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Personnel Performance Assessment Using Entropy Based MABAC Method: An Application in the Food Sector

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Abstract

Personnel selection is one of the decisions of strategic importance in terms of ensuring sustainability of companies. This decision is referred to as a multi-criteria decision-making problem in the literature in terms of the many criteria it contains and the determination of the candidate who meets these criteria at the most appropriate level. The use of these methods in order to decide on the most suitable candidate accelerates the nomination process for the enterprise, while at the same time preventing the loss of time that may occur. In this study, an evaluation was made among the personnel who applied for a food company. In the evaluation, some of the criteria determined by the company manager and found in the literature were taken into consideration. Entropy method was used for criterion weights in the solution of the problem. Afterwards, the weights obtained from this method were integrated with the MABAC method, and it was aimed to rank the most suitable candidates. Finally, the ranking results obtained were interpreted and the most suitable candidate was decided.

Keywords: Personnel selection, Multi-criteria decision making, Entropy method, MABAC method

Entropi Metodu Tabanlı MABAC Yöntemi ile Personel Performans Değerlendirmesi: Gıda Sektöründe Bir Uygulama

Öz

Personel seçimi işletmelerin sürdürülebilirlik sağlayabilmeleri açısından stratejik öneme sahip kararlardan biridir. Bu karar bünyesinde barındırdığı çok fazla sayıda kriter ve bu kriterleri en uygun düzeyde karşılayan adayın belirlenmesi açısından literatürde çok kriterli karar verme problemi olarak geçmektedir. En uygun adaya karar verebilmek için bu yöntemlerin kullanılması işletme için aday belirleme sürecini hızlandırırken aynı zamanda meydana gelebilecek zaman kayıplarını da önlemiş olmaktadır. Bu çalışmada bir gıda işletmesi için başvuru yapan personeller arasından değerlendirme yapılmıştır. Yapılan değerlendirmede işletme yöneticisinin belirlediği ve literatürde bulunan kriterlerden bazıları dikkate alınmıştır. Problemin çözümünde kriter ağırlıkları için Entropy yöntemi kullanılmıştır. Sonrasında bu yöntemden elde edilen ağırlıklar MABAC yöntemi ile entegre edilerek en uygun adayların sıralanması hedeflenmiştir. Son olarak elde edilen sıralama sonuçları yorumlanmış ve en uygun adaya karar verilmiştir.

Anahtar Kelimeler: Personel seçimi, Çok kriterli karar verme, Entropi metodu, MABAC metodu.

1. Introduction

Choosing the right personnel and using them most effectively is one of the most important responsibilities of managers. 95% of success in any business and organization depends on the right selection of personnel in that job. The primary task of human resources managers is to select and classify the right personnel for the companies they work with. A company must place the best candidates in the best positions in the most professional manner possible. The main purpose of personnel selection is to minimize selection mistakes by choosing the right person for the requirements. Good production is provided by good personnel. When the appropriate person for the job cannot be selected, incompatibilities and conflicts occur in the company. Moreover, occupational accidents appear and personnel circulation increases (Borman et al., 1997: 299-337).

The selection of the most appropriate personnel contributes to improving the performance of the company. On the other hand, if there is a bad selection process, the job will be affected and the cost to replace this situation will be high. To meet the company's objectives, it's critical to assess each candidate's credentials, skills, experience, and general attitudes. Finally, the most suitable person may be selected after all candidates are eliminated (Robertson & Smith, 2001: 441). In this study, a personnel selection algorithm based on Entropy and Multi-Attributive Border Approximation area Comparison (MABAC) methodologies is proposed. Proposed algorithms are applied to a personnel selection process of a company operating in the food sector in Izmir. Entropy methodology is used for the definition of criteria weights while the MABAC method is used for ranking alternatives. Entropy and MABAC methodologies are applicable in personnel selection. Moreover, this study is original in terms of using these methods together and being a real-life application as well as contributing to the sector.

The rest of the study is organized as follows: a literature review on personnel selection is described in Chapter 2. The methods used for Personnel Selection in this study are presented in detail in Chapter 3. The problems and the solutions of personnel selection are mentioned in Chapter 4. Finally, the results and future studies are shown in the final chapters.

