Available online at www.sciencedirect.com

ScienceDirect

Procedia Computer Science 72 (2015) 638 – 646

Procedia Computer Science

The Third Information Systems International Conference

Application of Fuzzy AHP-TOPSIS Method for Decision Making in Human Resource Manager Selection Process

Renny Pradina Kusumawardani, Mayangsekar Agintiara

Jurusan Sistem Informasi, Fakultas Teknologi Informasi, Institut Teknologi Sepuluh Nopember (ITS)
Jl. Arief Rahman Hakim, Surabaya, 60111, Indonesia

Abstract

This paper investigates the use of the Fuzzy AHP-TOPSIS method to the problem of human resource selection. Results are reported on the application of this hybrid method to the case of manager selection process in a prominent telecommunication company in Indonesia which has a robust human resource management process, including for assigning its employees to different roles in the company. However, our experiments results seem to indicate that although there is a set of commonly known values in the company, the process of manager selection might not strictly adhere to these values. Emphasis on the evaluation aspects shows some variation in different regions, indicating that local values might also influence the selection process.

Peer-review under responsibility of organizing committee of Information Systems International Conference (ISICO2015)

Keywords: *Manager Selection; AHP; TOPSIS; Fuzzy AHP-TOPSIS*

1. Introduction

High-quality Human Resources (HR) is essential in determining the success of a company. The first step to ensure the availability of a work force to drive a company to success is to conduct an appropriate selection process. According to I.T. Robertson and M. Smith, HR selection process usually involves personality testing, interviewing, and evaluation of the curriculum vitae of candidates [1]. However, the final decision usually involves a large degree of human judgment. A shortcoming of this traditional method is humans are known to be prone to bias, even though more experienced managers tend to be less affected by it [2].

To overcome this, various metrics have been developed and used in the process of candidate selection. This is the case in one of the largest telecommunication company in Indonesia, which this paper takes as a study case. PT. XYZ has developed quite an elaborate system of metrics for the measurement its

Peer-review under responsibility of organizing committee of Information Systems International Conference (ISICO2015)
doi:10.1016/j.procs.2015.12.173

employees, including in the case of selecting candidates for promotion. This practice safeguards the candidate selection process in that it is difficult for the committee in charge of the selection process to ignore facts about the candidate's background and past performance. This would also give a higher guarantee that the candidate selected will more strongly reflect the values of the organization.

However, human judgment still play an important role in making the decisions. Consequently, it is difficult to guarantee that the decisions are consistent and bias-free. Therefore, researchers explore various methods for computer-aided decision making, for example fuzzy logic, decision tree, and rough set theory. The problem of personnel selection is usually framed as a Multi Criteria Decision Making (MCDM), in which the candidates' performance are measured across various metrics. It is the combining of these scores in which researchers attempt to produce a decision that is close to the actual results.

One of the more popular MCDM methods for personnel selection is the Fuzzy Analytical Hierarchy Process (AHP). In this method, a set of criteria is produced and methodically weighted according to their importance. Candidates are measured based on these criteria and receives a final score which reflects this importance weighting. Another method that is also popular is the Fuzzy Technique for Order Preference by Similarity to Ideal Solution (TOPSIS). In this method, characteristics of the candidates are compared to that of an ideal. This mimics a common thought process in humans, in which people evaluate things not based on some criteria, but on comparison with an ideal instance of the same type.

To gain the benefits of these methods, this paper applies a combination of both: the Fuzzy AHP-TOPSIS method. It is applied to the case of Human Resources Manager selection in the seven regions into which the company divides its operation in Indonesia. Seven managers are selected; each from a set of five candidates. The criteria used are the measurement metrics developed by the HR department of the company. For the human judgment input in weighting these criteria, we asked five HR managers to give their opinions on the relative importance of the criteria. We also combine the opinions of these managers to gauge the overall employee perception of the company values, reflected in the criteria they think are more important.

The rest of this paper is organized as follows. This introduction is the first section of the main part of the paper, followed by a brief overview of related works in the Fuzzy AHP-TOPSIS method in the second section. The third section discussed the Fuzzy AHP-TOPSIS method itself. The fourth part is the implementation specifics of this work, and the results are presented and analyzed in the fifth section. The last section of this paper is the Conclusion, in which key takeaways from this paper are discussed, along with some suggestions for future work.

