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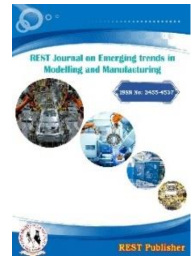

Selection of Product Promotion Advertising Agencies using Fuzzy Linguistic Expert Soft Matrix

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Abstract: *Group Decision making is a multistage process involving several interdependent entities and aggregate opinion of experts. This research work discusses the decision model based on Fuzzy soft expert matrices with linguistic representations. The proposed extended approach is applied in determining optimum solutions to the problem of selection of product promotion advertising agencies. The linguistic representations are more accommodative as they facilitate in capturing the realistic expressions of the experts. A case study is presented to demonstrate the efficacy of the proposed approach. The sensitivity analysis is performed to exhibit the efficacy and efficiency of the proposed approach over the existing multi-criteria decision-making methods. The background and cognition of the experts influence the resultant scores and these are identified as the limitations of the novel approach developed in this paper.*

Keywords: *Fuzzy set, Soft Matrix, Expert, Product Promotion, Advertising Agencies.*

1. INTRODUCTION

In this competitive business world, the products are competing one another at global markets. The race in product sales is highly influenced by the product promotion strategies and one such is advertising agencies [3]. Advertisements are the catalysts that persuades the product sales across the universe [6]. The choice of the advertising agencies is influenced by several criteria such as Creativity, Experience, Cost, performance and Expertise. Every business is in need of choosing suitable advertising agencies to propagate their products to reach all the customers across geographical and cultural barriers [7]. The decision making the choice of advertising agencies is intricate as it requires the intervention of experts in evolving a more optimal option. This process requires the strategy of group decision making with more logical and insightful mathematical approaches.

The literature of group decision making has several mathematical procedures and one such is Fuzzy Expert soft matrix. The theory of soft sets developed by Molodtsov [9] is more attribute centered. Soft sets-based decision-making models are formulated by the researchers to derive optimum results. Maji et al [8] extended soft sets to fuzzy soft sets integrating fuzzy logic in decisioning. Yang et al [10] constructed fuzzy soft matrix to structure the decision-making data. Bora et al [3] and Cagman et al [4] discussed the applications of fuzzy soft matrix. Alkhazaleh and Salleh[1-2] proposed the notion of soft expert sets and fuzzy soft expert sets. These experts based soft sets are applied in evolving a more comprehensive solutions to the decision-making problems. The representations of values in these sets involves only fuzzy values ranging from [0,1]. However, numerical values may not reflect the perception or the subjectivity of the experts realistically. Hence this research work suggests to develop fuzzy soft expert matrix with the representations of linguistic variables to make reflection of one's actual perception. Linguistic variables are basically assuming values such as Very High, High, Medium, Low, Very Low to represent the intensity of satisfaction of the criteria by the alternatives of advertising agencies. The remaining contents are structured into the following sections. Section 2 presents the methodology of Fuzzy Linguistic Expert Soft Matrix in ranking the alternatives. Section 3 applies the proposed approach in deriving optimal results. Section 4 analyzes the results and concludes the work.

2. METHODOLOGY OF FUZZY LINGUISTIC EXPERT SOFT MATRIX

This section presents the procedure of Fuzzy Linguistic Expert Soft Matrix in designing a decisioning framework.

Step 1: The decision making problem is well defined and the aspects of alternatives, criteria and experts are determined.
Step 2: Construct the fuzzy expert soft set with linguistic variables of the form (F, U). Here F is the mapping A to I^H i.e $F : A \rightarrow I^H$. $A \subseteq U$, here $U = V \times E \times O$, V is the criteria set , E is the expert set and, O = {1 = agree, 0 =disagree} an opinion set
Step 3: Determine the linguistic fuzzy soft expert matrices of (F,U) and find the complement of these matrices, respectively
Step 4: Convert the linguistic expressions to numerical values
Step 5 : Find the addition of the linguistic fuzzy soft expert matrices $X_1 + X_2 + X_3 + .. X_n$ and $X^c_1 + X^c_2 + X^c_3 + .. X^c_n$. The addition of two linguistic fuzzy soft expert matrices say A and B, where $A = [a_{ij}]$ and $B = [b_{ij}]$ is determined by $A + B = [\max(a_{ij}, b_{ij}), \min(a_{ij}, b_{ij})]$
Step 6: Find the value matrices and the score matrix. The value of the matrix say $X = [x_{ij}]$, where $V(x) = [ag_{ij} - dg_{ij}]$. The score of the matrices say X and Y are determined by $V(X) – V(Y)$.
Step 7: The total score of each of the alternatives is determined and the alternatives with the highest score is given first preference.