2. Literature Review

Literature of the personnel selection problems is increasing especially in recent years. In a study, personnel classification, availability of current employment, and a job satisfaction seminar could significantly affect the job satisfaction of university students (Jones & Jw, 1992: 34-38). Arguea, Cushing & Woodrow (1997) analyzed data from 666 personnel of a large midwest phone company to identify the communication model differences between the 3 different categories. These categories are: (i) men and women, (ii) exempt and non-exempt personnel, and (iii) personnel using lean and rich communication media. In another study, work-life, health, and exercise in the construction sector questionnaire was applied to 608 construction workers working in 15 construction sites in different regions of Istanbul. The findings obtained were evaluated using a computer program with the help of basic statistical theorems (Kuruoglu, 2006). Fuzzy Analytical Hierarchy Process (FAHP) was used to decide the most suitable personnel (Güngör, Serhadlıoğlu & Kesen, 2009: 641-646).

Analytical Network Process (ANP) and fuzzy Data Enveloping Analysis (DEA) method was also used for Personnel Selection (Lin, 2010: 937-944). Fuzzy Multi-Criteria Decision-Making (MCDM) algorithm used for personnel selection in linguistic representation model and the personnels are sorted using the Technique for Order Preference by Similarity to an Ideal Solution (TOPSIS) (Dursun & Karsak, 2010: 4324–4330). Gray Relational Analysis (GRA) was employed in conjunction with an intuitive fuzzy multi-criteria group decision-making process in another study. The Heuristic Fuzzy Weighted Average (IFWA) operator was used to obtain the Entropy weights of the criteria in the heuristic fuzzy Entropy method to gather individual opinions of Decision-Makers (DM)'s in a group view. GRA has been applied in the ordering and selection of the best personnel finally (Zhang & Liu, 2011: 11401–11405).

Fuzzy Multi-Objective Optimization by Ratio Analysis plus Full Multiplicative Form (MULTIMOORA) methodology is also used in personnel selection. Implementing MULTIMOORA offers us opportunities for improvement in Human Resource Management and other business decision areas (Baležentis & Brauers, 2012: 7961–7967). In another study, Karnik-Mendel algorithm, and fuzzy TOPSIS method is proposed. Instead of the net point or approximation fuzzy relative proximity estimation obtained by the existing TOPSIS technique for the personnel selection problem, the proper fuzzy relative proximity estimation was obtained (Sang, Liu & Qin, 2015: 190–204).

Another study is professionally examined personnel classification problems in professional practice. They worked on the economic and legal tax payment of retirees, volunteers, and workers according to the classification (VanDenHaute, Prescott, Altieri & Tietz, 2017: 43).

The research presents a competency framework that comprises five criteria for selecting the best information technology specialist from among five options. To derive criterion weights and present the final alternative, the procedures of Stepwise Weight Assessment Ratio Analysis (SWARA) and Gray Additive Ratio Assessment (ARAS-G) were utilized (Heidary, Beheshti, Vanaki & Firoozfar, 2018: 5-16). Fuzzy Analytical Hierarchy Process (FAHP) is also applied in personnel selection. Hierarchical level weights were applied in fuzzy AHP-TOPSIS calculations, indicating the importance of DMs verbal judgments in group decision-making. FAHP is used to estimate the relevance weights of the thirty sub-criteria. Finally, 5 personnel alternatives are sorted using fuzzy TOPSIS (Samanlioglu, Taskaya, Gulen & Cokcan, 2018: 1576-1591). Another study, aims the personnel selection process by combining the neutrosophic AHP with the order preference approach, as well as demonstrating analogies to TOPSIS to demonstrate an ideal solution between multiple options (Nabeeh, Smarandache, Abdel-Basset, El-Ghareeb & Aboelfetouh, 2019: 29734-29744)

In the intuitive fuzzy environment, an integrated technique is proposed that uses Decision-Making Trial and Evaluation Laboratory (DEMATEL) and Elimination and Choice Expressing Reality (ELECTRE) methods. The IF-DEMATEL approach was utilized to determine the importance weights of the emerging criteria in the suggested methodology, and then the IF-ELECTRE method was devised and applied to rank the personnels (Kilic, Demirci & Delen, 2020: 113360).

The popular VIse KriterijumsaOptimiz acija I Kompromisno Resenje (VIKOR) approach is also proposed in personnel selection problem (Krishankumar et al., 2020: 1063-1081). The heuristic Fuzzy Additive Rate Assessment (IF-ARAS) method for selecting the best information technology personnel candidate is also considered in the literature (Raj Mishra, Sisodia, Pardasani & Sharma, 2020: 55-68). The author also refers to Oswald et al. (2019: 129) study for more personnel selection studies.