2. Related Works

Dursun and Karsak[3] found that the Fuzzy Multi Criteria Decision Making (MCDM) gives effective results in solving personnel selection process. They use a fusion of fuzzy information, 2-tuple linguistic representation model and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) [2]. The method is used because it can accurately manage the information that is assessed using a scale linguistic and numerical decision making problem with multiple resources and information which heterogeneous.

There are various techniques that could be used to solve MCDMs, such as Analytic Hierarchy Process (AHP), Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), ELECTRE, rough sets theory and Multi-objective programming[4]. Hybrids of these methods in personnel selection has been explored by researchers [4][5][6][7][8], one of which combines Fuzzy AHP and Fuzzy TOPSIS.

3. The Fuzzy AHP-TOPSIS Method

The fuzzy AHP-TOPSIS method is basically a combination of the Fuzzy AHP method with the Fuzzy TOPSIS method. At the first stage, Fuzzy AHP is used to weight the relative importance of criteria when compared to each other. This weighted criteria are used to assign a score to the each candidate in every evaluation criteria. This stage is followed by the Fuzzy TOPSIS, in which based on the scores that have been assigned, the proximity score of each candidate to the ideal is calculated, both for the positive ideal and for the negative ideal. The best candidate should be as near as possible to the positive ideal, while as furthest as possible to the negative ideal. A concise steps of the Fuzzy AHP-TOPSIS is as follows.

3.1 Fuzzy AHP

First proposed by Thomas L. Saaty, the AHP is one of the MCDM method for solving complex, unstructured problems by creating a functional hierarchy [10]. The main concept of AHP is to develop a preference weighting of each alternative decision. Preferences can be specified using natural language or numeric values to determine the importance of each attribute. To determine ordering, first each two elements are compared using a nine point scale of importance [11]. To introduce fuzziness, the pairwise numerics are then operated in a matrix using Triangular Fuzzy Number (TFN) [12]. The steps are as follows:

1. Developing a fuzzy comparison matrix

First the scale of linguistics is determined. The scale used is the TFN scale from one to nine. Then defined by the membership function refers to research Metin Celik (table 3.1) [6].

Table 3. 1 Scale of Interest

Scale of Interest	Fuzzy Number	Linguistic Variable	Membership Function
1	1	Equally important	(1,1,3)
3	3	Weakly important	(1,3,5)
5	5	Strongly more important	(3,5,7)
7	7	Very strongly important	(5,7,9)
9	9	Extremely important	(7,9,9)

Then, using the TFN to make pair-wise comparison matrix for the main criteria and sub-criteria. Equation (1) shows the form of fuzzy comparison matrix.

$$\tilde{A} = \begin{bmatrix} 1 & \cdots & \tilde{a}_{1n} \\ \vdots & \ddots & \vdots \\ \tilde{a}_{n1} & \cdots & 1 \end{bmatrix} \tag{1}$$

2. Define Fuzzy Geometric Mean

The fuzzy geometric mean is then calculated using Equation (2)[13]:

$$\tilde{r}_i = (\tilde{a}_{i1} \otimes \tilde{a}_{i2} \otimes \ldots \otimes \tilde{a}_{in})^{1/n} \tag{2}$$

where $\tilde{a}$ in is a value of fuzzy comparison matrix from criteria I to n. Result from the fuzzy geometric mean will be referred to later as local fuzzy number.

