AN EXTENDED PROMETHEE II METHOD FOR WORKERS' INCENTIVE SALLOCATION PROBLEM WITH ROUGH INTERVAL DATA IN CONSTRUCTION COMPANIES

MOHAMED FATHI EL-SANTAWY

Financial Researcher at Ministry of Finance, Egypt

ABSTRACT

The precise selection of a set of employees to be rewarded has its crucial effect on the work progress. Recently, incentives' recipients are determined using quantitative approaches rather than management judgment only. In this paper, a novel Multi-Criteria Decision Making (MCDM) approach to tackle the incentives' allocation problem. In real-world MCDM situations, it is difficult to determine the exact value for each attribute when their values are rough interval data. This paper presents a new Rough Interval Preference Ranking Organization Method for Enrichment Evaluation (RIPROMETHEE II) approach for solving a real-life incentives' allocation problem with rough interval data. The proposed approach ranks the executive managers found in a construction company to highlight the proposed approach.

KEYWORDS: *Incentives' Allocation Problem, Multi-Criteria Decision Making (MCDM), PROMETHEE II & Rough Interval*

Received: Jun 06, 2020; **Accepted:** Jun 26, 2020; **Published:** Aug 18, 2020; **Paper Id.:** IJMPERDJUN2020804

1. INTRODUCTION

The achievement of an organizational goal set by a company requires more motivation that the company can give to employees, so that employee performance can improve [11]. The human factor is the most important among all ingredients of the success. Loyal workers and employees are really the main asset any organization must maintain before setting the other factors of production. One of the most important issues is keep the workers loyal and feel they are partners in accomplishing the organizations' goals and success. One of the most common ways to do this and improve the workers' performance is providing incentives to workers to motivate them more and reward the best of them. Also, allowances, profit shares, medical insurance, holidays and leaves are efficient methods to raise the employees' performance but still providing monthly incentives are the most the most effective method. Psychosocially, the direct impact of bonuses on the employees is the main drive in increasing productivity and efficiency [6].

Daily, in our real-life we face a decision making situations involve conflicting goals or objectives. It is human natural behavior to gain units of objectives and lose some in others depending on individuals' preference. Multiple-Criteria Decision-Making (MCDM) is the branch of science dealing with such cases and scenarios [9]. The MCDM problem is represented by decision matrix with alternatives and criteria on the two dimensions. Many philosophies are incorporated in MCDM; some of them are idealism methods which compare all alternatives to ideal situation (choice). The ideal vector is composed from ideal values of all criteria; in a way it is imaginary and cannot be accomplished in real-life so also it is called utopian vector. Other category is to compare the alternative via pairwise comparisons till one alternative outranks other alternatives. The oldest class of methods is the aggregating

methods; in which all performance ratings of alternatives are to be compiled into a single score and so rank is obtained. The way of aggregating differs from method to method but generally all weighting methods are easy to be implemented and solved despite of its well-known disadvantages. Some of the most widely used MCDM methods are SAW, AHP, COPRAS, ELECTRE, MOORA, DIA, and TOPSIS [4].

In many real-life problems, different types of uncertainty are found. There are few papers that deal with the cases involved rough interval data. Obviously, the representation of alternatives' ratings via the specified criteria turns the problem to be more complicated and requires auxiliary techniques to deal with this type of uncertainty. Zhu et. al. integrated AHP and VIKOR based on rough numbers [12]. Many other applications are done like in [5],[8], and [1].

The PROMETHEE method is an interactive MCDM approach designed to handle quantitative as well as qualitative criteria with discrete alternatives. In this method, pairwise comparison of the alternatives is performed to compute a preference function for each criterion. The PROMETHEE I and PROMETHEE II methods were developed by Brans [3]. PROMETHEE I can give a partial preorder of the candidate alternatives, whereas a complete ranking is obtained using PROMETHEE II method while PROMETHEE II provides a complete preorder of the alternatives by using a net flow. Although it loses much information of preference relations, there is a balance between the positive and negative outranking flows [2].