3. Entropy and MABAC Methods

The methodologies utilized in the study are detailed in this section. First and foremost, the Entropy method was suggested for establishing criterion weights. The weights obtained by this method were sorted using the MABAC method, which was also explained in detail.

3.1. Entropy method

The idea of entropy was developed by Shannon (1948) as the measurement of uncertainty in information. Criterion weights are calculated using the entropy approach. The entropy method's primary premise is that information is derived from differences between data sets. As a result, the objective weights of the criteria are decided by how distinct or distinct the alternatives' outputs are in relation to each criterion, i.e. the "intensity of their contrasts." The higher the contrast, the more information the relevant criterion covers and transmits (Çınar, 2004: 103-104).

The concept of Entropy, proposed by Wang and Lee (2009) Shannon (1948), was developed as a weight calculation method. The steps of this method are shown below; (Çakır & Perçin, 2013: 83, Li et al, 2011: 2087, Karami & Johansson, 2014: 523-524)

Step 1. Creating the decision matrix (A):

In the row part of the decision matrix, there are decision points, that is, criteria in the alternatives columns. The decision matrix is as follows:

$$A_{ij} = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & & & \vdots \\ a_{m1} & a_{m2} & \cdots & a_{mn} \end{bmatrix}$$

Step 2. Normalization of the decision matrix:

In order to eliminate the contrasts in different measurement units of the decision matrix, normalization process is performed and the P_{ij} value is calculated.

$$P_{ij} = \frac{a_{ij}}{\sum_{i=1}^{m} a_{ij}}; \forall_j \tag{1}$$

a_{ij} : The value of alternative i for index j;

P_{ij} : It is the scale of the value of index j for alternative i.

Step 3. Calculating the entropy value:

In the formula used to calculate the entropy value, ln is the natural logarithm; It represents a constant calculated from k = 1 / ln (m) ensuring that $0 \leq E_j \leq 1$.

$$E_j = \left(\frac{-1}{\ln(m)}\right) \sum_{i=1}^{m} \left[P_{ij} \ln P_{ij}\right]; \forall_j \tag{2}$$

Step 4. Calculating the d_j value:

$$d_j = 1 - e_j; \forall_j \tag{3}$$

Here d_j shows the contrast density inherent in any X_j criterion.

Step 5. Calculation of criterion weights (w_j):

The following formula is used to calculate entropy criterion weights.

$$w_j = \frac{d_j}{\sum_{j=1}^{n} d_j}; \forall_j \tag{4}$$

Entropy method is used for many evaluation processes in the literature. This method is used for cloud service selection (Akshya et al. 2017), apple selection (Işık, 2017), energy efficient material selection (Bhowmink, 2018), dental implant material selection (Senyigit & Demirel, 2018), sustainable building materials supplier selection (Chen, 2019), evaluation of environmental quality of OECD countries (Dang, 2019), supplier selection (Chen, 2000), energy technology selection (Alao et al. 2020), energy benchmarking evaluation (He et al. 2021), sustainable supplier selection (Peng et al. 2020) and evaluation of the companies (Vaid et al. 2022).

3.2. MABAC Method

Found criteria weights are transferred to the MABAC method. The MABAC method consists of the steps shown below (Pamučar et al. 2018).

Step 1: The first step is to create the decision matrix. The first step is shown in equation 5.

$$F = [f_{ij}]_{m\times n} = \begin{bmatrix} f_{11} & f_{12} & \cdots & f_{1n} \\ f_{21} & f_{22} & \cdots & f_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ f_{m1} & f_{m2} & \cdots & f_{n} \end{bmatrix} \tag{5}$$

Step 2: The decision matrix is normalized with the following equations. Equation 6 will be used for useful criteria and equation 7 will be used for cost criteria.

$$d_{ij} = \frac{f_{ij} - \min(f_i)}{\max(f_i) - \min(f_i)} \tag{6}$$

$$d_{ij} = \frac{f_{ij} - \max(f_i)}{\min(f_i) - \max(f_i)} \tag{7}$$

Step 3: Create a weighted matrix with Equation 8.

$$b_{ij} = w_j \times (d_{j+1}) \tag{8}$$

Step 4: Equation 8 yields the boundary proximity field matrix. The g_i value shown in Equations 9 and 10 is the element of the boundary proximity area matrix (G).

