Available online at: http://e-jurnal.lppmunsera.org/index.php/JSMI

Jurnal Sistem dan Manajemen Industri

ISSN (Print) 2580-2887 ISSN (Online) 2580-2895

Design of red chili commodity pricing using the BPMN approach and Sugeno's fuzzy inference system

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ARTICLE INFORMATION

Article history:

Received: June 13, 2022
Revised: November 14, 2022
Accepted: December 24, 2022

Keywords:

BPMN
Margin
Pricing
Red chili commodity
Sugeno

A B S T R A C T

Red chili is Indonesia's leading commodity. Red chili is a raw material for various food products, cosmetics, pharmaceuticals and others. Fluctuations in the availability of red chili commodity supply affect the price of red chili commodity products. Pricing can occur because of supply and demand. Uncertain conditions also influence pricing due to fluctuations in raw material prices, ultimately affecting the price of carrageenan products. This condition makes price determination very difficult. Therefore, this study aims to analyze and design a pricing mechanism and determine the optimal margin in the red chili commodity marketing system. This study uses a systems analysis and design approach. Input-process-output (IPO) diagrams describe system requirements. Industrial business processes are described by the Business Process Model and Notation (BPMN) ver. 16.0. Meanwhile, to determine the optimal margin, Sugeno's fuzzy inference system approach is used by simulating the model in 3 margin scenarios: pessimistic, moderate, and optimistic. The simulation results were tested using the MAPE test, in which the results were compared between fuzzy price results and markup prices using markup values of 20%, 25%, and 30%. The analysis results show that the price is determined by demand and supply. The price obtained from the formulation of the Sugeno fuzzy model shows an optimal margin of Rp. 16,600.

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1. INTRODUCTION

Red chili is one of Indonesia's leading commodities. Pricing has the following objecttives: achieving a return on investment, price stability, maintaining or increasing market share, facing or preventing competition, and pricing to maximize profit. In general, static pricing methods are used, namely markup pricing, target-return pricing, received-value pricing, and value pricing. The issue of pricing in red chili commodities is very complex. The price of red chili commodities is relatively fluctuating at the farmer level, collecting traders and prices at the exporter level. Red chili commodities have not been subject to Farmer Benchmark Prices (HPP), so prices are still largely determined by season and region. This condition affects the price determination made by the agroindustry. Determining the price will be very difficult because the producer wants a large profit while, on the other hand, the consumer wants a low product price [1]. This condition becomes a dilemma in determining the price because the determination of the price will indirectly affect the Profit of the red chili commodity.

Several previous studies have discussed the mechanism for determining market prices, among others those conducted by Ridayati et al. [2], which stated that market mechanisms and price fixing need to be regulated to enforce market balance and economic justice by considering the interests of the parties involved in the market. Fair and fair prices are based on the strength of supply and demand, [3], [4] stating that the pricing model is suggested to take into account two main factors, namely internal factors and external factors, using fuzzy logic. Zadeh introduced the concept of fuzzy logic in 1962. Fuzzy logic is a problem-solving control system methodology suitable for implementation in simple systems, small systems, embedded systems, PC networks, multi-channel or workstation-based data acquisition, and control systems. This methodology can be applied to hardware, software, or a combination of both [4]–[7], stating that the interaction between supply and demand determines prices.

State-of-the-art research determines the price of agricultural commodities in favor of the condition of farmers. The problem that often occurs is that wholesalers determine commodity prices. This study aimed to analyze the marketing system for red chili commodities in setting product prices by optimizing margins. In order to achieve this goal, static methods cannot be used in determining product prices but use approaches that can answer the uncertainty that occurs in current conditions. The calculation is carried out using the fuzzy logic method. The variables for determining the price are the cost of raw materials, labor costs, distribution costs, etc. can be converted into a mathematical model to determine the price. The calculation results obtained are optimal prices while still being profitable for producers and able to compete in the market. The benefit of research for the red chili commodity industry is that it helps producers determine the optimal price of product sales in the future and can be used as evaluation material in determining product selling prices.

2. RESEARCH METHODS

2.1. System Identification

The research flow starts from the system's requirements to find the solution (Fig. 1). System design and analysis following the SDLC (system development life cycle) system life cycle is the idea, human/user requirements, system requirements, design, evaluation, and deployment maintenance [8], [9]. The system to be built needs to be designed using system design steps, including determining the problem boundaries, goals, expected and unexpected inputs, stakeholders involved, expected and unexpected outputs, resources, rules, roles, and system weaknesses [10], [11]. The next step is an analysis of the needs of all stakeholders to determine the important factors to be analyzed. This study uses Wasson's systems analysis and design approach [9]. The system is an integrated collection of elements or entities, each with defined and constrained capabilities, configured in various combinations that allow specific behaviors to emerge for command and control by the user to achieve performance-based mission results in a defined operating environment with a probability of success [9]. Analytically, a system is represented as a simple entity depicted graphically as a rectangular box (Fig. 2).

