Combined compromise for ideal solution (CoCoFISo)
A Multi-Criteria Decision Making based on the CoCoSo method algorithm

Presented By: Raiha Imran, Sobia Ahsan, Khazaima Safdar, Waseem Ahmad, Kifayat Ullah

Email: raihaimran741@gmail.com, sobiaahsan1985@gmail.com, khazaimasafder55@gmail.com, waseemahmadjahanian@gmail.com, Kifayat.khan.dr@gmail.com

Department of Mathematics, Riphah International University Lahore

Abstract

Each decision-making tool should be tested and validated in real case studies to be practical and fit to global problems. The application of MCDM is currently a trend to rank alternatives. In the literature, there are several MCDM methods according to their classification. During our experimentation on the Combined Compromise Solution (CoCoSo) method, we encountered its limits for real cases. The authors examined the applicability of the CoCoFISo method (improved version of CoCoSo), by a real case study. Our research finding indicates that CoCoSo is an applied method that has been developed to solve complex multi-variable assessment problems, while CoCoFISo can improve the shortages observed in CoCoSo and deliver stable outcomes compared to other developed tools.

❑Improvement on CoCoSo Algorithm:

➢Classic CoCoSo model:

CoCoSo starts to find the most appropriate alternative by combining ideas of compromised solutions like mean evaluation weighting and power weight aggregation.

The step-by-step solution of CoCoSo is interpreted here:

Formation of Decision matrix

Normalize the matrix

$$r_{ij} = \frac{x_j - \min x_{ij}}{\max x_{ij} - \min x_{ij}}\text{; for benefit criterion;}$$

$$r_{ij} = \frac{\max_{ij} - x_{ij}}{\max x_{ij} - \min x_{ij}}\text{; for cost criterion}$$

Determines two strategies to aggregate weights

$$S_i = \sum_{j-1}^{n} w_j r_{ij}\ ;\ P_i = \sum_{j=1}^{N} (r_{ij})^{w_j}$$

Integrate S and P values by using three **appraisal score strategies**

$$k_{ia} = \frac{P_i + S_i}{\sum_{i-1}^{m} (P_i + S_i)}$$

$$k_{ib} = \frac{S_i}{\min_i S_i} + \frac{P_i}{\min_i P_i}$$

$$k_{ic} = \frac{\lambda(S_i) + (1-\lambda)(P_i)}{\left(\lambda \max_i + (1-\lambda)\max_i P_i\right)};\ 0 \le \lambda \le 1$$

Usually, ($\lambda = 0.5$) is chosen by decision-makers.

Ranking of the alternatives

$$k_i = (k_{ia} k_{ib} k_{ic})^{\dagger} + \frac{1}{3}(k_{ia} + k_{ib} + k_{ic})$$

- k_{ia} is the arithmetic mean of sums of (Weighted Sum Method) WSM and (Weighted Product Method) WPM scores.
- k_{ib} expresses a sum of relative scores of WSM and WPM compared to the best.
- k_{ic} represents the balanced compromise of WSM and WPM model scores.

Real Case Example and Discussion

During research on using MCDM methods to select students and allocate them university accommodation, we used several methods including CoCoSo. The objective is to sort students based on their qualifications. Five criteria to be able to select them according to the availability of accommodation. It is impossible to accommodate all students in university residences due to the lack of student accommodation. For this objective, there are social criteria chosen by universities to enable student assessment. The five (5) social criteria for selecting the students include:

Table 1: Describes these criteria and their value depending on the case.

Social criteria	Value
PC (Physical capacity of the student)	Normal = 5; Disability = 10
OP (Orphanage situation of the student's parent)	None =5; Father or Mother =10; Father and Mother =15
PW (Parent's professional condition)	University=10; Other = 5
DC (Number of dependent children of the parent)	By number
DR (Distance of student's main residence from the university)	By mileage

The weight values define the priority level of these criteria as follows:

W_{PC}: 0.45; W_{OP}: 0.18;
W_{PW}:0.1;W_{DC}:0.1;W_{DR}: 0.18

Table 2: Decision Matrix

Student	PC	DR	DC	PW	OP
L101	5	100	3	5	5
L102	5	100	5	5	10
L103	5	100	6	5	5
L104	5	102	2	5	10
L105	5	100	3	5	5
L106	10	100	5	5	10
L107	5	100	4	5	10

