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A DECISION MODEL SUGGESTION FOR DECISION-MAKING PROCESSES OF TECHNOLOGY DEVELOPMENT ZONES[1]

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ABSTRACT

Knowledge and technology take indispensable place in developing world. Firms are in a continuous competition in the production sector. Thus, in order to be successful in this competition and get the place in market, firms should be compatible with knowledge and technology. This knowledge and technology meet with production at Technology Development Zones (TDZs) and in TDZs, manager firms are responsible for management and other important operational processes of Zone. Firms can not overcome all these tasks solely that they need to make collaboration. Collaboration process is a decision-making process, which needs to decide with whom to collaborate and there exist various criteria affect this decision-making process. Since, this process is somehow a complex one, a mathematical model as Fuzzy Analytical Hierarchy Process (FAHP) is proposed in this study. Data was obtained from a three parted data form, which was applied to specialists, who are occupied at Technology Development Zones in Ankara city. As compared main criteria, it is found that institutional development got highest rank among other criteria, which means when manager firm decides to make collaboration, it gives more importance on this criterion. Among the sub criteria, project improvement, intellectual property rights, activities (academic and practical ones) and social responsibilities were found as more important than other sub criteria. Among the alternatives, collaboration with universities, national and international institutes got the highest rank compared with other alternative choices. For further studies, it will be beneficial to expand the framework of this study.

Keywords: Technology Development Zone, manager firm, FAHP
JEL Codes: M42, O30

1 This study is taken from Master Thesis Named as 'A Decision Model Suggestion For Collaboration Decisions Of Manager Fırms At Technology Development Zones: Application Of Fuzzy AHP Model'

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1. INTRODUCTION

Formerly isolated organizations come together in order to form a new structure and a commitment with a defined mission and each organization makes its own duty by using their own sources by means of collaboration (Bailey and Koney,2000). Today, mostly in many communities, for groups, organizations and institutions, working collaboratively is an important factor when confronted with complex issues.

Technology and information are the most important components in order to get leadership position in economy and politics in today's world (Bailey and Koney, 2000). Although production sector still uses traditional production methods, Technology Development Zones, who blend technology and knowledge with production, offer opportunities for producing technological products. Main role of Technology Development Zones is hosting research institutions and industrial enterprises together in the same environment and allow them to perform research, innovation and developmental facilities with the help of reciprocal transfer of technology and know-how in order to make real valuable products. Since it is not easy to perform this main role solely, working collaboratively seems an indispensable factor for Technology Development Zones (Spithoven et.al.,2010).

Technology Development Zones can be thought as simply as a company, which should have management and other operational organs. The management and other main operational facilities are carried by management companies at Technology Development Zones, so main decisions are taken by management companies at Technology Development Zones.

Since there are various collaboration alternatives and many criteria that affect these alternatives, it is not an easy job to overcome this multi criteria decision-making process. As a result, the target of this study is to propose a mathematical model in order to make easier the job of manager companies at Technology Development Zones and get more reliable results from that complex decision-making process. The aim of this study is to select the best collaboration partner and arrange the criteria, which affect the alternative choices and help manager companies during this complex process. In order to simplify the multi criteria decision-making process of management companies of Technology Development Zones, a mathematical model is proposed and data is analyzed by Fuzzy Analytical Hierarchy Process (FAHP) Method in this study.

A three parted data form was prepared and applied to seven experts (general/vice managers) at Technology Development Zones of Ankara city. The expert group, to whom data form was applied, has at least three or more year-experience as a manager at Technology Development Zones in average.

In the first part of this study, Technology Development Zones are analyzed in a detailed manner. In the second part there exists review of literature, in the third part of this study the methodology and results of this study is represented and in the last part conclusions, limitations and recommendations for this study is given.

2. LITERATURE REVIEW

In today's knowledge society, universities play key role and they produce knowledge to develop firms for the reason of local and national development.