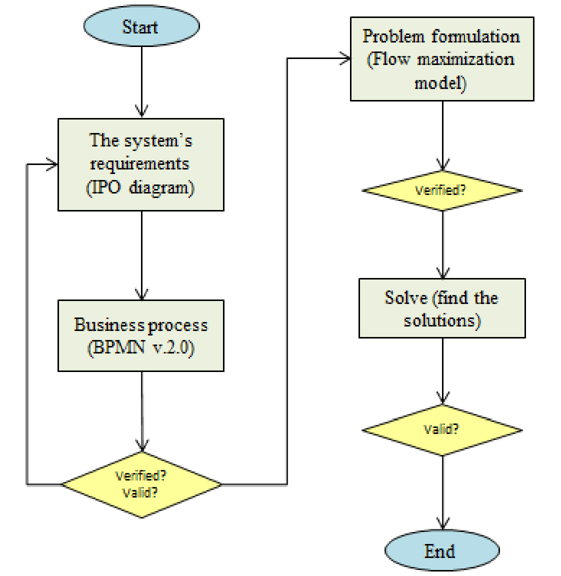

Fig. 1. Research methodology flowchart

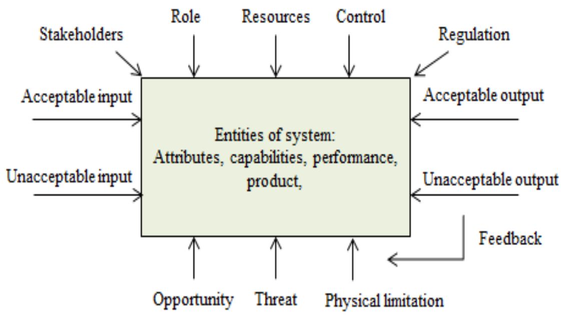

Fig. 2. Input-output diagram

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2.2. Business Process Model dan Notation (BPMN)

Then the business process analysis was carried out by Business Process Model and Notation (BPMN) version 2.0 using Sysbase Power Designer 16.5. BPMN was originally published in 2004 by the Business Process Modeling Initiative as a graphical notation (inspired in part by UML Activity Diagrams) to represent the graphical layout of business processes [10], [12], [13]. There are several notations in BPMN 2.0, as shown in Fig. 3.

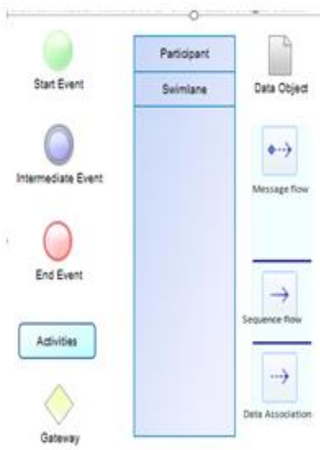

Fig. 3. BPMN notation using power designer 16.0

2.3. Problem Formulation

The marketing system's analysis in this research aims to determine market prices. The market mechanism is a free market with the characteristics of transactions between farmers and the red chili commodity, following the supply and demand equilibrium law to maximize profits for each entity, namely farmers, collectors, and agroindustry [14]. Total Profit is obtained from the difference between the income received and the expenses each actor bears during the free market [15]. The formulation for determining the price for each actor uses the Sugeno Fuzzy Inference System (FIS) method approach [7], [16].

In preparing the application of fuzzy logic to determine the selling price of red chili commodities, several steps were taken to obtain valid data in its preparation. The steps for determining prices using the fuzzy logic method include [3], [17], [18].

1. ***Fuzzification***

A set is a collection of objects with specific characteristics in common [19]. A fuzzy set is a further development of the concept of sets in mathematics. In a crisp set, the membership value of a set A($\mu A(x)$) has two possibilities, namely:

a) One (1) which means that an item is a member in a set, or
b) Zero (0) means that an item is not a set member.

If X is a collection of objects which are generally denoted by X, then a fuzzy set A in X is defined as a set of ordered pairs:

$$A = \{ (x, \mu A(x)) \mid x \in X\} \tag{1}$$

Where _(A) (x) is the membership function for the fuzzy set, the membership function maps each element from X to the degree of membership that lies in the range [0,1] [20], [21]. The fuzzy set has two attributes [22], namely: linguistic and numerical.

2. ***Implication function app***

The basic fuzzy rule defines the relationship between the membership function and the form of the resulting membership function. Sugeno method shows the output (consequent) system is not in fuzzy set form but in constant form or linear equation.

The Sugeno method consists of 2 types [23], namely:

a. Zero-Order Sugeno Fuzzy Model [24]. The general form of the Zero-Order Sugeno fuzzy model is :

$$IF\ (x_1\ is\ A_1)\ o\ (x_2\ is\ A_2)\ o \ldots\ldots o\ (x_n\ is\ A_n)\ THEN\ z = k \tag{2}$$

where AI is the i fuzzy set as the antecedent, and k is a constant as the consequent.

b. First-Order Sugeno Fuzzy Model, The general form of the First-Order Sugeno fuzzy model, is

$$IF\ (x_1\ is\ A_1)\ o\ (x_2\ is\ A_2)\ o \ldots\ldots o\ (x_n\ is\ A_n)\ THEN\ z = p_1 * x_1 + \ldots\ldots + p_n * x_n + q \tag{3}$$

where AI is the i fuzzy set as the antecedent and is an I (firm) constant, and q is also a constant on the consequent

Decision-making with the min function is by finding the minimum value based on the first rule and can be expressed by:

$$\alpha_i = \mu_{Ai}(x) \cap \mu_{Bi}(x) = \min\{\mu_{Ai}(x), \mu_{Bi}(x)\} \tag{4}$$

3. ***Rules component (aggregation)***

If the system consists of several rules, then the inference is obtained from the collection and correlation between the rules, namely calculating the results of

$$\sum_{r=1}^{R} \alpha_r z_r \tag{5}$$

where R is the number of rules, α_r is the α predicate of the r, and zr is the output of the r rule antecedent.

