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Suggestion of a Reform for Moroccan Pension Funds using Multicriteria Decision Analysis

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Abstract: The Multi-Criteria Decision Analysis (MCDA) methods are the mathematical and technical science that serves to clarify and solve a decision problem they have become among the more popular in the field of decision-making. In this study as there is no reference method for determining the weights in the MCDA methods because most of them are based on the choice of decision-makers switch their experiences, hopes and preferences, to respond to this deficiency, we propose a technique that determines the weights to evaluate the importance of each criterion in different scenarios which we will apply subsequently to the MCDA methods to guarantee more objectivity and relevance of these methods. As for numerical application, we adopt our technique in the TOPSIS and weighted sum methods, so that, we suggest a good reform to the Moroccan pension funds in terms of financial, economic, demographic and social balance.

Key words: Multicriteria decision analysis, TOPSIS, weighted sum, reform, pension, scenario

INTRODUCTION

Pension is one of the fundamental pillars of social protection, to provide a replacement income to the elderly after years of activity (Benjelloun, 2009). It is one of the ways to fight against poverty and the preservation of social cohesion. Demographic trends and labor market situation now constitute a major challenge for the future of retirement. Indeed, the socioeconomic and demographic factors upset the balance of pension systems and weigh heavily on their functioning. For these reasons, the uncertainties about the future of pensions, the fear of non-sustainability of funds and preservation of their financial stability constitute therefore, a challenge for the coming years. However, although the reform of pension systems ensures current and future affiliates a decent replacement income, the study of this issue is still a difficult problem in future. In fact, this reform often requires a change in the functioning, these results in judgments and reforms in that system. Mathematical methods are a necessary tool to present key issues to promote to a better reform.

Multi-Criteria Decision Analysis (MCDA) according to Doyon (1994) is: "A technical science dedicated to the clarification of the understanding of a decision problem and its resolution. It becomes multi-criteria when the problem has multiple conflicting objectives and multi-decision maker when several stakeholders have different views on the considered objectives." Generally, the MCDA problem is evaluated m alternatives over n criteria, we can see that the decision problem concerning alternatives, criteria, weights and evaluating the results. The proceedings of the decision may generally comprise four main steps: the selection of the formulation of criteria and alternatives, the weighting of the criteria, evaluation, final processing and aggregation. The preliminary step in MCDA is to formulate alternatives to the Decision Maker (DM) problem studied from a selected set of criteria and normalize the original data criteria. Second, the weighting of the criteria are determined to show the relative importance of the criteria in MCDA. Then, acceptable alternatives are classified by methods of MCDA weighted criteria. Finally, the ranking of alternatives is ordered. If the collation sequences of all the alternatives and methods in different MCDA are the same, decision analysis is complete. Otherwise, the classification results are aggregated again and the best system is selected.

In this study, we present, first, a few methods of MCDA which are mostly used for the selection of an action or an alternative in a problem of decision aid. Then we propose our method that determines the weights to evaluate the importance of each criterion which we will apply subsequently to the MCDA methods in different scenarios, to guarantee more

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objectivity and relevance of these methods. Finally, we make an application and numerical simulation for the establishment of a MCDA of pension funds in Morocco based on the TOPSIS and weighted sum methods to classify the alternatives and suggest a good reform to the Moroccan pension funds in terms of financial, economic, demographic and social balance.

Some mathematical methods known in the field of decision aid

Basic methods (elementary): The categorical method by Borgers and Timmermans (1986) is to make an evaluation of the performance of each action in respect of each criterion and this by affecting a "Grade": a categorical single term such as "Good", "Unsatisfactory", "Neutral". We execute in a second step the sum of the evaluations of each action to obtain an overall score for each action. The method of the weighted sum is to establish a set of criteria and rank them by assigning each of them a weight, evaluate each action on each of the criteria and calculate the total score (weighted ratings) for each action, this method is easy and practical in using (Goumi *et al.*, 2016a, b). The method "Maxmin" by Guitouni and Martel (1998) is used to select an action considered as the best action from a set of actions. The term "Maxmin" indicates that the procedure seeks to select the maximum of minimum evaluation. Thus, the overall performance of an action is determined by its worst performance. This procedure is suitable in the case where the decision maker has a pessimistic attitude.

Methods of mathematical optimization multi-criteria: The mathematical optimization methods are the most used in the domain of scientific research (Wang *et al.*, 2009), to treat the selection problem which is often formalized in the form of one or more objective functions and a set of constraints to be respected. The resulting models can be linear or non-linear depending on the problem to formalize. The mathematical optimization methods are often operated in two steps, modelling step and resolution step. The selection problem is multi-criteria in the sense that the evaluation of an action is often done by considering several criteria at once. In this case, we limit the presentation of mathematical optimization methods for the integration of several criteria. This integration is done in three ways, aggregation criteria into a single objective function (Flavell, 1976) (compromise programming, goal programming method of global criterion, ...,), Optimizing a criterion in the objective function and the integration of other criteria within the constraints of the model (•-constraint method (Grandinetti *et al.*, 2010)) and the formulation of the problem in a mathematical multiple objective program (Keeney and Howard, 1993; Lahdelma *et al.*, 1998).

