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Research paper

Extension of the ELECTRE II method to group decision-making

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Abstract

Multi-criteria decision support has long been treated in a single-decision maker framework . It seems that a decision made by a single decision-maker does not reflect reality . There are multi-criteria group decision support methods in the literature . In order to find a collective aggregation method fulfilling good properties , we have in this work , used the median and the quadratic mean to make the Extension of ELECTRE II (EE-II) to the group decision . We have made numerical applications and we have obtained interesting results.

Keywords: *Group decision – median – quadratic mean – Extension of Electra II*

Introduction

According to[3] , multi-criteria decision support is developed to deal with different decision issues (choice , sorting , description and storage , etc). while taking into account a set of criteria (attributes), often conflicting and not commensurable and seeking to best model the preferences and values of the decision maker(s).[4] indicates that multicriteria decision support aims to provide a decision maker with tools allowing him to progress in solving the decision problem where several points of view, often contradictory, must be taken into account . Multiactor decision problems are characterized by the existence of at least 2 decision makers , each with their own perceptions , attitudes , motivations and personalities with regard to the decision alternatives and who are motivated by the fact of achieving a collective choice [1] . In order to find a collective aggregation method with good properties , we combined the median , the quadratic mean and the classic Electre II method to design the new method that we will describe after the literature review . Then , we will make numerical applications and we will end with a conclusion.

1. Literature review on some aggregation functions

According to [2, 8], a multi-decider-multi-criteria problem can take the following form:

- $D = \{D_1; D_2; \cdots\cdots; D_l\}$ avec $l \geq 2$, all decision-makers ;
- $A = \{a_1; a_2; \cdots\cdots; a_m\}$ avec $m \geq 2$, all potential actions ;
- $C = \{c_1; c_2; \cdots\cdots; c_n\}$ avec $n \geq 2$, all the criteria considered ;
- w_j, the weight assigned to the criterion $c_j(j = 1; 2; \cdots; \cdots; n)$ by a decision maker $D_k(k = 1; 2; \cdots; \cdots; l)$;
- Et g_j , the partial evaluation of the action a_i $(i = 1; 2; \cdots; \cdots; m)$ with regard to the criterion c_j by the decision maker D_k . by the decision maker . Then a decision matrix has the following form :

1.1. The Lon-Zo method

The Lon-Zo method uses cumulatively the weighted sum and the harmonic mean as aggregation functions:

- By the weighted sum we determine the overall performance given to each alternative by the l makers [2, 4] .

$$g_{j,l}(a_i) = \Sigma_{j=1}^{n} w_{j,l} g_{j,l}(a_i)$$

Table 1: Matrix of a decision maker k

actions\criteria	c_1	c_2	$\cdots$	$\cdots$	c_j	$\cdots$	$\cdots$	c_n
a_1	$g_1(a_1)$	$g_2(a_1)$	$\cdots$	$\cdots$	$g_j(a_1)$	$\cdots$	$\cdots$	$g_n(a_1)$
a_2	$g_1(a_2)$	$g_2(a_2)$	$\cdots$	$\cdots$	$g_j(a_2)$	$\cdots$	$\cdots$	$g_n(a_2)$
$\vdots$	$\vdots$	$\vdots$	$\dots$	$\dots$	$\dots$	$\dots$	$\dots$	$\vdots$
a_i	$g_1(a_i)$	$g_2(a_i)$	$\cdots$	$\cdots$	$g_j(a_i)$	$\cdots$	$\cdots$	$g_n(a_i)$
a_m	$g_1(a_m)$	$g_2(a_n)$	$\cdots$	$\cdots$	$g_j(a_n)$	$\cdots$	$\cdots$	$g(a_m)$
weight of criteria	w_1	w_2	$\cdots$	$\cdots$	w_j	$\cdots$	$\cdots$	w_n

- The harmonic mean is used to determine the overall performance $g(a_i)$ of the alternative a_i .