4. *Affirmation (defuzzification)*

Defuzzification in the Sugeno method is done by simulating the Sugeno fuzzy inference system model using Matlab software.

2.4. Mean Absolute Percentage Error (MAPE)

Mean Absolute Percentage Error (MAPE) is a measure of forecasting accuracy of a forecasting method [23]. The trick is to calculate the difference between the output obtained and the actual data, then divide it by the actual data. The result in the form of a percentage is then absolute. This calculation is carried out on each observation and then Moderated. Forecasting results are excellent if the MAPE value is less than 10%, while the MAPE value is said to be good if it is less than 20% [25], [26].

$$\text{MAPE} = \frac{\sum_{i=1}^{n}\left|\frac{X_i - F_i}{X_i}\right|}{n} x\ 100\% \tag{8}$$

Where Xi = the original data value of the i observation; Fi = forecast value of the i observation and n = number of data

3. RESULTS AND DISCUSSION

This section consists of system requirements analysis, business process analysis, model formulation, and discussion.

3.1. System Identification

Identifying the marketing system begins with making an input process output (IPO) diagram and conducting a needs analysis of each stakeholder. The system requirements analysis is based on the IPO diagram (Fig. 2). The system stakeholders are red chili commodity farmers, the red chili commodity industry and consumers. In the marketing system, farmers sell their commodities to the red chili commodity industry in the form of red chili commodities to the red chili commodity processing industry. One red chili commodity processing industry is the red chili commodity industry. Red chili commodity products are raw materials for various products needed by downstream industries, including the food industry, cosmetics, etc.

The input that can be accepted is the red chili commodity with a fairly good quantity and production quality. Unwanted inputs are fluctuating prices and demand. In the process of determining the price mechanism, several aspects must be considered, such as the amount of production, the number of requests, production costs, and margins. The output is the optimal Profit for the perpetrators of the red chili commodity marketing system. In addition to the desired output, there may be unwanted output. Unwanted output and must be eliminated are fluctuations in raw material prices and increased production costs. The output can be overcome by controlling and repairing. The control functions as feedback to the system to reduce unwanted output (Fig. 4).

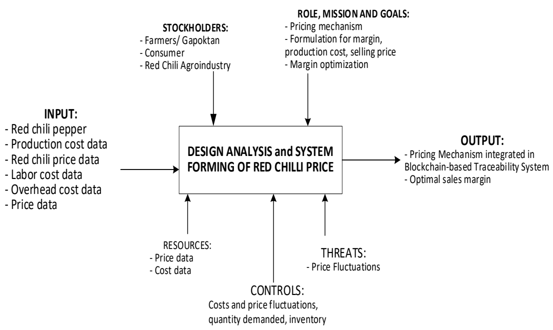

Fig. 4. IPO diagram analysis and design of market pricing for red chili agroindustry commodities

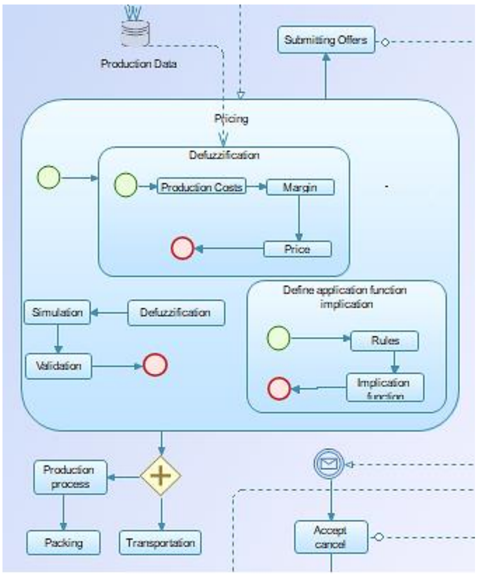

Fig. 5. BPMN pricing mechanism

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3.2. Business Process Analysis

This study analyzes the price formation mechanism in system actors, including farmers, the red chili commodity industry, and consumers. Where the formation of prices occurs because of supply and demand. The marketing system is analyzed using a business process analysis approach described by the BPMN (Fig, 5). BPMN The pricing mechanism is made using the Sugeno fuzzy inference system approach.

3.3. Problem Formulation

The application of fuzzy logic to determine the selling price of red chili commodities is carried out in several steps to obtain valid data in its preparation. Then the completion of this price determination is applied to the MATLAB programming language. The following are the results of the implementation of the Sugeno method in determining the price of red chili commodities. The steps for determining prices using the fuzzy logic method include the following:

1) *Fuzzyfication*

The variables used in determining the price are

a. *Variable production costs.*

Variable production costs are incurred in the production process of making carrageenan products. This production cost variable is the sum of 3 sub-variables: the cost of main raw materials, auxiliary materials, labor, and overhead costs. The cost of the main raw materials is the purchase price of raw materials for red chili commodities. The cost of auxiliary raw materials is the purchase price of auxiliary raw materials. The price of this material is constantly fluctuating, so it affects production costs to fluctuate as well. Meanwhile, labor and overhead costs are assumed to be expected. The following is a fuzzy set of production costs(Table 1) and (Fig. 6).