3. Calculate the weight of fuzzy of each dimension

The next step is to calculate the global fuzzy number for each evaluation dimension with Equation (3).

$$\widetilde{w}_i = \tilde{r}_1 \otimes (\tilde{r}_1 \oplus \tilde{r}_1 \oplus \ldots \oplus \tilde{r}_1)^{-1} \tag{3}$$

4. Define the best non fuzzy performance (BNP)

The global fuzzy number is then converted to crisp weight value using the Centre of Area (COA) method to find the value of best BNP from the fuzzy weight in each dimension, calculated using Equation (4).

$$BNP_{wi} = \frac{[(u_{wi} - l_{wi}) + (m_{wi} - l_{w1})]}{3} + l_{wi} \quad (4)$$

3.2 Fuzzy TOPSIS

The Fuzzy TOPSIS is a MCDM method developed by Hwang and Yoon[14], in which the solution is the one with the Euclidean distance nearest to the best hypothesis, the Positive Ideal Solution (PIS), and the farthest with the worst hypothesis, the Negative Ideal Solution (NIS)[15]. Fuzzy TOPSIS needs information about the relative importance of each criteria for weighting. In Fuzzy AHP-TOPSIS, the weights has been calculated in the Fuzzy AHP step[16]. The steps are as follows:

1. *Developing a fuzzy comparison matrix*

Fuzzy values in this matrix looks at the scale of membership functions defined in Table 3.2[6].

Table 3. 2 Lingusitics scale for each candidate

Crisp Value	Linguistic Variabel	Membership Function
1	Very poor (VP)	(0,1,3)
3	Poor (P)	(1,3,5)
5	Fair (F)	(3,5,7)
7	Good (G)	(5,7,9)
9	Very Good (VG)	(7,9,11)

Next is the normalization of value r_{ij} in the matrix using Equation (5).

$$\tilde{r}_{ij} = \left(\frac{l_{ij}}{u_j^+}, \frac{m_{ij}}{u_j^+}, \frac{u_{ij}}{u_j^+}\right) \quad (5)$$

2. *Weighting a Normalized Matrix*

Each member is given matrix normalized weight w = (w_1, w_2, w_3 ..., w_n), resulting in a matrix V. Then the elements of the matrix V is $V_{IJ} = w_{ij}\, r_{ij}$, for i = 1, ..., m and j = 1, ..., n, calculated with Equation (6).

$$\tilde{v}_{ij} = \tilde{w}_j \otimes \tilde{r}_{ij}\,, \quad i = 1,2,..,m; \quad j = 1,2,\dots,n. \quad (6)$$

3. *Identification of Fuzzy Positive Ideal Solution (FPIS) and Fuzzy Negative Ideal Solution (FNIS)*

Equations (7) and (8) give the formulae for calculating FPIS, denoted as A+, and FNIS, denoted as A-.

$$A^+ = \{v_1^+, v_2^+, \dots, v_j^+, \dots, v_m^+\} \quad (7)$$
$$A^- = \{v_1^-, v_2^-, \dots, v_j^-, \dots, v_m^-\} \quad (8)$$

where $v_j^+ = (1,1,1) \otimes \tilde{w}_j$ and $v_j^- = (0,0,0)$, j = 1,2,…m

4. *Definition of the Best Non Fuzzy performance (BNP)*

Next, the BNP is calculated using the COA method, the same as in Equation (4).

5. *Calculating the distance between the alternatives with FPIS and FNIS*

Calculation of the distance of each candidate to FPIS and FNIS are given in Equations (9) and (10).

$$S_i^+ = \left\{\sum_{j=1}^{n} (v_{ij} - v_j^+)^2\right\}^{1/2}, \quad i = 1,2,\dots,m \quad (9)$$

$$S_i^- = \left\{ \sum_{j=1}^{n} (v_{ij} - v_j^-)^2 \right\}^{1/2}, \quad i = 1,2,\dots,m \tag{10}$$

6. Calculating the relative proximity

Calculation for the relative proximity with ideal solution is performed using Equation (11).

$$c_i = \frac{S_i^-}{(S_i^+ + S_i^-)}, \quad i = 1,2,\dots,m \quad c_i \in \{0,1\} \tag{11}$$

7. Develop ranking Preferences

The final stage of the Fuzzy AHP-TOPSIS is sorting of candidates in the order of Ci. The candidate with the highest Ci is selected, since it is closest to the positive ideal and farthest to the negative ideal.

4. Assessment Criteria and Data Processing

4.1 Candidate Assessment

In evaluating candidates, the Division of Human Capital Center in PT XYZ performs an 360 degrees appraisal process, also known as the multi-rater feedback, multi-source feedback, full-circle appraisal, and report group performance[9]. The performance assessment covers the ten criteria in Table 4.1.

