ADVANCED FUZZY DECISION SUPPORT MODEL FOR EVALUATING THE CRYPTOCURRENCY'S PERFORMANCE

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ABSTRACT

Cryptocurrency is a digital currency that uses a cryptographic system as a protection system so that transaction processes can be carried out safely. Digital currency is used as an investment which is seen as a trading commodity whose profits are derived from the difference between the buying price and the selling price. Of the many types of existing cryptocurrencies, an investor or layman who is new to cryptocurrencies must be careful in choosing investment options, because each cryptocurrency has performance (criteria). Therefore, to determine the performance of cryptocurrencies, an analysis is carried out using a Decision Support Model (DSM). DSM is used to evaluate the performance of cryptocurrencies in conducting transactions by applying the advanced fuzzy method. The data used comes from the Kaggle website "Cryptocurrency Historical Prices" and "Cryptocurrency Prices Data" for the period January 1 2021 to June 30 2022 which consists of 23 types of cryptocurrency. The parameters used are price trends, price consistency, and transaction volume consistency. Evaluation is done by performing verification and validation. The results of this study are cryptocurrency performance based on defuzzification using Mean of Maximum used to find the best type of cryptocurrency. The type of cryptocurrency that gets the best performance is Bitcoin with a performance value of 50.0. Meanwhile, the type of cryptocurrency that gets the worst performance value is Ethereum with a performance value of 29.5.

Keywords: *Advanced Fuzzy, Cryptocurrency, Decision Support Model, Evaluation, Mean of Maximum (MOM)*

1. INTRODUCTION

Cryptocurrency is a digital currency that uses a cryptographic system as a protection system so that transaction processes can be carried out safely [1]. In Indonesia, the government has granted permits to trade digital currency or cryptocurrency, so that many Indonesians use digital currency. According to a survey conducted by i-Finder as of December 2021, Indonesia ranks 4th out of 27 countries with 22.4% of cryptocurrency users [2].
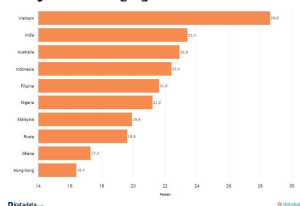

Figure 1. Cryptocurrency Users of the Year 2021

There are many types of cryptocurrency, there are 229 types of crypto currency in Indonesia which have

been registered with the Commodity Futures Trading Regulatory Agency (Bappebti) [3]. Cryptocurrency is used as an investment which is seen as a trading commodity whose profit is derived from the difference between the buying price and the selling price [4]. Of the many types of existing cryptocurrencies, an investor or layman who is new to cryptocurrencies must be careful in choosing investment options, because each cryptocurrency has performance (criteria). Therefore, to determine the performance of cryptocurrencies, an analysis is carried out using a Decision Support Model (DSM). DSM is used to evaluate the performance of cryptocurrencies in conducting transactions by applying the fuzzy method. The criteria used in this model are cryptocurrency price trends, price consistency, and transaction consistency.

Related research conducted by Utama [5], discusses cryptocurrency performance evaluation using simple fuzzy. In the research conducted, researchers succeeded in implementing DSM which can evaluate cryptocurrencies with three types of cryptocurrencies and over a period of 6 months. The parameters used are price trends,

price consistency, and number of transactions. The data is analyzed using fuzzy logic to produce that Bitcoin has the best performance with 36.39 points. Other research conducted by Ecer, Böyükaslan, & Zolfani [6] discusses Cryptocurrency evaluation for investment decisions in the Industrial Age 4.0. In this study, 15 types of cryptocurrencies were evaluated using an intuitionistic set-driven fuzzy methodology. This methodology combines evaluation based on distance from the average solution (EDAS), as well as using multi-attribute real ideal comparative analysis (MAIRCA) and using alternative measurements and ranking according to compromise solutions (MARCOS), so that this research produces the 3 best types of cryptocurrency namely Ethereum , Tether, and Bitcoin with some of the most influential factors to consider for investors such as reliable software, ease of insertion into wallets, and prominent price/trade volume volatility.