Table 1. Fuzzy levels of red chili commodity production costs in kg

No	Production cost (kg)	Fuzzy rate
1	55109 - 64388	Low
2	59748 - 69027	Moderate
3	64388 - 73666	High

The production variable formulation is formulated as follows:

$$\mu_{low}(m) = \begin{cases} 1 & , 55109 \leq m \leq 59748 \\ \dfrac{64388 - m}{64388 - 59748} & , 59748 < m < 64388 \\ 0 & , m \geq 64388 \end{cases}$$

$$\mu_{average}(S) = \begin{cases} 0 & , S \leq 59748 \text{ or } s \geq 69027 \\ \dfrac{s - 59748}{64388 - 59748} & , 59748 < s \leq 64388 \\ \dfrac{69027 - s}{69027 - 64388} & , 64388 < s < 69027 \end{cases}$$

$$\mu_{high}(h) = \begin{cases} 0 & , h \leq 64388 \\ \dfrac{h - 64388}{69027 - 64388} & , 64388 < h \leq 69027 \\ 1 & , h \geq 69027 \end{cases}$$

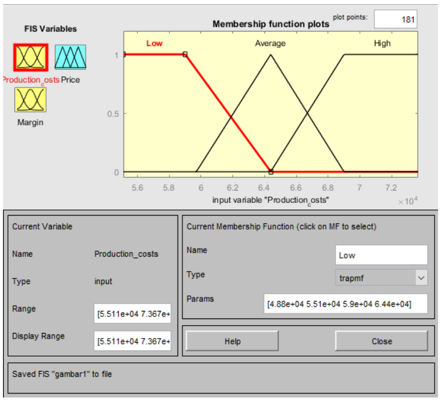

Fig. 6. Membership function for production costs

b. *Variable margin*

Variable margin is the amount of money earned compared to the value of the costs incurred to obtain profits. The margin obtained can be categorized into low, medium and high. The amount of margin obtained can be calculated from the difference in income, in this case, the price minus the cost of production or costs incurred in making the product. Low margin if the margin value is less than 20% of production costs, reasonable margin if the margin value is 25% of production costs, and high margin if the margin value is more than 30% of production costs (Table 2) and (Fig. 7).

Table 2. Levels of fuzzy margin

No	Margin	%	Fuzzy rate
1	0 - 16618	20	Low
2	12481 - 20754	25	Moderate
3	16618 - 24890	30	High

The variable margin formulation is as follows :

$$\mu_{low}(p) = \begin{cases} 1 & , p \leq 12481 \\ \dfrac{16618 - p}{16618 - 12481} & , 12481 < p < 16618 \\ 0 & , p \geq 16618 \end{cases}$$

$$\mu_{average}(S) = \begin{cases} 0 & , S \leq 12481 \text{ atau } s \geq 20754 \\ \dfrac{s - 12481}{16618 - 12481} & , 12481 < s \leq 16618 \\ \dfrac{20754 - s}{20754 - 16618} & , 16618 < s < 20754 \end{cases}$$

$$\mu_{high}(t) = \begin{cases} 0 & , t \le 16618 \\ \dfrac{t-16618}{20754-16618} & , 16618 < t \le 20754 \\ 1 & , t > 20754 \end{cases}$$

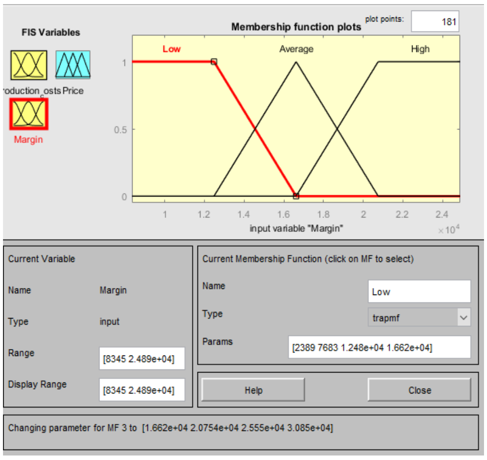

Fig. 7. Membership function margin

c. Variables Price

The price variable is the expected output in this system. Product price is the amount charged to consumers for the products they buy. The product price is calculated based on the sum of production costs, non-production costs and the profit/margin desired by the seller. In this case, what is used in calculating the selling price is the cost of production and margin (Table 3).