$$g_i = \left(\prod_{i=1}^{m} b_{ij} \right)^{1/m}$$

(9)

$$G = \left[g_i \right]_{i \times n} \tag{10}$$

Step 5: The distances of the alternatives to the boundary proximity area (Q) matrix are obtained by equation 11.

$$Q = B - G = \begin{bmatrix} b_{11} - g_1 & b_{12} - g_2 & \cdots & b_{1n} - g_n \\ b_{21} - g_1 & b_{22} - g_2 & \cdots & b_{2n} - g_n \\ \cdots & \cdots & \cdots & \cdots \\ b_{m1} - g_1 & b_{m2} - g_2 & \cdots & b_{mn} - g_n \end{bmatrix} = \begin{bmatrix} q_{11} & q_{12} & \cdots & q_{1n} \\ q_{21} & q_{22} & \cdots & q_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ q_{m1} & q_{m2} & \cdots & q_{mn} \end{bmatrix} \tag{11}$$

Step 6: Alternatives are determined according to the border proximity area. An alternative can be found in 3 positions as shown in Equation 12.

$$A_i \in \left\{ \begin{matrix} G^+ & if & q_{ij} > 0 \\ G & if & q_{ij} = 0 \\ G^- & if & q_{ij} < 0 \end{matrix} \right\} \tag{12}$$

Step 7: Values are obtained by summing the distance (q_{ij}) values from the boundary proximity area for each alternative. The best alternative is determined to be the alternative with the highest value.

$$S_i = \sum_{j=1}^{n} q_{ij} \tag{13}$$

MABAC method is used in different studies in the literature. This method is used for location selection (Bozanic et al. 2019), third-party logistic provider selection (Pamucar et al. 2019), portfolio selection (Biswas et al. 2019), assessment of programming language (Mishra et al. 2020), green supplier selection (Wei et al. 2020), selection of emergency alternatives (Liang et al. 2020), electric vehicle selection (Soner & Kulkarni 2021), fire position selection (Jokic et al. 2021), high-performance work system selection (Zhang et al. 2021) and site selection (Wu et al. 2021).

4. Case Study for Personnel Selection

In this part of the study, a real-life application has been made for personnel selection. In the beginning phase of this application, the criterion weights were determined by the Entropy method. Afterward, the most suitable personnel were decided by considering the weights, by listing the appropriate personnel with the MABAC method. The structure and solution of the problem in the study are detailed below.

4.1. Definition of the problem

In the study, the recruitment process of a food company in Konak, Izmir was discussed. In this process, the company manager wants to decide on the most suitable out of five candidates for recruitment. For this, the criteria in the literature and the criteria needed by the manager were taken into account. The personnel who meet these criteria at the most appropriate level from five candidates were selected. The hierarchical structure of the problem is shown in Figure 1. The explanations of the criteria used in the study are as follows:

Initiative (C1): Assertiveness is the ability to defend one's rights and express his thoughts without ignoring the other person's rights. The most appropriate way to act assertively is through direct, open, and honest communication. Communication is very important because of the collective work in business life.

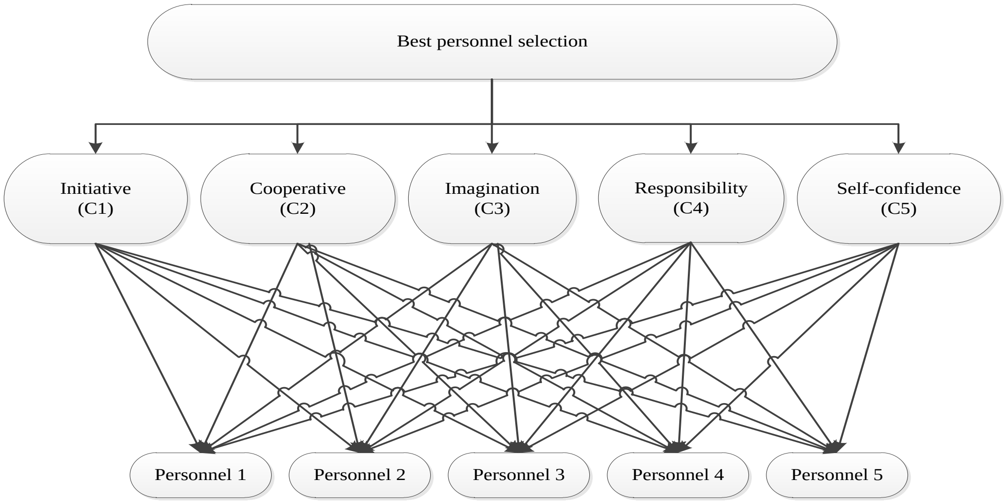
Cooperative (C2): Since the personnel tends to collaborate, they share work at an organizational level, so the harmony and unity in the workplace allow both the personnel to adopt the job and the development of the business in line with the purpose.