Based on the description, this research evaluates the performance of cryptocurrencies by applying the advanced fuzzy decision support model. The data used comes from the Kaggle website "Cryptocurrency Historical Prices" and "Cryptocurrency Prices Data" for the period January 1 2021 to June 30 2022 which consists of 23 types of cryptocurrency. The parameters used are price trends, price consistency, and transaction volume consistency. The novelty of this study is the use of the advanced fuzzy decision support model method using the defuzzification method, namely the Mean of Maximum (MOM) in determining the performance of cryptocurrencies on transactions of each type of crypto with the latest dataset in 2022. The fuzzy logic method is used because it has advantages, namely faster in computing, more intuitive, accepted by many parties, more suitable for input received from humans not by machines. Each IF-THEN rule is represented by a fuzzy set with a monotonous membership function. As a result, the output of each rule is given unequivocally based on the predicate alpha (α), then the final result is obtained using a centered average [7]. The purpose of this study is to analyze the performance of cryptocurrencies using the advanced fuzzy decision support model method using the defuzzification method, namely the Mean of Maximum (MOM), the results of which can contribute to consideration in making investments. The results of this study are the types of cryptocurrency that have the best performance in the most transactions, so investors can use them to choose the type of investment in crypto.

2. LITERATURE REVIEW

Research related to decision support models and cryptocurrency has been carried out using various methods, where the methods used in one field can of course be used also in other fields. The research related to the research to be carried out is as follows:

In a study conducted by Wan, et al [8], This study discusses the development of a model to assess maritime supply chain risk factors by combining the fuzzy trust rule approach with Bayesian networks. Compared to traditional risk analysis methods, this new method provides sensitive and flexible risk results in real situations, without sacrificing the ease of the modeling process and the transparency of the information that is passed through the model to the final results.

In the research conducted by Akcay & Manisali [9], This study discusses the fuzzy decision support model for selecting contractors in construction work. In this research, Istanbul University construction tenders were evaluated and as a result, it has been revealed that certain problems were experienced with companies that had secured the job due to very low bids. This study has revealed a decision model by Fuzzy Logic which will display other aspects that will affect quality and duration while deciding the most economically profitable bid for tenders in construction works.

In research conducted by Prieto, Macías-Bernal, Silva, & Ortiz [10], This study discusses fuzzy decision support systems for securing tangible and intangible cultural heritage. The fuzzy logic model proposed in this study can assist in systematizing maintenance interventions in terms of decision making by stakeholders. Automated interventions and maintenance actions can reduce consumption of natural resources, enabling more rational management of future maintenance operations in cultural heritage. The ART-RISK2.5 Tool can be of great use to stakeholders (public and private administration) and non-specialized users, as an important reference on diagnosis, including an updated, inexpensive and sustainable methodology for managing monument preservation, that is easy to use in developed and developing countries. develop.

In a study conducted by Budiman, et al [11], This study discusses the evaluation of the behavior of individual crypto investors in making investment decisions. the results of the study can

be concluded that the existence of financial literacy, risk tolerance, and overconfidence will encourage investor behavior to make crypto investment decisions. In addition, the experience regret factor, where most crypto investors have had a bad experience, still does not rule out investors making investment decisions in crypto again.

In research conducted by Utama [5], discusses cryptocurrency performance evaluation using simple fuzzy. In the research conducted, researchers succeeded in implementing DSM which can evaluate cryptocurrencies with three types of cryptocurrencies and over a period of 6 months. The parameters used are price trends, price consistency, and number of transactions. The data is analyzed using fuzzy logic to produce that Bitcoin has the best performance with 36.39 points.

Related research conducted by Purwanti & Ekawati [12] discusses the use of fuzzy logic in determining community satisfaction with the performance of sub-district employees using the mamdani method. Based on the results of testing the data that has been processed, the results of manual calculations are 68.4162 while for testing the system using Matlab the results are 68.7. Based on the test results, it can be concluded that the fuzzy logic of the Mamdani method can be used to determine community satisfaction with the performance of employees in Sagulung District.

Related research conducted by Handayani & Wibowo [13] which discusses the analysis of the influence of selecting the number of membership function linguistic variables on the Fuzzy Simple Additive Weighting (FSAW) method for ranking scholarship acceptance for underprivileged students at Petompon 02 State Elementary School. The results of measuring accuracy to analyze the success of the algorithm for ranking scholarship acceptance for underprivileged students can be done with the accuracy formula on the confusion matrix, and the results obtained for selecting the number of linguistic variables 5 have an accuracy value of 83.69% and for parameter selection the number of linguistic variables 7 has an accuracy value of 96.08%.