Table 3: Normalize the matrix

Student	PC	DR	DC	PW	OP
L101	0	0	0.4	#DIV/0!	0
L102	0	0	0.8	#DIV/0!	0.5
L103	0	0	1	#DIV/0!	0
L104	0	0.0023	0.2	#DIV/0!	0.5
L105	0	0	0.4	#DIV/0!	0
L106	1	0	0.8	#DIV/0!	0.5
L107	0	0	0.6	#DIV/0!	0.5

For L1 students, the normalization of the values of the PW criteria causes some errors. This means that for L1 students, we are not able to proceed the following steps of applying the CoCoSo method. This is because the PW criterion has the same value for all students.

➢ CoCoFISo Algorithm:

To resolve the error in Table 3, we will modify the two components of the CoCoSo algorithm.

- **Modification on normalization part:**

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} (x_{ij})^2}}$$

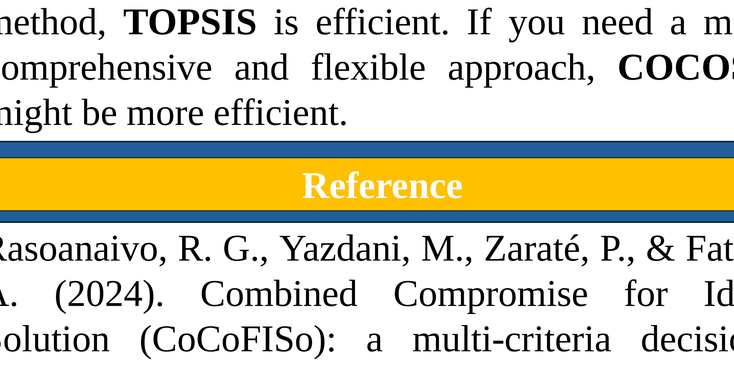
- **Modifying the k_{ib}:** Evaluation strategy

$$k_{ib} = \frac{P_i + S_i}{1 + \frac{P_i}{1+P_i} + \frac{S_i}{1+S_i}}$$

Student	PC	DR	DC	PW	OP	S	P
L101	0.17	0.07	0.16	0.19	0.11	0.141	3.408
L102	0.17	0.07	0.27	0.19	0.21	0.171	3.541
L103	0.17	0.07	0.33	0.19	0.11	0.158	3.468
L104	0.17	0.07	0.11	0.19	0.21	0.155	3.466
L105	0.17	0.07	0.16	0.19	0.11	0.141	3.408
L106	0.33	0.07	0.27	0.19	0.21	0.246	3.704
L107	0.17	0.07	0.22	0.19	0.21	0.166	3.521

Student	k_{ia}	k_{ib}	k_{ic}	k_i	Ranking
L101	0.036	0.438	0.868	0.758	1
L102	0.037	0.441	0.908	0.751	2
L103	0.036	0.439	0.887	0.740	3
L104	0.036	0.439	0.886	0.737	4
L105	0.036	0.438	0.868	0.734	5
L106	0.040	0.444	0.966	0.731	6
L107	0.037	0.440	0.902	0.713	7

Figure 1: Ranking Stability



Conclusion

In this study, we have proposed a new version of the CoCoSo method according to some errors observed in the algorithm in special cases which we called CoCoFISo. Along with the extended version, the real cases study also discussed which show us the limit of the CoCoSo method. The main advantage of CoCoFISo is now usable without any exceptions and can solve any MCDM problem. Both methods have their strengths and limitations. If your primary goal is to have a simple and widely understood method, **TOPSIS** is efficient. If you need a more comprehensive and flexible approach, **COCOSO** might be more efficient.

Reference

Rasoanaivo, R. G., Yazdani, M., Zaraté, P., & Fateh, A. (2024). Combined Compromise for Ideal Solution (CoCoFISo): a multi-criteria decision-making based on the CoCoSo method algorithm. *Expert Systems with Applications*, *251*, 124079.