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Identify and Evaluate the Factors Influencing Technological Capabilities Using Fuzzy Dematel Techniques at Science and Technology Parks (Case Study: Knowledge-Based Companies at Mashhad's Science and Technology Park)

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Abstract: Science and technology parks are considered as the main hub for technological development in the country. Science and technology parks consist of knowledge-based companies which are engaged in designing and producing innovative products and services. The technological capabilities is one of the important issues that are extremely important for knowledge-based companies. In this study, important and key aspects and technological capabilities in knowledge-based companies will be identified and evaluated. In this study, the key factors in technological ability and capability using fuzzy dematel techniques have been analyzed. The main factors influencing technological capability in this research include: creativity and innovation capabilities, flexibility in business processes of the company, the acquisition and transfer of technologies, capabilities and competencies of human resources, the ability to take advantage of information and communication technological tools, the ability to commercialize products and services on the market, the the use of knowledge management in the creation and management of technology. The results showed that the ability to use knowledge management is considered as the most influential factor in the creation and management of technology, the ability to commercialize products and services in the market is considered as the most affected factor and the use of knowledge management in the creation and management of technology was considered as a factor that has the most interaction with other factors.

Key words: Technological capabilities, fuzzy dematel, knowledge-based companies, interaction, Iran

INTRODUCTION

Technology is made up of two greek words which are "techno" and "logy". In fact, it is the set of physical processes, methods, techniques, tools and equipment by which products and services can be provided (Tabatabaeian, 2008). In other words, technology is a systematic knowledge to produce output, using a process or providing a service, this knowledge may be a form of invention, industrial design or service which is provided by professionals. In fact, this knowledge is an intangible asset which be created, transferred, acquired and finally, it should be decommissioned. In the context of business, the technology is regarded as a practical application of engineering knowledge in order to understand, develop or use products, processes, operations and services.

A comprehensive definition of technology include a set consisting of tools and techniques that are derived from science and practical experience and they are used to develop, design and produce products, systems, processes and services (Gharibnejad, 2012).

The importance of technology: Chris Floyd describes technology as a critical matter for the following reasons:

- Technology is essential to the success of manufacturing activities and even to the success of numerous service activities
- The continuation of technological innovation is the only way to revive long-term growth and technologies should be managed in the long-term

Some experts has underlined the importance of technology from the perspective of economy and consider it important, because a significant effect on the value of each factor of production and a decisive role as an indicator in the investment, labor force and management.

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Nawaz Sharif described technology as an index of investment and an essential tool for all economic dataand the most powerful agent of change at developed and developing countries and introduced it as the main weapon of development. He pointed to the presence of a bilateral relationship between technological changes and believes that technology not only causes change but also respond to changes in society. Technology or combination of all available technologies, at some point, operates as a pressure factor to develop community (Tareq, 2007).

Technology is the foundation of success in business, product development and many services and there won't be any competitive advantage without effective use of technology. In other words, technology is the main factor to differentiate products, reduce costs and create new business opportunities (or addressing the threat of replacement) and to facilitate and support strategic changes (Esbati *et al*., 2009).

Technology components: Zeleni states that any technology is made up of three interdependent and equally important components.

Hardware: Physical structure and logical arrangement of equipment or machinery that are used to perform the necessary tasks

Software: Learn how to use hardware to perform the necessary tasks.

Subjective knowledge: Reasons for using technology to specific practices can be called technical justification. In addition to these three components, many studies have found that a fourth component should be considered and analyzed independently. Because, this is the part of all levels of technological success.

Technical knowledge: Knowledge or technical skills regarding how to do things right. Technical knowledge can be a result of experience, knowledge transfer or practical training.

Technological features: One of the technological features is that it is constantly changing and this change is caused by several forces and the most important forces are Mofateh and Khamse:

- The nature of technology itself
- Economic force
- The environmental force

In general, according to experts, technical features can be summarized as follows. A tool to transform natural resources into usable goods, a tool to change and control environmental condition, an agent for social change, a source of increasing wealth, consciously force to influence the process of economic, social and cultural development and a marketable commodity. In today's world, authority, power and dominance are undeniable which have been introduced by creating a exclusive knowledge for beneficiaries as the primary key of development and it is the only way to revive the long-term growth.

