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Trade-Off Value Precision Analysis On Ideal Solution Value In Distance Based Multi Criteria Decision-Making Techniques

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Abstract

Most of the problems that exist in this world fall into the category of multi-criteria decision-making problems. Multi-criteria decision-making problems are characterized by conflicting objectives on a problem to be decided or resolved. Most of the problems in an industry are also included in the category of multi-criteria decision-making problems. Multi-criteria decision making is done by determining the trade-off value of conflicting objective functions using multi-criteria decision-making techniques. The trade-off value is the compromised solution value of conflicting objective-function objectives. A good trade-off value is a trade-off value that is close to the ideal solution value of each objective function. To determine the trade-off value in multi-criteria decision making, multi-criteria decision-making techniques can be used. Distance-based multi-criteria decision-making techniques include the minimum deviation method and the global criterion method. The precision of the trade-off value to the value of the ideal solution is needed by the industry when making decisions. A precise trade-off value, one that is very close to its ideal value, will help the industry make the best decisions. This research will analyze the multi-criteria decision-making techniques based on distance in producing the trade-off value. Through this research, we will find the most precise distance-based multi-criteria decision-making technique in generating trade-off values so that it can be a reference for the management of an industry in choosing the best multi-criteria decision-making technique when solving multi-criteria decision-making problems in the industry. Based on the analysis that has been done, it can be concluded that the minimum deviation method is more precise than the global criterion method in producing a trade-off value.

Keyword: distance-based multi-criteria decision-making techniques, precision, the trade of value, ideal value

I. INTRODUCTION

I.1. Background of the problem

Most of the problems that exist in this world fall into the category of multi-criteria decision-making problems. Multi-criteria decision-making problems are characterized by conflicting objectives on a

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problem to be decided or resolved. Conflicting objectives mean that the optimization of the objective function will reduce the level of optimality of the other objective functions. Most of the problems in an industry are also included in the category of multi-criteria decision-making problems; for example, suppose that industry has the goal of maximizing customer satisfaction and minimizing operating costs. This includes multi-criteria decision-making problems because maximizing customer satisfaction requires additional operational costs; even though the industry has a second objective, namely minimizing operational costs, these are two conflicting objectives, which are characteristic of multi-criteria decision-making problems.

Multi-criteria decision making is done by determining the trade-off value of conflicting objective functions using multi-criteria decision-making techniques. The trade-off value is the compromised solution value of conflicting objective-function objectives. A good trade-off value is a trade-off value that is close to the ideal solution value of each objective function on a multi-criteria problem.

To determine the trade-off value in multi-criteria decision making, multi-criteria decision-making techniques can be used. Distance-based multi-criteria decision-making techniques include the minimum deviation method, global criterion method, goal programming, and compromise programming. Distance-based here means that the multi-criteria decision-making techniques attempt to minimize the distance or deviation between the trade-off value and the ideal solution value. In distance-based multi-criteria decision-making techniques, the deviation of the trade-off from the ideal value occurs naturally without being regulated by the decision-maker, so that the level of goodness of the distance-based multi-criteria decision-making techniques can be measured through the level of precision between the trade-off values against its ideal value.

Most of the problems in the industry fall into the category of multi-criteria decision-making problems so that the precision of the trade-off value against the ideal solution value is needed by the industry when making decisions. A precise trade-off value, one that is very close to its ideal value, will help the industry make the best decisions.

This research will analyze the multi-criteria decision-making techniques based on distance in producing the trade-off value. Through this research, we will find the most precise distance-based multi-criteria decision-making technique in producing the trade-off value and what factors affect the precision of the trade-off value of a multi-criteria decision-making technique so that it can become a reference for the management of an industry. In choosing the best multi-criteria decision-making technique when solving multi-criteria decision-making problems that exist in the industry.

I.2. Formulation of the problem

Based on the description in the background of the problem above, the problem raised in this study is how to analyze the precision of the trade-off value against the ideal solution value in distance-based multi-criteria decision-making techniques?

