The Application of Weighted Decision Matrix for the Selection of Non-state Pension Provision Strategy

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Abstract. In this paper, it was proposed to justify the selection of a non-state pension provision strategy, which takes into account the possibility of using the limited financial resources of potential participants of the non-state pension system. The criteria to choose the appropriate non-state pension provision entity as well as the criteria to choose the priority association of non-state pension entities were justified. The solution of these problems with the automatic decision making tool known as a weighted decision matrix that is simple to implement and understand was proposed. Additionally, it was proposed a method, which extends the functionality of decision making with the estimation of the stability of the decision made. It was denoted the decision to be confident if there is no opportunity to change one or two criteria weights and alternative coefficients and get a totally different decision. The modeling has shown that the usage of a weighted decision matrix allows making the decisions for complex tasks with a lot of criteria and weights in a fraction of a second.

Keywords: Weighted Decision Matrix, Entity Association, Non-state Pension Provision, Decision Making.

1 Introduction

Updating the issues of forming an additional non-state part to the state pension increases the importance of a professional multi-criteria selection of a strategy for the accumulation of funds in the system of voluntary funded pension provision (non-state pension provision).

A strategic approach to the accumulation of funds in the voluntary retirement pension system is to choose the strategy (in the long term) that best serves the interests of potential participants in the non-state pension system.

The development of the non-state component of the pension provision among the working population is conditioned by the presence of economic and social preconditions, in particular the deficit of the Pension Fund of Ukraine, the number of retirees, etc.

The introduction of the second level of the pension system of Ukraine – the system of mandatory funded pension provision, which is at the stage of initiation by the state regulatory and supervision bodies, through the development of the draft Law of Ukraine "On Mandatory funded pension provision" is an element of the reform of the pension system of Ukraine. Approval of the second level of the pension system in the future will complement the existing solidarity pension system of Ukraine with a new, mandatory savings account, in which working citizens will make payments to an individual savings pension account [1].

So the prospects of the pension system of Ukraine are [1, 14]:

- the development of non-state (voluntary) component;
- the formation of a mandatory funded pensions system (obligatory) that complements the existing solidarity pension system.

 The development of a system of funded pension provision generally depends on the level of financial support of potential clients. This development also depends on the potential clients' understanding of the need to protect and expedient the formation of an additional state pension, the availability of non-state pension services, the development of alternative strategies for securing a future non-state pension.

Therefore, the issue of finding technical solutions in order to improve the efficiency of decision making for customers of entities providing services of non-state pension provision as a basis for the development of private pensions, and thus the basis for future additional benefits and select the best option strategy allocation of these funds.

2   Related Work

A wide range of issues related to the functioning of entities providing services of non-state pension provision and the development of the non-state pension system have been investigated by Messacar D. [2], Zelenko N. [3], Haiduk I. [4], Malyshko Ye. [5], Tkachenko N. [6], Smovzhenko T. [7], Iaroshenko O. [8] and others. These authors have identified the peculiarities of the functioning of entities providing non-state pension and the selection of these entities, taking into account these characteristics.

According to the authors, mentioned above, it is advisable to try to find a way to simplify the decision-making process by participants when choosing strategies for non-state pension provision.

It should be noted that the effectiveness of the formation of the additional (non-state) pension depends on the level of state regulation and supervision of the non-state pension provision entities; the ability to invest effectively (for example, low-risk investment instruments).

The development of the non-state pension component depends mainly on the level of trust of participants to the entities providing services of non-state pension provision, since there is a limited mechanism for guaranteeing the return of the invested funds.

For banks (entities providing services of non-state pension provision) the Deposit Guarantee Fund guarantees to each depositor of the bank the repayment of funds on his deposit, reimburses the funds in the amount of the deposit, including interest, as of the day of the beginning of the procedure of withdrawal of the bank from the market, but no more than the amount of the maximum value of the deposit repayment on that day, regardless of the number of deposits in one bank. The value of the deposit limit may not be less than 200,000 UAH, according to source [9].