Research background: In a study entitled "Study the factors influencing in decision-making of Fars's industry leaders to choose technology" which was conducted in 1998, Shirazi and colleagues described four factors as important factors in the choice of technology. Economic factors, financial factors, technical factors and strategic factors and each of these factors has its own components.

In a study entitled "factors affecting the choice and transfer of technology (Iran Khodro production line)" which was conducted in 2008, Ansari stated that factors such as technological factors, financial factors, technical factors, commercial factors, organizational factors and environmental factors are among the factors which were identified in this study and each of them have features and parameters as well.

Mofateh and Khamse investigated the development of the automotive industry's technological capability. One of the major factors in the failure of using technology to gain competitive advantage in developing countries is lack of knowledge in the enterprise technological capabilities and use them to gain relative advantages. Great importance of technology development makes senior corporate executives attempting to identify and assess the capabilities of their organization's technology and parallel to it, they strive to identify technological developments in the world and monitor the efforts of competitors to achieve new technologies and upgrade technological capabilities in the organization. On the other hand, this assessment is one of the key tools in the management of technology and this tools can be used to identify strengths and improvement with the aim of measuring the technological gap. In this study, we try to assess the technological capability using existing models and present a native and developed technological assessment model for Iran's automotive industry, including mega motor company.

In a study entitled "Framework for the Evaluation and Selection of Learning Technologies", Zaid introduced

19 indicators for technology selection process: comfortable access, usability feedback, versatility, technology life cycle, maintenance, required technical skills, compliance with expectations and preferences of users, usability and reliability, time required for learning, materials and activities required for learning, development activities and promoting the satisfaction of users (students), cost, motivated users, level of engagement, user support and communications.

In a study entitled "Selection of Photo Voltaic Technology: Fuzzy Multi-criteria Decision-making Approach" that carried out in 2014, Kaa *et al.* (2014) identified four important factors. These factors include supporters of standard specification, standard features, standard support strategy and other stakeholders. Each of these factors have settings and parameters. Then the model was solved using fuzzy AHP technique.

Ershadi (2010) examined and evaluated technological components with the help of the Atlas technology model (case study: saipa engineering design and construction of equipment and tools company). At first, the concept of technology, technological components and its assessment presented in this study and then, the analysis of technology and its components in engineering design company in Tabriz's Saipa will be discussed with the help of technological evaluation model and the atlas of technology. Using software QSB, the results are as follows: the rating related to technology is equal to 55%, the rating related to human resources is equal to 64%, the rating related to information is equal to 40% and the rating related to organization is equal to 41%. Compared with the whole country industry, each of the components were TCC = 52, 58, 36, 31.2, 31.2 and 52%, respectively. Finally, conclusions and recommendations be presented.

Science and technology parks: Science and technology park is an organization that is managed by professionals and its main objective is to increase wealth of society by encouraging and promoting a culture of innovation and increase competition among companies and institutions that are active based on science and knowledge in the park.

Science and technology parks are considered to be a social institution and a place for the development of knowledge-based innovation through assistance in the establishment and strengthening of Small and Medium Enterprises (SMEs) and part of a thoughtful and coordinated strategy for national development.

Knowledge-based companies: Knowledge-based company is a private or cooperative company or institution which is formed in order to boost knowledge and wealth, knowledge-based economic development, achieving the scientific and economic goals (including the development and application of invention), commercialization of research and development (including the design and production of goods and services) in the field of superior technology and especially in the production of high value-added software.

MATERIALS AND METHODS

In terms of purpose, it is an applied research and in terms of nature, it is a descriptive research. The study population consisted of all knowledge-based companies in science and technology parks. In this study, 10 knowledge-based companies located in Mashhad's Science and Technology Park were selected through purposive sampling. Initially, the factors affecting technological capability were collected and summarized using a comprehensive library studies. Then, through interviews with experts working in that 10 knowledge-based companies located in Mashhad's Science and Technology Park, some of these factors were screened. Then, fuzzy dematel standard questionnaire designed to determine the severity of the relationships between factors and were distributed among experts and managers of knowledge-based companies. The final factor is the result of a comprehensive literature review and interviews with experts and managers of knowledge-based companies which is given in Table 1.