Imagination (C3): Although it can be noticed in various ways in different areas of life, during daily-ordinary activities; It is dynamic that motivates situations that require extraordinary situations such as artistic events and design creation processes. Therefore, it is an important criterion in personnel selection.

Responsibility (C4): Responsibility means that an individual adapts, fulfills all his / her duties, and respects the rights and decisions of other people. There are job descriptions that the personnel should do in the definition of each business and job. Responsible personnel is expected to act following these job descriptions.

Self-confidence (C5): In business life, the personnel reaching the given goals, believing that they are part of a team in an organizational sense, and the personnel being at peace with themselves increase their self-confidence. Thus, self-confidence is important in personnel selection.

Figure 1: The Hierarchical Structure of the Problem



4.2. Application of Entropy and MABAC Methods

The weights of the criteria determined by the business manager were found using the Entropy method. For this, the initial matrix of Table 1 was created by the manager. The criteria weights obtained after the calculation made by considering this matrix are given in Table 2.

Table 1: Decision Matrix

	Initiative	Cooperative	Imagination	Responsibility	Self-confidence
Personnel 1	68	75	90	87	54
Personnel 2	72	51	72	91	73
Personnel 3	42	69	75	79	65
Personnel 4	61	35	67	80	56
Personnel 5	82	64	49	67	70

Table 2: Priorities to Personnel Selection

Rank	Criterion Name	Criterion Weight
1	Initiative	0,185
2	Cooperative	0,226
3	Imagination	0,224
4	Responsibility	0,217
5	Self-confidence	0,148

According to the results of the weight calculations made with the entropy method, the highest weight value was seen in the "Cooperative" criterion. Afterwards, although there was not much difference, the criterion with the second highest weight value was the "Imagination" criterion. "Responsibility", "Initiative" and "Self-confidence" criteria are other important criteria, respectively.

The ranking of the personnel was made with the MABAC method considering the weights obtained by the Entropy method. For this, the initial matrix was also considered as mentioned in Table 1. To eliminate anomalies, the decision matrix is normalized and Table 3 was created by using the utility formulas in equation 6 and 7.

Table 3: Normalized Decision Matrix

	Initiative	Cooperative	Imagination	Responsibility	Self-confidence
Personnel 1	0,65	1	1	0,833333333	0
Personnel 2	0,75	0,4	0,56097561	1	1
Personnel 3	0	0,85	0,634146341	0,5	0,578947368
Personnel 4	0,475	0	0,43902439	0,541666667	0,105263158
Personnel 5	1	0,725	0	0	0,842105263

The weighted matrix is calculated using Equation 8 and the calculation results are provided in Table 4.

Table 4: Weighted Matrix

	Initiative	**Cooperative**	**Imagination**	**Responsibility**	**Self-confidence**
Personnel 1	0,305592045	0,453845602	0,448282964	0,398625022	0,146296634
Personnel 2	0,324112775	0,317691921	0,349879387	0,43486366	0,292593268
Personnel 3	0,1852073	0,419807182	0,366279983	0,326147745	0,230994685
Personnel 4	0,273180768	0,226922801	0,322545059	0,335207405	0,16169628
Personnel 5	0,3704146	0,391441832	0,224141482	0,21743183	0,269493799

According to the weighted decision matrix, the boundary proximity area matrix was created as shown in Table 5 with the help of equation 9 and 10. The distances of the alternatives from the boundary proximity area are found using equation 11 and 12. It is shown in Table 6. For each alternative, it is obtained by summing the distance values from the border proximity area as shown in Table 7 using equation 13.

Table 5: Determine the Border Approximation Area Matrix

	Initiative	**Cooperative**	**Imagination**	**Responsibility**	**Self- confidence**
g_i	0,284267299	0,351642944	0,333948335	0,333421619	0,212260803

According to the results in Table 7, it is seen that "personnel 1" is the most suitable candidate among the five candidates according to the criteria. The second most suitable candidate was "personnel 2". The last candidate to be preferred was "personnel 4" according to the MABAC results.