Method of multi-criteria analysis: Mathematical programming methods permit to treat a selection problem with constraints (Roy, 1984) in other words, a selection problem where solutions are not known a priori. However, methods of multiple-criteria decision analysis that we will present in the following assume that the solutions are known a priori. The method of choosing the best solution is conditioned by the way in which the decision maker expresses its preferences. The aid process multi-criteria decision can usually be seen as a recursive process (iterative), nonlinear, composed of four main steps by Guitouni and Martel (1998). The definition of problems and the structuring of the situation (problem) decision (Dias and Mousseau, 2003), the modelling of preferences at each point of view (modelling of local preferences), the aggregation of these local preferences to establish one or more relational systems of global preferences and the recommendation after exploiting aggregation.

The popular methods of multi-criteria analysis are: the technique for order by similarity to ideal solution (Hwang and Kwangsun, 1981; Guitouni and Martel, 1998), the basic idea of this method is to choose a solution that is closest to the ideal solution (better on all criteria) and away as possible from the worst solution (which degrades all criteria). The simple multi-attribute rating technique method by Edwards (1971) is to use the additive form for the aggregation of assessments on different criteria, this approach is justified by the fact that in some cases, also, obtained good approximations with the additive form with other nonlinear shapes which are much more complex. The multiple attribute value theory (Keeney and Howard, 1993; Jacquet-Lagreze *et al.*, 1987) method is based on the following fundamental idea: every decision maker tries unconsciously (or implicitly) to maximize a function V = V[g1, ..., gn] that aggregates all attributes, this method is of Anglo-Saxon inspiration is mainly used in the US in the problems to the decision aid, economic problems, finance and actuarial. The utility theory additive (Jacquet-Lagreze *et al.*, 1987; Hokkanen and Salminen, 1997) method is based on the following idea: we assume that the decision maker knows a subset of actions A'(A' CA). We seek to estimate the utility function then, we ask the decision maker to, classify the actions of A', provide significant criteria and provide the evaluations of the actions of A' against criteria (matrix of judgments). Promethee (Mareschal *et al.*, 1986) methods are based on an extension of the notion of criterion by introducing a function expressing the preference of the decision maker for action a_i has compared to another action a_k. The ELECTRE (Scharlig, 1985, 1996) method is part of the choice problem, its way of establishing the over classing of one action over another relies on the condition of concordance and discordance, ELECTRE TRI is one of the most applied in this method (Jeong-Hwa, 2011) for example it was used to analyze the competencies and accomplish classification of the employees (Moura and Sobral, 2016).

MATERIALS AND METHODS

Principle of the weighted sum method and the topsis method

Weighted sum method: The weighted sum method (Borjers and Timmermans, 1986) is the most used one in practice technique among other techniques MCDA, view that it has the advantage of being easy to understand and implement. Recall that the principle of weighted sum method involves the following four steps:

- Step 1: for each alternative A_j relevant to the problematic, identify n criteria
- Step 2: assign the weight P_i (i = 1, 2, …, n) to each of the listed criteria, reflecting the relative importance of each criterion
- Step 3: evaluate each alternative on each of the criteria C_{ij} (i = 1, 2, ..., n) (j = 1, 2, ..., m)
- Step 4: calculate the total score (weighted ratings) for each alternative:

$$S(A_j) = \sum_{i=1}^{n} P_i.C_{ij}$$

- Step 5: arrange the alternatives according to their scores from largest to smallest:

Technique for Order Preference by Similarity to Ideal Solution (TOPSIS): The TOPSIS method is a multi-criteria decision making method developed by Hwang and Kwangsun (1981). The basic concept of this method is that the chosen alternative must have the shortest distance to the ideal alternative (the best on all criteria) and the greatest distance to the ideal negative alternative (which degrades all criteria).

The aim is to reduce the number of disambiguating scenarios by excluding dominated scenarios and to classify the effective scenarios according to their calculated global scores. To illustrate that TOPSIS considers both the distance to the ideal and anti-ideal, just look at Fig. 1.