3. APPLICATION OF FUZZY LINGUISTIC EXPERT SOFT MATRIX IN RANKING THE ADVERTISING AGENCIES

Let us consider a company which wishes to maximize its product reach through advertising agencies. Since there are several options, the company decides to leave the decisioning to a group of experts. The criteria considered by the experts are Creativity (C1), Experience (C2), Cost (C3), performance (C4) and Expertise (C5). The procedure of Fuzzy Linguistic Expert Soft Matrix based decisioning is applied. Let us consider H = {A1,A2,A3,A4,A5}, V = {C1,C2,C3,C4,C5}, E = { E1, E2, E3} O = {1 = agree, 0 =disagree}.

Initialization of the Linguistic Values.

$$
\left\{
\begin{array}{c}
\left[(C_1,E_1,1),\left\{\frac{A_1}{H},\frac{A_2}{L},\frac{A_3}{M},\frac{A_4}{L},\frac{A_5}{VH}\right\}\right],\left[(C_1,E_2,1),\left\{\frac{A_1}{L},\frac{A_2}{VL},\frac{A_3}{M},\frac{A_4}{M},\frac{A_5}{H}\right\}\right],\left[(C_1,E_3,1),\left\{\frac{A_1}{M},\frac{A_2}{VL},\frac{A_3}{M},\frac{A_4}{L},\frac{A_5}{VH}\right\}\right], \\
\left[(C_2,E_1,1),\left\{\frac{A_1}{M},\frac{A_2}{L},\frac{A_3}{H},\frac{A_4}{L},\frac{A_5}{M}\right\}\right],\left[(C_2,E_2,1),\left\{\frac{A_1}{M},\frac{A_2}{VH},\frac{A_3}{M},\frac{A_4}{L},\frac{A_5}{VH}\right\}\right],\left[(C_2,E_3,1),\left\{\frac{A_1}{H},\frac{A_2}{M},\frac{A_3}{M},\frac{A_4}{VL},\frac{A_5}{VH}\right\}\right]' \\
\left[(C_3,E_1,1),\left\{\frac{A_1}{VH},\frac{A_2}{VL},\frac{A_3}{M},\frac{A_4}{H},\frac{A_5}{VH}\right\}\right],\left[(C_3,E_2,1),\left\{\frac{A_1}{H},\frac{A_2}{L},\frac{A_3}{VL},\frac{A_4}{VH},\frac{A_5}{M}\right\}\right],\left[(C_3,E_3,1),\left\{\frac{A_1}{H},\frac{A_2}{M},\frac{A_3}{M},\frac{A_4}{H},\frac{A_5}{VH}\right\}\right], \\
\left[(C_4,E_1,1),\left\{\frac{A_1}{H},\frac{A_2}{L},\frac{A_3}{M},\frac{A_4}{L},\frac{A_5}{VH}\right\}\right],\left[(C_4,E_2,1),\left\{\frac{A_1}{H},\frac{A_2}{L},\frac{A_3}{M},\frac{A_4}{L},\frac{A_5}{VH}\right\}\right],\left[(C_4,E_3,1),\left\{\frac{A_1}{H},\frac{A_2}{L},\frac{A_3}{M},\frac{A_4}{L},\frac{A_5}{VH}\right\}\right], \\