To the best of our knowledge, a single proposal was done by Mersanet. al. to tackle the workers' incentives allocation problem aforementioned; in their paper they employ VIKOR method to determine the workers obtained incentives [6]. This proposal is the first to tackle the problem in a different manner under rough environment also in the construction field. The current paper is to propose a new Rough Interval Preference Ranking Organization Method for Enrichment Evaluation (RIPROMETHEE II) approach for solving workers' incentives allocation with rough interval data. The rest of this paper is organized as follows; Section 2 reviews the basic definitions of rough set theory. Section 3 presents a new approach to extend ROMETHEE II to deal with rough interval data. In Section 4 a real-life problem existed in a construction company is illustrated and used to validate the proposed approach. Section 5 concludes the paper.

2. ROUGH SET THEORY

Rough set theory, first proposed by Pawlak [7], can be regarded as an effective mathematical vehicle for dealing with imprecise and ambiguous data analyses. Rough set concept can be defined quite generally by means of topological operations, interior and closure, called approximations. Generally, a rough interval comprises two parts: an upper approximation interval (UAI) and a lower approximation interval (LAI) [10].

Basic Operations of Rough Interval

Let $*$ $\in \{+, -, \times, \div\}$ be a binary operation on rough intervals. For rough intervals x^R and y^R when $x^R \geq 0$ and $y^R \geq 0$, we have:

$$x^R + y^R = [x^{(UAI)} + y^{(UAI)}; x^{(LAI)} + y^{(LAI)}] \quad (1)$$

$$x^R - y^R = [x^{(UAI)} - y^{(UAI)}; x^{(LAI)} - y^{(LAI)}] \quad (2)$$

$$x^R \times y^R = [[x^{(UAI)} \times y^{(UAI)}] : [x^{(LAI)} \times y^{(LAI)}]] \quad (3)$$

$$x^R \div y^R = [[x^{(UAI)} \div y^{(UAI)}] : [x^{(LAI)} \div y^{(LAI)}]] \quad (4)$$

As $x^{(UAI)}, x^{(LAI)}, y^{(UAI)}$ and $y^{(LAI)}$ are conventional intervals, $x^{UAI} = [x^{(-UAI)}, x^{(+UAI)}]$, $x^{LAI} = [x^{(-LAI)}, x^{(+LAI)}]$, $y^{UAI} = [y^{(-UAI)}, y^{(+UAI)}]$, and $y^{LAI} = [y^{(-LAI)}, y^{(+LAI)}]$, where $x^{(-LAI)}$, $x^{(+LAI)}$, $y^{(-UAI)}$, $y^{(+UAI)}$, $y^{(-LAI)}$, and $y^{(+LAI)}$ are deterministic numbers denoting bounds of intervals.

3. ROUGH INTERVAL PREFERENCE RANKING ORGANIZATION

METHOD FOR ENRICHMENT EVALUATION (RIPROMETHEE II) APPROACH

In this section, some modifications are illustrated to extend the original PROMETHEE II method to deal with problems when the data given are rough intervals. The proposed RIPROMETHEE II method consists of the following steps:

Step 1: Construct the decision matrix with Rough Interval data X^{RI}

$$X^{RI} = \begin{bmatrix} x_{11}^{RI} & \cdots & x_{12}^{RI} & \cdots & x_{1n}^{RI} \\ \vdots & & \vdots & & \vdots \\ x_{21}^{RI} & \cdots & x_{22}^{RI} & \cdots & x_{2n}^{RI} \\ \vdots & & \vdots & & \vdots \\ x_{m1}^{RI} & \cdots & x_{m2}^{RI} & \cdots & x_{mn}^{RI} \end{bmatrix} \quad (5)$$