In Fig. 1, five alternatives A, B, C, D, E, two criteria C1 and C2 and the ideal and anti-ideal points are represented. Using the usual Euclidean distance with equal weights, we find that C is the nearest point of the ideal whereas D is the farthest from the anti-ideal. TOPSIS solves this dilemma of choosing between ideal and anti ideal by using for each alternative the weighted distances to the ideal and the anti ideal. The steps of the TOPSIS method are as follows:

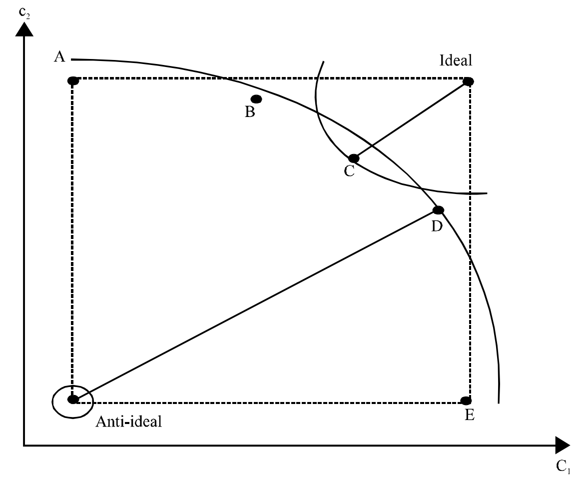

Fig. 1: The distance to the ideal and to anti-ideal (Mendez *et al*., 2009)

- Step 1: create an evaluation matrix $(x_{ij})_{ij}$ of m alternatives and n criteria
- Step 2: normalize the evaluation matrix x_{ij} using the normalization method:

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}}, i = 1,2, ..., m,\ j = 1,2, ..., n$$

- Step 3: calculate the weighted normalized decision matrix:

$$t_{ij} = r_{ij}.w_j, i = 1,2, ...,m,\ j = 1,2, ...,n$$

Where:

$$w_j = \frac{w_j}{\sum_{j=1}^{n} w_j},\ j = 1,2, ..., n$$

With $\sum_{j=1}^{n} w_j = 1$ and w_j is the original weight

- Step 4: determine the ideal alternative (A_b) and anti-ideal alternative (A_w):

$$A_w = \left\{ \begin{matrix} \left(\max\left(t_{ij}\ i = 1,2, ..., m\right) \backslash j \in J-\right), \\ \left(\min\left(t_{ij}\ i = 1,2, ...,m\right) \backslash j \in J_+\right) \end{matrix} \right\}$$

$$A_b = \left\{ \begin{matrix} \left(\min\left(t_{ij}\ i = 1,2, ..., m\right) \backslash j \in J-\right), \\ \left(\max\left(t_{ij}\ i = 1,2, ...,m\right) \backslash j \in J_+\right) \end{matrix} \right\}$$

Table 1: Weight of criteria in different scenarios

Class	Criteria	Reference weight in scenario 1	Weight in scenario 2	Weight in scenario 3	Weight in scenario 4
Economic and financial	Contribution rate	30	40	20	20
	Replacement rate	30	40	20	20
	Annuity rate	30	40	20	20
	Projected evolution of debt	30	40	20	20
	Financial reserve	30	40	20	20
Demographic	Dependency ratio	30	5	90	20
Social	Starting salary at retirement	30	5	20	90
Score		210	210	210	210

With:

$$J_+ = \left\{ \begin{matrix} j = 1, 2, ..., n \backslash j \text{ associated with the} \\ \text{criteria having a positive impact} \end{matrix} \right\}$$

$$J_- = \left\{ \begin{matrix} j = 1, 2, ..., n \backslash j \text{ associated with the} \\ \text{criteria having a negative impact} \end{matrix} \right\}$$

- Step 5: calculate the Euclidean distance between the target alternative i and the worst (A_w) and between the target I and the best (A_b)

$$d_{iw} = \sqrt{\sum_{j=1}^{n} \left(t_{ij} - t_{wj}\right)^2}, \; i = 1, 2, ..., m$$

$$d_{ib} = \sqrt{\sum_{j=1}^{n} \left(t_{ij} - t_{bj}\right)^2}, \; i = 1, 2, ..., m$$

- Step 6: calculate a coefficient of similarity to the worst condition of the approximation to the ideal profile:

$$S_{iw} = \frac{d_{iw}}{\left(d_{iw} + d_{ib}\right)}, \le s_{iw} \le 1, i = 1, 2, ..., m$$

$$\begin{cases} s_{iw} = 1 \text{ if only if the alternative solution} \\ \quad \text{has the best condition} \\ s_{iw} = 0 \text{ if and only if the alternative solution} \\ \quad \text{has the worst condition} \end{cases}$$

- Step 7: arrange the alternatives according to the coefficient s_{iw}(i = 1, 2, ..., m) (Yang and Hung, 2007).

Weights weighting: This part is corresponding to the allocation P_i weight of the listed criteria, reflecting the relative importance of these criteria and as there is not a reference method for the assignment of weight because most of them are based on the choice of decision-makers switch their experiences, hopes and preferences. To respond to this neediness in this study, we propose our method that determines the weights to evaluate the importance of each criterion which we will apply subsequently to the MCDA methods.

First, we fix all the weights of the criteria in a common value that is to say all the weights follow the uniform law and have an equal importance, this represents a first scenario. Second, we make an increase at the level of the first global criterion this leads to a decrease in the other criteria, this scenario valorizes the first criterion compared to the others and helps the decision maker to note the importance impact of the valorized criterion over others. Finally, we continue to increase one by one the other weight of the other global criteria until the arrival to the last while building with each increase a scenario which helps the decision maker in his multi-criteria decision study.