Table 6: The Distance Matrix of Alternatives from the Boundary Proximity Area

	Initiative	Cooperative	Imagination	Responsibility	Self-confidence
Personnel 1	0,021324746	0,102202658	0,114334629	0,065203403	-0,065964199
Personnel 2	0,039845476	-0,033951023	0,015931052	0,101442041	0,080332405
Personnel 3	-0,099059999	0,068164238	0,032331648	-0,007273874	0,018733835
Personnel 4	-0,011086531	-0,124720143	-0,011403275	0,001785786	-0,050564556
Personnel 5	0,086147301	0,039798888	-0,109806853	-0,115989789	0,057232942

Table 7: Ordering Results by the Best Alternative

Alternatives	Q	Rank
Personnel 1	0,237101238	1
Personnel 2	0,203599953	2
Personnel 3	0,012895849	3
Personnel 4	-0,195988719	5
Personnel 5	-0,04261751	4

5. Conclusion And Suggestions

Finding qualified personnel to meet the needs of the enterprise in line with the positions determined in an enterprise is named as personnel selection problem. Personnel selection is vital for an enterprise, and this process needs to be processed quickly so that the processes are not interrupted. In the personnel selection process, it is best to choose the right person at the right place and time, in the right conditions, by the right people, for the right job and purpose.

In this study, the personnel selection problem of a company operating in the food sector is discussed. To solve the problem under consideration, the company manager tried to decide on the best of five suitable personnel in line with certain criteria. The Entropy method was used in the process of determining criterion weights for the solution of this decision problem. After determining the weights, the MABAC method was used to decide the most appropriate personnel, and the personnel was listed. As a result of the study, it was seen that the most suitable personnel were the first personnel. The lack of results using comparative methods in the study can be said as a limitation of the study. However, obtaining a solution through a real-life application in the study can be considered as a contributor and guide to the industry in terms of companies. It is important for future studies that the results can be changed, and a comparison can be made considering the fuzzy values. Besides, the same problem can be solved by considering different methods such as PROMETHEE, DEMATEL, or linear programming and the results can be compared.

References

Akshya Kaveri, B., Gireesha, O., Somu, N., Gauthama Raman, M. R., & Shankar Sriram, V. S. (2017). E-FPROMETHEE: an entropy based fuzzy multi criteria decision making service ranking approach for cloud service selection. In International Conference on Intelligent Information Technologies, 224-238.

Alao, M. A., Ayodele, T. R., Ogunjuyigbe, A. S. O., & Popoola, O. M. (2020). Multi-criteria decision based waste to energy technology selection using entropy-weighted TOPSIS technique: The case study of Lagos, Nigeria. Energy, 201, 117675.

Arguea M., Cushing J., & Woodrow W., (1997) "Neural Network Analysis of the Employee Classification Problem for Tax Purposes", *Documentos de Trabajo del Instituto Complutense de Análisis Económico* 01.

Baležentis, A., Baležentis, T., & Brauers, W. K. M. (2012). Personnel Selection Based On Computing With Words And Fuzzy MULTIMOORA. *Expert Systems with Applications,* 39(9).

Bhowmik, C., Gangwar, S., Bhowmik, S., & Ray, A. (2018). Selection of energy-efficient material: an entropy–TOPSIS approach. *In Soft Computing: Theories and Applications*,31-39.

Borman, W. C., Hanson, M. A., & Hedge, J. W. (1997). Personnel Selection. *Annual review of psychology*, 48(1), 299-337.

Bozanic, D., Tešić, D., & Kočić, J. (2019). Multi-criteria FUCOM–Fuzzy MABAC model for the selection of location for construction of single-span bailey bridge. *Decision making: applications in management and engineering*, 2(1), 132-146.

Biswas, S., Bandyopadhyay, G., Guha, B., & Bhattacharjee, M. (2019). An ensemble approach for portfolio selection in a multi-criteria decision making framework. *Decision Making: Applications in Management and Engineering*, 2(2), 138-158.

Chen, C. H. (2019). A new multi-criteria assessment model combining GRA techniques with intuitionistic fuzzy entropy-based TOPSIS method for sustainable building materials supplier selection. *Sustainability*, 11(8), 2265.