$$i = 1, 2, \dots, m; j = 1, 2, \dots, n$$

where $x_{ij}^{RI} = [x_{ij}^{LAI}, x_{ij}^{UAI}]$, $x_{ij}^{LAI} = [x_{ij}^{-LAI}, x_{ij}^{+LAI}]$, x_{ij}^{-LAI} = lower lower interval and x_{ij}^{+LAI} = lower upper interval. $x_{ij}^{UAI} = [x_{ij}^{-UAI}, x_{ij}^{+UAI}]$, x_{ij}^{-UAI} = upper lower interval and x_{ij}^{+UAI} = upper upper interval, m = number of alternatives, n = number of criteria, $i = 1, 2, \dots, m$; and $j = 1, 2, \dots, n$.

Step 2: Normalize the Rough Interval decision-making matrix $R_{ij}^{RI} = [[R_{ij}^{-UAI}, R_{ij}^{+UAI}] : [R_{ij}^{-LAI}, R_{ij}^{+LAI}]]$

For rough interval beneficial criteria

$$R_{ij}^{RI} = \frac{[x_{ij}^{-UAI}, x_{ij}^{+UAI}] : [x_{ij}^{-LAI}, x_{ij}^{+LAI}] - \min[x_{ij}^{-UAI}, x_{ij}^{-LAI}]}{\max[x_{ij}^{+UAI}, x_{ij}^{+LAI}] - \min[x_{ij}^{-UAI}, x_{ij}^{-LAI}]} \quad (6)$$

For rough interval non-beneficial criteria

$$R_{ij}^{RI} = \frac{\max[x_{ij}^{+UAI}, x_{ij}^{+LAI}] - [x_{ij}^{-UAI}, x_{ij}^{+UAI}] : [x_{ij}^{-LAI}, x_{ij}^{+LAI}]}{\max[x_{ij}^{+UAI}, x_{ij}^{+LAI}] - \min[x_{ij}^{-UAI}, x_{ij}^{-LAI}]} \quad (7)$$

where R_{ij}^{RI} is the normalized value of x_{ij}^{RI} , $\max[x_{ij}^{+UAI}, x_{ij}^{+LAI}]$ and $\min[x_{ij}^{-UAI}, x_{ij}^{-LAI}]$ are the minimum and maximum values of x_{ij}^{RI} , respectively.

Step 3: Calculate the evaluative differences of (i^{th}) alternative with respect to other alternative. The resulted differences will be rough intervals.

Step 4: Calculate the rough interval preference function $P_j^{RI}(a, b)$.

$$P_j^{RI}(a,b) = [P_j^{-UAI}(a,b), P_j^{+UAI}(a,b)]: [P_j^{-LAI}(a,b), P_j^{+LAI}(a,b)]$$

$$P_j^{RI}(a,b) = 0 \text{ if } R_{aj}^{RI} \leq R_{bj}^{RI} \quad (8)$$

$$P_j^{RI}(a,b) = (R_{aj}^{RI} - R_{bj}^{RI}) \text{ if } R_{aj}^{RI} > R_{bj}^{RI} \quad (9)$$

Step 5: Calculate the rough interval aggregated preference function taking into account the criteria weights. Rough interval aggregated preference function will be as follows:

$$\pi^{RI}(a,b) = [\pi^{-UAI}(a,b), \pi^{+UAI}(a,b)]: [\pi^{-LAI}(a,b), \pi^{+LAI}(a,b)]$$

$$\pi^{RI}(a,b) = [\sum_{j=1}^n P_j^{RI}(a,b) * w_j] / \sum_{j=1}^n w_j \quad (10)$$

where w_j is the relative importance (weight) of (j^{th}) criterion.

