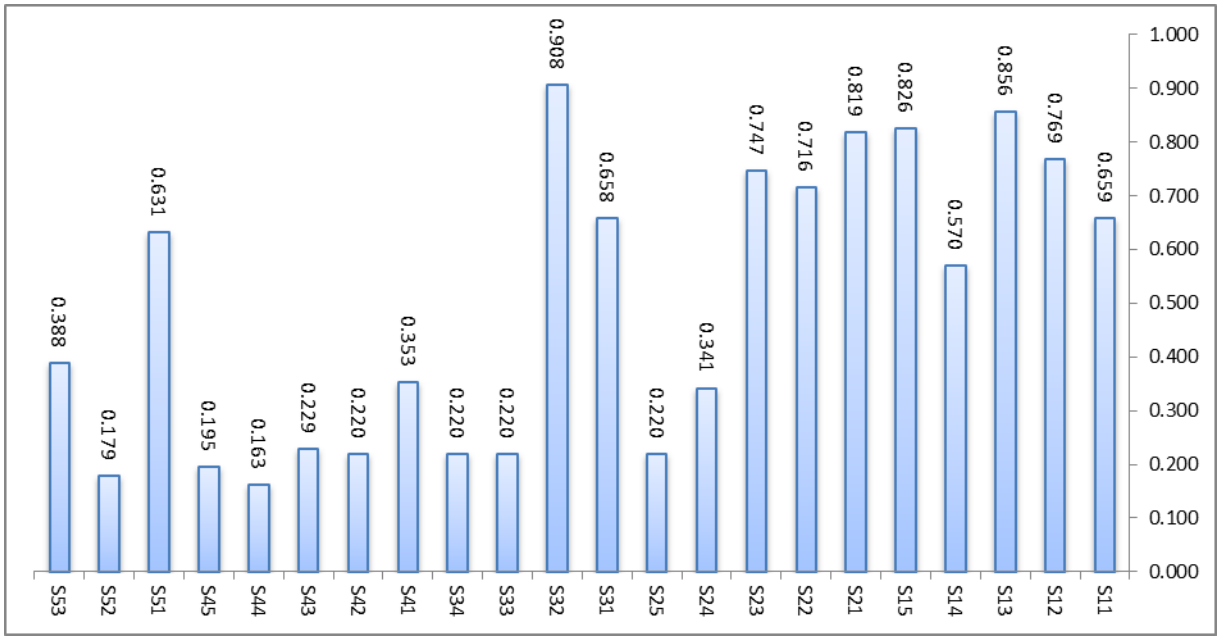


Figure 2 : The ratings with TOPSIS Technique

Table 9 : The fuzzy values of innovation capital subscales (C5)

Crisp	X1max	X2max	X3max	Deffuzy	Normal
Innovation achievements	0.442	0.438	0.435	0.442	0.427
Innovation mechanism	0.201	0.199	0.197	0.201	0.194
Innovation culture	0.392	0.389	0.386	0.392	0.379

Based on the special vector obtained, innovation achievements being 0.427 is of highest priority and the innovation culture being 0.379 is the second. The inconsistency rate of the comparisons is 0.012 at the threshold of 0.1.Therefore, considering the calculations, the final weight of each of the model indexes is calculated with TOPSIS-AHP technique.

Table 10 : A summary of TOPSIS technique results

	Distance to positive ideal	Distance to negative ideal	Score	Rate
S11	0.119	0.230	0.659	8
S12	0.077	0.256	0.769	5
S13	0.049	0.292	0.856	2
S14	0.145	0.191	0.570	11
S15	0.059	0.280	0.826	3
S21	0.062	0.281	0.819	4
S22	0.093	0.234	0.716	7
S23	0.084	0.247	0.747	6
S24	0.230	0.119	0.341	14
S25	0.258	0.073	0.220	16
S31	0.114	0.219	0.658	9
S32	0.031	0.306	0.908	1
S33	0.258	0.073	0.220	16
S34	0.258	0.073	0.220	16
S41	0.213	0.116	0.353	13
S42	0.258	0.073	0.220	16
S43	0.284	0.084	0.229	15
S44	0.283	0.055	0.163	22
S45	0.267	0.065	0.195	20
S51	0.122	0.208	0.631	10
S52	0.283	0.062	0.179	21
S53	0.205	0.130	0.388	12

5. CONCLUSION

Today, moving from an industrial age to an information age, the intellectual capital and intangible assets are absolutely critical tools for the competitive advantage of the organizations and even countries. It is the intellectual capital and management of the capital which is the key to success in such a challenging society (Mehralian et al 2013). The increase in the importance of intellectual capital has made its measurement and management essential in order to better understand how intellectual capital can lead to the creation of values. Companies that learn how to measure and manage the intellectual capital are able to considerably improve their performance in a competitive market (Jorge Juan Boj-Viudez, et al 2014).

The first step to manage the organization's intellectual capital is to determine the intellectual capital indexes and measure them. This way, beside developing a basis to describe the current condition of the organization's intangible assets, there is provided a criterion for making decisions in order to develop them. Therefore, this study identified and determined the important intellectual capital indexes in Shahid TondGooyan Petrochemical Company in Iran. According to the calculations with SuperDivision software, the human capital is the most prioritized criterion of all.

This complies with most of the results obtained from other researches. The findings show that intellectual capital is a combination of knowledge, skills and experiences of the staff and plays an important role in improving the organization's efficiency (Alžbeta Kuchar íkováa et al, 2015). In this regard, Ştefania Zlatea, Cerasela and Enacheb (2015) stated that the components of intellectual capital are professional skills, experience, skills and innovation and it therefore is the most important one. Also the findings indicate that among the subscales, relationships with providers and competitors and staff competence are of the highest importance. The results obtained in this study 1) can be a guideline and complement for the purpose of managing the intellectual capital so that the organization, considering the priorities, allocate its financial and time resources in order to fulfill and improve the key indexes of intellectual capital 2) this study, using research techniques in operations, tried to utilize the tested engineering models in the management field in order to facilitate the important managerial and organizational decisions so that there are provided motivations for further researches with more complicated methods like Promethee, Dematel and network analysis with a fuzzy approach 4) this study used the triangular fuzzy approach in all the steps, while there could also be used the trapezoidal fuzzy numbers.

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