Chen, C. H. (2020). A novel multi-criteria decision-making model for building material supplier selection based on entropy-AHP weighted TOPSIS. *Entropy*, 22(2), 259.

Çakır, S. & Perçin, S., (2013). AB ülkeleri'nde bütünleşik entropi ağırlık-topsis yöntemiyle ar-ge performansının ölçülmesi. *Uludağ Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi*, 32(1), 77-95.

Çınar, Y. (2004). Çok nitelikli karar verme ve bankaların mali performanslarının değerlendirilmesi örneği. Yayınlanmamış yüksek lisans tezi, Ankara Üniversitesi Sosyal Bilimler Enstitüsü İşletme Anabilim Dalı, Ankara.

Dang, W. V. (2019). Multi-criteria decision-making in the evaluation of environmental quality of OECD countries: the entropy weight and VIKOR methods. *International Journal of Ethics and Systems*.

Dursun, M., & Karsak, E. E. (2010). A Fuzzy MCDM Approach For Personnel Selection. *Expert Systems With Applications*, 37(6), 4324—4330.

Güngör, Z., Serhadlıoğlu, G., & Kesen, S. E. (2009). A Fuzzy AHP Approach To Personnel Selection Problem. *Applied Soft Computing*, 9(2), 641—646.

He, L., Shao, F., & Ren, L. (2021). Sustainability appraisal of desired contaminated groundwater remediation strategies: an information-entropy-based stochastic multi-criteria preference model. *Environment, development and sustainability*, 23(2), 1759-1779.

Heidary Dahooie, J., Beheshti Jazan Abadi, E., Vanaki, A. S., & Firoozfar, H. R. (2018). Competency Based IT Personnel Selection Using A Hybrid SWARA And ARASG Methodology. *Human Factors and Ergonomics in Manufacturing & Service Industries*, 28(1), 5—16.

Işık, A. T. (2017). The decision-making approach based on the combination of entropy and ROV methods for the apple selection problem. *European Journal of Interdisciplinary Studies*, 3(3), 80-86.

Jones, M., & Obermesik, J (1992), "Effects Of Worker Classification And Employment Relatedness On Student Employee Job Satisfaction", *Journal of College Student Development,* 33(1), 34—38.

Jokić, Ž., Božanić, D., & Pamučar, D. (2021). Selection of fire position of mortar units using LBWA and Fuzzy MABAC model. *Operational Research in Engineering Sciences: Theory and Applications*, 4(1), 115-135.

Kilic, H. S., Demirci, A. E., & Delen, D. (2020). An Integrated Decision Analysis Methodology Based On IF-DEMATEL and IF-ELECTRE for personnel selection. *Decision Support Systems*, 113360.

Karami, A. & Johansson, R. (2014). Utilization of multi attribute decision making techniques to integrate automatic and manual ranking of options. *Journal Of Information Science and Engineering*, 30, 519-534.

Krishankumar, R., Premaladha, J., Ravichandran, K. S., Sekar, K. R., Manikandan, R., & Gao, X. Z. (2020). A Novel Extension to VIKOR Method Under Intuitionistic Fuzzy Context For Solving Personnel Selection Problem. *Soft Computing*, 24(2), 1063—1081.

Kuruoğlu M., (2006), "İnşaat Sektöründe Fiziksel Güce Dayalı İşlerin Sınıflandırılması ve Bu İşlerde Çalışanların Aktivite Düzeyinin Belirlenmesi", Marmara Üniversitesi Tez Koleksiyonu 35691.

Lı, X., Wang, K., Lıu, L. X., Jing, Y., H., & Gao, C. (2011). application of the entropy weight and topsıs method in safety evaluation of coal mines. *Procedia Engineering*, 26, 2085-2091.

Liang, X., Teng, F., & Sun, Y. (2020). Multiple group decision making for selecting emergency alternatives: a novel method based on the LDWPA operator and LD-MABAC. *International Journal of Environmental Research and Public Health*, 17(8), 2945.

Lin, H. T. (2010). Personnel Selection Using Analytic Network Process And Fuzzy Data Envelopment Analysis Approaches. *Computers & Industrial Engineering,* 59(4), 937—944.

Mishra, A. R., Chandel, A., & Motwani, D. (2020). Extended MABAC method based on divergence measures for multi-criteria assessment of programming language with interval-valued intuitionistic fuzzy sets. *Granular Computing*, 5(1), 97-117.