Related research conducted by Havid [14] which discusses the application of the Tsukamoto fuzzy logic method for determining student achievement at SMAN 1 South Sangatta. The Tsukamoto Fuzzy Logic Method can be applied in making decisions in determining student achievement based on predetermined criteria using the Tsukamoto fuzzy method. There are 4 assessment criteria for determining outstanding students, namely report cards, attendance, attitude and extracurricular values. Tsukamoto's Fuzzy Logic method embedded in the system is running well where it is shown in the results of manual calculations with the system that a 100% conformity is obtained.

Related research conducted by Amriana, Kasim, & Maghfirat [15] discusses the determination of the price of oil palm Fresh Fruit Bunches (FFB) using the fuzzy logic method. This study uses 100 data to be tested using MAPE so that a percentage value of 85.75% is obtained. While the average value of the difference between the actual data and the fuzzy mamdani results is 17852 with an average error percentage of fuzzy mamdani is 14.25%. The result of this system is the output variable of oil palm FFB prices based on 5 input variables. The Mamdani Fuzzy Logic method determines the result of an uncertain value. The fuzzy logic process starts from the formation of fuzzy sets, then the application of implication functions, then the rule composition stage, then the deffuzification stage.

Related research conducted by Santosa & Hidayat [16] which discusses the model for determining the number of orders in the chicken egg supply chain activity using fuzzy logic. The variables used in developing the fuzzy set model are the price of eggs/crate, the composition of the weight of the eggs in the crate and the number of egg stocks in the warehouse at the time of order. The membership set of the number of egg orders uses the Tringular and Trapezodial membership functions. The fuzzy set model produced in this study can be used as a decisionmaking tool in determining the optimal number of egg orders from suppliers.

Based on related research that has been done previously, it can be concluded that the use of the decision support model has been successfully implemented and can assist in decision making. This is proven by research conducted by Akcay & Manisalı [9] which discusses the application of fuzzy logic in the use of decision support models and results that the Fuzzy Logic decision model can display other aspects that will affect quality and duration while deciding on decision outcomes.

Therefore, researchers will use the Fuzzy Mamdani model (Min-Max) with the development of the deffuzification method, namely the Mean of Maximum (MOM) method to evaluate cryptocurrency's performance. From this research it is hoped that it can help an investor or ordinary person who is new to crypto currency choose which investment to make.

3. RESEARCH METHODS

In this research, the research stages are described in the form of a flowchart so that it can be easily understood. The flowchart of the research stages in the advanced fuzzy decision support model for evaluating the cryptocurrency's performance can be seen in Figure 2.
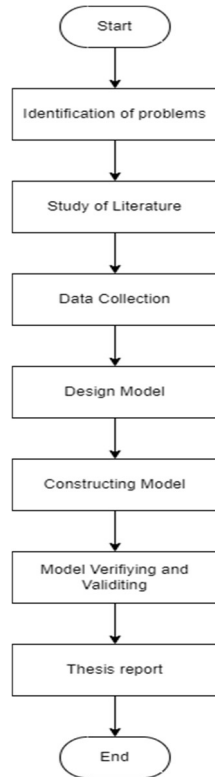

Figure 2. Research Stages

From Figure 2 the research method used, there are several stages that must be carried out, namely problem identification, literature study, data collection, model design, model construction, model verification and validation, and finally making a final report. Problem identification is the stage of identifying problems, in this study related to the many types of cryptocurrencies that can be used as investment options. The literature study stage is carried out to find and understand literature to support research. The data collection stage is carried out to collect data on the research to be carried out. The model design stage is carried out by designing the model. The construction stage is carried out to build a model to evaluate the performance of cryptocurrencies using advanced fuzzy decision support model

namely the Mean of Maximum (MOM) defuzzification method so that you can find out the best type of cryptocurrency. The verification and validation stage is carried out to evaluate the model that has been created to determine the performance of the model, in this study using the MoM method to obtain the average value taken in the membership function domain maximum value [18]. The last stage is to make a thesis report based on the results of the research that has been carried out.