In full agreement with the opinion of H. Mintzberg [10], the authors consider a strategic plan that integrates the main goals of a financial institution, its policies, and actions into one.

A properly formulated strategy allows the ordering and allocation of always limited resources in a highly efficient manner [10]. That is why the selection of a non-state pension strategy that takes into account the ability to use the limited financial resources of potential participants of the non-state pension system to maximize the additional pension to the state (non-state) pension is relevant, and the use of a decision support system will facilitate this process.

Ye. Malyshko identified the following criteria for choosing financial strategies for non-state pension provision by business entities: diversity of pension programs; risk of loss of contributions; reliability of financial instruments; activity monitoring; state control [5]. Also determined that the cluster (insurance companies, non-state pension funds, banks, and business entities) is a priority (priority by weight ratio was 0.448). This strategy is considered as the interaction of elements of a complex system that will allow reconciling the interests of competing financial institutions and set the directions of financial strategies of private pension provision by business entities [5].

O. Dolhova mentioned that the criteria for choosing a non-state pension fund are generally the same for all financial institutions. The scientist has identified two directions: first, the criteria related to the rational perception of non-state pension entities, covering the history of profitability and success of the non-state pension fund, as well as the lifetime of a particular fund on the market; second, the criteria that have more emotional connotations: this is the quality of customer service and reliability information, as well as the various recommendations of stakeholders. Another important criterion for selecting a fund is accessibility, which is difficult to secure without an effective marketing policy [11].

According to O. Khudolii, one of the main criteria that attract investors when choosing a non-state pension fund is the effectiveness of its activity, which is characterized by an increase in the value of participants' contributions due to the investment activity of the fund [12].

According to the Law of Ukraine "On implementation of lifetime retirement programs" Art. 9 identifies the peculiarities of the selection of a non-state pension fund by an entity and other persons for the implementation of a pension program for which the entity (employer) selects a non-state pension fund, concludes a pension contract and pays pension contributions in the amount established by the program for the benefit of employees -participants of the program who are members of the fund under this pension contract [13].

The contribution of the paper includes:

- an improved approach to choose a priority strategy for non-state pension provision in Ukraine, which, unlike the existing ones, uses the weighted decision matrix as an automatic decision making tool;
- the practical application scope of the traditional WDM method has been expanded with the novel module, that allows to measure the confidence level of the decision being made.

3   Selection of Non-state Pension Provision Strategy

The criteria and procedures for selecting a non-state pension fund for the implementation of the lifetime retirement program is established and applied solely by the parties to the sectoral agreement (collective agreement), taking into account the requirements of the Law of Ukraine "On implementation of lifetime retirement programs" [13]. This confirms the urgency of finding a way to simplify the decision-making process of participants in the selection of entities providing services of non-state pension provision.

According to the Law of Ukraine "On non-state pension provision" the entities providing services of non-state pension provision are: non-state pension funds through the conclusion of pension contracts between pension fund administrators and contributors of such funds; life insurance companies by concluding life insurance contracts with members of the fund, ensuring the risk of disability or death of the fund member; banking through the conclusion of agreements on the opening of pension deposit accounts for the accumulation of pension savings within the amount determined for repayment of deposits by the Deposit Guarantee Fund [14].

According to the authors, it is advisable to base this set of criteria on the selection of an already appropriate non-state pension provision entity. The selection of strategies should be based on the list of criteria (accessibility, diversification, economic efficiency) and the range of possible strategies by different associations of entities providing services of non-state pension provision (non-state pension funds, life insurance companies, banks, following the Law of Ukraine "On non-state pension provision" [14]), which is presented in Table 1, formed based on sources [5, 8 – 12, 14].

As one can see from Table 1, the proposed strategies collectively shape the approach to prioritizing a potential non-state pension strategy for a potential participant.