To explain our approach we have selected the criteria in three classes in the part of numerical application: class of economic and financial criteria, class of social criteria and class of demographic criteria. The method that we will follow is to give more weight to each class of criteria in each scenario, other class of criteria being defined in a complementary manner.

In Table 1, we will try to allocate weight for each criterion used in our numerical application in part 4:

Numerical application to three Moroccan pension funds: In this part, we present a numerical application of the Moroccan pension funds based on the comparison of analysis multi-criteria decision aid MCDA via the TOPSIS method and weighted sum method using the approach of scenarios of allocation the weight of the criteria mentioned in part 3. Indeed, our aim in this part is to test and evaluate the effects of reform on individual situations in changing the values of parameters for calculating the pension, this for indicate the influence of using the reform based on our analysis to classify the Moroccan pension funds functioned with the regime of distribution pay-as-you-go by annuities like a public sectors CMR (Moroccan pension fund) and RCAR (collective scheme of allocation of pension) and private sector CNSS (interprofessional fund Moroccan pension).

Table 2: Classification matrix of criteria associated with each pension system

Class	Criteria	CMR (%)	CNSS (%)	RCAR (%)
Economic and financial	Contribution rate	20	13 .89	18
	Replacement rate	87.5	70	76
	Annuity rate	2.5	3.33	2
	Projected evolution of debt	583	197	82.9
	Financial reserve	77 Milliard	27 Mi	82,9 Mi
Demographic	Dependency ratio	3	9.5	3
Social	Starting salary at retirement	Last salary	Average salary	Average salary

In order to apply our analysis MCDA, we will need to specify the classes of the criteria and sub criteria adopted:

The classes of criteria and sub criteria: In our analysis we use data given by Court of Moroccan accounts which is based on three classes of criteria as follows:

Class demographic criteria: we consider in this class one criterion called demographic dependency ratio expressed by the number of employees divided by the number of pensioners and represent the benchmark for demographic evolution, this criterion based on the mortality tables adopted by Moroccan pension funds when they want to prepare their actuarial statement of accounts.

Class of economic and financial criteria: This class contains data on the financial and macroeconomic evolutions and represents the important class in the application concerning the reform. In this class we adopt the five criteria as follows:

- Contribution rate
- Replacement rate
- Annuity rate
- Projected evolution of debt
- Financial reserve

Class of social criteria: we consider in this class one criterion called starting salary at retirement, its treats influencing social behaviour on pension funds.

Our classification of class of criteria and sub criteria corresponding to each pension fund using data given in Court of Moroccan accounts is summarized in the table as shown in Table 2.

Study of scenarios, numerical application and comparison of the results of the methods MCDA: In our study, we chose the TOPSIS method and weighted sum method because they have an advantage of being easy to understand and implement and known by their mathematical accessibility. In the rest of the study, we will adopt our approach presented in part 3 in three scenarios. In each scenario, we valorize a class of criteria compared to others classes, i.e., we make an increase at the level of the first class criteria this leads to a decrease in the other classes of criteria, this scenario valorizes the first criterion compared to the others and helps the decision maker to note the importance impact of the valorized criteria over others.

Table 3: Weights values in first scenario

Criterion	Description	Reference weight P_j
1	Contribution rate	0.142857
2	Replacement rate	0.142857
3	Annuity rate	0.142857
4	Projected evolution of debt	0.142857
5	Financial reserve	0.142857
6	Dependency ratio	0.142857
7	Starting salary at retirement	0.142857

Scenario 1; References weights following the uniform law: In scenario 1, we assume that all criteria of the problem have the same proportion, so, references weight values in the first scenario follow the uniform law and are fixed to the same value 1/7 (i.e., 0.142857) the table as follow show weights values in first scenario Table 3.

Implementation of the TOPSIS method

Step 1: Create an evaluation matrix $(x_{ij})$of m alternatives and n criteria. Our decision's goal is to propose the optimal pension fund in term of stability, financial, economic, demographic and social equilibrium through the study of the scenarios using the TOPSIS method. We construct our matrix of decisions $(x_{ij})_{ij}$ (performance table) using data from Court of Moroccan accounts Table 4.