Table 4. 1 Ten candidate assessment criteria

Criteria	Description	Range of Value
Assessment Center Score	Assessment Centre evaluation of the suitability of the candidate's personality to the position to be filled	Excellent / Ready Now / Ready with Development / Very Good / Good / Needs Improvement / Not Ready
Level of Education	The highest education level of the candidate	D1 - S2
Major at School/University	The major taken by the candidate while studying in school/university	0.7 / 1 (The score is 1 if the candidate's major matches the position to be filled, else i tis)
Stream Match	The suitability of the candidate's current work area with the position that will be addressed	0.7 / 1 (The score is 1 if the candidate's current position belongs to the same stream with the position to be filled, and 0.7 otherwise.)
Length of Time on Stream	The period of time the candidate has worked in the stream of his position	Numeric continuous value
Talent Cluster Index	The classification of the candidate based on the performance and behaviour of the individual	Very High Potential / High Potential / Potential
Performance Index	Value of the candidate's contribution to the overall result of the performance of his work unit	P1 - P5
Competence Index	The final value of the candidate assessment of his/her match to the company corporate value	K1 - K5

Criteria	Description	Range of Value
Length of Time on Position Band	The length of time the candidate has spent in his rank	Numeric continuous value
Disciplinary Sanction	Whether the candidate has ever violated any of the company rule and received disciplinary sanctions	Yes / No

After several stages of assessments, a number of candidates are selected. These candidates are then invited to hearing sessions hosted by a committee of directors, which will eventually determines the candidate chosen to fill the position.

4.2 Data and Data Processing

For the process of criteria-weighting in the Fuzzy AHP, we ask five HR managers for pairwise comparisons on the ten assessment aspects. Furthermore, we use the assessment data for the selection of Human Resource (HR) Manager in seven regions into which the company divides its operational area in Indonesia. For each of the seven regions, five candidates are considered. The assessment data of these candidates, and the data on which candidate is selected, are the primary inputs to the Fuzzy TOPSIS method. As can be seen in Table 4.1, some assessment criteria are in nominal format, so it is necessary to map these to crisp values, especially retaining the order inherent in the value. These data are then processed using the Fuzzy AHP-TOPSIS method in Section 3 to determine the selected candidate. The results are presented and discussed in Section 5.

5. Results and Discussion

Table 5.1 shows the ranking and the BNP of the importance of the criteria according to the aggregated opinions of the respondents and their individual judgments. The rankings are calculated using the Fuzzy AHP method. It can be seen that the respondents seem to put somewhat similar emphasis to the criteria, demonstrating that there exist some company values guiding employees of what qualities matter the most.

Table 5. 1 Importance Rank Based on the Fuzzy AHP Method
Abbreviations: ASC = assessment center score, Edu = level of education, Mj = major at school/university, Strmtch = stream match, StrmT = length of time working in stream, Talent = talent cluster index, Perf = performance index, Compt = competence index, BT = length of time working in current rank, Sanct = disciplinary sanction

Importance Rank	Aggregate		Respondent A		Respondent B		Respondent C		Respondent D		Respondent E	
	Aspect	BNP	Aspect	BNP	Aspect	BNP	Aspect	BNP	Aspect	BNP	Aspect	BNP
1	ASC	0.296	Sanct	0.323	ASC	0.352	Talent	0.389	Sanct	0.34	Talent	0.367
2	Talent	0.293	Talent	0.309	Talent	0.332	ASC	0.329	ASC	0.221	ASC	0.32
3	Compt	0.193	ASC	0.178	Perf	0.200	Compt	0.169	Perf	0.198	Compt	0.218
4	Sanct	0.163	Perf	0.117	Compt	0.200	Edu	0.121	Compt	0.198	Perf	0.105
5	Perf	0.136	Compt	0.117	Sanct	0.122	Strmtch	0.121	Talent	0.096	StrmT	0.088
6	Edu	0.083	Edu	0.069	StrmT	0.114	Mj	0.114	Edu	0.078	Mj	0.083
7	StrmT	0.071	Mj	0.043	Strmtch	0.101	BT	0.113	Mj	0.048	Strmtch	0.08