Nabeeh, N. A, Smarandache, F., Abdel-Basset, M., El-Ghareeb, HA & Aboelfetouh, A. (2019). An Integrated Neutrosophic-TOPSIS Approach and Its Application to Personnel Selection: A New Trend in Brain Processing and Analysis. *IEEE*, 7, 29734—29744.

Oswald, F. L., Hough, L. M., & Zuo, C. (2019). Personnel Selection And Vocational Interests: Recent Research and Future Directions. *Vocational Interests in the Workplace,* 129-141.

Pamučar, D., Petrović, I. & Ćirović, G. (2018). Modification of the Best–Worst and MABAC methods: A Novel Approach Based on Interval-

Valued Fuzzy-Rough Numbers. *Expert systems with applications*, 91, 89—106.

Pamucar, D., Chatterjee, K., & Zavadskas, E. K. (2019). Assessment of third-party logistics provider using multi-criteria decision-making approach based on interval rough numbers. *Computers & Industrial Engineering*, 127, 383-407.

Peng, J. J., Tian, C., Zhang, W. Y., Zhang, S., & Wang, J. Q. (2020). An integrated multi-criteria decision-making framework for sustainable supplier selection under picture fuzzy environment. *Technological and Economic Development of Economy*, 26(3), 573-598.

Raj Mishra, A., Sisodia, G., Raj Pardasani, K., & Sharma, K. (2020). Multi-Criteria IT Personnel Selection on Intuitionistic Fuzzy Information Measures and ARAS Methodology. *Iranian Journal of Fuzzy Systems*, 17(4), 55—68.

Robertson, I. T., & Smith, M. (2001). Personnel Selection. *Journal of occupational and Organizational psychology,* 74(4), 441-472.

Samanlioglu, F., Taskaya, Y. E., Gulen, U. C., & Cokcan, O. (2018). A fuzzy AHP–TOPSIS-Based Group Decision-Making Approach to IT Personnel Selection. *International Journal of Fuzzy Systems*, 20(5), 1576—1591.

Sang, X., Liu, X., & Qin, J. (2015). An Analytical Solution to Fuzzy TOPSIS And Its Application in Personnel Selection for Knowledge-Intensive Enterprise. *Applied Soft Computing*, 30, 190-204.

Shannon, C. E. (1948). A mathematical theory of communication. *The Bell system technical journa*l, 27(3), 379-423.

Sonar, H. C., & Kulkarni, S. D. (2021). An integrated ahp-mabac approach for electric vehicle selection. *Research in Transportation Business & Management*, 41, 100665.

Şenyiğit, E., & Demirel, B. (2018). The selection of material in dental implant with entropy based simple additive weighting and analytic hierarchy process methods. *Sigma Journal of Engineering and Natural Sciences*, 36(3), 731-740.

Vaid, S. K., Vaid, G., Kaur, S., Kumar, R., & Sidhu, M. S. (2022). Application of multi-criteria decision-making theory with VIKOR-WASPAS-Entropy methods: A case study of silent Genset. *Materials Today: Proceedings*, 50, 2416-2423.

VanDenHaute K., Prescott W., Altieri M., & Tietz R., (2017). Worker Classification Issues in Professional Practices. 24-43.

Zhang, S., & Liu, S. (2011). A GRA-based Intuitionistic Fuzzy Multi-Criteria Group Decision Making Method for Personnel Selection. *Expert Systems with Applications*, 38(9), 11401-11405.

Zhang, H., Wei, G., & Chen, X. (2021). CPT-MABAC method for spherical fuzzy multiple attribute group decision making and its application to green supplier selection. *Journal of Intelligent & Fuzzy Systems*, 1-11.

Wang, T. C., & Lee, H. D. (2009). Developing a fuzzy TOPSIS approach based on subjective weights and objective weights. *Expert systems with applications*, 36(5), 8980-8985.

Wei, G., He, Y., Lei, F., Wu, J., Wei, C., & Guo, Y. (2020). Green supplier selection with an uncertain probabilistic linguistic MABAC method. *Journal of Intelligent & Fuzzy Systems*, 39(3), 3125-3136.

Wu, Y., Deng, Z., Tao, Y., Wang, L., Liu, F., & Zhou, J. (2021). Site selection decision framework for photovoltaic hydrogen production project using BWM-CRITIC-MABAC: A case study in Zhangjiakou. *Journal of Cleaner Production*, 324, 129233.