Kjearsdam and Enemark (1994), carried a study at Denmark – Aalborg location with the aim of proving university roles of any location. They found that universities are catalysts and may enhance both students' and industry's capabilities. The studies of Chalmers Technology University at Sweden-Gothenburg location were investigated by Dahlstrand and Jacobsson (2003:80) they stated that the roles of universities in local development mainly depend on clusters of innovation capabilities. In recent epoches, literature research generally focuses on bibliographic studies about university-industry collaboration. Skute et.al (2019) has cathegorized university-industry relationship research in literature systematically (Mutlu, Eren, Yıldırım, Pasaoglu and Mertek, 2019). Kılıc (2009) carried his study at METU Technopark and Bilkent Cyberpark in Ankara Turkey in order to analyse the collaboration relationships by applying a survey to participants. In this study the highest rankings were found in management activities, which are directed collaboration. Karagoz et.al (2020) analyzed the effects of open innovation and contribution of it on the software firms of Dokuz Eylul University Technology Development Zone (Karagoz, Goksen & Eminagaoglu, 2020). In this study, it is demonstrated that the software firms at Dokuz Eylul University Technology Development Zone are eager to open innovation.

Santoro et. al. (2018) conducted a study in order to understand the engagement between small and medium sized entrepreneurs (SMEs) and open innovation. This study was carried through a questionnaire and it investigated to identify the sources of knowledge used by SMEs for innovations. As a result, for the ideas and knowledge development only 20 percent of the sample identified relationship with universities as an important factor of this study. The relationship between small and medium sized entrepreneurs (SMEs) and open innovation is also investigated by Guertler and Sick (2021), as open innovation helps management during the project management and partner selection process. Results show that utilizing open innovation opportunities may take the advantage of focusing on best suitable partner and tasks of innovation. Brunswicker and Chesbrough (2018) conducted a study in order to understand the practices of open innovation belong to global companies. Results indicated that 78 percent of respondents are eager to open innovation (Brunswicker and Chesbrough, 2018).

2.1. Technology Development Zones

Technology and knowledge play important role for competing leadership in today's global and competing environment. Technology Development Zone is a site, where academic, social and cultural facilities are supported and pose various opportunities for entrepreneurs, researchers and academicians.

The outer framework of Technology Development Zone or techno park is constructed by research and development, industry, human resources and potential of location. (Ruttan &

Vernon,1959). The first applications of techno parks were seen after Second World War. The first example of techno park was seen at United States of America in North California as Stanford Research Park (Ministry of Industry and Technology, 2021). The establishment works of Technology Development Zones started during the period of 1980s in Turkey. The first target to install Technology Development Zones was to improve biotechnology, renewable energy sources, marine sciences, food sciences and so on (Ministry of Industry and Technology, 2021).

Technology Development Zones pose many opportunities and benefits in local and national levels. Technology Development Zones ensure suitable environment for the firms, who make research and development studies. Firms, which are located at Technology Development Zones, have the opportunity of effective research and development collaborations with universities and take the advantage of the synergy, caused by this collaboration. (Lundvall, 2007). Technology Development Zones also pose some benefits to universities. Universities become closer to industry with the help of Technology Development Zones (Snee,1984).

2.2. Management Company

Management company is the core element of any Technology Development Zone. From the installing activities to all other ones, management company is all responsible with the whole process of Technology Development Zone. One of the duties of management company is to prepare performance index of Technology Development Zone. It should also prepare an annual report. Another report that management company should prepare impact evaluation report. Management company should prepare strategic report, which defines the future plans and activities of Technology Development Zone, in this report there should be plans for future and plans for collaboration activities. Management company is responsible for the whole operation process of firms at Technology Development Zones. When the firms, existing in Technology Development Zones face to any problem, they should consult to the manager company first.

2.3. Collaboration Appliances at Technology Development Zones

The interactions and collaborations at Technology Development Zones, include transfer of human source, data, knowledge, technology, product or service. The interactions may also be between two shareholders in or out of Technology Development Zone.

Clusters, common projects with universities and industry are all included to the collaboration examples of Technology Development Zones.