Step 6: Determine rough interval the leaving and the entering outranking flows as follows:

Rough interval leaving (positive) flow for (a^{th}) alternative;

$$\varphi^{+RI}(a) = [\varphi^{-UAI+}(a), \varphi^{+UAI+}(a)]: [\varphi^{-LAI+}(a), \varphi^{+LAI+}(a)]$$

$$\varphi^{+RI}(a) = \sum_{b=1}^m \pi^{RI}(a,b) \quad (a \neq b) \quad (11)$$

Rough interval entering (negative) flow for (a^{th}) alternative;

$$\varphi^{-RI}(a) = [\varphi^{-UAI-}(a), \varphi^{+UAI-}(a)]: [\varphi^{-LAI-}(a), \varphi^{+LAI-}(a)]$$

$$\varphi^{-RI}(a) = \sum_{b=1}^m \pi^{RI}(a,b) \quad (a \neq b) \quad (12)$$

where m is the number of alternatives.

Step 7: Calculate the rough interval net outranking flow for each alternative.

$$\varphi^{RI}(a) = [\varphi^{-UAI}(a), \varphi^{+UAI}(a)]: [\varphi^{-LAI}(a), \varphi^{+LAI}(a)]$$

$$\varphi^{RI}(a) = \varphi^{+RI}(a) - \varphi^{-RI}(a) \quad (13)$$

where $\varphi^{RI}(a)$ is the rough interval net outranking flow value for alternative a .

Step 8: Transform the rough interval values of $\varphi^{RI}(a)$ into the crisp values by the centroid method.

$$\varphi(a) = \frac{1}{4} [\varphi^{-UAI}(a) + \varphi^{+UAI}(a) + \varphi^{-LAI}(a) + \varphi^{+LAI}(a)] \quad (14)$$

Step 9: Determine the ranking of all the considered alternatives depending on the values of $\varphi(a)$.

The higher value of $\varphi(a)$, the better is the alternative.

4. WORKERS' INCENTIVES ALLOCATION PROBLEM

In this section, we consider a real-life case study found in a construction company located in Egypt. The company assigns an executive manager for every project done. The company restricted the selection to the top five executive managers. In this study, the performance of these five managers in the company is evaluated using the proposed approach. Incentives will be given to some of them who will exceed certain threshold as shown later in this section.

The Human Resources department specifies five criteria to compare the five managers. The process of ranking the five managers is a typical MCDM problem. The Human Resources department limited the comparison criteria to four as follows; C_1 is the delay quantity of all projects (previous and current) for every manager, C_2 is previous achievements of projects in the same field, C_3 is the attitude with subordinates and top management, and finally C_4 is made for the manager discipline.

All ratings are represented in the form of rough interval data as shown below in the rough interval decision matrix represented in Table 1. Also, the Human Resources department assigns the following weights 0.35, 0.25, 0.25, and 0.15 to C_1 , C_2 , C_3 , and C_4 , respectively. Results and illustrations are shown in the rest of the section.

Table 1: Rough Interval Decision Making Matrix

	Criteria			
Optimization	Min	Max	Max	Max
Weights	0.35	0.25	0.25	0.15
Alternatives	C_1	C_2	C_3	C_4
	UAILAI	UAILAI	UAILAI	UAILAI
Manager 1	[[70, 85] : [75,80]]	[[200, 220] : [205,210]]	[[270, 285] : [275, 280]]	[[440,460]:[445,456]]
Manager 2	[[90,110]:[95,100]]	[[20,35] : [25,30]]	[[300, 320] : [310, 315]]	[[300, 400]:[350,390]]
Manager 3	[[100,150]:[120,130]]	[[95, 130] : [110,120]]	[[330, 360] : [340, 350]]	[[470,485]:[475,480]]
Manager 4	[[50,60]:[53,58]]	[[230,240 : [233, 238]]	[[380,410] : [390,400]]	[[200,300]:[270,290]]
Manager 5	[[40,65]:[45,55]]	[[250,265] : [255,260]]	[[420,345] : [425, 430]]	[[395,490]:[455,477]]

5. RESULTS AND DISCUSSIONS

By applying the steps of the RIPROMETHEE II approach as illustrated before, we obtain the rough interval leaving and entering outranking flows as in table 2 by applying Eqs. (6-12). The rough interval net outranking flow values for each alternative are calculated based on Eq. (13) as shown in Table 3. Mathematical Model found in Eq. (7). Then, the final overall weights will be as shown in table 4.