Table 1. Characteristics of non-state pension strategies

Strategy #1	Strategy #2	Strategy #3
Non-state pension monosubject (only one non-state pension fund, or only one life insurance company, or only one bank)	Non-state pension polysubjects (two or more non-state pension funds, or two or more life insurance companies, or two or more banks)	Association of entities providing services of non-state pension provision regardless of number (non-state pension fund, life insurance company and a bank; non-state pension fund and life insurance company; life insurance company and a bank; non-state pension fund and a bank)

4   Weighted Decision Matrix Method (WDM)

A lot of different methods [15] to solve multi-criteria decision analysis (MCDA) problems in diverse scientific and practical applications (e.g. the choice of solar collector structure [16], assessment of the environmental impact of different types of vehicles [17]) were proposed previously.

The Weighted Decision Matrix (WDM) [18] is used in the research as a simple tool to compare alternatives according to multiple criteria with importance level assigned to each criteria.

Let us denote the quantity of strategies as M and the quantity of criteria as N. The decision matrix size of $M \times N$ contains the coefficients $x_{ij}, i = \overline{1,M}, j = \overline{1,N}$, that measure the importance of each criteria for each strategy. Additionally, each criteria has its own significance level $w_i, i = \overline{1,M}$. The importance of criteria is measured according to five-level Likert-type scale from "Low" to "High", in a similar way like it is done in Decision Making Helper software [19]. The coefficients x_{ij} may get values in range $[-5;5]$. Typically, w_i and x_{ij} values are assigned by the experts in corresponding fields.

Summary scores for strategy i are calculated according to:

$$S_i = \sum_{i=1}^{M} \sum_{j=1}^{N} x_{ij}, w_i \ , \ i = \overline{1,M}, j = \overline{1,N} \tag{1}$$

following by the normalization with:

$$S_i' = \frac{S_i}{T_{max}}, \tag{2}$$

where T_{max} – is the maximum theoretically available score, $T_{max} = N \times w_{max} \times x_{max}$, $w_{max} = x_{max} = 5$ as was mentioned above.
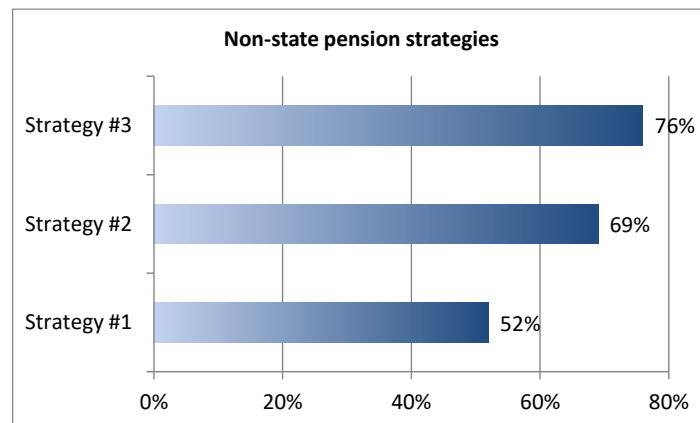
Numerical values w_i and x_{ij} for strategies 1-3 (Table 1) and 3 criteria (accessibility, diversification, effectiveness) are the following:

$$W = (4,4,5), \ X = \begin{pmatrix} 5 & 4 & 3 \\ 1 & 4 & 5 \\ 3 & 4 & 5 \end{pmatrix},$$

where $w_i \in W$, $x_{ij} \in X$, i – is the number of criteria (row), j – is the number of strategy (column). All numerical coefficients here and below (in Tables 2-4) are provided by the expert committee from 5 persons of the Banking and Financial Services department of Simon Kuznets Kharkiv National University of Economics.

The results after the applying WDM approach based on (1) and (2) are shown in Fig. 1. It was defined 3 types of strategies (they are shown in Table 1) for non-state pension

provision. The decision on the use of strategy #3 (association of entities providing services of non-state pension provision regardless of number (non-state pension funds and life insurance company as well as a bank; non-state pension funds and life insurance company; life insurance company and a bank; non-state pension fund and a bank) is a positive that can be taken into account either by a financial adviser or by a potential participant in the non-state pension system when making appropriate decisions. The analysis suggested by the authors of the criteria and strategies is consistent.