Changing of researchers, supporting consultancy and technical services, exchange programs, which are personal changes from universities or industry and this will lead knowledge transfer, common research and development attempts, contractual research, which is made between research center and firm that research will be done by institute for account of firm and trainings are the other groups, which are defined as collaboration examples of Technology Development Zones (Hagedoorn, 1993).

3. METHODOLOGY

In the represented figure the methodology of this study is schematized.

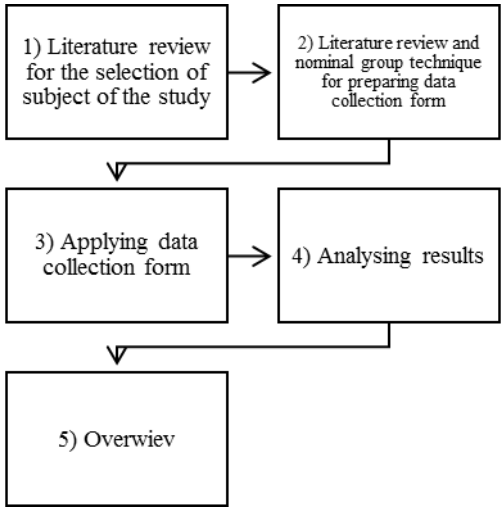

Figure.3.1 Schematic Representation of Study's Methodology

The subject of this study is selected and data form is prepared as a result of deeper literature review with the help of nominal group technique, which is a is a devised variation of a small-group discussion to reach concurrence. After these steps, the analyzing part has come.

Seven experts, occupied at Technology Development Zones at Ankara city in Turkey replied the data form, which is three parted. In Table.3.1 there exist selection criteria and sub criteria, which affect the selection alternatives of this study. These criteria, sub criteria and alternatives were selected because of deeper literature review (Hsu et.al.,2015), nominal group technique and previous experiences. In Table.3.1 the detailed definitions of criteria, sub criteria and alternatives of this study is expressed.

Table.3.1 Criteria and Sub criteria of the Study

Main Criteria	Sub Criteria	Definition	Reference
Innovativeness (C_1) (Levine and Prietula, 2013)	Project Improvement (C_{11})	Innovation and innovativeness is necessary for firms and this can be achieved by making new projects. These new projects need collaborations.	Girard and Robin, 2006
	Research Infrastructure (C_{12})	Research and development facilities are important for innovativeness that firms need collaboration for that infrastructure.	Chen S., 1997
	Improvement of New Product or Service (C_{13})	New product or services mean that firms compete within each other. Sometimes the possibilities of firms may limited that they need collaboration.	Jasawalla A. and Sashittal H.,2003
	Amendment of Product, Service or Process (C_{14})	With the help of Amendment of Product, Service or Process Collaboration enhances the process of developing new products	Tseng, 2013
Knowledge and	Technology Transfer (C_{21})	Technology transfer is a natural result of collaboration that it accelerates producing new and innovative products.	Luukkonen,1992

Main Criteria	Sub Criteria	Definition	Reference
Technology Transfer (C_2) (Oxford,2017)	Intellectual Property Rights (C_{22})	Producing new and innovative products requires ensuring and protecting Intellectual Property Rights. Ensuring and protecting Intellectual Property Rights need collaborations.	Edwin L.,1998
	Clusters (C_{23})	In order to be successful in the competition environment, clusters and clustering take an important part, which may occur as a result of collaboration.	Folta B.T.et.al.,2006
Instituve Improvement (C_3) (Chapman L.R., Corso M., 2005)	Occupational Development (C_{31})	The quality of occupants is directly related with making innovations and getting a guaranteed position in the competition environment. Thus, firms need collaborations in order to increase occupational quality.	Mortensen M.,Neeley B.T., 2012
	Consultancy (C_{32})	Firms need consultancy at all levels of their operational processes that they need collaboration to get consultancy.	Collinson E., Quinn L., 2002
	Academicals/Practical Activities (C_{33})	Congresses, fairs can be counted as activities. These organizations may be the result of collaborations.	Bozeman B.,Fay D.,Slade C.P.,2012
Society Contribution (C_4) (Rosenbaum A.,2006)	National Development (C_{41})	Firms contribute national development in order to overcome competition environment and for this reason, they need collaboration.	Martini L., et.al.,2012
	Local Development (C_{42})	Firms may contribute local development in order to increase economic welfare, thus they need collaboration to contribute local development.	Walser N., Merret D.C.,2002
	Social Responsibility (C_{43})	Social responsibility projects propose solutions to social problems and they can be made with the help of collaboration.	Peloza J.,Falkenberg L.,2009
	Environmental Responsibility (C_{44})	Firms should be responsible for the environment during their operational processes. This obligatory is also supported by regulations.	Lewis V.K., Cassells S., Roxas H., 2014