$$g_j(a_i) = \frac{l}{\Sigma_{k=1}^{l} \frac{1}{g_{j,l}(a_i)}} ;$$

1.2. The MASCAP method

Given that most current problems require a group decision (multi-decider-multi-criteria problem) , MACASP, collective aggregation model using the weighted sum first transforms the multi-decider problem -multi-criteria into a single multi-criteria problem . In the literature , there are several methods for transforming a multi-decider-multi-criteria problem into a single-decider-multi-criteria problem . As for MASCAP , it uses the following

$$g_j(a_i)= \Sigma_{k=1}^{l} w_{j,k} g_{j,k}(a_i)$$

$g_j(a_i)$ the evaluation that the l decision makers give by common agreement to the action a_i with regard to the criterion j . Consequently , the global performance $g_j(a_i)$ of the action a_i is obtained by the relation :

$$g(a_i)= \frac{1}{l}\Sigma_{j=1}^{n} g_j(a_i) = \frac{1}{l}\Sigma_{j=1}^{n} \left(\Sigma_{k=1}^{l} w_{j,k} g_{j,k}(a_i)\right) \text{ for } i = 1,\cdots,m$$

2. New aggregation method: Extension of the ELECTRE II method

Consider the decision matrix formulated in table 1 Compared to our method , the aggregation of individual preferences into a collective preference proceeds in two steps :

- **Step 1 :** The median weights of the criteria for the l decision makers are obtained by the following formula :
  $\hat{w}_j = mediane(w_j^k)$ for $k = 1,....,l$; $j = 1,....,n$ where k designates a decision maker and j a criterion . We thus obtain the median weight vector of the criteria defined as follows :

$$\widehat{w} = \left(\widehat{w}_1, \widehat{w}_2, \cdots, \cdots, \cdots, \widehat{w}_n\right) \tag{1}$$

  where $\widehat{w_j}$ is the median weight associated with the criterion j and $\widehat{w_j}$, the vector median weight of all the median weights of the criteria .
  Note that the central limit theorem gives great importance to the quadratic mean in the case of error modeling , where what is averaged is the sum of a multitude of independent influences . In group decision making , individual preferences are independent of each other and equally influenced by each other ; which could justify the choice of the quadratic mean as the aggregation function in this article .
- **Step 2** :**The average score of an alternative** a_i according to a criterion j is obtained by :

$$\begin{cases} \widehat{g_j} = \sqrt{\frac{1}{n}\Sigma_{k=1}^{l}(g_j^k(a_i))^2} \\ i = 1,\dots,m \;\; ; \;\; j = 1,\dots,n \;\; ; \;\; k = 1,....,l \end{cases} \tag{2}$$

  where $\widehat{g_j}(a_i)$ represents the average performance or average score of the action a_i granted (s) by all the l decision-makers according to the criterion j .
  We thus obtain the aggregate valuation matrix of all a_i stocks defined as follows :

$$\widehat{G} = \begin{pmatrix} \widehat{g_1(a_1)} & \widehat{g_2(a_1)} & \cdots & \widehat{g_n(a_1)} \\ \widehat{g_1(a_2)} & \widehat{g_2(a_2)} & \cdots & \widehat{g_n(a_2)} \\ \vdots & \vdots & & \vdots \\ \widehat{g_1(a_m)} & \widehat{g_2(a_m)} & \cdots & \widehat{g_n(a_m)} \end{pmatrix} \tag{3}$$

  Again denoted simply by :

$$\widehat{G} = \begin{pmatrix} \widehat{g_j(a_1)} \\ \widehat{g_j(a_2)} \\ \vdots \\ \widehat{g_j(a_m)} \end{pmatrix} \tag{4}$$

for $j = 1; 2; \dots\dots\dots; n$
The matrix of global judgments of the l decision makers ($\widehat{M}$)is then obtained with the relations (1) and (2)

$$\widehat{M} = \begin{pmatrix} \widehat{w_t} \\ \widehat{G} \end{pmatrix} \tag{5}$$

or

$$\widehat{M} = \begin{pmatrix} \widehat{w_1} & \widehat{w_2} & \cdots & \widehat{w_n} \\ \widehat{g_1(a_1)} & \widehat{g_2(a_1)} & \cdots & \widehat{g_n(a_1)} \\ \widehat{g_1(a_2)} & \widehat{g_2(a_2)} & \cdots & \widehat{g_n(a_2)} \\ \vdots & & \vdots & \\ \widehat{g_1(a_m)} & \widehat{g_2(a_m)} & \cdots & \widehat{g_n(a_m)} \end{pmatrix} \tag{6}$$

- **Step 3 :**
  This step proceeds by exploiting all the steps of the ELECTRE II method applied to the matrix (6) to arrive at the final result . See [10, 9] , for the steps of the ELECTRE II method .