Import	Aggregate		Respondent A		Respondent B		Respondent C		Respondent D		Respondent E	
8	Mj	0.071	Strmtch	0.032	BT	0.088	StrmT	0.108	BT	0.044	Sanct	0.06
9	StrmT	0.064	BT	0.025	Edu	0.067	Sanct	0.098	Strmtch	0.036	Edu	0.059
10	BT	0.061	StrmT	0.023	Mj	0.058	Perf	0.062	StrmT	0.026	BT	0.055

Table 5.2 shows for each region the candidate selected by Fuzzy AHP-TOPSIS versus the one who actually gets the position. In general, the results from the Fuzzy-AHP TOPSIS match, or nearly match the real decision taken. However, there are several regions in which exact match tend not to occur. These mismatches occur only on regions 1, 4, and 7, and the candidate actually chosen is consistent from evaluator to evaluator.

Table 5. 2 The candidate actually chosen for the HR Manager position for each region versus the one selected by Fuzzy AHP-TOPSIS. The cells are greyed-out when these two match.

	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Region 7
Aggregated							
Chosen for Position	ID 10381883	ID 10396877	ID 10203978	ID 11072287	ID 10563596	ID 10746584	ID 12077803
Fuzzy AHP-TOPSIS	ID 10916465	ID 10396877	ID 10203978	ID 10914493	ID 10563596	ID 10746584	ID 12246069
Respondent A							
Chosen for Position	ID 10381883	ID 10396877	ID 10203978	ID 11072287	ID 10563596	ID 10746584	ID 12077803
Fuzzy AHP-TOPSIS	ID 10381883	ID 10396877	ID 10203978	ID 10914493	ID 10563596	ID 10746584	ID 12246069
Respondent B							
Chosen for Position	ID 10381883	ID 10396877	ID 10203978	ID 11072287	ID 10563596	ID 10746584	ID 12077803
Fuzzy AHP-TOPSIS	ID 10916465	ID 10396877	ID 10203978	ID 11072287	ID 10563596	ID 10746584	ID 12246069
Respondent C							
Chosen for Position	ID 10381883	ID 10396877	ID 10203978	ID 11072287	ID 10563596	ID 10746584	ID 12077803
Fuzzy AHP-TOPSIS	ID 10916465	ID 10396877	ID 10203978	ID 10720608	ID 10563596	ID 10746584	ID 12246069
Respondent D							
Chosen for Position	ID 10381883	ID 10396877	ID 10203978	ID 11072287	ID 10563596	ID 10746584	ID 12077803
Fuzzy AHP-TOPSIS	ID 10381883	ID 10396877	ID 10203978	ID 10914493	ID 10563596	ID 10746584	ID 12246069
Respondent E							
Chosen for Position	ID 10381883	ID 10396877	ID 10203978	ID 11072287	ID 10563596	ID 10746584	ID 12077803
Fuzzy AHP-TOPSIS	ID 10916465	ID 10396877	ID 10203978	ID 10914493	ID 10563596	ID 10746584	ID 12246069

It is therefore interesting to investigate what might cause the mismatch. Inspection on the evaluation scores of each candidate reveals that in these regions, some aspects might be more emphasized compared to its relative importance in other regions. Table 5.3 shows that the candidate chosen in Region 1, ID10381883, only have one assessment score higher than that of the candidate selected by the Fuzzy AHP-TOPSIS method, ID10916465, while the proposed candidate is actually superior in four assessment aspects. This one aspect which seems to have a larger influence is Index Talent Cluster (ITC); the selected candidate is Very High Potential, while the candidate chosen by the Fuzzy AHP-TOPSIS is High

Potential. This result indicates that in Regional 1, the ITC value holds very high importance when compared to other criteria.