In Table.3.2 the collaboration alternatives of this study are described.

Table.3.2 Alternatives of the Study

Alternative	Description
Collaboration with universities (A_1)	National/International/Public/Private universities
Collaboration with industry (A_2)	Firms out of Technology Development Zone
Collaboration with firms (A_3)	Firms inside the Technology Development Zone
Collaboration with research institutes (A_4)	National/International/Public/Private institutes
Collaboration with TDZs(A_5)	National/International Technology Development Zones
Collaboration with international institutes (A_6)	Several international institutes
Collaboration with national institutes (A_7)	All national institutes including public and private

3.1 Extended Analysis Method of Chang

Before using FAHP in this study, a detailed literature review has been done in literature. Classical AHP is not suitable for this study, since there are many uncertain conditions of this study. Data collection form of this study is the replies of specialists and the results are objective.

Fuzzy logic is used to describe uncertain situations and was first used by Zadeh in 1965. Than other earliest examples of this method came into use in 1983 (van Laarhoven & Pedrycz, 1983).

Although there are various types of models in literature about fuzzy analytical hierarchy process, the most widely used one in literature is Chang's (1996) fuzzy analytical hierarchy method (Chang, 1996).

Because of user friendly feature and wider application examples in literature, Extended Analysis Method of Chang is used in this study.

Detailed information about Chang method is given in below pharagraphs.

Let $Xn = 1,2,3,\ldots.n$ is set of objects, and $Um = 1,2,3 \ldots m\, is$ set of purpose. According to Chang's method, all objectives are taken and for the size analysis, gi is applied seperately. In Equation 3.1, it is shown that for *m* numbered analysis, the size analysis values are obtained as well (Kahraman, Cebeci & Ruan,2004).

$$M_{gi,}^{1}\ \ M_{gi,}^{2} M_{gi}^{3}, \ldots., M_{gi}^{m} i = 1,2, \ldots.n \tag{3.1}$$

In this equation, all $M_{gi}^{j}\ (j = 1,2, \ldots m)$ numbers are fuzzy numbers, which are triangular. The steps of size analysis of Chang are given in the folloving sections (Chang, 1992; Chang, 1996).

In the first step, the fuzzy size equation is found like Equation 3.2.

$$S_i = \sum_{j=1}^{m} M_{gi}^{j} \otimes \left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^{j}\right]^{-1} \tag{3.2}$$

To obtain $\sum_{j=1}^{m} M_{gi}^{j}$ value, m numbered size value analysis can be obtained according to Equation 3.3.

$$\sum_{j=1}^{m} M_{gi}^{j} = \left(\sum_{j=1}^{m} l_j \sum_{j=1}^{m} m_j \sum_{j=}^{m} u_j\right) \tag{3.3}$$

To obtain $\left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^{j}\right]^{-1}$ value, first the fuzzy summation of $M_{gi}^{j}\ (j = 1,2, m \ldots.)$ should be obtained from Equation 3.4.

$$\left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^{j}\right]^{-1} = \left(\frac{1}{\sum_{i=1}^{n} u_i}, \frac{1}{\sum_{i=1}^{n} m_i}\ , \frac{1}{\sum_{i=1}^{n} l_i}\right) \tag{3.4}$$

In the second step, the possibility of $M_2\ =\ (l_2\ , m_2, u_2) \geq M_1\ = (l_1, m_1, u_1)$ is defined in Equation 3.5.