3. Applications

We will make the applications on two problems : the choice of the best product and the choice of the best partner.

3.1. Application 1

This example is taken from the thesis for obtaining the doctorate from the University of Law and Sciences of Aix-Marseille presented by [5] .
-Statement :
The problem is to find the best product of the set ,
$A = \{Produit1, Produit2, Produit3, Produit4\}$, the set of actions .
The set of criteria is $F = \{C_1; C_2; C_3; C_4; C_5\}$. where C_1 : Production price (Francs/litre) , C_2 : Hinge lifespan (years) , C_3 : Paint harmfulness (Very little , Moderately harmful , Very harmful) , C_4 : Duration drying time , C_5 : Paint odor (not strong , medium , strong , very strong) . Data are provided by the decision makers (or assigned to the criteria) in the form of notes . The extent of the rating scales may differ from one decision-maker to another , and each of the criteria may be assigned a weighting coefficient . The result obtained is a distribution over all A of actions (products), with one or more outperforming the others . The principle is as follows : the solution that outclasses the others must be accepted by the greatest possible number of people , and must not be rejected too clearly , even by only one of them. Each decision maker constructs the judgment matrix .

Table 2: Judgment matrix decision maker 1

criteria	Production price	Hinge lifespan	Paint harmfulness	Duration drying time	Paint odor
Scale min	0	0	0	0	0
Scale max	10	10	10	10	10
Weights	6	3	2	4	3
product 1	6	5	2	4	5
product 2	5	6	3	3	4
P product 3	7	5	4	6	3
product 4	6	4	5	3	6

Table 3: Judgment matrix decision maker 2

criteria	Production price	Hinge lifespan	Paint harmfulness	Duration drying time	Paint odor
Scale min	0	0	0	0	0
Scale max	10	10	10	10	10
Weights	7	5	3	3	4
Product 1	7	6	2	3	3
Product 2	6	5	2	5	3
Product 3	5	7	3	6	4
Product 4	5	4	4	4	3

Table 4: Judgment matrix decision maker 3

criteria	Production price	Hinge lifespan	Paint harmfulness	Duration drying time	Paint odor
Scale min	0	0	0	0	0
Scale max	10	10	10	10	10
Weights	6	4	2	3	3
Product 1	6	5	2	4	4
Product 2	7	6	3	5	3
Product 3	6	5	4	3	5
Product 4	5	4	3	6	4

Table 5: Ranking of Lon-Zo

Products	Overall Scores	Rank
Product1	91,00	2^{nd}
Product2	90,26	3^{rd}
Product3	98,63	1^{st}
Product4	80,84	4^{th}

-Resolution by MASCAP

Table 6: Score calculation

	$\Sigma_{j=1}^{3} w_{j,1} g_{j,1}(a_i)$	$\Sigma_{j=1}^{3} w_{j,2} g_{j,2}(a_i)$	$\Sigma_{j=1}^{3} w_{j,3} g_{j,3}(a_i)$	$\Sigma_{j=1}^{3} w_{j,4} g_{j,4}(a_i)$	$\Sigma_{j=1}^{3} w_{j,5} g_{j,5}(a_i)$	$g(a_i)$
Product1	121	65	14	37	39	92,00
Product2	114	67	18	42	33	91.33
Product3	113	70	25	51	40	99,67
Product4	101	48	28	42	42	87,00

Table 7: Ranking of MASCAP

Products	Overall Scores	Rank
Product1	92,00	2^{nd}
Product2	91,33	3^{rd}
Product3	99,67	1^{st}
Product4	87,00	4^{th}

-Resolution by Extension of ELECTRE II(EE-II)

Step 1 : We obtain the median weights of the criteria recorded in the table **??**, using the median function on MATLAB.