Table 5.3 Score details of candidates in Region 1

ID	Position	ACR	Edu	Mj	Strmtch	StrmT	Talent	Perf	Compt	BT	Sanct
10381883	**ASMAN LEARNING**	**GOOD**	**S1**	**0.7**	**1**	**1**	**Very HIPO**	**P2**	**K2**	**4.1**	**No**
10762224	FUNCTIONAL EXPERT	GOOD	S1	0.7	1	1.2	Potensial	P3	K3	7.6	No
10916465	**FUNCTIONAL EXPERT**	**EXCELLENT**	**S1**	**0.7**	**1**	**1.2**	**HIPO**	**P3**	**K2**	**12.1**	**No**
10880901	FUNCTIONAL EXPERT	RWD	S1	0.7	1	0.7	HIPO	P3	K2	1.4	No
11392533	FUNCTIONAL EXPERT	GOOD	S1	0.7	1	1.2	HIPO	P3	K2	8.4	No

Table 5.4 Score details of candidates in Region 4

ID	Position	ACR	Edu	Mj	Strmtch	StrmT	Talent	Perf	Compt	BT	Sanct
11072287	**ASMAN HR DEVELOPMENT**	**VERY GOOD**	**S1**	**0.7**	**1**	**1.2**	**Potential**	**P3**	**K3**	**8.3**	**No**
10914493	ASMAN PLAN & BUDGET CONTROL	EXCELLENT	S2	0.7	0.7	1.2	Very HIPO	P2	K2	8.1	No
10413146	FUNCTIONAL EXPERT	NR	S1	0.7	1	1.2	Potential	P3	K3	10.3	No
10720608	**ASMAN RELATIONS**	**GOOD**	**S1**	**0.7**	**1**	**1**	**HIPO**	**P3**	**K2**	**6.3**	**No**
12413451	OFF 1 CAREER DEVELOPMENT	EXCELLENT	S2	0.7	1	0.7	HIPO	P3	K2	2.9	No

Table 5.5 Score details of candidates in Region 7

ID	Position	ACR	Edu	Mj	Strmtch	StrmT	Talent	Perf	Compt	BT	Sanct
12077803	**ASMAN HR DEVELOPMENT**	**GOOD**	**S1**	**0.7**	**1**	**1.2**	**HIPO**	**P3**	**K2**	**6.8**	**No**
10569019	OFF 1 CAREER DEVELOPMENT	NFI	D3	**0.7**	**1**	1.2	HIPO	**P3**	**K2**	6.1	No
12246069	**OFF 1 LEARNING**	**GOOD**	**S1**	**0.7**	**1**	**1.2**	**HIPO**	**P3**	**K2**	**8.3**	**No**
10754166	OFF 1 UNION & EMPLOYEE	RWD	S1	**0.7**	**1**	1	HIPO	**P3**	**K2**	4.1	No
10243282	OFF 1 COMPETENCY & CHARACTER	NR	S1	**0.7**	**1**	0.7	HIPO	**P3**	**K2**	0.5	No

However, in the last region where different result is returned, Region 7, it is less clearer as to what aspect is emphasised, since in fact the selected candidate is not better to the candidate chosen by the Fuzzy AHP-TOPSIS method in any aspects, who has at least been in his current rank longer than the selected candidate. The scores for the candidates are shown in Table 5.5. This reflects that some discretionary consideration has been taken by the committee in charge of the final manager selection process. A closer inspection to the current positions held by the candidate shows that the position held by candidate ID12077803, Assistant Manager in Human Resource Development, might be deemed more similar to the Human Resource Manager position, when compared to the First Officer in Learning Events position held by candidate ID12246069 selected by the Fuzzy AHP-TOPSIS.

6. Conclusion

We have seen from the results that in general the priorities in candidate selection in the telecommunication company is quite similar from one evaluator to the others. This reflects the existence of a set of values that are known to be important in the company in selecting its employees for certain positions. The Fuzzy AHP-TOPSIS has succeeded in capturing this by consistently selecting the candidate who actually gets the HR Manager position in 4 out of the 7 regions across the five evaluators and their aggregation.