4. RESULTS AND DISCUSSION

4.1 Algorithm Models

In this study, the algorithm model uses activity diagrams and class diagrams to describe a model to be built.
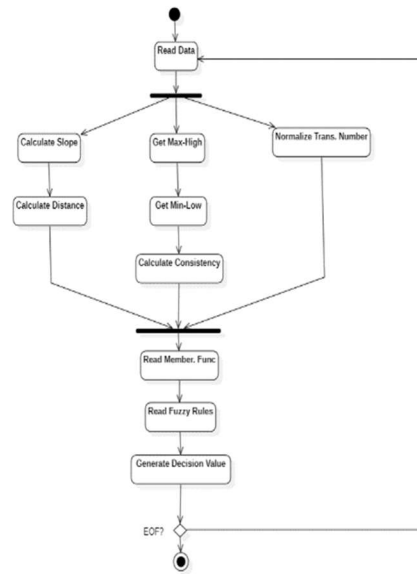

Figure 3. Activity Diagram

From Figure 3 it is explained that in this study the first step taken was to read the data that had been previously entered. In this study, researchers used a dataset sourced from public data, namely Kaggle Cryptocurrency Historical Prices. The next step is to do the join process on the Calculate Slope, Get Max-High and Normalize Trans Number processes. From each process it has the next stage as in the Calculate Slope stage then it processes Calculate Distance, Get Max-High will perform Calculate Slope and Calculate Consistency so as to produce membership

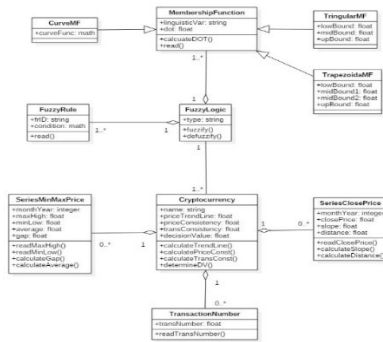functions and fuzzy rules and the final stage is to generate decision values.

Figure 4. Class Diagram

From Figure 4 is a class diagram that is used consisting of several classes that are related to each other with other classes in the system.

4.2 Research Results

In this study using the Python programming language to build the model. The Advanced Fuzzy Decision Support Model is used to evaluate cryptocurrency performance.

The dataset used has several criteria, namely open, high, low, close, volume, marketCap, timestamp, crypto_name and date. These criteria will be used to evaluate the type of cryptocurrency.

The type of decision that is produced is the result of information and data that has been processed using a model that has been built to support decisions in determining the type of cryptocurrency based on its performance, where this decision is taken based on price trends (slope distance), price consistency, and consistency. number of transactions (transaction consistency).

In the fuzzification process there is a slope distance consisting of 3 categories, namely good, medium and bad. The good category has a value range of 0 – 4.86, the medium category has a value range of 4.86 – 1.25 and the bad category has a value range of 4.86 – 9.65. The slope distance graph can be seen in Figure 5.
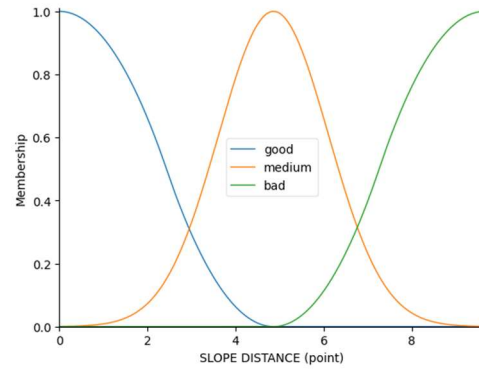

Figure 5. Slope Distance

Next, calculate the linear regression value which results in Figure 6.

In the results of the linear regression method, the results of slope, max, min, mean, transaction consistency, price consistency of each type of cryptocurrency are obtained.

Figure 6. Results of the Linear Regression Method

After getting the linear regression value, look for the membership value of each type of cryptocurrency. The results of the membership degree values can be seen in Figure 7. In the table there is Cryptocurrency information, Slope which is the value of the slope of the line, Price Consistency is the price of consistency, Transactions are transactions carried out on each type of cryptocurrency.

	Cryptocurrency	Slope	Price Consistency	Transaction consistency
0	Bitcoin	-12.781636	67563.475932	6.387204e+05
1	BNB	0.574456	675.677808	3.953492e+04
2	Chainlink	-0.035985	52.197651	2.918045e+04
3	Dogecoin	0.000066	0.657632	5.095736e+04
4	Ethereum	3.851519	4811.966821	3.658484e+05
5	FTXToken	0.045444	79.870351	3.266669e+03
6	Tether	-0.000002	1.011365	1.275327e+06
7	USDCoin	-0.000001	1.010331	4.662656e+04

Figure 7. Result of Membership Degree Value

The maximum value of each attribute is the slope of 3.85, the price consistency of 67563.47 and the maximum transaction consistency value of 1275326.81.