Dematel technique: In 1971, Fontela and Gabus proposed Dematel technique along with Battelle Memorial Human and Science Institute in Geneva. This method which stem from decision-making methods based on paired comparisons with the benefit of expert judgment in the extraction of system factors and their systematic structuring and by using principles of the theory of graphs, proposed a hierarchical structure of the agents in the system along with the mutual interaction and determined the impact of these interactions by numerical score (Agha *et al*., 2008). But, the failure of this approach in decision-making in uncertain situations, prepared the ground for the emergence of fuzzy dematel.

Solving method based on fuzzy dematel

Step one: To quantify the association between factors and indicators, the group of decision makers which included p expert and p fuzzy matrix $(\tilde{z}^1, \tilde{z}^2, ..., \tilde{z}^p)$ been asked to express verbally their opinion. The constituent

Table 1: Technological capabilities

Code	Index name
C1	Creativity and innovation
C2	Flexibility in the company's business processes
C3	Acquisition and technology transfer
C4	Human resource competency
C5	Taking advantage of information and communication technological tools
C6	Commercialization of products and services in the market
C7	Use of knowledge management in the creation and management of technology

Table 2: Linguistic variables and fuzzy dematel

The values of linguistic scales	Triangular fuzzy numbers
Very high impact	(0.75, 1,1)
High impact	(0.5, 0.75, 1)
Low impact	(0.25, 0.5, 0.75)
Very low impact	(0, 0.25, 0.5)
Affectless	(0, 0, 0.25)

elements of this matrix is triangular fuzzy numbers. Then, for the formation of the matrix, the initial direct connection with the mean matrix (matrix Z) is used in Table 2.

$$\begin{bmatrix} 0 & \tilde{Z}_{12} & \cdots & \tilde{Z}_{1n} \\ - & \vdots & \ddots & \vdots \\ \tilde{Z}_{n1} & \tilde{Z}_{n2} & \cdots & 0 \end{bmatrix} \quad (1)$$

$$Z = \frac{\tilde{Z}^1 + \tilde{Z}^2 + \ldots + \tilde{Z}^p}{p} \quad (2)$$

In this matrix, I is the identity matrix of H_l, h_m and H_u and each element is the matrix n×n in which the elements are the lower number, the middle number and upper in the triangular fuzzy numbers and can form the matrix H.

RESULTS AND DISCUSSION

Second step: Obtain direct connection of matrix normalized: to normalize the obtained matrix, we use the following equations (Table 3):

$$\tilde{H}_{ij} = \frac{\tilde{Z}_{ij}}{r} = \left(\frac{l_{ij}}{r}\frac{m_{ij}}{r}\frac{u_{ij}}{r}\right) = \left(l_{ij} m_{ij} u_{ij}\right) \quad (3)$$

$$r = \max_{1 \le i \le n}\left(\sum_{j=x}^{n} u_{ij}\right) \quad (4)$$

The third step: To obtain the whole relationship matrix: the element t_{ij} shows that i has an indirect impact on the element j. Thus, the matrix T can reflect whole relationships between couples of the system. The whole fuzzy relationship matrix is calculated as follows:

$$T = \lim_{k \to \infty}\left(\tilde{H}^1 + \tilde{H}^2 + \ldots + \tilde{H}^k\right) \quad (5)$$

Each element is a fuzzy number $\tilde{t}_{ij} = \left(l_{ij}^t m_{ij}^t u_{ij}^t\right)$ and can be calculated by the following Eq. 6 (Table 4):

$$\left[l_{ij}^t\right] = H_l \times \left(I - H_l\right)^{-1} \quad (6)$$

The middle limit matrix is calculated from Eq. 7 (Table 5):

$$\left[m_{ij}^t\right] = H_m \times \left(I - H_m\right)^{-1} \quad (7)$$

The upper limit matrix is calculated from Eq. 8 (Table 6):

$$\left[u_{ij}^t\right] = H_u \times \left(I - H_u\right)^{-1} \quad (8)$$

Fourth step: Get the whole rows and columns of the matrix $\tilde{T}$ and determine the importance of the relationship between indicators and benchmarks for fuzzy and definitive numbers:

$$\tilde{D} = \left(\tilde{D}_i\right)_{n\times 1} = \left[\sum_{j=1}^{n} \tilde{T}_{ij}\right]_{n\times 1} \quad (9)$$

$$\tilde{R} = \left(\tilde{R}_i\right)_{1\times n} = \left[\sum_{j=1}^{n} \tilde{T}_{ij}\right]_{1\times n} \quad (10)$$