We remark that the criteria contribution rate, financial reserve and dependency ratio are to maximize but the criteria replacement rate, annuity rate, projected evolution of debt and starting salary at retirement are to be minimized. In order to have a coherent matrix of decisions in optimization sense (all criteria are to maximize or to minimize), a transformation of this data will be necessary to obtain all criteria to maximize is as follows:

$$x_{ij} = \max_{l=1}^{3} (x_{il})-x_{ij} \ \forall i = 1, 2, 3 \ \forall j = 1, 2, ..., 7$$

Table 4: The matrix of decisions

Pension systems	Contribution rate (%)	Replacement rate (%)	Annuity rate (%)	Financial reserve	Projected evolution of debt	Dependency ratio (%)	Starting salary at retirement
CMR	20.00	87.5	2.50	77.0	583.0	3.0	Last salary
CNSS	13.89	70.0	3.33	27.0	197.0	9.5	Average salary
RCAR	18.00	76.0	2.00	82.9	82.9	3.0	Average salary

Table 5: The matrix of decisions after transformation

Pension systems	Contribution rate (%)	Replacement rate (%)	Annuity rate (%)	Financial reserve	Projected evolution of debt	Dependency ratio (%)	Starting salary at retirement
CMR	20.00	0.00	0.83	77.0	0.00	3.0	Last salary
CNSS	13.89	17.5	0.00	27.0	3860	9.5	Average salary
RCAR	18.00	11.5	1.33	82.9	500.1	3.0	Average salary

Table 6: The matrix normalized of decisions $(r_{ij})_{ij}$

Pension systems	Contribution rate (%)	Replacement rate (%)	Annuity rate (%)	Financial reserve	Projected evolution of debt	Dependency ratio (%)	Starting salary at retirement
CMR	0.660482	0.00	0.52942	0.661965	0.00	0.28834	0.333333
CNSS	0.46	0.84	0	0.23	0.61	0.91	0.67
RCAR	0.59	0.55	0.85	0.71	0.79	0.29	0.67

Table 7: The weighted normalized decision matrix $(t_{ij})_{ij}$

Pension system	Contribution rate (%)	Replacement rate (%)	Annuity rate (%)	Financial reserve	Projected evolution of debt	Dependency ratio (%)	Starting salary at retirement
CMR	0.086	0	0.069	0.086	0.00	0.05	0.05797
CNSS	0.06	0.11	0	0.03	0.08	0.16	0.12
RCAR	0.08	0.07	0.11	0.09	0.10	0.05	0.12

This transformation exchanges the optimization sense and then criteria that should be minimized become criteria to be maximized.

The matrix of decisions on which the TOPSIS method and the weighted sum method can then be applied to each pension fund (alternatives) is shown in Table 5-7.

Step 2: Normalize the evaluation matrix x_{ij} using the normalization method:

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}}, i = 1, 2, 3, \ j = 1, 2, ..., \ 7$$

Step 3: Calculate the weighted normalized decision matrix:

$$t_{ij} = r_{ij} \ , \ w_j, i = 1, 2,3, \ j = 1, 2, ..., \ 7$$

where:

$$w_j = \frac{w_j}{\sqrt{\sum_{j=1}^{n} w_j}}, \ j = 1, 2, , ..., 7$$

with: $\sum_{j=1}^{n} w_j = 1$ and w_j is the original weight.

Step 4: Determine the ideal alternative (A_b) and anti-ideal alternative (A_w):

$$A_w = \begin{Bmatrix} (\max(t_{ij} \ i = 1,2,3) \setminus j \in J\text{-}), \\ \left(\min\left(t_{ij} \ i = 1,2,3\right) \setminus j \in J+\right) \end{Bmatrix}$$

$$A_b = \begin{Bmatrix} (\min(t_{ij} \ i = 1,2,3) \setminus j \in J\text{-}), \\ \left(\max\left(t_{ij} \ i = 1,2,3\right) \setminus j \in J+\right) \end{Bmatrix}$$

With:

$$J_+ = \begin{Bmatrix} j = 1,2, ...,7 \setminus j \text{ associated with the} \\ \text{criteria having a positive impact} \end{Bmatrix}$$

$$J_- = \begin{Bmatrix} j = 1,2, ...,7 \setminus j \text{ associated with the} \\ \text{criteria having a negative impact} \end{Bmatrix}$$

Step 5: Calculate the Euclidean distance between the target alternative i and the worst (A_w) and between the target I and the best (A_b):

$$d_{iw} = \sqrt{\sum_{j=1}^{7} \left(t_{ij}\text{-}t_{wj}\right)^2}, i = 1,2,3$$

$$d_{ib} = \sqrt{\sum_{j=1}^{7} \left(t_{ij}\text{-}t_{bj}\right)^2}, i = 1,2,3$$

Step 6: Calculate a coefficient of similarity to the worst condition of the approximation to the ideal profile Table 8-10.