Table 3. The fuzzy price level

No	Price	Fuzzy rate
1	65753 - 79648	Low
2	72701 - 86596	Moderate
3	79648 - 93543	High

The selling price variable formula is:

$$\mu_{low}(p) = \begin{cases} 1 & , 65753 \le p \le 72701 \\ \dfrac{79648-p}{79648-72701} & , 72701 < p < 79648 \\ 0 & , p \ge 79648 \end{cases}$$

$$\mu_{average}(S) = \begin{cases} 0 & , S \le 72701 \; atau \; s \ge 86596 \\ \dfrac{s-72701}{79648-72701} & , 72701 < s \le 79648 \\ \dfrac{86596-s}{86596-79648} & , 79648 < s < 86596 \end{cases}$$

$$\mu_{high}(t) = \begin{cases} 0 & , t \le 79648 \\ \dfrac{t-86596}{93543-86596} & , 86596 < t \le 93543 \\ 1 & , t \ge 93543 \end{cases}$$

3.4. Implication Function Application

Forming fuzzy implication rules is obtained by combining each linguistic attribute in each input variable. Of the two input variables, each has three linguistic attributes. So that the implication rules that can be formed are $3^2 = 9$ fuzzy implication rules. The fuzzy inference method that will be used is the first-order Sugeno Fuzzy Method (Fig 8).

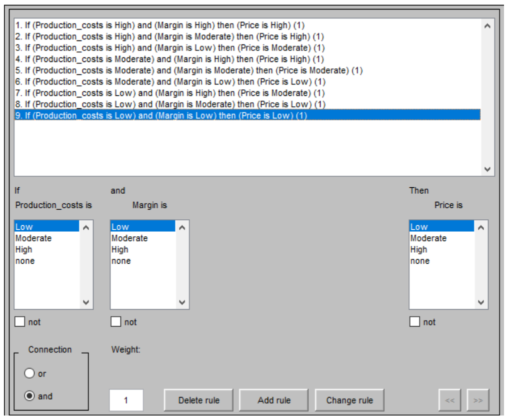

Fig. 8. Rules of the marketing system

Defuzzification is carried out through a process with the help of Matlab software. The fuzzy pricing model is then simulated by changing several parameter values of production costs and margins.

3.5. Simulation

Simulation analysis refers to Zadeh [24], which consists of three optimistic, moderate, and pessimistic scenarios. Show the results as follows:

1. Moderate Scenario

The moderate scenario is carried out with the assumption that the margin is in a moderate position, namely 25%. The simulation results show that the reasonable margin is obtained from rule no 5; namely, if the production costs are moderate and the margin is moderate, the price is moderate. Where in rule no 5, with a production cost of Rp. 64,400 and a margin of Rp. 16,600 or 25% of the production costs will get a price of Rp. 79,600.

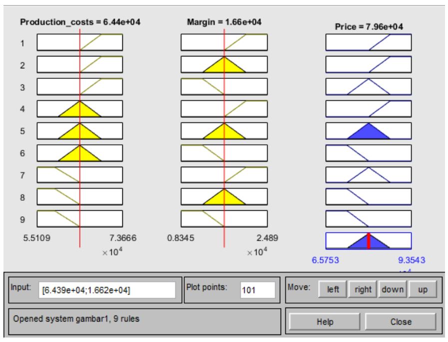

Fig. 9. Moderate fuzzy scenario results

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Moderate scenario results are shown in Fig. 9. In this moderate scenario, in addition to rule no 5, reasonable margins can occur in rules no 2 and 8.

- Rule no. 2 if the production cost is high and the margin is medium, then the price is high
- Rule no. 8 if the production cost is low and the margin is medium then the price is low

2. Pessimistic Scenario

A pessimistic scenario means that the margin obtained by the red chili commodity industry is in a low position or less than 20%. With production costs increased to Rp. 70,000 - because the price of raw materials rose, while the price of red chili commodity products in the market remained at Rp. 79,700. Then the margin earned will be reduced to Rp. 12,100, which is 17% of the production cost, so the margin is included in the low level because it is less than 20%. It can be concluded that the higher production cost is not accompanied by an increase in product prices in the market, the lower the margin obtained by the industry. In addition, to rule no 3, this low margin (pessimistic) scenario will occur in the 6th rule and 9th rule, namely

- Rule 6 if the production cost is moderate and the margin is low, then the price is low.
- Rule 9 if production costs are low and margins are low, then prices are low (Fig. 10)

The two rules or low margins mentioned above can occur if market prices are low and production costs are low to moderate. Low market prices can occur if the number of products in the market is abundant while demand is small [27], [28].

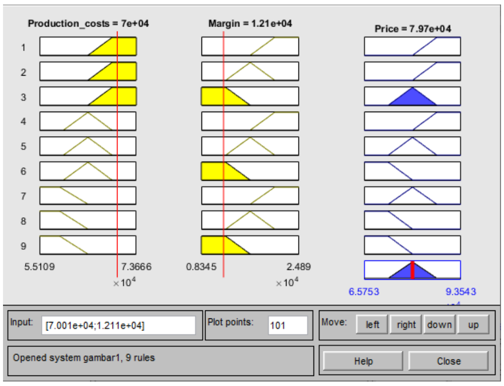

Fig. 10. Fuzzy results for pessimistic scenario

3. Optimism Scenario

A pessimistic scenario means that the margin obtained by the red chili commodity industry is in a high position or more than 30%. With a low production cost to Rp. 60,000, - because the price of raw materials fell, while the price of red chili commodity products in the market remained at Rp. 79,600. then the margin earned will increase to Rp. 20,200, which is 33.6% of the production cost, so the margin is in a high level because it is more than 30%. So it can be concluded that the lower production costs that are not accompanied by a decrease in product prices in the market, the higher the margin obtained by the industry. In addition to rule 7, this optimistic scenario (high margin) will occur in rule 1 and rule 4, namely

- Rule 1 if the production cost is high and the margin is high then the price is high.
- Rule 4 if the production cost is medium and the margin is high, then the price is high (Fig. 11)

The two rules or high margins mentioned above can occur if market prices are high and production costs are low to moderate. High market prices can occur if the number of products in the market is small while demand is high [29] [30].