$$V(M_2 > M_1)\ = sup_{y \geq x}\left[min\left(\mu_{M1}(x), \mu_{M2}(y)\right)\right] \tag{3.5}$$

And the explanation of Equation 3.5 is given in Equation 3.6.

$$V(M_2 > M_1) = hgt\left(M_1 \cap M_2 = \mu_{M2}(d) = \begin{Bmatrix} if\ m_2 > m_1\ then\ 1, \\ if\ l_1 > u_2\ then\ 0, \\ otherwise\ \frac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)} \end{Bmatrix} \right) \quad (3.6)$$

In here, d is the intersection ordinate of between μ_{M1} and μ_{M2}. In order to compare M_1 and M_2 values, both $V(M_1 \geq M_2)$ and $V(M_2 \geq M_1)$ values are necessarry.

In third step, Equation 3.7 tells the possibility of convex fuzzy number's greatness from k numbered fuzzy $M_i(i = 1,2,3 \ldots\ldots k)$ numbers.

$$V(M > M_1, M_2, \ldots . M_k) = V[(M > M_1) and\ (M > M_2)\ and \ldots . (M > M_k)]$$

$$= minV(M > M_i), i = 1,2,3 \ldots \ldots k \quad (3.7)$$

In this situation, for the S_{js} assumptions are done as Equation 3.8.

Then the weight vector $A_i(i = 1,2 \ldots . n)$ is obtained by n elements and shown in Equation 3.8.

$$W' = \left(d(A_1), d(A_2), \ldots . d(A_n)\right)^T \quad (3.8)$$

In the last step, normalized vector W is shown in Equation 3.9 that normalized means the fuzziness W is vanished.

$$W = \left(d(A_1), d(A_2), \ldots . d(A_n)\right)^T \quad (3.9)$$

4. FINDINGS

The first part of our findings is about comparison between main criteria. After applying the operations described in Equations 3, 1-3,9; it has been found that the criteria of institutional development took the highest rank among other criteria. In Table.4.1 all of the main criteria's weight values can be seen.

Table 4.1. Weight Values of Main Criteria

C	W
C_1	0,56
C_2	0,00
C_3	1,00
C_4	0,25

According to Table.4.1, it can be concluded that when manager company decides to make collaboration, it gives more importance on institutional development than the other main criteria.

The second part operations were done for sub criteria as following the same equations described above. The results are shown in Table.4.2.

Table.4.2 Weight Values of Sub Criteria

Main Criteria	Sub Criteria	W
C_1	C_{11}	0,83
	C_{12}	0,16
	C_{13}	0,00
	C_{14}	0,00
C_2	C_{21}	0,00
	C_{22}	1,00
	C_{23}	0,00
C_3	C_{31}	0,00
	C_{32}	0,34
	C_{33}	1,00
C_4	C_{41}	0,00
	C_{42}	0,66
	C_{43}	1,00
	C_{44}	0,00

For the first part of Table.4.2; it can be easily seen that the maximum value is taken for C_{11} sub criteria, which is Project improvement. This means, when manager company decides to make collaboration project improvement took the highest rank among other sub criteria of first main criteria. The other parts of the table can be interpreted like that and as a conclusion it can be said that C_{22} (Intellectual Property Rights), C_{33}(Academic/Practical Activities) and C_{43} (Social Responsibility) took the highest ranks among other sub criteria.

The comparison of alternatives is the last part of operations of this study. In Figure.4.1 the result of ordering alternatives can easily be seen.