I.3. Scope of the problem

So that the discussion of the problems carried out is not too wide so that it deviates from the problems formulated, it is necessary to limit the problem. The limitation of the problem in this study is that the precision analysis of the trade-off value against the ideal solution value is only carried out on distance-based decision-making techniques, namely the minimum deviation method and the global criterion method.

I.4. Research purposes

The aim of this research is to analyze the precision of the trade-off value against the ideal solution value in distance-based multi-criteria decision-making techniques.

II. LITERATURE REVIEW

II.1. Multi-Criteria Decision Making

Multiple Criteria Decision Making is a method of the alternative selection process to obtain optimal solutions from several alternative decisions by taking into account more than one criterion or objective that is in conflicting situations. This paradigm differs from the traditional point of view of the problem of finding the optimal solution to a decision. A complex decision problem is modeled only as a simple problem of a single objective decision optimization model. So that there is an excessive reality problem implication, in the end, the decision solution fails to find a real solution to the problem. This means that the single-approach optimization model approach fails to accommodate the "heterogeneity," dynamics, and conditions of the conflicting criteria (Rahardjo et al., 2000).

Multi-criteria decision making becomes more complex because it takes into account many criteria that need to be formulated explicitly. In a single objective decision situation, the evaluation process to get the optimal solution from a set of alternative solutions can be done relatively easily because the decision solution is a unique solution in terms of one objective only, meaning that the decision does not meet a "trade-off" situation with the achievement of other objectives.

Si et al. (2016) divide the scientific taxonomy of multi-criteria decision making into two different approaches, namely: Multiple Objective Decision Making (MODM) and Multiple Attribute Decision Making (MADM). Each of them has different characteristics, attributes, and properties, as well as applications to solve various decision problems.

II.2. Minimum Deviation Method

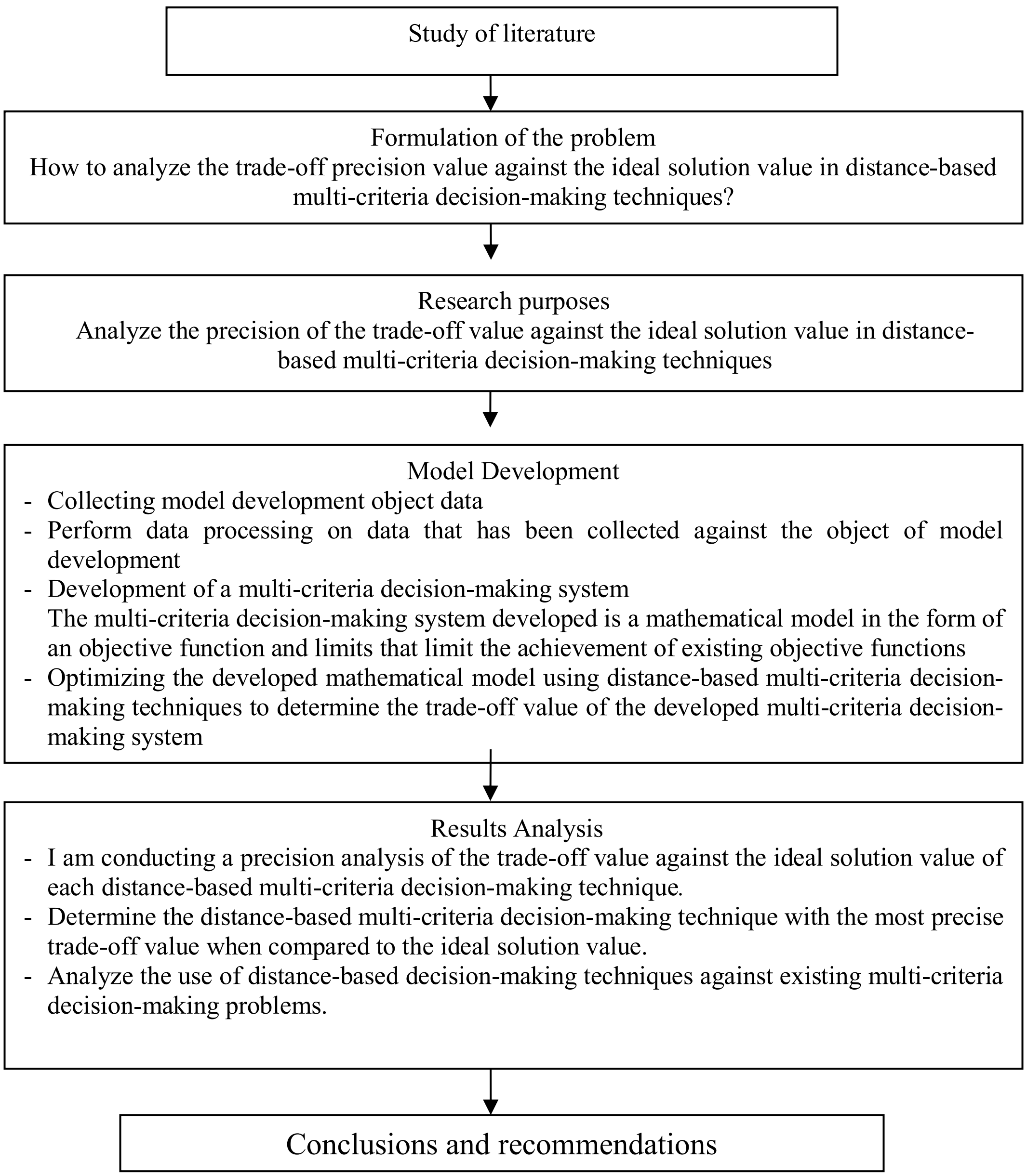
This method is applied when the analyst has partial information; that is, the optimal value of the objectives is known, but the relative importance of each objective is unknown. The objective of this method is to determine a trade-off value that minimizes the number of individual fractional objective deviations. The fractional deviation of an objective refers to the ratio between the deviation of the objective value from the individual's optimal solution and the maximum deviation. The maximum deviation of objective results from the difference between the individual solution and the smallest solution desired, in relation to the individual optimal solution of one or more goals. (Indrianti and Sutrisno, 2014).