Table 8: Matrix of median weights

	Quality	Technology	Time	Cost
Weights	4	4	3	5

Etape 2 : By using the relation (1) and (2), we obtain the global evaluation matrix of the actions , given by the table9 :

Table 9: Matrix consisting of mean scores

criteria	C_1	C_2	C_3	C_4	C_5
Product 1	6,35	5,35	2	3,70	4,08
Product 2	6,06	5,69	2,71	4,43	3,37
Product 3	6,06	5,74	3,70	5,20	4,08
Product 4	5,35	4	4,08	4,51	4,51

The array 9 to which we associate the array 8 , gives us the global matrix of judgments of the decision makers , represented by the array 10

Table 10: Global Matrix of Decision Maker Judgments

criteria	C_1	C_2	C_3	C_4	C_5
Weights	6	4	2	3	3
p_1	6,35	5,35	2	3,70	4,08
p_2	6,06	5,69	2,71	4,43	3,37
p_3	6,06	5,74	3,70	5,20	4,08
p_4	5,35	4	4,08	4,51	4,51

Etape 3 : Apply the ELECTRE II method to the array 10 . Here the concordance and discordances indices are determined by the formula (7) and (8) . See [11]

$$C(p_i;p_k) = \begin{cases} C(p_i;p_k) = \dfrac{P^{+}(p_i;p_k) + P^{=}(p_i;p_k)}{P(p_i;p_k)} \\ 0 \leq C_{p_i;p_k} \leq 1 \end{cases} \tag{7}$$

where the p_i, p_k $denote\ a\ product\ for\ i,k = 1,.....,4$

$$D(p_i;p_k) = \begin{cases} 0\ ,\quad si\ \ J^{-}(p_i;p_k) = \phi \\ \dfrac{max_{J^-}\left[g_j(p_k) - g_j(p_i)\right]}{max_{J^-}\left[gmax_j - gmin_j\right]} \quad sinon \end{cases} \qquad 0 \leq D(p_i;p_k) \leq 1\ \ and\ j = 1,......,5 \tag{8}$$

Table 11: Matching Matrix

Actions	p_1	p_2	p_3	p_4
p_1		0,50	0,50	0,56
p_2	0,50		0.33	0,56
p_3	0,67	1		0,72
p_4	0,44	0,44	0,28	

Table 12: Product pair mismatch matrix

Actions	p_1	p_2	p_3	p_4
p_1		0,07	0,02	0,02
p_2	0,04		0,10	0,14
p_3	0,03	0	-	0,04
p_4	0,14	0,17	0,17	-

Table 13: Matrix of coefficients $\frac{P^+}{P^-}$

Actions	p_1	p_2	p_3	p_4
p_1		1	0,67	1,25
p_2	1		0	1,26
p_3	1,50	$+\infty$		2,58
p_4	0,80	0,79	0,38	

- Construction of outranking relations
We set thresholds as follows :

$$\begin{cases} c^+ = 0,70 \;\; strong\ match\ threshold \\ c^0 = 0,6 \;\; threshold\ of\ concordance\ average \\ c^- = 0,56 \;\; low\ match\ threshold \end{cases} \tag{9}$$

$$\begin{cases} d^+ = 0,5 \;\; threshold\ of\ strongagreement \\ d^- = 0,25 \;\; low\ match\ threshold \end{cases} \tag{10}$$

-Exploitation of strong outranking relationship :

$$p_i S^F p_k \Longleftrightarrow \begin{cases} C(p_i;p_k) \geq 0.70 \\ d(p_i;p_k) \leq 0.5 \\ \dfrac{P^+(p_i;p_k)}{P^-(p_i;p_k)} \geq 1 \; for\ i,k = 1,.....,4 \end{cases} \tag{11}$$

or / and

$$\begin{cases} C(p_i;p_k) \geq 0,65 \\ d(p_i;p_k) \leq 0,25; \\ \dfrac{P^+(p_i;p_k)}{P^-(p_i;p_k)} \geq 1 \end{cases} \tag{12}$$

- Exploitation of the weak outranking relation :
Let's recall the principle principle:

$$p_i S^f p_k \Longleftrightarrow \begin{cases} C(p_i,p_k) \geq 0,56 \\ d(p_k,(p_i) \leq 0,25; \forall j = 1,.....,5 \\ \dfrac{P^+(p_i,p_k)}{P^-(p_i,p_k)} \geq 1 \end{cases} \tag{13}$$

- Outranking matrix:

Table 14: Upgrading table

$\downarrow S^f \longrightarrow S^F$	p_1	p_2	p_3	p_4
p_1			S^f	
p_2			S^f	
p_3	S^F	S^F		S^F
p_4	S^f	S^f	S^f	

S^F and S^f mean respectively Strong outrank et Weak outranking . Blank boxes in the table mean that there is no outranking relationship between certain products

Table 15: Direct ranking

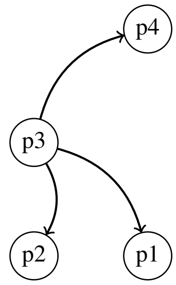
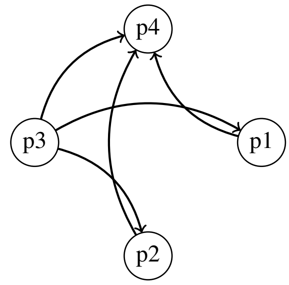
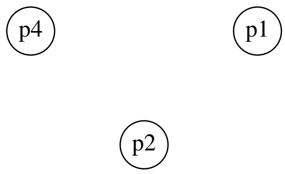
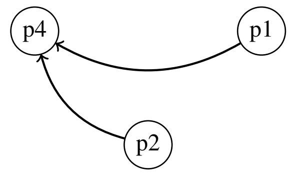
Steps	Strong outrank graph	Weak outranking graph
Step1 Y_0={$p1;p2;p3;p4$} D={$p3$} U={} B={} A_0=(D\U)∪B={$p3$} rank(p3)=1 Y_1={$p1;p2;p4$}		
Step2 D={$p1;p2;p4$} U={$p1;p2;p4$} B={$p1;p2$} A_0=(D\U)∪B={$p1;p2$} rank(p1;p2)=2 Y_2={$p4$}		
Step3 D={$p4$} U={} B={} A_0=(D\U)∪B={$p4$} rank(p4)=3 Y_2={}		

Table 16: Indirect ranking

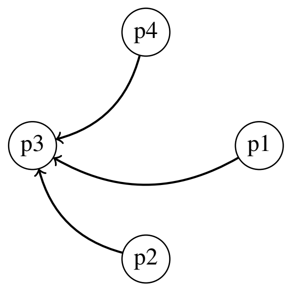
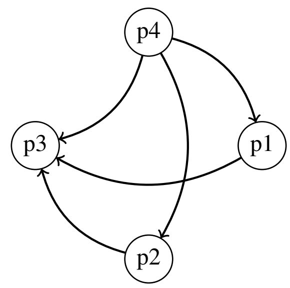
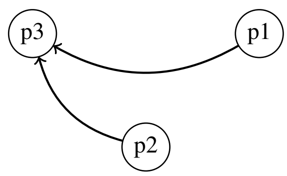
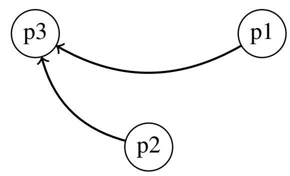
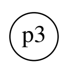
Steps	Strong outrank graph	Weak outranking graph
Step0 Y_0={$p1;p2;p3;p4$} D={$p1;p2;p4$} U={$p1;p2;p4$} B={$p4$} A_0=(D\U)∪B={$p4$} rang(p4)=1 Y_1={$p1;p2;p4$}		
Step1 D={$p1;p2$} U={} B={} A_1=(D\U)∪B={$p1;p2$} rank(p1;p2)=2 Y_1={$p3$}		
Step2 D={$p3$} U={} B={} A_2=(D\U)∪B={$p3$} rank(p3)=3 Y_1={}		

Table 17: Classification proposed by the Extension of ELECTRE II (EE-II)

Products	Direct ranking	Indirect ranking	Final ranking
	Rank1	Rank2	final Rank
Product1	2	2	2
Product2	2	2	2
Product3	1	1	1
Product4	3	3	3

Analysis and interpretation of results
For this first application , we find that the Lon-Zo , MASCAP and Extension of ELECTRE II (EE-II) methods still rank product 3 as the best . However , with the ELECTRE II Extension , product 1 and product 2 are tied . This is not the case with the Lon-Zo and MASCAP methods . This could be explained by the fact that the Lon-Zo and MASCAP methods use a total aggregation approach where the compensatory effect of the weighted sum most often intervenes considerably, while the ELECTRE II method uses a total aggregation approach . partial aggregation.