\left[(C_5,E_1,1),\left\{\frac{A_1}{M},\frac{A_2}{M},\frac{A_3}{H},\frac{A_4}{L},\frac{A_5}{VH}\right\}\right],\left[(C_5,E_2,1),\left\{\frac{A_1}{H},\frac{A_2}{M},\frac{A_3}{M},\frac{A_4}{L},\frac{A_5}{H}\right\}\right],\left[(C_5,E_3,1),\left\{\frac{A_1}{H},\frac{A_2}{M},\frac{A_3}{M},\frac{A_4}{VL},\frac{A_5}{VH}\right\}\right], \\
\left[(C_1,E_1,0),\left\{\frac{A_1}{L},\frac{A_2}{L},\frac{A_3}{H},\frac{A_4}{L},\frac{A_5}{H}\right\}\right],\left[(C_1,E_2,0),\left\{\frac{A_1}{L},\frac{A_2}{L},\frac{A_3}{M},\frac{A_4}{M},\frac{A_5}{VH}\right\}\right],\left[(C_1,E_3,0),\left\{\frac{A_1}{L},\frac{A_2}{VL},\frac{A_3}{M},\frac{A_4}{VL},\frac{A_5}{H}\right\}\right], \\
\left[(C_2,E_1,0),\left\{\frac{A_1}{M},\frac{A_2}{VL},\frac{A_3}{M},\frac{A_4}{L},\frac{A_5}{M}\right\}\right],\left[(C_2,E_2,0),\left\{\frac{A_1}{M},\frac{A_2}{H},\frac{A_3}{M},\frac{A_4}{VL},\frac{A_5}{H}\right\}\right],\left[(C_2,E_3,0),\left\{\frac{A_1}{H},\frac{A_2}{L},\frac{A_3}{M},\frac{A_4}{VL},\frac{A_5}{M}\right\}\right]' \\
\left[(C_3,E_1,0),\left\{\frac{A_1}{H},\frac{A_2}{L},\frac{A_3}{M},\frac{A_4}{H},\frac{A_5}{H}\right\}\right],\left[(C_3,E_2,0),\left\{\frac{A_1}{H},\frac{A_2}{VL},\frac{A_3}{L},\frac{A_4}{VH},\frac{A_5}{M}\right\}\right],\left[(C_3,E_3,0),\left\{\frac{A_1}{H},\frac{A_2}{L},\frac{A_3}{M},\frac{A_4}{L},\frac{A_5}{H}\right\}\right], \\
\left[(C_4,E_1,0),\left\{\frac{A_1}{VH},\frac{A_2}{L},\frac{A_3}{H},\frac{A_4}{VL},\frac{A_5}{VH}\right\}\right],\left[(C_4,E_2,0),\left\{\frac{A_1}{VH},\frac{A_2}{L},\frac{A_3}{M},\frac{A_4}{VL},\frac{A_5}{VH}\right\}\right],\left[(C_4,E_3,0),\left\{\frac{A_1}{H},\frac{A_2}{VL},\frac{A_3}{M},\frac{A_4}{VL},\frac{A_5}{VH}\right\}\right], \\
\left[(C_5,E_1,0),\left\{\frac{A_1}{M},\frac{A_2}{VL},\frac{A_3}{L},\frac{A_4}{VL},\frac{A_5}{H}\right\}\right],\left[(C_5,E_2,0),\left\{\frac{A_1}{H},\frac{A_2}{M},\frac{A_3}{M},\frac{A_4}{VL},\frac{A_5}{H}\right\}\right],\left[(C_5,E_3,0),\left\{\frac{A_1}{VH},\frac{A_2}{L},\frac{A_3}{M},\frac{A_4}{L},\frac{A_5}{VH}\right\}\right],
\end{array}
\right\}
$$

$$E_1 = \begin{bmatrix} (H,L) & (L,L) & (M,H) & (L,L) & (VH,H) \\ (M,M) & (L,VL) & (H,M) & (L,L) & (M,M) \\ (VH,H) & (VL,L) & (M,M) & (H,H) & (VH,H) \\ (H,VH) & (L,L) & (M,H) & (L,VL) & (VH,VH) \\ (M,M) & (M,VL) & (H,L) & (L,VL) & (VH,H) \end{bmatrix}$$