II.3. Global Criterion Method

The global criterion method is a multi-objective problem-solving method in multi-criteria decision-making problems. The global criterion method is one of several methods included in the unifying objective function approach group. The principle of the global criterion method is to create a global objective function that minimizes the total deviation of the value of the individual objective function against ideal values (as a ratio to ideal values (Indrianti and Sutrisno, 2014).

III. RESEARCH METHODOLOGY

The research steps taken can be seen in the following research framework.



Gambar 1.KerangkaPenelitian

IV. FINDING AND DISCUSSION

IV.1. Data collection

The company that is the object of this research is the food company X, which makes this. The data needed to develop a multi-criteria decision-making model in this company are labor capacity data, labor availability data, raw materials, production processes, processing time observation data, product sales data, production cost data, product selling prices, and maximum production quantities of each product.

IV.2. Data processing

The data that has been collected will be processed to determine the parameters, constants, and decision variables of the developed mathematical model. Furthermore, it can be developed a mathematical model consisting of two conflicting objective functions and a barrier to the achievement of these two company goals.

IV.2.1. Development of a Multi-Criteria Decision Making System

The multi-criteria decision-making system developed is in the form of a mathematical model consisting of two conflicting company goals and limiting the achievement of these two goals. The stages of developing mathematical nodules in this problem are

IV.2.1.1.Determine the decision variable

The decision variable is the output that will be optimized so that it meets the target criteria and constraints. Thus, the decision variable is the number of each type of product to be made in lots, one lot = 24 product units.