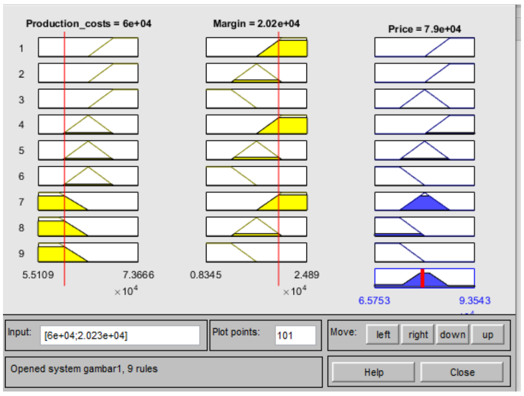

Fig. 11. Optimistic fuzzy scenario results

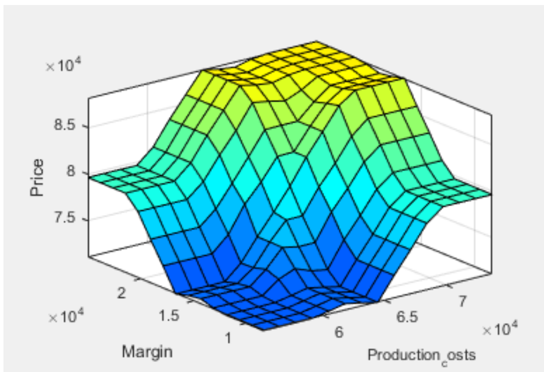

Fig. 12. Price surface view

The structure of the price can be seen based on the following surface (Fig. 12). Based on the surface image above, the price structure shows that the dark blue color indicates low production costs and margins, hence low prices. The light blue indicates that prices are moderate when production costs and margins are moderate. The higher you go up, the more yellow the color shows, the higher the cost of production and the higher the margin, the higher the price.

3.6. Validation

Validation of the calculation of price determination with the fuzzy method is done by comparing the results of the price calculation with the fuzzy method and the markup price method. The markup method is calculated by adding production costs with a specified margin; in this case, there are three levels: a low margin of 20%, a medium margin of 25%, and a high margin of 30%. From the comparison of the two methods, namely the markup price and fuzzy logic methods, there is a price difference (error) between the actual price (markup price) and the price in fuzzy logic. The Mean Absolute Percentage Error (MAPE) test is carried out to find out the calculation error level indication in fuzzy logic. The MAPE test is shown in Table 4.

Table 4. MAPE test results

No	production cost	profit	markup price (Rp)	Fuzzy Result price (Rp.)	error percentage
1	56000	20%	67200	72700	0.076
		25%	70000	72700	0.037
		30%	72800	73000	0.003
2	58000	20%	69600	72700	0.043
		25%	72500	72700	0.003
		30%	75400	74000	0.019
3	60000	20%	72000	72700	0.010
		25%	75000	73000	0.027
		30%	78000	75600	0.032
4	62000	20%	74400	72700	0.023
		25%	77500	75500	0.026
		30%	80600	81500	0.011
5	64000	20%	76800	73400	0.046
		25%	80000	78500	0.019
		30%	83200	87400	0.048
6	66000	20%	79200	77000	0.029
		25%	82500	84000	0.018
		30%	85800	87000	0.014
7	68000	20%	81600	82000	0.005
		25%	85000	90700	0.063
		30%	88400	93300	0.053
8	70000	20%	84000	85400	0.016
		25%	87500	93500	0.064
		30%	91000	93500	0.027
9	72000	20%	86400	86700	0.003
		25%	90000	93500	0.037
		30%	93600	93500	0.001
				Total	0.753
				MAPE	0.028

MAPE test results show a value of 0.028 or 2.8%. The MAPE value will be smaller if the calculation error rate also gets smaller. The MAPE value generated in comparing the two methods above is very small in this calculation. The fuzzy logic calculation method has a minimal error in the markup pricing calculation method (actual price), so the calculation results can be used to determine the optimum price range.

3.7. Advantages of Previous Research

This research is more advanced than previous studies that used the application of fuzzy theory in predicting prices as in studies [29], [31], [32] and [33]. Most studies that use fuzzy are limited to price forecasting, especially stock price forecasting. This research has touched on real problems related to determining the selling price of agricultural commodities, which are expected to contribute to red chili farmers positively. This research has provided decision-makers with whether to take a pessimistic, optimum or maximum position.