$$E_2 = \begin{bmatrix} (L,L) & (VL,L) & (M,H) & (M,M) & (H,VH) \\ (M,M) & (VH,H) & (L,M) & (L,VL) & (VH,H) \\ (VH,H) & (VL,L) & (M,M) & (H,H) & (M,M) \\ (M,M) & (L,L) & (M,H) & (L,VL) & (VH,H) \\ (H,H) & (M,M) & (M,M) & (L,VL) & (VH,H) \end{bmatrix}$$

$$E_3 = \begin{bmatrix} (M,L) & (VL,VL) & (M,VL) & (L,L) & (VH,H) \\ (H,H) & (M,L) & (M,M) & (VL,VL) & (VH,M) \\ (H,H) & (M,L) & (M,H) & (H,L) & (VH,H) \\ (H,H) & (L,VL) & (M,L) & (L,VL) & (M,VH) \\ (H,VH) & (M,L) & (M,M) & (VL,L) & (VH,VH) \end{bmatrix}$$

Conversion of Linguistic Variables to Numerical Values

The modified matrices are

$$E_1 = \begin{bmatrix} (0.7,0.2) & (0.2,0.2) & (0.5,0.7) & (0.2,0.2) & (0.9,0.7) \\ (0.5,0.5) & (0.2,0.1) & (0.7,0.5) & (0.2,0.2) & (0.5,0.5) \\ (0.9,0.7) & (0.1,0.2) & (0.5,0.5) & (0.7,0.7) & (0.9,0.7) \\ (0.7,0.9) & (0.2,0.2) & (0.5,0.7) & (0.2,0.1) & (0.9,0.9) \\ (0.5,0.5) & (0.5,0.1) & (0.7,0.2) & (0.2,0.1) & (0.9,0.7) \end{bmatrix}$$

$$E_2 = \begin{bmatrix} (0.2,0.2) & (0.1,0.2) & (0.5,0.7) & (0.5,0.5) & (0.7,0.9) \\ (0.5,0.5) & (0.9,0.7) & (0.2,0.5) & (0.2,0.1) & (0.9,0.7) \\ (0.9,0.7) & (0.1,0.2) & (0.5,0.5) & (0.7,0.7) & (0.5,0.5) \\ (0.5,0.5) & (0.2,0.2) & (0.5,0.7) & (0.2,0.1) & (0.9,0.7) \\ (0.7,0.7) & (0.5,0.5) & (0.5,0.5) & (0.2,0.1) & (0.9,0.7) \end{bmatrix}$$

$$E_3 = \begin{bmatrix} (0.5,0.2) & (0.1,0.1) & (0.5,0.1) & (0.2,0.2) & (0.9,0.7) \\ (0.7,0.7) & (0.5,0.2) & (0.5,0.5) & (0.1,0.1) & (0.9,0.5) \\ (0.7,0.7) & (0.5,0.2) & (0.5,0.7) & (0.7,0.2) & (0.9,0.7) \\ (0.7,0.7) & (0.2,0.1) & (0.5,0.2) & (0.2,0.1) & (0.5,0.9) \\ (0.7,0.9) & (0.5,0.2) & (0.5,0.5) & (0.1,0.2) & (0.9,0.9) \end{bmatrix}$$

The complements of the modified matrices are

$$E_1{}^c = \begin{bmatrix} (0.3,0.8) & (0.8,0.8) & (0.5,0.3) & (0.8,0.8) & (0.1,0.3) \\ (0.5,0.5) & (0.8,0.9) & (0.3,0.5) & (0.8,0.8) & (0.5,0.5) \\ (0.1,0.3) & (0.9,0.8) & (0.5,0.5) & (0.3,0.3) & (0.1,0.3) \\ (0.3,0.1) & (0.8,0.8) & (0.5,0.3) & (0.8,0.9) & (0.1,0.1) \\ (0.5,0.5) & (0.5,0.9) & (0.3,0.8) & (0.8,0.9) & (0.1,0.3) \end{bmatrix}$$