That $\tilde{D}$ and $\tilde{R}$, respectively are n×1 and 1×n matrices. After that, the interaction between the factors and indicators $\tilde{D}_i + \tilde{R}_i$ and the amount of influence and impact of factors and indicators $\tilde{D}_i - \tilde{R}_i$ will be determined. If $\tilde{D}_i - \tilde{R}_i \geq$, then that factor or indicator is an effective factor or indicator. If $\tilde{D}_i - \tilde{R}_i \leq$, then that factor or indicator known to be impressionable. In the final step, the numbers $\tilde{D}_i + \tilde{R}_i$ which obtained from the previous step, will be defused based on Eq. 11 (Table 7):

$$B = \frac{a_1 + 2\times a_2 + a_3}{4} \quad (11)$$

As you can see, the ability to use knowledge management to create and manage technology is the most influential factor on other factors with a score of 0.717 (Table 8).

As you can see, the ability to commercialize products and services on the market is the most influenced factor by other factors with a score of -1.298 (Table 9).

As you can see, the ability to use knowledge management to create and manage technology have most interaction with other factors with a score of 3.543 (Table 10).

Table 3: Normalized fuzzy matrix based on the average of expert opinions

Codes	---------C1---------			--------C2---------			----------C3----------			----------C4---------			----------C5----------			----------C6----------			--------C7---------		
C1	0.00	0.00	0.00	0.09	0.13	0.17	0.13	0.17	0.17	0.02	0.06	0.11	0.02	0.06	0.11	0.13	0.17	0.17	0.11	0.15	0.17
C2	0.00	0.02	0.06	0.00	0.00	0.00	0.11	0.15	0.17	0.04	0.06	0.11	0.04	0.09	0.13	0.06	0.11	0.15	0.06	0.11	0.15
C3	0.02	0.04	0.09	0.06	0.11	0.15	0.00	0.00	0.00	0.02	0.04	0.09	0.02	0.06	0.11	0.09	0.13	0.17	0.02	0.04	0.09
C4	0.11	0.15	0.17	0.02	0.06	0.11	0.11	0.15	0.17	0.00	0.00	0.00	0.02	0.04	0.09	0.09	0.13	0.17	0.04	0.09	0.13
C5	0.02	0.06	0.11	0.11	0.02	0.06	0.06	0.11	0.15	0.04	0.09	0.13	0.00	0.00	0.00	0.06	0.11	0.15	0.04	0.09	0.13
C6	0.00	0.00	0.04	000	0.02	0.06	0.00	0.04	0.09	0.00	0.02	0.06	0.00	0.02	0.06	0.00	0.00	0.00	0.02	0.06	0.11
C7	0.09	0.13	0.15	0.11	0.15	0.17	0.13	0.15	0.17	0.13	0.17	0.17	0.11	0.15	0.17	0.11	0.15	0.17	0.00	0.00	0.00

Table 4: Direct and indirect relationship matrix at the low limit

Codes	C1	C2	C3	C4	C5	C6	C7
C1	0.020	0.113	0.166	0.048	0.045	0.172	0.127
C2	0.017	0.020	0.130	0.059	0.056	0.095	0.077
C3	0.029	0.073	0.021	0.031	0.030	0.103	0.034
C4	0.118	0.048	0.139	0.017	0.036	0.126	0.066
C5	0.034	0.037	0.086	0.054	0.011	0.089	0.055
C6	0.002	0.003	0.004	0.003	0.003	0.004	0.022
C7	0.111	0.138	0.186	0.150	0.126	0.170	0.040

Table 5: Direct and indirect relationship matrix at the middle limit

Codes	C1	C2	C3	C4	C5	C6	C7
C1	0.084	0.236	0.317	0.161	0.160	0.325	0.248
C2	0.086	0.087	0.252	0.133	0.151	0.222	0.178
C3	0.085	0.161	0.092	0.095	0.113	0.211	0.107
C4	0.207	0.165	0.276	0.082	0.123	0.266	0.180
C5	0.123	0.145	0.215	0.149	0.069	0.221	0.161
C6	0.027	0.054	0.085	0.050	0.049	0.046	0.089
C7	0.223	0.277	0.356	0.270	0.250	0.344	0.144