3.2. Application 2

This example is taken from the article : The multi-decider multi-criteria decision support approach of [6] and the thesis [5]
Statement :
This problem consists of choosing a partner from the following set :
$A = \{NipponPaintKK\ ,\ CourtaouldsCoatingsHolding\ ,\ KansaiPaint\ ,\ InternationalPaint\ ,\ USsecofnavyg\}$. The set of criteria is :
$F = \{C_1\ ;\ C_2\ ;\ C_3\ ;\ C_4\}$ where :
C_1 : Product quality (Good , Average , Bad) ,
C_2 : Technology (Good , Average , Bad) ,
C_3 : Cost (Francs) ,
C_4 : time a common preference scale for the four criteria was selected .
In practice , this choice facilitates the assignment of importance values(or weights) associated with the criteria . A partner with an average price is preferred . Choosing a common preference scale greatly facilitates the assignment of weights to the criteria . Indeed changing a preference scale associated with a criterion requires changing the value of the weight of this criterion to have a kind of compensation . The data is provided by the decision makers (or assigned to the criteria) in the form of scores . The extent of the rating scales may differ from one decision maker to another , and each of the raters (or criteria) may be assigned a weighting coefficient . The result obtained is a distribution over the set of A stocks (companies), with one or more outperforming the others . The principle is as follows : the solution that outclasses the others must be accepted by the greatest possible number of people , and must not be rejected too clearly , even by only one of them . Each decision maker constructs the judgment matrix .

Table 18: Decision Maker Judgment Matrix 1

	Quality	Technology	Time	Cost
Scale min	0	0	0	0
Scale max	10	10	10	10
Weight	3	4	3	5
Nippon Paint KK	6	8	9	4
Courtaulds Coatings	4	5	6	7
International Paints	7	6	8	4
Kansai Paint	6	8	4	7
US Sec Navy	5	4	7	6

Table 19: Decision Maker Judgment Matrix2

	Quality	Technology	Time	Cost
Scale min	0	0	0	0
Scale max	10	10	10	10
Weight	4	3	2	5
Nippon Paint KK	7	5	3	8
Courtaulds Coatings	3	6	8	4
International Paints	6	8	4	3
Kansai Paint	5	4	6	7
US Sec Navy	2	3	7	5

Table 20: Decision Maker Judgment Matrix 3

	Quality	Technology	Time	Cost
Scale min	0	0	0	0
Scale max	10	10	10	10
Weight	4	5	3	5
Nippon Paint KK	8	3	6	7
Courtaulds Coatings	6	5	7	3
International Paints	5	8	4	2
Kansai Paint	4	7	3	6
US Sec Navy	7	6	5	8

-Resolution by the Lon.Zo method

Table 21: Score calculation

	$\Sigma_{j=1}^{5} w_{j,1} g_{j,1}(a_i)$	$\Sigma_{j=1}^{5} w_{j,2} g_{j,2}(a_i)$	$\Sigma_{j=1}^{5} w_{j,3} g_{j,3}(a_i)$	$g_j(a_i) = \frac{3}{\Sigma_{l=1}^{3} \frac{1}{g_{j,l}(a_i)}}$
Nippon Paint KK	97	89	100	95,10
Courtaulds Coatings	85	66	85	77,56
International Paints	89	71	82	79,97
Kansai Paint	97	79	90	88,03
US Sec Navy	82	56	113	77,11

Table 22: Ranking proposed by Lon-Zo

Partenaires	Scores globaux	Rangs
Nippon Paint KK	95,10	1^{st}
Courtaulds Coatings	77,56	4^{th}
International Paints	79,97	3^{rd}
Kansai Paint	88,03	2^{nd}
US Sec Navy	77,11	5^{th}

- Resolution by MASCAP .