Fig. 1. The results of WDM application to select a strategy for non-state pension provision

Based on sources [5, 8 – 12, 14], the criteria for choosing a priority association of non-state pension entities (according to strategy #3) by a participant and their weights are given in Table 2.

As one can see from Table 2, according to the results of weighting for each selection criterion of a participant of an association of entities providing services of non-state pension provision (according to strategy #3), the most priority selection criteria are those that have a weight of 5, in particular: the effectiveness of asset management the entity/entities providing services of non-state pension provision; availability of guarantees for the return of accumulated pension funds; requirements for the minimum amount of contribution from the participant; the variety of pension programs for the participant; the possibility of early termination of a pension contract, or a life insurance contract or a deposit agreement (pension) without financial losses.

Four alternatives are considered to select the priority association of entities (proposed based on sources [5, 14]):

— non-state pension fund, life insurance company and a bank (Alternative #1);
— non-state pension fund and life insurance company (Alternative #2);
— life insurance company and a bank (Alternative #3);
— non-state pension fund and a bank (Alternative #4).

The weights X of corresponding criteria for all alternatives, assigned by expert assessment, are presented in Table 3.
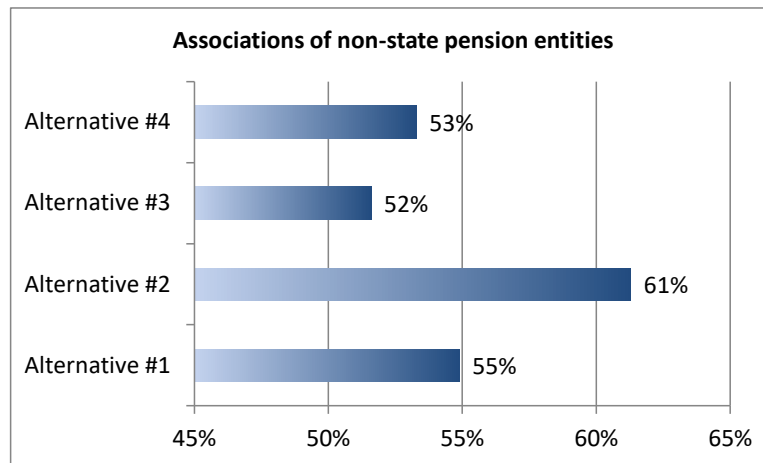
Table 2. Selection criteria for priority association of entities providing services of non-state pension provision (according to winning strategy #3)

#	Criteria	Weight
1	The effectiveness of asset management the entity/entities providing services of non-state pension provision	5
2	The availability of guarantees for the return of accumulated pension funds	5
3	The requirements for the minimum contribution fee from the participant of non-state pension provision	5
4	A variety of retirement programs for the participants of non-state pension provision	5
5	The possibility of early termination of a pension contract, or an insurance contract, or a deposit agreement (retirement) without financial losses	5
6	The financial status of the entity/entities providing services of non-state pension provision	4
7	The transparency of the activities of the entity/entities providing services of non-state pension provision	4
8	The availability of advertising for the entity/entities providing services of non-state pension provision	4
9	The possibility of consulting a participant of non-state pension provision online	4
10	The reputation of the entity/entities providing services of non-state pension provision among clients	3
11	The reputation of the entity/entities providing services of non-state pension provision among other entities of non-state pension provision	3
12	The existence of an internal risk management system, including risks of financial monitoring for the entity/entities providing services of non-state pension provision	3
13	The existence of violations established by regulators for the entity/entities providing services of non-state pension provision	3
14	The place of entity/entities providing services of non-state pension provision in the ratings (by the size of assets, number of participants, etc.)	2
15	The stage of the life cycle of the entity/entities providing services of non-state pension provision	2
16	The availability of the contract between the participant and the entity/entities providing services of non-state pension provision, territorial location	2
17	The level of professional competence of employees of the entity/entities providing services of non-state pension provision	2
18	The participation of the entity/entities providing services of non-state pension provision in professional associations of financial institutions	2