$$E_2{}^c = \begin{bmatrix} (0.8,0.8) & (0.9,0.8) & (0.5,0.3) & (0.5,0.5) & (0.3,0.1) \\ (0.5,0.5) & (0.1,0.3) & (0.8,0.5) & (0.8,0.9) & (0.1,0.3) \\ (0.1,0.3) & (0.9,0.8) & (0.5,0.5) & (0.3,0.3) & (0.5,0.5) \\ (0.5,0.5) & (0.8,0.8) & (0.5,0.3) & (0.8,0.9) & (0.1,0.3) \\ (0.3,0.3) & (0.5,0.5) & (0.5,0.5) & (0.8,0.9) & (0.1,0.3) \end{bmatrix}$$

$$E_3{}^c = \begin{bmatrix} (0.5,0.8) & (0.9,0.9) & (0.5,0.9) & (0.8,0.8) & (0.1,0.3) \\ (0.3,0.3) & (0.5,0.8) & (0.5,0.5) & (0.9,0.9) & (0.1,0.5) \\ (0.3,0.3) & (0.5,0.8) & (0.5,0.3) & (0.3,0.8) & (0.1,0.3) \\ (0.3,0.3) & (0.8,0.9) & (0.5,0.8) & (0.8,0.9) & (0.5,0.1) \\ (0.3,0.1) & (0.5,0.8) & (0.5,0.5) & (0.9,0.8) & (0.1,0.1) \end{bmatrix}$$

Addition of the Modified Matrices and their complements

$$E_1 + E_2 + E_3 = \begin{bmatrix} (0.7,0.2) & (0.2,0.1) & (0.5,0.1) & (0.5,0.2) & (0.9,0.7) \\ (0.7,0.5) & (0.9,0.1) & (0.7,0.5) & (0.2,0.1) & (0.9,0.5) \\ (0.9,0.5) & (0.5,0.2) & (0.5,0.5) & (0.7,0.2) & (0.9,0.5) \\ (0.7,0.5) & (0.3,0.1) & (0.5,0.2) & (0.3,0.1) & (0.9,0.7) \\ (0.7,0.5) & (0.5,0.1) & (0.7,0.2) & (0.2,0.1) & (0.9,0.7) \end{bmatrix}$$

$$E_1{}^c + E_2{}^c + E_3{}^c = \begin{bmatrix} (0.8,0.8) & (0.9,0.8) & (0.5,0.3) & (0.8,0.5) & (0.3,0.1) \\ (0.5,0.3) & (0.8,0.3) & (0.8,0.5) & (0.9,0.8) & (0.5,0.3) \\ (0.3,0.3) & (0.9,0.8) & (0.5,0.3) & (0.3,0.3) & (0.5,0.3) \\ (0.5,0.1) & (0.8,0.8) & (0.5,0.3) & (0.8,0.9) & (0.5,0.1) \\ (0.5,0.1) & (0.5,0.5) & (0.5,0.5) & (0.9,0.8) & (0.1,0.1) \end{bmatrix}$$

The value of V$(E_1 + E_2 + E_3)$ and V$(E_1{}^c + E_2{}^c + E_3{}^c)$ are determined using step 6.

$$\mathrm{V}(E_1 + E_2 + E_3) = \begin{bmatrix} 0.5 & 0.1 & 0.4 & 0.3 & 0.2 \\ 0.2 & 0.8 & 0.2 & 0.1 & 0.4 \\ 0.4 & 0.3 & 0 & 0.5 & 0.6 \\ 0.2 & 0.2 & 0.3 & 0.1 & 0.2 \\ 0.2 & 0.4 & 0.5 & 0.2 & 0.2 \end{bmatrix}$$

$$\mathrm{V}(E_1{}^c + E_2{}^c + E_3{}^c) = \begin{bmatrix} 0 & 0.1 & 0.2 & 0.3 & 0.2 \\ 0.2 & 0.5 & 0.3 & 0.1 & 0.2 \\ 0 & 0.1 & 0.2 & 0 & 0.2 \\ 0.4 & 0 & 0.2 & -0.1 & 0.4 \\ 0.4 & 0 & 0 & 0.1 & 0 \end{bmatrix}$$