Table 8: The ideal alternative (A_b) and anti-ideal alternative (A_w)

Pension systems	Contribution rate (%)	Replacement rate (%)	Annuity rate (%)	Financial reserve	Projected evolution of debt	Dependency ratio (%)	Starting salary at retirement
A_b	0.086	0.109	0.1106	0.09	0.103	0.15879	0.12
A_w	0.060	0.000	0	0.03	0	0.05	0.05797

Table 9: The Euclidean distance (d_{ib})

Pension systems	Distance (d_{ib})
CMR	0.19870478
CNSS	0.13199012
RCAR	0.11522106

Table 10: The Euclidean distance (d_{iw})

Pension systems	Distance(d_{iw})
CMR	0.09276237
CNSS	0.18275469
RCAR	0.18878702

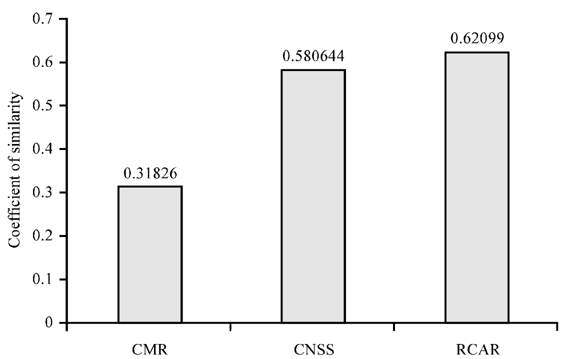

Fig. 2: TOPSIS result of scenario 1

$$S_{iw} = \frac{d_{iw}}{(d_{iw}+d_{ib})}, 0 \leq S_{iw} \leq 1, i = 1, 2, 3$$

Arrange the alternatives according to the coefficient s_{iw} (I = 1, 2, 3) Fig. 2:

$$\begin{cases} s_{iw} = 1 \text{ if only if the alternative solution} \\ \quad \text{has the worst condition} \\ s_{iw} = 0 \text{ if and only if the alternative solution} \\ \quad \text{has the worst condition} \end{cases}$$

RESULTS AND DISCUSSION

Implementation of the weighted sum method: In order to have a coherent weighted sum in optimization sense, a transformation of data will then be necessary to obtain all criteria to maximize. We adopt the same transformation used in TOPSIS method and then we exploit the Table 5. Next step is to normalize the new criteria evaluations $C'_{ij}, \forall i = 1,2, ..., 7 \text{ et } \forall j = 1,2,3$. We choose as a normalization procedure the following relationship Table 11:

$$v_{ij} = \frac{C'_{ij}}{\sum_{i=1}^{3} C'_{ij}}, \forall i = 1,2, ..., 7 \text{ et } \forall j = 1, 2, 3$$

After calculation, we get the following results. After normalization of criteria and weights, we calculate the values of function S for each alternative, i.e., for each Moroccan pension fund: CMR, CNSS, RCAR:

$$S(A_j) = \sum_{i=1}^{n} P_i . C_{ij} \quad \forall_j \in \{1,2,3\}$$

Once this calculation is made interpretation of results is required. We classify the alternatives according to their scores $S(_{aj})$ which allow a ranking of pension funds in Morocco (Fig. 3).

Interpretation of the result scenario one: According to the result of Fig. 1 of the TOPSIS method and Fig. 2 of the weighted sum method of scenario one based on weight references, we remark that the results of the ranking of alternatives, (i.e., the pension funds) by the two methods are the same, we find RCAR in the first rank, CNSS in the second and CMR in the last rank. This provoked to a criteria and demographic, economic, financial and social factors that the parametric construction of the CMR system is not able to support. Efficient control mechanisms to cope with the elements of this imbalance for CMR must implement adjustments to not least increase the imbalance.

Globally, according to the result obtained by the multi-criteria analysis, the main factors of imbalance can be presented as follows:

For the regime of civil pension CMR

Demographic factor: The stability of recruitment and the growing population of pensioners had a negative impact. Thus, 12 assets for a pensioner in 1986, the demographic ratio fell to <3 in 2012 and should reach 1, since, 2024 (Moroccan Court of Accounts).

Economic and financial factor: Civil pension fund CMR is characterized by generous benefits compared to other systems. It offers its affiliates an annuity of 2.5% of final salary for every year of contributions and the high replacement rate will become the main cause of the imbalance of the CMR fund.

Table 11: The matrix normalized of decisions

Pension systems	Contribution rate (%)	Replacement rate (%)	Annuity rate (%)	Financial reserve of debt	Projected evolution	Dependency ratio (%)	Starting salary at retirement
CMR	0.38543	0	0.38425	0.41198	0	0.19354	0.2
CNSS	0.26768	0.603448	0	0.14446	0.43561	0.61290	0.4
RCAR	0.34688	0.39655	0.61574	0.4435	0.5643	0.19354	0.4