4. CONCLUSION

The analysis and design of this marketing system adopt a systems approach. Determining optimal product prices and margins is completed using the BPMN approach and the Sugeno fuzzy inference system. The pricing mechanism is based on industrial business processes described by the BPMN ver. 16.0. Meanwhile, to determine the optimal margin, Sugeno's fuzzy inference system approach is used by simulating the model in 3 margin scenarios: pessimistic, moderate, and optimistic. The analysis results show that the price is determined by demand and supply. The model solution shows how production costs and margins can affect selling prices. The price obtained from the formulation of the Sugeno fuzzy model shows an optimal margin of Rp. 16,600. The test results of the MAPE test model show a value of 0.028 or 2.8%. The MAPE value will be smaller if the calculation error rate also gets smaller. The pricing model that has been built can be decision support for industry activists. The limitation of this research is the use of hypothetical data; the variables forming the production costs are not described individually. Then the following work can be made a model of each entity's supply and price balance.

http://dx.doi.org/10.30656/jsmi.v6i2.4829

REFERENCES

[1] E. P. Lestari, S. D. W. Prajanti, W. Wibawanto, and F. Adzim, 'ARCH-GARCH Analysis: An Approach to Determine The Price Volatility of Red Chili', *Agrar. J. Agribus. Rural Dev. Res.*, vol. 8, no. 1, pp. 90–105, Jun. 2022, doi: 10.18196/agraris.v8i1.12060.

[2] R. Ridayati, S. Sujarwo, and F. Fahriyah, 'Development of Prices and Market Integration of Red Chillies (Capsicum annuum L.) in Malang Regency, Malang City, and Surabaya City', *Agric. Soc. Econ. J.*, vol. 22, no. 2, pp. 95–102, Apr. 2022, doi: 10.21776/ub.agrise.2022.022.2.3.

[3] X. Chen, S. Wu, X. Wang, and D. Li, 'Optimal pricing strategy for the perishable food supply chain', *Int. J. Prod. Res.*, vol. 57, no. 9, pp. 2755–2768, May 2019, doi: 10.1080/00207543.2018.1557352.

[4] J. Rhuggenaath, P. R. de Oliveira da Costa, Y. Zhang, A. Akcay, and U. Kaymak, 'Dynamic Pricing Using Thompson Sampling with Fuzzy Events', in *Communications in Computer and Information Science*, vol. 1237 CCIS, no. 1, Springer International Publishing, 2020, pp. 653–666, doi: 10.1007/978-3-030-50146-4_48.

[5] S. Asadi, 'Evolutionary fuzzification of RIPPER for regression: Case study of stock prediction', *Neurocomputing*, vol. 331, pp. 121–137, Feb. 2019, doi: 10.1016/j.neucom.2018.11.052.

[6] M. Kabak, E. Köse, O. Kırılmaz, and S. Burmaoğlu, 'A fuzzy multi-criteria decision making approach to assess building energy performance', *Energy Build.*, vol. 72, pp. 382–389, Apr. 2014, doi: 10.1016/j.enbuild.2013.12.059.

[7] D. Heien, 'Price Determination Processes for Agricultural Sector Models', *Am. J. Agric. Econ.*, vol. 59, no. 1, pp. 126–132, Feb. 1977, doi: 10.2307/1239616.

[8] A. Halog and Y. Manik, 'Advancing Integrated Systems Modelling Framework for Life Cycle Sustainability Assessment', *Sustainability*, vol. 3, no. 2, pp. 469–499, Feb. 2011, doi: 10.3390/su3020469.

[9] C. S. Wasson, *System Analysis, Design, and Development*. Hoboken, NJ, USA: John Wiley & Sons, Inc., 2005, doi: 10.1002/0471728241.

[10] T. Djatna and A. Ginantaka, 'An analysis and design of frozen shrimp traceability system based on digital business ecosystem', in *2014 International Conference on Advanced Computer Science and Information System*, Oct. 2014, pp. 157–163, doi: 10.1109/ICACSIS.2014.7065876.

[11] H. Lee, T. Zhang, M. Boile, S. Theofanis, and S. Choo, 'Designing an integrated logistics network in a supply chain system', *KSCE J. Civ. Eng.*, vol. 17, no. 4, pp. 806–814, May 2013, doi: 10.1007/s12205-013-0087-5.

[12] S. A. White and D. Miers, *BPMN Modeling and Reference Guide: Understanding and Using BPMN*. Future Strategies Incorporated, 2008, [Online]. Available: https://books.google.co.id/books?id=0Z2Td3bCYW8C.

[13] K. Meidayanti, Y. Arkeman, and Sugiarto, 'Analysis and design of beef supply chain traceability system based on blockchain technology', *IOP Conf. Ser. Earth Environ. Sci.*, vol. 335, no. 1, p. 12012, 2019, doi: 10.1088/1755-1315/335/1/012012.

[14] W. Chen, H. Liu, and D. Xu, 'Dynamic Pricing Strategies for Perishable Product in a Competitive Multi-Agent Retailers Market', *J. Artif. Soc. Soc. Simul.*, vol. 21, no. 2, pp. 1–18, 2018, doi: 10.18564/jasss.3710.

[15] D. O. Faith and A. M. Edwin, 'A Review of The Effect of Pricing Strategies on The Purchase of Consumer Goods', *Int. J. Res. Manag. Sci. Technol.*, vol. 2, no. 2, pp. 2321–3264, 2014, [Online]. Available: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3122351.