However, there are some regions in which the priorities given to the importance of the selection criteria seems to differ than the general norm, resulting in a miss for the Fuzzy AHP-TOPSIS. Therefore, we can conclude that the Fuzzy AHP-TOPSIS is in general give satisfactory results when applied in candidate selection process. However, it comes with the limitation that the person whose opinion is used as the input must have excellent understanding or values similar to the committee in charge of the selection process. On the other hand, the Fuzzy AHP-TOPSIS could serve as an excellent tool in giving inputs to a selection process which is expected to comply to a certain set of values, as it is more thoroughly objective when compared to humans.

For future works, it will be interesting to study the effect of local values as demonstrated in the results of this research. In that case, beside respondents who work at a national level, it is also necessary to gather the importance input from respondents working in the same region as the location of the position to be filled. The results from both types of respondents could then be compared to study what might be the differences of value between both.

References

[1] I.T. Robertson and M Smith, "Personel Selection," *Journal of Occupational and Organizational Psychology*, vol. 74, no. The British Psychological Society, pp. 441-472, 2001.

[2] Cynthia M. Marlowe, Sandra L. Schneider, and Carnot E. Nelson. "Gender and attractiveness biases in hiring decisions: Are more experienced managers less biased?" *Journal of Applied Psychology*, vol. 81(1), American Psychological Association, pp. 11-21, 1996.

[3] Mehtap Dursun and E. Ertugrul Karsak, "A fuzzy MCDM approach for personnel selection," *Expert System with Application*, p. 3, 2010.

[4] Devendra Choudhary and Ravi Shankar, "An STEEP-fuzzy AHP-TOPSIS framework for evaluation and selection of thermal power plant location : A case study from India," *Energy*, pp. 510-521, March 2012.

[5] Turan Paksoy, Nimet Yapici Pehlivan, and Cengiz Kahraman, "Organizational strategy development in distribution channel management using fuzzy AHP and hierarchical fuzzy TOPSIS," *Expert Systems with Applications*, 2012.

[6] Chia-chi Sun, "A performance evaluation model by integrating fuzzy AHP and fuzzy TOPSIS methods," *Expert Systems with Applications*, vol. 37, pp. 7745-7754, 2010.

[7] Metin Celik, Ahmet Kandakoglu, and I. Deha Er, "Structuring fuzzy integrated multi-stages evaluation model on academic personnel recruitment in MET institutions," *Expert System with Application*, vol. 36, pp. 6918-6927, 2009.

[8] Sachin K. Patil and Ravi Kant, "A fuzzy AHP-TOPSIS framwork for ranking the solutions of Knowledge Management adoption in Supply Chain to overcome its barriers," *Expert Systems with Applications*, vol. 41, pp. 679-693, 2014.

[9] Richard Lepsinger and Anntoinette D. Lucia, *The Art and Science of 360-Degree Feedback*, 2nd ed. San Fransisco, United States of America: Jossey-Bass, 2009.

[10] T.L. Saaty, "What is the analytic hierarchy process?," *Springer Berlin Heidelberg*, pp. 109-121, 1988.

[11] Zulal Gungor, Gurkan Serhadlioglu, and Saadettin Erhan Kesen, "A fuzzy AHP approach to personnel selection problem," *Applied Soft Computing*, vol. 9, pp. 641-646, September 2009.

[12] Wiwik Anggraeni, Renny Pradina Kusumawardani, and Risky Dinal Ardianto, "Penerapan fuzzy analytical hierarchy process pada sistem penilaian pegawai di rumah sakit onkologi Surabaya," *Seminar Nasional Sistem Informasi Indonesia*, September 2014.

[13] J. J. Bukley, "Fuzzy Hierarchical Analysis," *Fuzzy Set and Systems*, no. 17, pp. 233-247, 1985.

[14] Hwang C.L and Yoon K., "Multiple Attributes Decision Making Methods and Applications," *Springer*, 1981.

[15] D. Sameer Kumar, S. Radhika, and K.N.S. Suman, "MADM Methods for Finding The Right Personnel in Academic Institutions," *International Journal of u- and -e Service*, vol. 6, pp. 133-144, 2013.

[16] Gulcin Buyukozkan and Gizem Cifci, "A combined fuzzy AHP and fuzzy TOPSIS based strategic analysis of electronic service quality in healthcare industry," *Expert Systems with Applications*, vol. 39, pp. 2341-2354, 2012.