X_1 = the number of Phia Cheese products being produced (lot)
X_2 = the number of Phia Cappuccino products produced (lot)
X_3 = the number of Phia Pineapple products produced (lot)
X_4 = the number of Phia Chocolate products being produced (lot)
X_5 = the number of Phia Strawberry products being produced (lot)
X_6 = the number of Phia Nuts products being produced (lot)

IV.2.1.2. Determine the objective function

The objective function of this model is to minimize production costs and maximize production output. The objective function formulation is as follows:

$$Min\ Z_1 = f_1(X) = 255298{,}82X_1 + 192333{,}12X_2 + 289717{,}72X_3 + 312385{,}87X_4 + 313572{,}01X_5 + 334434{,}68X_6$$

$$Max\ Z_2 = f_2(X) = X_1 + X_2 + X_3 + X_4 + X_5 + X_6$$

IV.2.1.3. Determine the constraint function

a) Demand Limits

The formulation of the demand limitation function is as follows:

$$X_1 \geq 93$$
$$X_2 \geq 55$$
$$X_3 \geq 57$$

b)

$$X_4 \geq 45$$
$$X_5 \geq 68$$
$$X_6 \geq 60$$

b) Limits on the availability of working hours

The function formulation for limiting the availability of working hours is as follows:

$$511{,}104X_1 + 494{,}64X_2 + 501{,}264X_3 + 483{,}96X_4 + 487{,}824X_5 + 488{,}04X_6 \leq 286000$$

c) Limitation of production level

The function formulation for the production level limitation is as follows:

$$X_1 \leq 140$$
$$X_2 \leq 90$$
$$X_3 \leq 90$$
$$X_4 \leq 70$$
$$X_5 \leq 80$$
$$X_6 \leq 90$$

d) Nonnegative boundaries

A limit that states that the amount of phia produced cannot be negative. A nonnegative limit is:

$X_1, X_2, X_3, X_4 \geq 0$

IV.2.2. Determination of the Trade-Off Value

IV.2.2.1. Using the minimum deviation method

a) Determining individual solutions

The individual solution of Z_1 is :

$$X_1 = 93$$
$$X_2 = 55$$
$$X_3 = 57$$
$$X_4 = 42$$
$$X_5 = 68$$
$$X_6 = 60$$

With value $-Z_1$ *= -104228600, so the value Z_1 *= 104228600

b) The individual solution of Z_2 is :

$$X_1 = 126{,}5$$
$$X_2 = 90$$
$$X_3 = 90$$
$$X_4 = 70$$
$$X_5 = 80$$
$$X_6 = 90$$

c)

With value Z_2 *= 546,5

b) Creating *Pay-off* Table

	X^{1^*}	X^{2^*}
$f_1(X)$	-104228600	-155140489,3
$f_2(X)$	373	546,5

c) Performing Computation Procedures

The formulation of the Minimum Deviation Method mathematical model is as follows:

$$MinZ_0 = \left[\frac{-104228600 - \begin{pmatrix} -255298{,}82X_1 - 192333{,}12X_2 - 289717{,}72X_3 \\ -312385{,}87X_4 - 313572{,}01X_5 - 334434{,}68X_6 \end{pmatrix}}{-104228600 - (-155140489{,}3)} \right]$$

$$+ \left[\frac{546{,}5 - (X_1 + X_2 + X_3 + X_4 + X_5 + X_6)}{546{,}5 - (373)} \right]$$

Subject to :

$$X_1 \geq 93$$
$$X_2 \geq 55$$
$$X_3 \geq 57$$
$$X_4 \geq 42$$
$$X_5 \geq 68$$
$$X_6 \geq 60$$
$$511{,}104X_1 + 494{,}64X_2 + 501{,}264X_3 + 483{,}96X_4 + 487{,}824X_5 + 488{,}04X_6 \leq 286000$$
$$X_1 \leq 150$$
$$X_2 \leq 90$$
$$X_3 \leq 90$$
$$X_4 \leq 70$$
$$X_5 \leq 80$$
$$X_6 \leq 90$$
$$X_1, X_2, X_3, X_4 \geq 0$$

Then the optimal point using the Minimum Deviation Method is:

$X_1 = 150$, $X_2 = 90$, $X_3 = 57$, $X_4 = 42$, $X_5 = 68$, $X_6 = 60$

With trade-off value (compromise solution):

$Z_1 = 125403895{,}6$

$$Z_2 = 467$$

IV.2.2.2.Using the global criterion method

a) Determining individual solutions

Individual solutions are the same as searching for using the minimum deviation method.

b) Creating *Pay-off* Table

The pay-off table is the same as the pay-off table for searching using the minimum deviation method.

c) Performing Computation Procedures

The formulation of the global criterion method mathematical model is as follows:

$$MinZ_0 = \left[\frac{-104228600 - \begin{pmatrix} -255298,82X_1 - 192333,12X_2 - 289717,72X_3 \\ -312385,87X_4 - 313572,01X_5 - 334434,68X_6 \end{pmatrix}}{-104228600} \right]$$

$$+ \left[\frac{546,5 - (X_1 + X_2 + X_3 + X_4 + X_5 + X_6)}{546,5} \right]$$

Subject to :

$$X_1 \geq 93$$
$$X_2 \geq 55$$
$$X_3 \geq 57$$
$$X_4 \geq 42$$
$$X_5 \geq 68$$
$$X_6 \geq 60$$
$$511,104X_1 + 494,64X_2 + 501,264X_3 + 483,96X_4 + 487,824X_5 + 488,04X_6 \leq 286000$$
$$X_1 \leq 150$$
$$X_2 \leq 90$$
$$X_3 \leq 90$$
$$X_4 \leq 70$$
$$X_5 \leq 80$$
$$X_6 \leq 90$$
$$X_1, X_2, X_3, X_4 \geq 0$$

Then the optimal point to use the Global Criterion Method is:

$$X_1 = 140\ ,\ X_2 = 90\ ,\ X_3 = 57\ ,\ X_4 = 45\ ,\ X_5 = 68\ ,\ X_6 = 62$$

With trade-off value (compromise solution):

$$Z_1 = 125403995,8$$

$$Z_2 = 435$$

IV.2.3. Analysis of Results

The distance-based multi-criteria decision-making techniques discussed here, namely the minimum deviation method and global criterion method, are suitable if the decision-maker or here is that the company's management does not know or does not understand the importance of each company's goals. This means that from each company goal, management has not been able to determine the weight or level of importance of each company goal. In the mathematical model formula, the minimum deviation method and global criterion method can be seen that the objective function does not involve the weight of the importance of each objective function so that the minimum deviation (the difference between the trade of value and the ideal solution of each objective function) is not influenced by the weight of importance. From each objective function, or in other words, the minimization of the deviation obtained is purely based on the behavior of the method.

Based on the results of determining the trade-off value, it can be seen that the deviation of the trade-off value against the ideal solution at the minimum deviation method is (125403895,6 - 104228600) + (546,5 – 467) = 21175375,1; while the deviation of the trade-off value against the ideal solution in the global criterion method is (125403995,8 – 104228600) + (546,5 – 435) = 21175507,3. In the deviation of the trade-off value against the ideal solution obtained, it can be seen that the deviation in the minimum deviation method is smaller than the global criterion method so that the minimum deviation method can be said to be more precise than the global criterion method. One of the reasons that the minimum deviation method has a smaller deviation compared to the global criterion method is the denominator in the objective function in the mathematical model formulation of the minimum deviation method; the result is greater than the denominator in the objective function in the global criterion method mathematical model formulation.

V. CONCLUSION AND FURTHER RESEARCH

V.1. Conclusion

Based on the analysis carried out, it can be concluded that distance-based decision-making techniques, such as the minimum deviation method and the global criterion method, are more suitable to be applied to a situation where the decision-maker does not know the level of importance of each of the existing objectives. Based on the analysis carried out, it can also be concluded that the minimum deviation method is more precise in producing a trade-off value than the global criterion method.

V.2. Further research

For further research, it would be better to consider other distance-based multi-criteria decision-making techniques to analyze the precision of the resulting trade-offs, such as goal programming and compromise programming.

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