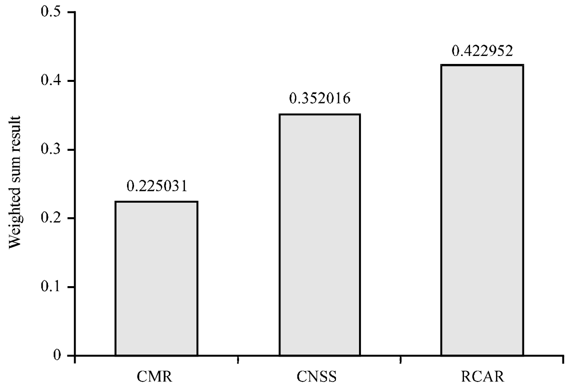

Fig. 3: Weighted sum result of scenario 1

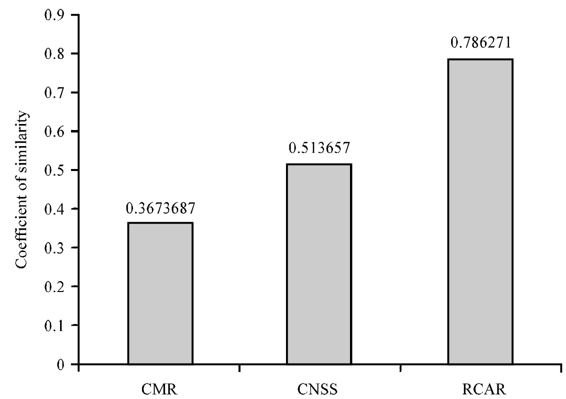

Fig. 4: TOPSIS result of scenario 2

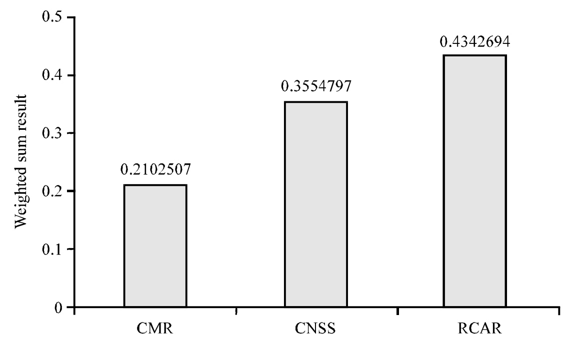

Fig. 5: Weighted sum result of scenario 2

Social factor: The calculation of pension based on last salary increases and more aggravates the pricing benefits of civil pension system CMR compared with the CNSS and RCAR.

For the regime RCAR: According to the result of the method of the weighted sum and TOPSIS method in first scenario, we can consider that the RCAR fund control riskiness that are normally faced by pension regimes which has the effect of reducing the imbalance and extend the viability of the system compared with the CMR and CNSS. Among the benefits the general regime RCAR is: the liquidation based on the average salary of the revalued career ensures better equity between affiliates and a real link between the effort of contribution and the amount of rent receivable, the RCAR is the regime that accumulates more reserves relative to other pension regimes, the annuity liquidation of pension law is 2%< the annuity of the others pension funds.

For the CNSS regime: We can consider that the functioning of the CNSS fund is somewhat mastered following the criteria adopted by the analysis which has the effect of reducing the imbalance and extend the viability of the system in comparison with the CMR. Among the advantages of the CNSS regime are: it makes a search for balance in a 5 years which delays the onset time of deficits which is masked by the very high demographic factor. This allows the regime to consolidate its financial position in excess of contributions over benefits each year. Despite these advantages, the regime of the CNSS should have some difficulties in terms of financial stability, though less severe than the system of civil pensions CMR, due to generous annuities of 3.33% which are high in compared to 2.5% of the CMR and 2% of RCAR.

Scenario 2; Case valorizing financial and economic class: In this scenario, we will introduce our approach which valorizes the class of five economic and financial criteria, i.e., maximize the weights and decrease the others of these five criteria presented in part 3.

Once our weight vector is obtained, we will apply then the procedure of the implementation of the TOPSIS method and the weighted sum method to classify the different alternatives, i.e., the pension funds CMR, CNSS and RCAR, we have then the following results Fig. 4 and 5.

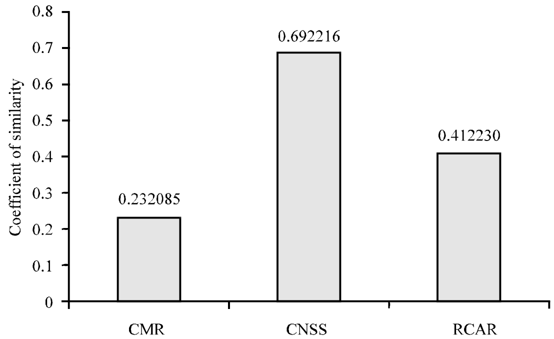

Fig. 6: TOPSIS result of scenario 3

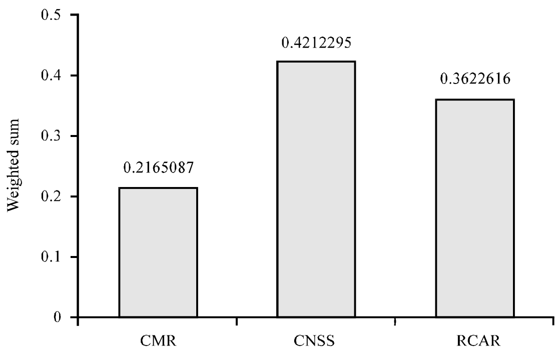

Fig. 7: Weighted sum result of scenario 3

Scenario 3; Case valorizing demographic criterion: In this scenario, we valorize the second class of demographic criteria based, we apply then the procedure of the implementation of the TOPSIS method and the weighted sum method to classify the different alternatives, i.e., the pension funds CMR, CNSS and RCAR Fig. 6 and 7.