Table 23: Calculation of overall scores

	$\Sigma_{j=1}^{3} w_{j,1} g_{j,1}(a_i)$	$\Sigma_{j=1}^{3} w_{j,2} g_{j,2}(a_i)$	$\Sigma_{j=1}^{3} w_{j,3} g_{j,3}(a_i)$	$\Sigma_{j=1}^{3} w_{j,4} g_{j,4}(a_i)$	$\frac{1}{3}\Sigma_{j=1}^{5} \left(\Sigma_{l=1}^{3} w_{j,l} g_{j,l}(a_i)\right)$
Nippon Paint KK	78	62	51	95	95,33
Courtaulds Coatings	48	63	55	70	78,67
International Paints	65	88	44	45	80,67
Kansai Paint	54	79	33	100	88,67
US Sec Navy	51	55	50	95	83,67

Table 24: Ranking proposed by MASCAP

	Scores globaux	Rangs
Nippon Paint KK	95,33	1^{st}
Courtaulds Coatings	78,67	5^{e}
International Paints	80,67	4^{e}
Kansai Paint	88,67	2^{nd}
US Sec Navy	83,67	3^{e}

-Solving by Extension of ELECTRE II(EE-II)

Etape1 : We obtain the median weights of the criteria recorded in the table 24 , using the median function on EXCEL

Table 25: Matrix of median weights

	Quality	Technology	Time	Cost
Weight	4	4	3	5

Etape2 : By using the relation (2) and (3) , we obtain the global evaluation matrix of the actions , given by the table25 :

Table 26: Matrix of evaluations of all decision makers

	Quality	Technology	Time	Cost
Nippon Paint KK	7,05	5,72	6,48	6,56
Courtaulds Coatings	4,51	5,35	7,05	4,97
International Paints	6,06	7,39	5,66	3,11
Kansai Paint	5,07	6,56	4,51	6,68
US Sec Navy	5,10	4,51	6,40	6,45

The table 26 to which we add the median weights (table 25), gives us the global matrix of decision makers' judgments , represented by the table 27

Table 27: Global matrix of judgments of decision makers

	Quality	Technology	Temps	Cost
Poids	4	4	3	5
Nippon Paint KK	7,05	5,72	6,48	6,56
Courtaulds Coatings	4,51	5,35	7,05	4,97
International Paints	6,06	7,39	5,66	3,11
Kansai Paint	5,07	6,56	4,51	6,68
US Sec Navy	5,10	4,51	6,40	6,45

Etape3 : Proceeding in the same way as in application 1 and keeping the same agreement and discrepancy thresholds set , here are the results obtained :

Table 28: Classification of the Extension of the ELECTRE II method (EE-II)

Partners	Direct Ranking	Indirect Ranking	Final Ranking
Nippon Paint KK	1	1	1
Courtaulds Coatings	4	4	5
International Paints	2	2	2
Kansai Paint	3	3	4
US Sec Navy	2	3	3

- Analysis and interpretation of results : The Lon-Zo, MASCAP and Extension of ELECTRE II (EE-II) methods each rank the company Nippon Paint as the best partner. The ELECTRE II(EE-II) Extension ranks partner Kansai Paint 3^{rd} while Lon-zo , MASCAP ranks it 2^{nd} . Another important remark to make is that the Extension of ELECTRE II and MASCAP have an almost similar classification except at the level of the partners Kasai Paint and International Paints where the classifications are opposite . This rank differentiation could also be explained by the fact that the Lon-Zo , MASCAP and ELECTRE II Extension methods do not have the same aggregation approaches .

Conclusion :

In multi-criteria group decision support , the notion of aggregation is essential . There are a multitude of aggregation methods in the literature . However , it is still not easy to find the best one . According to [7] , the arithmetic mean is sometimes the most interesting and used statistic , both in scientific , professional and everyday life . According to the same source , despite its compensating effect , the mean is the best estimate of the central tendency of a sample and makes the fewest errors when used to "predict" each value of the distributio . Like the ELECTRE II method , the Lon-Zo and MASCAP methods are subject to a storage problem . This ranking is done using the global scores generated by the aggregation function. Numerical applications have shown that for some examples the results provided by the Extension of ELECTRE II differ little from those generated by Lon-Zo and MASCAP .
We recall that the Extension of ELECTRE II combines the quadratic mean and the median , the Lon-Zo method uses both arithmetic and harmonic mean while MASCAP is only based on arithmetic mean [8] . Given the compensating effect of the arithmetic mean , the Extension of ELECTRE II seems better suited than MASCAP and Lon-Zo to solve multicriteria-multidecision maker problems .

In-depth studies could be carried out to decide between Lon-Zo , MASCAP and the Extension of the Electre II method as well as the study of their comple .

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