[16] M. Mordjaoui and B. Boudjema, 'Forecasting and Modelling Electricity Demand Using Anfis Predictor', *J. Math. Stat.*, vol. 7, no. 4, pp. 275–281, Oct. 2011, doi: 10.3844/jmssp.2011.275.281.

[17] J. O'Shaughnessy, 'Pricing—role, objectives, factors, strategies', in

Competitive Marketing (RLE Marketing), Routledge, 2014, pp. 606–653, doi: 10.4324/9781315761718-27.

[18] T. T. Nagle, J. Hogan, and J. Zale, *The Strategy and Tactics of Pricing*. Routledge, 2016, doi: 10.4324/9781315266220.

[19] K. Subulan, A. S. Taşan, and A. Baykasoğlu, 'A fuzzy goal programming model to strategic planning problem of a lead/acid battery closed-loop supply chain', *J. Manuf. Syst.*, vol. 37, pp. 243–264, Oct. 2015, doi: 10.1016/j.jmsy.2014.09.001.

[20] K.-Y. Shen and G.-H. Tzeng, 'Advances in Multiple Criteria Decision Making for Sustainability: Modeling and Applications', *Sustainability*, vol. 10, no. 5, p. 1600, May 2018, doi: 10.3390/su10051600.

[21] R. Bhattacharya, A. Kaur, and R. K. Amit, 'Price optimization of multi-stage remanufacturing in a closed loop supply chain', *J. Clean. Prod.*, vol. 186, pp. 943–962, Jun. 2018, doi: 10.1016/j.jclepro.2018.02.222.

[22] U. A.Umoh and A. A. Udosen, 'Sugeno-Type Fuzzy Inference Model for Stock Price Prediction', *Int. J. Comput. Appl.*, vol. 103, no. 3, pp. 1–12, Oct. 2014, doi: 10.5120/18051-8957.

[23] Y. F. Hernández-Julio, M. J. Prieto-Guevara, and W. Nieto-Bernal, 'Fuzzy clustering and dynamic tables for knowledge discovery and decision-making: Analysis of the reproductive performance of the marine copepod Cyclopina sp.', *Aquaculture*, vol. 523, p. 735183, Jun. 2020, doi: 10.1016/j.aquaculture.2020.735183.

[24] L. A. Zadeh, 'Fuzzy sets', *Inf. Control*, vol. 8, no. 3, pp. 338–353, Jun. 1965, doi: 10.1016/S0019-9958(65)90241-X.

[25] S. Lahmiri, 'Minute-ahead stock price forecasting based on singular spectrum analysis and support vector regression', *Appl. Math. Comput.*, vol. 320, pp. 444–451, Mar. 2018, doi: 10.1016/j.amc.2017.09.049.

[26] H. M, G. E.A., V. K. Menon, and S. K.P., 'NSE Stock Market Prediction Using Deep-Learning Models', *Procedia Comput. Sci.*, vol. 132, pp. 1351–1362, 2018, doi: 10.1016/j.procs.2018.05.050.

[27] A. Aleem, M. A. El-Sharief, M. A. Hassan, and M. G. El-Sebaie, 'Implementation of Fuzzy and Adaptive Neuro-Fuzzy Inference Systems in Optimization of Production Inventory Problem', *Appl. Math. Inf. Sci.*, vol. 11, no. 1, pp. 289–298, Jan. 2017, doi: 10.18576/amis/110135.

[28] K. F.-R. Liu, J.-Y. Kuo, K. Yeh, C.-W. Chen, H.-H. Liang, and Y.-H. Sun, 'Using fuzzy logic to generate conditional probabilities in Bayesian belief networks: a case study of ecological assessment', *Int. J. Environ. Sci. Technol.*, vol. 12, no. 3, pp. 871–884, Mar. 2015, doi: 10.1007/s13762-013-0459-x.

[29] P. Aßmuth, 'Stock price related financial fragility and growth patterns', *Economics*, vol. 14, no. 1, pp. 1–34, Dec. 2020, doi: 10.5018/economics-ejournal.ja.2020-10.

[30] Y. E. Cakra and B. Distiawan Trisedya, 'Stock price prediction using linear regression based on sentiment analysis', in *ICACSIS 2015 - 2015 International Conference on Advanced Computer Science and Information Systems, Proceedings*, 2016, pp. 147–154, doi: 10.1109/ICACSIS.2015.7415179.

[31] R. Nopianti, A. T. Panudju, and A. Permana, 'Stock Price Index Prediction Using Adaptive Neural Fuzzy Inference System', *Int. J. Manag. Account. Econ.*, vol. 8, no. 10, pp. 715–732, 2021, [Online]. Available: https://www.ijmae.com/article_141986.html.

[32] M. Mutmainah, U. Marfuah, R. Nopianti, and A. Tri Panudju, 'LSTM Algorithm Analysis of Banking Sector Stock Price Predictions', *Int. J. Adv. Res.*, vol. 10, no. 01, pp. 627–634, 2022, doi: 10.21474/ijar01/14082.

[33] K. Chen, Y. Zhou, and F. Dai, 'A LSTM-based method for stock returns prediction: A case study of China stock market', in *2015 IEEE International Conference on Big Data (Big Data)*, Oct. 2015, vol. 2014, no. 3 PART 2, pp. 2823–2824, doi: 10.1109/BigData.2015.7364089.