The score of the above two matrices is determined as

$$\text{Score Matrix} = \begin{bmatrix} 0.5 & 0 & 0.2 & 0 & 0 \\ 0 & 0.3 & -0.1 & 0 & 0.2 \\ 0.4 & 0.2 & -0.2 & 0.5 & 0.4 \\ -0.2 & 0.2 & 0.1 & 0.2 & -0.2 \\ -0.2 & 0.4 & 0.5 & 0.1 & 0.2 \end{bmatrix}$$

Using the above values, the final scores of the alternatives are determined as follows

S (A1) = 0.9. S (A2) = 1.1, S(A3) = 0.3, S(A4) = 0.8 and S(A5) =0.6

A2 > A1 > A4 > A5 > A3

4. RESULTS AND CONCLUSION

The sensitivity analysis based on the aggregated scores—S(A1) = 0.9, S(A2) = 1.1, S(A3) = 0.3, S(A4) = 0.8, and S(A5) = 0.6—reveals a clear ranking among the advertising agencies: A2 > A1 > A4 > A5 > A3. Agency A2 emerges as the most preferred option, indicating a strong consensus among experts on its effectiveness in product promotion. The marginal difference between A2 and A1 suggests a competitive advantage but not a dominant lead, highlighting the importance of precise expert evaluations. A4 and A5 fall in the mid-range, suitable for consideration but less optimal, while A3 is consistently rated the lowest, indicating limited suitability. The sensitivity analysis confirms the stability of this ranking against variations in expert opinions, though minor changes in linguistic weights or expert biases could alter the middle-tier rankings slightly. This underscores the robustness of the proposed fuzzy soft expert model in handling subjective assessments, while also pointing to the critical influence of expert cognition on final decisions.

In conclusion, this research introduces a robust group decision-making model utilizing fuzzy soft expert matrices with linguistic representations, effectively capturing the nuanced judgments of experts. The approach demonstrates significant potential in addressing complex selection problems, such as choosing optimal advertising agencies for product promotion. The accompanying case study and sensitivity analysis affirm the model's effectiveness and superiority over conventional multi-criteria decision-making methods. While the model enhances realism and adaptability in expert evaluations, it also highlights limitations linked to expert background and cognition, suggesting areas for future refinement and investigation.

REFERENCES

[1]. Alkhazaleh, S. and Salleh, A.R. (2011) Soft Expert Sets. Advances in Decision Sciences,
[2]. Alkhazaleh, S. and Salleh, A.R. (2014) Fuzzy Soft Expert Sets and Its Application. Applied Mathematics , 5, 1349-1368. https://doi.org/10.4236/am.2014.59127.
[3]. Balocco, F., Lu, Y., Li, T., & Gupta, A. (2025). Lemon Ads: Adverse Selection in Multichannel Display Advertising Markets. *Management Science*.
[4]. Borah, M.J., Neog, T.J. and Sut, D.K. (2012) Fuzzy Soft Matrix Theory and Its Decision
[5]. Cagman, N. and Enginoglv, S. (2012) Fuzzy Soft Matrix Theory and Its Application
[6]. Christian, A., & Hidayat, N. K. (2022). The impact of media selection on advertising effectiveness an empirical study from the consumer behavior perspective. *Fair Value: Jurnal Ilmiah Akuntansi dan Keuangan*, *4*(11), 4983-4991. Conference on Artificial Intelligence and Computational Intelligence , Lanzhou, in Decision Making. Iranian Journal of Fuzzy Systems , 9, 109-119.
[7]. Katz, H. (2019). The Media Handbook: A Complete Guide to Advertising Media Selection, Planning, Research, and Buying.
[8]. Maji, P.K., Biswas, R. and Roy, A.R. (2001) Fuzzy Soft Set. Journal of Fuzzy Mathematics,9, 589-602. Making. International Journal of Modern Engineering Research , 2, 121-127.
[9]. Molodtsov, D. (1999) Soft Set Theory—First Results. Computers and Mathematics with Applications , 37, 19-31. https://doi.org/10.1016/S0898-1221(99)00056-5
[10]. Yang, Y. and Ji, C.L. (2011) Fuzzy Soft Matrices and Their Applications. International Conference on Artificial Intelligence and Computational Intelligence , Lanzhou, 24-25 September 2011, 618-627. https://doi.org/10.1007/978-3-642-23881-9_79