Table 2: Rough Interval Leaving and Entering Outranking Flows

Alternatives	Rough interval leaving positive flow	Rough interval entering negative flow
Manager 1	[0.39654, 1.06552]:[0.65307,0.88372]	[0.53311,1.18628]:[0.79472, 1.07569]
Manager 2	[0.02273, 1.18163]:[0.17360,0.35689]	[1.24951,2.33912]:[1.50650, 2.10311]
Manager 3	[0.34963, 1.00804]:[0.50928,0.72442]	[0.70349,2.23394]:[1.30974, 1.75465]
Manager 4	[0.85133, 1.72065]:[1.20119,1.52774]	[0.23484,1.10213]:[0.46198, 0.71952]
Manager 5	[1.10073, 2.45322]:[1.57698,2.25728]	[0.00000,0.56761]:[0.04118, 0.09708]

Table 3: Rough Interval Net Outranking Flow

Alternatives	Rough Interval Net Outranking Flow
Manager 1	[-0.78974,0.53241]:[-0.42263, 0.08900]
Manager 2	[-2.31639,-0.06788]:[-1.92951, -1.14961]
Manager 3	[-1.88431,0.30455]:[-1.24538, -0.58532]
Manager 4	[-0.25080,1.48581]:[0.48167, 1.06576]
Manager 5	[0.53312, 2.45322]:[1.47990, 2.21611]

At the end, the Final ranking of alternatives is calculated using Eq.(14) as shown in Table 4. A threshold value is set that managers with net outranking flow values are given incentives while managers with net outranking flow values are not. In this study we set the threshold value at zero. Table 4 shows the status of each manager whether he gets incentive or not.

Table 4: Final Ranking of Alternatives

Alternatives	Net Outranking Flow	Rank	Status
Manager 1	-0.14774	3	Not given
Manager 2	-1.36585	4	Not given
Manager 3	-0.85261	5	Not given
Manager 4	0.695611	2	Get incentives
Manager 5	1.670587	1	Get incentives

6. CONCLUSIONS

The proposed approach successfully extended PROMETHEE II method to solve is a real-life workers' incentive allocation problem with rough interval data located in a construction company. The proposed approach is the first to tackle such category with rough interval data. The paper also illustrates a new scheme to give incentives for workers which can be generalized in real-life. The new MCDM problem illustrated draws a new category of MCDM problems which can be solved with different methods and under different uncertain data of different types in further research streams.