Scenario 4; Case valorizing social class: We will introduce the weight of criteria where valorizing the social class, we apply then the procedure of transformation, normalization of criteria and the implementation of the TOPSIS and weighted sum methods. We obtain the following result Fig. 8 and 9.

Results interpretation: According to the result in Fig. 4 and 5 of the weighted sum method and TOPSIS method in second scenario valorizing the economic and financial criteria according to the result. We always find the RCAR regime in the first rank, CNSS in the second and CMR in the last rank with a significant difference which shows the inability of the CMR to cope with its future engagements. But, we note that CMR had a small deterioration in this scenario, comparing to the scenario 1 indicating that criteria of the economic and financial class are the main weaknesses of this fund. Our

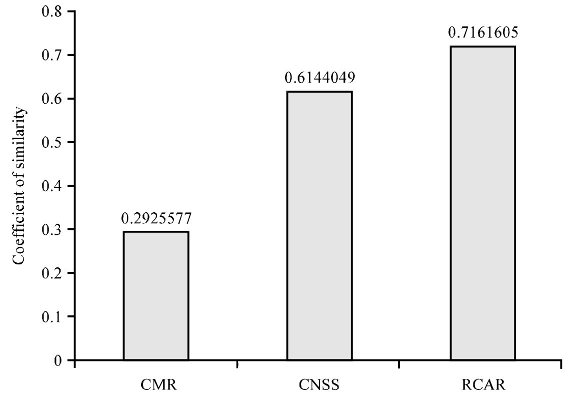

Fig. 8: TOPSIS result of scenario 4

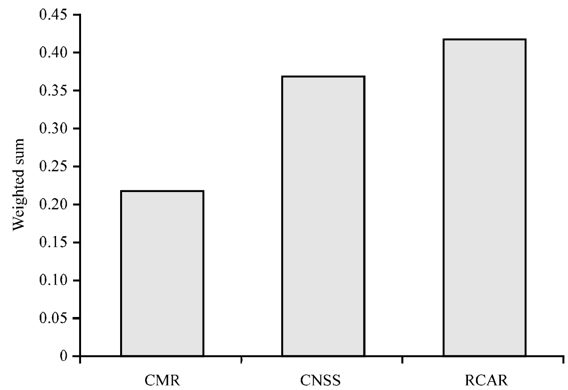

Fig. 9: Weighted sum result of scenario 4

recommendation for CMR is to implement parametric adjustments in the criteria of the economic and financial class to not reinforce and aggravate the imbalance. In this scenario, the RCAR regime induces a small augmentation by the way that the economic and financial parameters of this regime are adjusted which consolidates our first idea that affirms that the balance of the RCAR regime postpones the onset deficits.

From the result of Fig. 6 and 7 of the weighted sum method and TOPSIS method in scenario valorizing the demographic criteria, we always find the CMR in the last rank with a big gap to other funds which shows the inability of this fund to cope with its future engagements. However, we remark that the CNSS in this scenario occupies the lead the ranking and exceeds the RCAR fund. Indeed the CNSS induced a strong augmentation thanks to very high demographic factor which consolidates our first idea which affirms that the balance of the CNSS postpones in time the onset of deficits that is masked by this factor.

In the last scenario valorizing the social criteria, we always find the RCAR in the first rank but this scenario has not added a new on classification, CMR is always last in the ranking while the CNSS is ranked second. The social generosity is in the CMR with the liquidation of the pension based on last salary that is generally the highest remuneration of all staff careers instead of a career average salary for the other funds. Therefore, the liquidation of the pension on that basis is not properly correlated with the contribution effort, since, ignores low contribution levels of the civil servant at the beginning and mid-career comparison with remuneration end of career. Finally, the calculation of pension based on final salary accentuate and more aggravates charging for the CMR civil pension benefits compared to the CNSS and the RCAR and represents in the coming years one of the main causes of the crisis and the financial deficit of the CMR regime (Benjelloun, 2009).

CONCLUSION

In this study, we propose our technique that determines the weights to evaluate the importance of each criterion which we will apply subsequently to the multi-criteria analysis of decision aid. We exploit the technique in the TOPSIS method and in the weighted sum method to guarantee more objectivity and relevance of this method.

IMPLEMENTATIONS

The implementation of the two methods gave the same results and allowed consequently a classification of the three pension funds considered in Morocco. Therefore, the study of scenarios based on MCDA methods has also determined the criteria and parameters aggravating or improving the financial, economic, demographic and social equilibrium of each Moroccan pension fund, finally we suggest a reform to stop the crisis of certain of them.

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