Table 6: Direct and indirect relationship matrix at the upper limit

Codes	C1	C2	C3	C4	C5	C6	C7
C1	0.313	0.538	0.600	0.436	0.441	0.636	0.534
C2	0.333	0.336	0.537	0.390	0.490	0.553	0.463
C3	0.314	0.424	0.344	0.335	0.356	0.519	0.374
C4	0.440	0.461	0.569	0.314	0.397	0.604	0.475
C5	0.370	0.434	0.523	0.508	0.297	0.556	0.449
C6	0.207	0.263	0.313	0.237	0.239	0.254	0.295
C7	0.479	0.577	0.649	0.522	0.525	0.688	0.429

Table 7: The effectiveness and affectedness and interaction between indices

Codes	D+R	D-R
C1	2.928	0.698
C2	2.853	-0.005
C3	3.041	-0.684
C4	2.825	0.381
C5	2.593	0.191
C6	2.622	-1.298
C7	3.543	0.717

Table 8: The results showed that the technological factors affecting on other factors include

Rate	Criterion	Score
1	Ability to use knowledge management to create and manage technology	0.717
2	Ability to carry out creativity and innovation	0.698
4	Capabilities and competencies of human resources	0.381
5	Utilization of information and communication technological tools	0.191

Table 9: The results also showed that the technological influenced factors by other factors include

Rate	Criterion	Score
1	Ability to commercialize products and services on market	-1.298
2	Ability of acquisition and transfer of technology	-0.684
3	Flexibility in the company's business processes	-0.005

Table 10: The results of this research regarding the interaction of each factor with other factors (relative importance)

Rate	Criterion	Score
1	Ability to use knowledge management to create and manage technology	3.543
2	Ability of acquisition and transfer of technology	3.041
3	Ability to creativity and innovation	2.928
4	Flexibility in the company's business processes	2.853
5	Capabilities and competencies of human resources	2.825
6	Ability to commercialize products and services on the market	2.622
7	Utilization of information and communication technology tools	2.593

CONCLUSION

The results showed that the use of knowledge management in the creation and management of technology is the most influential factor on other technological capabilities and in this sense, it is a very important issue. In fact by applying knowledge management systems, knowledge-based companies can turn into reality tacit knowledge that lies within all company employees and then share the knowledge generated. Thus, having powerful programs in the area of implementation of knowledge management in knowledge-based companies is necessary and inevitable. It is recommended that knowledge-based companies design and promote knowledge management systems in various ways and by taking advantage of this powerful tool, tacit knowledge turns into explicit knowledge and then, becomes useful functionalities and capabilities include technological capabilities. So, having powerful programs in the field of implementation of knowledge management in knowledge-based companies is necessary and inevitable.

The next important influential factor which has the greatest impact on other factors after knowledge management is creativity and innovation functionality. In fact, creativity and innovation are a kind of spirit that get blown to the organization and makes the organization still remain competitive. On the other hand, technological capabilities are heavily dependent on creativity and innovation and the more the creativity and innovation, the more technological capability. Thus, it is suggested that knowledge-based companies which are based on the creativity and innovation should develop a culture of

creativity and innovation in order to take advantage of this important factor and propel it to the technological competences and capabilities. Then, companies should be encouraged to develop creativity and innovation with the creation of mechanisms and processes.

The next influential factor after the above two factors, are capabilities and competencies of human resources. At present, human resources are considered as the most original and the most valuable asset in any organization. On the other hand, capabilities and technological capabilities can be optimized through efficient human resources. Therefore, it is suggested that programs be used to make improvements and assess strategically the staff competencies in human resources.

And finally, the last factor affecting is the ability to use of information and communication technological tools that actually refers to the era of information and information technology. In fact, one of the aspects of technology and the acquisition of its capabilities is to use the information technology tools and knowledge-based companies are suggested to implement new tools in order to obtain technological capabilities.

RECOMMENDATIONS

It is recommended that technological capabilities be investigated by using other decision-making techniques such electre, topsis, vikor, promethe and so on. In future research, it is suggested that the impact of technological capabilities and competencies in knowledge-based companies on organizational variables such as productivity, efficiency, effectiveness and so on be examined.

In future research, it is suggested that different aspects of technological competencies and capabilities in knowledge-based companies be analyzed. In future research, it is suggested that the impact of the implementation of technological capabilities in the future success of knowledge-based companies be investigated using simulation models of dynamic system.

In future research, it is suggested that technological capabilities in other knowledge-based companies be investigated.

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