Table 3. Coefficients of importance criteria for all alternatives

Alternative	Criteria coefficient																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
#1	4	4	3	5	4	4	4	4	4	4	4	4	3	4	4	3	4	4
#2	4	3	4	4	4	4	5	5	5	5	5	5	4	5	5	4	5	5
#3	3	4	3	4	3	3	4	4	4	4	4	4	3	5	4	4	4	4
#4	4	5	3	3	5	3	4	4	4	4	4	4	3	4	4	4	4	4

WDM was applied to make the decision about the choice of the most preferred alternative, the chart with results is presented in Fig. 2. As one can see, it is preferable to bring together entities that provide non-state pension provision provided by a non-state pension fund and a life insurance company (Alternative #2).

Fig. 2. The results of WDM application to select the priority association of entity in terms of strategy #3
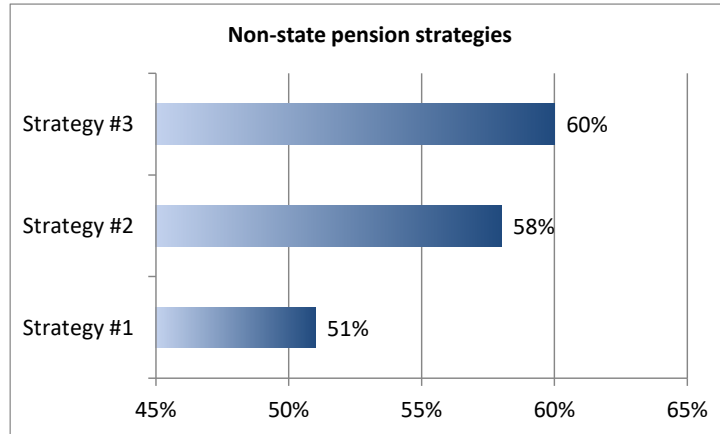
WDM method was also applied for the initial set of strategies, mentioned in Table 1 and criteria from Table 2. Corresponding expert importances are shown in Table 4.

Table 4. Coefficients of importance criteria for all strategies

Strategy	Criteria coefficient																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
#1	3	4	3	3	5	4	3	4	4	5	5	3	3	3	3	3	3	4
#2	4	5	4	4	4	4	4	5	4	4	4	4	4	4	4	4	4	5
#3	5	4	3	5	3	5	4	5	5	4	4	4	4	5	4	4	4	5

The results of the application of WDM method are presented in Fig. 3. These results correspond to previous ones in Fig. 1, which means that the expert estimations are correct for both cases.

Fig. 3. The results of WDM application to select the strategy for non-state pension provision (by 18 criteria)

5 Confidence estimation

Sometimes, it is not possible to understand whether the decision, provided by decision making systems is confident or not. Often the solution of this problem comes from some manual artificial threshold that allows distinguishing different levels of confidence, which is not convenient enough.

The decision is suggested to be the confident one, if it is not possible to find such pair of weight $\hat{w}$ and coefficient $\hat{x}$ changing which immediately leads to the change of the global decision. If it is possible to find such pair it means that the common decision may depend only on just some particular expert value.

Let's denote S_1' as the best score, calculated according to (1)-(2), and S_2' as the second best score. Corresponding weighted vectors without the summarization are $s_1 = (x_{11,}w_1, x_{12,}w_2,.., x_{1N,}w_N)$ and $s_2 = (x_{21,}w_1, x_{22,}w_2,.., x_{2N,}w_N)$, where N is the quantity of criteria.