The resulting fuzzy representation of membership degrees can be seen in Figure 8. The Bad category is marked with a blue line, the Medium category is marked with a green line and the Good category is marked with a red line.
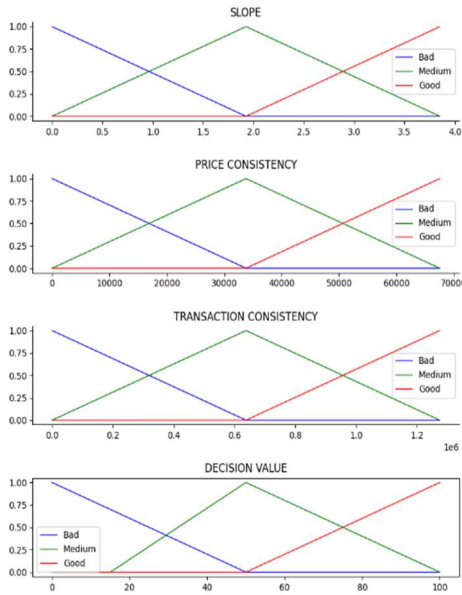

Figure 8. Membership Degree Fuzzy Representation

Based on Figure 8, a fuzzy representation of the degree of membership can be explained as follows:
1. Category/Set of SLOPE
   a. In the Bad category, it has a slope value of <1.9
   b. In the Medium category it has a slope value of 0.0 – 3.8
   c. In the Good category it has a slope value of > 1.9

   Example of reading fuzzy membership values:

   a. The slope value of 1.5 is included in the Bad fuzzy set with a membership value of 0.24.
   b. The slope value of 2.5 is included in the Medium and Good fuzzy sets with a membership value of 0.40.
2. PRICE CONSISTENCY Category/Group
   a. In the Bad category, it has a price consistency value of <32000
   b. In the Medium category, it has a price consistency value of 0 – 68000
   c. In the Good category, it has a price consistency value of > 32000

   Example of reading fuzzy membership values:
   a. The price consistency value of 10000 is included in the fuzzy Bad set with a membership degree value of 0.30.
   b. The price consistency value of 50000 is included in the Good and Medium fuzzy sets with a membership degree value of 0.49.
3. Category/Set of TRANSACTION CONSISTENCY
   a. The Bad category has a transaction consistency value < 0.7
   b. In the Medium category, it has a transaction consistency value of 0.0 – 1.3
   c. In the Good category, it has a transaction consistency value of > 0.7

   Example of reading fuzzy membership values:
   a. The transaction consistency value of 0.4 is included in the Bad fuzzy set with a membership degree value of 0.49.
   b. The transaction consistency value of 1.0 is included in the Good and Medium fuzzy sets with a membership degree value of 0.70.
4. Category/Set of DECISION VALUE
   a. In the Bad category, it has a decision value <50
   b. The Medium category has a decision value of 18-100
   c. In the Good category, it has a decision value > 50

   Example of reading fuzzy membership values:

a. The decision value of 20 is included in the Bad and Medium fuzzy sets with a membership value of 0.20.

b. The decision value of 60 is included in the Medium and Good fuzzy sets with a membership value of 0.30.

The next step is to determine the rules of advanced fuzzy using the rules activation function to create rules for each degree of fuzzy membership. In this study there are 3 rules is:

1. Rules 1
   IF Slope level bad AND Price Consistency level bad AND Transaction Consistency level bad THEN Decision Value bad.

2. Rules 2
   IF Slope level medium AND Price Consistency level medium AND Transaction Consistency level medium THEN Decision Value medium.

3. Rules 3
   Slope level high AND Price Consistency level high AND Transaction Consistency level high THEN Decision Value good

The fuzzy aggregation and defuzzification processes are carried out using the rules that have been made. The defuzzification stage is used for the process of mapping the magnitude of the fuzzy set into crisp values, so that the cryptocurrency performance values are obtained. The evaluation used to produce the performance value of the best cryptocurrency uses the mean of maximum for the cryptocurrency dataset. The mean of maximum (Mom) is done by taking the average z value of the degree of membership.

The results of the evaluation of the MoM calculation for cryptocurrency get the result that the type of cryptocurrency that has the best performance is Bitcoin with a performance value of 50.0. Meanwhile, the type of cryptocurrency that gets the worst performance value is Ethereum with a performance value of 29.5.

