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Dynamic Weighted Sum Multi-Criteria Decision Making: Mathematical Model

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ABSTRACT : *Multi-criteria decision making is a sub discipline of operations research that explicitly considers multiple criteria in decision making problems. Several methods have been proposed for solving multi-criteria decision making problems (MCDM). The weighted sum method (WSM) is the best known and simplest multi-criteria decision making method for evaluating a number of alternatives in terms of a number of decision criteria. The current Weighted Sum Method helps the decision maker to choose when the scenario is static. However, the time consideration is another significant factor that influences decisions. In this study, a mathematical model is presented for a Dynamic Weighted Sum Method (DWSM). Moreover, optional applications of DWSN are discussed.*

KEYWORDS : *Multi-criteria decision making, weighted sum method and Dynamic Weighted Sum Method.*

I. INTRODUCTION

Decision making is the study of identifying and choosing alternatives based on the values and preferences of the decision maker. Making a decision implies that there are alternative choices to be considered, and in such a case, we want not only to identify as many of these alternatives as possible but also to choose the one that best fits our goals, objectives, desires, and values [1]. Multi-criteria decision making is concerned with structuring and solving decision and planning problems involving multiple criteria. Its purpose is to support decision makers facing such problems. Typically, there is no unique optimal solution for such problems, and it is necessary to use the decision maker's preferences to differentiate among solutions [2]. In our daily lives or in professional settings, there are typically multiple conflicting criteria to be evaluated in making decisions. Cost or price is usually one of the main criteria. Some measure of quality is typically another criterion that is in conflict with the cost. In purchasing a car, cost, comfort, safety, and fuel economy may be some of the main criteria we consider.

It is unusual for the cheapest car to be the most comfortable and the safest. In portfolio management, we are interested in getting high returns but at the same time reducing our risks. Again, the stocks with the potential for high returns typically also carry high risks of losing money. In the service industry, customer satisfaction and the cost of providing service are two conflicting criteria that would be useful to consider. In our daily lives, we usually weigh multiple criteria implicitly, and we may be comfortable with the consequences of such decisions that are made based on only intuition. On the other hand, when the stakes are high, it is important to properly structure the problem and explicitly evaluate multiple criteria. In deciding whether to build a nuclear power plant, and where to build it, there are not only very complex issues involving multiple criteria, but there are also multiple parties who are deeply affected by the consequences. The Weighted Sum Method (WSM) is probably the best known and most widely used method of multiple-criteria decision making. The method is explained clearly by [3], and a basic discussion is given by [4]. To each of the criteria in SAW, the decision maker assigns importance weights, which become the coefficients of the variables. These weight coefficients must be normalized.

To reflect the decision maker's marginal worth assessments within the criteria, the decision maker also creates a numerical scaling of the intra-criteria values. The decision maker can then obtain a total score for each alternative by simply multiplying the scale rating for each criteria value by the importance weight assigned to the criteria and then summing these products over all the criteria. After the total scores are computed for each alternative, the alternative with the highest score (the highest weighted average) is recommended to the decision maker. The current Weighted Sum Method assists the decision maker when the scenario is static. However, the time consideration is another significant factor that often influences decisions. In this study, a mathematical model is presented for a Dynamic Weighted Sum Method (DWSM). In addition, a numerical example is presented to explain the DWSM, and some Potential applications of DWSM have been discussed.

II. MATHEMATICAL MODEL OF DWSM

Mathematically, the Dynamic Weighted Sum Method can be described as follows. Its decision and weight matrixes are shown in Figure 1. Suppose the decision maker assigns a set of importance weights to the criteria,

$w = (w_1, w_2, \ldots\ldots w_n)$. (1)

The weights w_j should be normalized so that

$\sum_{j=1}^{n} w_j = 1$ (2)

Linear scale transformation is a straightforward process to divide the product of a definite criterion by its maximum value, on the condition that the criteria are defined as benefit criteria (the larger x_j , the greater preference); then, the transformed result of x_{ij} is

$r_{ij} = \frac{x_{ij}}{x^*_j}$ where, $x^*_j = \max_i x_{ij}$ (3)

where $0 < r_{ij} < 1$, i.e., the value of r_{ij} will be between 0 and 1.

O (s) are the outcomes, and the most preferred outcome O* will be selected such that

$O^* = \{O_i | \max_i \sum_{j=1}^{n} w_j x^*_{ij\,(t)} / \sum_{j=1}^{n} w_j\}$ (4)

where, C_j is the criteria and $x^*_{ij\,(t)}$ is the outcome of the i^{th} outcome and the j^{th} criteria at time (t).

Note that $x^*_{ij\,(t)}$ can be changed based on the decision maker:

$x^*_{ij\,(t)} = \min x_{ij\,(t)}$ (5)

$x^*_{ij\,(t)} = \max x_{ij\,(t)}$ (6)

$x^*_{ij\,(t)} = \text{mean } x_{ij\,(t)}$ (7)

$x^*_{ij\,(t)} = \text{median } x_{ij\,(t)}$ (8)

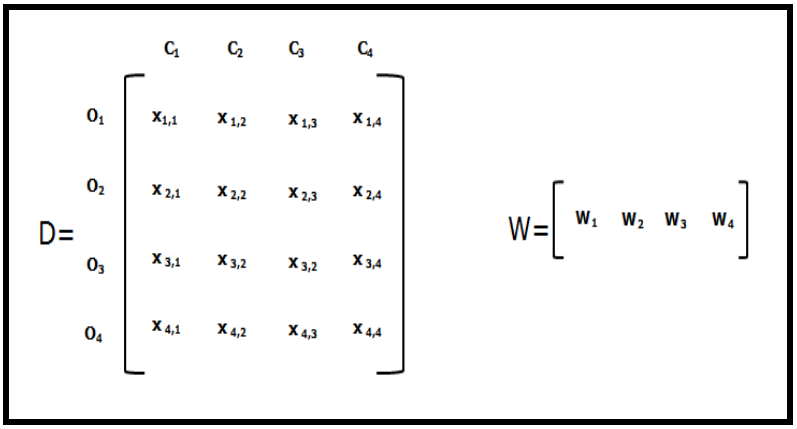

Figure 1: The decision and weight matrixes of DWSM.

III. POTENTIAL APPLICATIONS

This dynamic multi-criteria decision making model can be widely applied. The DWSM might be used by organizations that wish to make better decisions when time is an important consideration. This model could be used by education and training providers, politicians, doctors, and financers. In addition, Personnel Selection problem is one of a good application to use DWSM. Due to its simplicity of this method, a fast implementation can be performed for a larger number of criteria and criteria.

IV. CONCLUSION

Decision making is the discipline of identifying and choosing alternatives based on the values and preferences of the decision maker. Multi-criteria decision making is a field within operations research that addresses multiple criteria in decision making problems. Several methods have been proposed for solving multi-criteria decision making problems, but the Weighted Sum Method (WSM) is the best known and widely used method of Multiple-Criteria Decision Making. The Weighted Sum Method is time independent and can be described as a static weighted sum method. The Dynamic Weighted Sum Model has been introduced in this study, and the mathematical model for it has been presented. This model does not require very complex

operations, and it can be used in the fields of economics, education, politics, medicine, and the social sciences.

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