The weighted difference between two best decisions is $D = T_{\max} \times (S_1' - S_2')$, it is always positive because $S_1' > S_2'$. Elements of vectors s_1 and s_2 are compared one by one in turn, searching for the way to compensate the required D value with increasing of x_{2i} or w_i or even both of them. Only the increasing values of the second best strategy were considered here in the effort to improve it. The reverse approach with the decreasing of corresponding coefficients x_{1i} and weights w_i of the winning strategy is possible too. The pseudocode to implement this search is below.

```
Calculate D and weighted vectors s₁ and s₂
Set N as the quantity of weights
Set X as the coefficients matrix, X[0,:] is the best
strategy coefficients, X[1,:] is the second best strategy
coefficients, etc.
Set W as the criteria weights vector
Iterate I from 0 to N:
    Calculate the difference between pair d = s₁[i]-s₂[i]
    If d > 0: // attempt to increase s₂
        If d > D: // if that's enough to compensate
            Current coefficient = X[1,i]
            Current weight = W[i]
            Find such a combination of new coefficient
and weight (changing one of them firstly, both if re-
quired) that allows to increase current product at a
value, that is bigger than d
            If new coefficient and/or new weight is
found:
                Update X[1,i] = new coefficient
                Update W[i] = new weight
                Stop calculations if there is enough to
find just one change
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Let's consider the example of how this measurement of the confidence works. The weights, provided in Table 2 are used together with and a bit modified (compared to Table 3) coefficients, provided in Table 5.

Table 5. Modified coefficients of importance criteria for all alternatives

Alternative	Criteria coefficient																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
#1	5	4	4	4	4	4	4	5	5	5	5	4	3	4	4	3	4	4
#2	4	4	5	5	3	4	5	4	**3**	4	4	5	4	5	5	4	3	3
#3	3	4	3	4	3	3	4	4	4	4	4	4	3	5	4	4	4	4
#4	3	5	3	3	5	3	4	4	4	4	4	4	3	4	4	4	4	4

Scores vector after the WDM was applied is $S' = (0.59, 0.58, 0.52, 0.53)$, so the first alternative is the best one. The difference between the highest and the second highest is just 0.01, so, there is a question if this distance is valuable enough or not.

The application of confidence analysis, described above, shows, that the change of the only coefficient #9 for the second alternative from 3 to 5 (it is marked with bold in Table 5) immediately leads to the change of the scores vector to $S' = (0.59, 0.6, 0.52, 0.53)$ and the second alternative becomes the best one. In this case

the decision is considered not to be confident. Of course, such analysis is possible not only for first and the second best scores, but for any pair.

It is worth mentioning, that only the decision that is shown in Fig. 2 is confident, the decisions, presented in Fig. 1 and Fig. 3 are not.

Increasing the number of selection criteria complicates the decision-making process of a potential client of an entity engaged in providing non-state retirement benefits, but the results witch obtained did not significantly affect the priority of the third strategy. The decision will be positive for strategy #3.

6   Conclusion

The paper proposes the solution of the problem related to the choosing a priority strategy for non-state pension provision. This research proposes the usage of the decision making system commonly known as Weighted Decision Matrix, which is simple enough to implement.

The selection of the appropriate non-state pension provision entity is based on three criteria: accessibility, diversification and economic efficiency. Three strategies are considered as alternatives and it was found, that association of entities providing services of non-state pension provision regardless of number is the best choice.

The criteria for choosing a priority association of non-state pension entities amongst four alternatives were proposed. It was found, that non-state pension funds and life insurance companies are the best alternatives.

Additionally, the module that complements weighted decision matrix decision making method is proposed. It allows to understand, whether the final decision is confident or not. The decision is suggested to be stable (confident), if that is not possible to change just a single value or pair of criteria weights or expert coefficients for alternatives which leads to a different decision.

The practical value of the work is the usage of automatic WDM tool following by the confidence analysis of the decision which has been applied for the solution of the problem of the choice strategies for private pension provision and entities that provide these services.

The comparative analysis of WDM and another multi-criteria decision methods (e.g, TOPSIS, AHP) for solving of the non-state pension provision strategy selection could be the topic for future research.

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