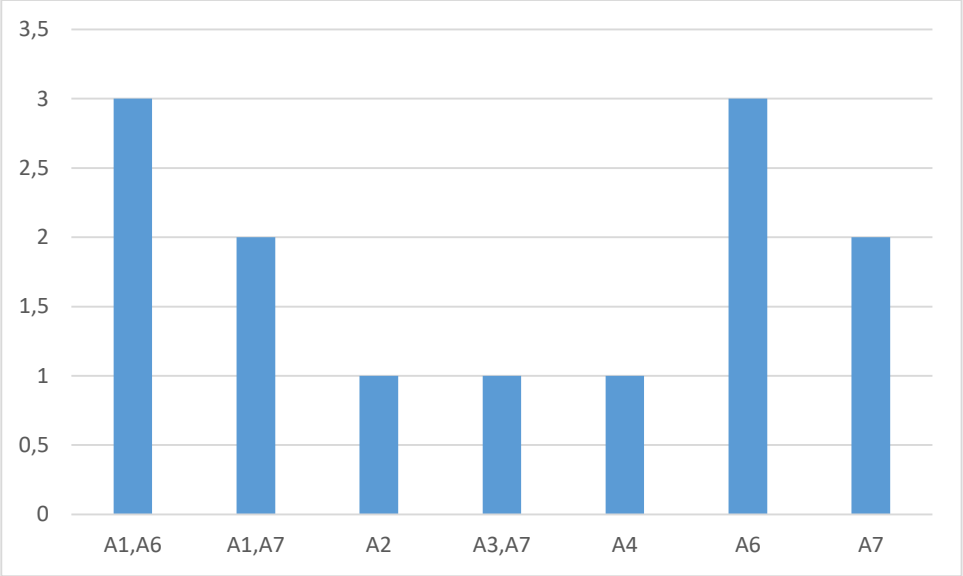

Figure.4.1 Comparison of Alternatives

When Figure.4.1 is analyzed, it can easily be seen that the highest rank of alternatives are taken for A_1, A_6 and A_7, which are collaboration with universities and collaboration with national and international institutes.

5. DISCUSSION AND CONCLUSION

This study is done with the aim of offering a mathematical model for the complex problem, which is the collaboration decision-making of manager companies of Technology Development Zones. Generally, for operational activities, decision-making is not being made in a planned and organized manner, this study aimed to increase the awareness of people from this perspective. Although there is not totally similiar study existing in literature, results are compared with the results found in other nearly similiar studies existing in literature. First, main criteria of this study is compared within each other and found that when management company of Technology Development Zone decides to make collaboration, institutional development got the highest rank among the others. In literature many research reveal that a continuous feeding exists between technology and institutional development. For instance, Omurbek and Halıcı (2012) found that the eagerness for competition of firms increases parallel to the collaboration with Technology Development Zones and this eagerness also allows institutional development. Thianyi et. al. (2002) demonstrated that technological developments lead to institutional development, too. Alkibay et.al (2012) found that firms make collaboration with Technology Development Zonesin order to increase their research and development capacities, make technology transfer, convert research and development facilities into mass production, increase the prestige of university and make occupational opportunities to university graduates. A study carried by Lee (2000) demonstrated that when a university planned to produce a new product, it is very important to make collaboration with industry. Taking into consideration of subcriteria as project improvement, it is found that making collaboration with industry is more important than other alternatives. Also in this study, it is found that collaboration with industry and university took the highest rank among the other altenatives. Like stated in this study,

Narasımhalu (2012) pointed out in his study that firms, universities, angels and venture capitalists, research labs and government are all the key elements of science and technology parks. The key elements mean that they can be the collaboration partnerships of science and technology parks, thus as pointed out in this study, firms, universities, research labs are the main collaboration partnerships of science and technology parks or technology development zones, as well.

In his study, Ozgul (2018) investigated research and development based collaborations at technoparks and what has been gained from this collaboration. In this study, it is pointed out that collaboration ensures firms to penetrate into new market, increase technology transfer, share possible risks, synergy and competetion advantage, decreasing uncertanities, ensuring proactivity, decreasing of expenditures. In this study it is also stated that if research and development based firms want to increase their efficiency in market, they should increase their potential of collaboration. One of the main factor that is stressed in this study is collaboration is necessary for firms in today's global and competetive market. The number of studies existing in literature that completely resembles or similar to this study is limited, so one of the main aim of this study is to fill the gap in this manner. This study can be thought as a pilot one to represent the conditions in a limited place, but the framework of this study may be broadened for the future studies. And although data form has been prepared in a detailed manner, for future studies, the partners of nominal group may be extended and the content of the form may be varied.

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