Table 1. Cryptocurrency Evaluation Results

Crypto currency	Slope	Price Consistency	Transaction Consistency	Performance
Bitcoin	-12.781636	67563.475932	6.387204e+05	50.0
Tether	-0.0000002	1.011365	1.275327e+06	32.5
Chainlink	-0.035985	52.197651	2.918045e+04	32.0
Dogecoin	0.000066	0.657632	5.095736e+04	32.0
FTXToken	0.045444	79.870351	3.266669e+03	32.0
USDCoin	-0.0000001	1.010331	4.662656e+04	32.0
BNB	0.574456	675.677808	3.953492e+04	30.5
Ethereum	3.851519	4811.966821	3.658484e+05	29.5

Based on the results of research that has been conducted on cryptocurrency performance, it can be concluded that the type of cryptocurrency that gets the best performance is Bitcoin with a performance value of 50.0. Meanwhile, the type of cryptocurrency that gets the worst performance value is Ethereum with a performance value of 29.5.

From the results of research that has been conducted on 8 types of cryptocurrencies used to evaluate performance using advanced fuzzy decision support models, there are differences in results from research conducted by Utama [5] who evaluated the performance of cryptocurrencies on 3 types, namely Bitcoin, Ethereum and Dogecoin with the best performance results obtained by Bitcoin with a performance value of 36.39, followed by Etehreum 36.12 and Dogecoin 15.06. Meanwhile, in this study the 3 best performances

were obtained by Bitcoin with a performance value of 50.0, Chainlink of 32.5 and Dogecoin 32.0.

In a study conducted by Budiman, et al [11], this study evaluates the behavior of cryptocurrency investors in making investment decisions which results in that there are factors that make investors invest, namely financial literaty, risk tolerance and overconfidence. Meanwhile, this study evaluates the performance of cryptocurrency to be considered by investors in making investments using the advanced fuzzy decision support model method with the evaluation method used, namely MoM which results in the type of cryptocurrency Bitcoin getting the best performance with a value of 50.0.

In research conducted by Akcay & Manisali [9] conducting contractor selection using the fuzzy decision support model method. The method used for evaluating contractor selection is fuzzy mamdani. Meanwhile, this study uses an advanced fuzzy decision support model that applies the MoM method to the defuzzification process.

5. CONCLUSION

From the results of research that has been carried out in the advanced fuzzy decision support model to evaluate cryptocurrency performance, conclusions are drawn, namely:

The parameters used for evaluating cryptocurrency performance use the Advanced Fuzzy Decision Support Model with Membership Function and Slope Distance, namely the slope, price consistency and transaction consistency of each type of cryptocurrency. The types of cryptocurrencies used are Bitcoin, BNB, Chainlink, Dogecoin, Ethereum, FTXToken, Tether, USDCoin.

In building a model using the Python programming language with Google Collab tools. The implementation of the fuzzy logic algorithm consists of stages, namely the formation of slope distance, calculating the mean value, the formation of a linear regression method to perform fuzzy representations, fuzzification, rules, fuzzy aggregates, defuzzification. The results of the parameters used for cryptocurrency performance using the Advanced Fuzzy Decision Support Model with Membership Function and Slope Distance successfully form a slope graph, price consistency, transaction consistency and decision value. Each membership function consists of 3 categories namely Bad, Medium and Good. Membership function slope has a slope value < 1.9

for the Bad category, 0.0 - 3.8 for the Medium category and > 1.9 for the Good category. The membership function price consistecy has a value < 32000 for the Bad category, 0 - 68000 for the Medium category and > 32000 for the Good category. Furthermore, the membership function transaction consistecy has a value < 0.7 for the Bad category, 0.0 - 1.3 for the Medium category and > 0.7 for the Good category. Next, the membership function decision value has a value of < 50 for the Bad category, 18 - 100 for the Medium category and > 50 for the Good category. The results of cryptocurrency performance calculated using the mean of maximum (MoM) method show that the type of cryptocurrency that gets the best performance is Bitcoin with a performance value of 50. Meanwhile, the type of cryptocurrency that gets the worst performance value is Ethereum with a performance value of 29.5.

From the conclusions that have been made, the limitations in this study are the types of cryptocurrencies using 8 types consisting of Bitcoin, Tether, Chainlink, Dogecoin, FTXToken, USDCoin, BNB, Ethereum to evaluate the performance of cryptocurrencies using an advanced fuzzy decision support model that applies the MoM method for evaluation at the defuzzification stage. The research suggestion is for research to implement the results of cryptocurrency performance evaluation in the form of a website application, so that it can be used by the public in knowing the performance of cryptocurrency types.

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