REFERENCES

1. Ağırün, B. (2012). *Supplier SelectionBased on Fuzzy Rough-AHP and VIKOR*. NevşehirÜniversitesi Fen BilimleriEnstitüsüDergisi, 1(2), pp. 1-11
2. Brans, J. P. and Vincke, P. (1985). *Note-A Preference Ranking Organisation Method: (The PROMETHEE Method for Multiple CriteriaDecision-Making)*. Management science, 31(6), pp. 647-656.
3. Doumpos, M. andZopounidis, C. (2004). *A multicriteria classification approach based on pairwise comparisons*. European Journal of Operational Research, 158(2), pp. 378-389.
4. El-Santawy, M. F. and Mohamed, S. (2020). *A New ELECTRE-II Approach Using Separation Method And Grey Subjective-Objective Weights' Allocation Scheme*. International Journal Of Scientific and Technology Research, 9(1), pp. 3251-3257.
5. El-Santawy, M. F. and Mohamed, S. (2019). *A New Approach for Solving Rough Interval MCDM ProblemsBased on BWM and WASPAS Methods*. International Journal of Advanced Trends in Computer Science and Engineering, 8(6), pp. 3615-3620.
6. Gupta, R. A. J. N. I., and V. E. E. N. U. Gupta. "Constructivist approach in teaching." *International Journal of Humanities and Social Sciences* 6.5 (2017): 77-88.
7. Khaira, A. S. H. I. S. H., and RAVI K. Dwivedi. "Identification of critical component to enhanceequipmentavailability in a graphite manufacturingindustry." *International Journal of Mechanical and Production Engineering Research and Development* 7.3 (2017): 25 32 (2017).
8. Mesran, M., Siregar, D., Nasution, S. D., Sahir, S. H., Diansyah, T. M., Agustina, I., ... and Anas, A. (2019). *The VIKOR Method to Support the Effectiveness of Decisions in Determining WorkIncentive Recipients*. Journal of Physics: Conference Series, 1175 (1). IOP Publishing.
9. Pawlak, Z. (1982). *Rough sets*. International Journal of Computer and Information Science, 11(5), pp. 341-356.
10. Radović, D., Stević, Ž.,Pamučar, D., Zavadskas, E. K., Badi, I., Antuchevičiene, J. and Turskis, Z. (2018). *Measuring performance in transportation companies in developing countries: a novel rough ARAS model*.Symmetry, 10(10), 434.
11. Raulea, C. (2016). *About Mathematical Methods for Multi-Criteria Decision*. Bulletin of the Transilvania University of Brasov. Mathematics, Informatics, Physics. Series III, 9(2), pp. 147-152.

12. Rebolledo, M. (2006). Rough intervals—enhancing intervals for qualitative modeling of technical systems. *Artificial Intelligence*, 170(8-9), pp. 667-685.
13. Sahir, S. H., Rosmawati, R. and Minan, K. (2017). Simple Additive Weighting Method to Determining Employee Salary Increase Rate. *International Journal of Scientific Research in Science and Technology*, 3(8), pp. 42-48.
14. Suresh, N., B. Srinivasa Reddy, and M. Ravindra Gandhi. "Manufacturing and analysis of four-way hacksaw machine by pedaling." *International Journal of Industrial Engineering & Technology (IJIET)* 8.2 (2018): 13-20.
15. Singh, Rakesh Kumar, and Makarand S. Kulkarni. "Criticality Analysis of power-plant equipments using the Analytic Hierarchy process." *International Journal of Industrial Engineering & Technology (IJIET)* 3.4 (2013).
16. Zhu, G. N., Hu, J., Qi, J., Gu, C. C. and Peng, Y. H. (2015). An integrated AHP and VIKOR for design concept evaluation based on rough number. *Advanced Engineering Informatics*, 29(3), pp. 408-418.

AUTHOR PROFILE

B.Sc. of accountancy at Helwan University, Faculty of Commerce and Business Administration (English Section), Egypt, 2001

Diploma in Operations Research, Cairo University, Institute of Statistical Studies and Research (ISSR), Egypt, 2006

M.Sc. in Operations Research, Cairo University, Institute of Statistical Studies and Research (ISSR), Egypt, 2009

Ph.D. in Operations Research, Cairo University, Institute of Statistical Studies and Research (ISSR), Egypt, 2015

His research interests:

Incorporating statistical tools and techniques into decision making, Multi-Criteria Decision Making (MCDM)

Quantifying randomness in decision techniques, Building models and techniques based on random variables and Uncertainty Optimization

Multi-Objective Evolutionary Algorithms (MOEA), Swarm Intelligence (SI), and Chaos Optimization.

The author published more than 40 articles in prestigious journals. He is an Editor for El-Sevier Editorial System (EES) as well as many honorable journals plus and international conferences. The author is a Member of IEEE Egypt Computational Intelligence Society Chapter, and MCDM Society. His current research is to explore the MCDM techniques to solve real-life scenarios and problems with no preference under uncertainty found in Economics, Management, Information Systems, Budgeting and Finance.