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# APPLICATION OF FUZZY TSUKAMOTO METHOD IN DETERMINING THE STOCK OF COCONUT SHELL CRAFT GOODS

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## *ABSTRACT*

*This research applies the Fuzzy Tsukamoto Method to optimize the inventory management of coconut shell handicraft products in Bantul Regency, Indonesia. The aim is to develop a predictive system to determine production quantities based on market demand and inventory levels, so as to overcome challenges such as over- and under-stocking. Data was collected from Marem.id's production records between January and April 2024, which included demand, inventory, and production variables. Fuzzy modeling is performed with three variables: two inputs (demand and inventory) and one output (production). The system integrates fuzzification, inference, and defuzzification processes to calculate the optimal production level. The results show that for April 2024, a production quantity of 92,432 units is recommended to meet demand and maintain efficient inventory levels. This approach improves operational efficiency, reduces costs, and increases competitiveness in local and international markets.*

***Keywords**: Fuzzy Tsukamoto, inventory management, coconut shell crafts, production optimization*

## *ABSTRAK*

*Penelitian ini menerapkan Metode Fuzzy Tsukamoto untuk mengoptimalkan manajemen persediaan produk kerajinan tempurung kelapa di Kabupaten Bantul, Indonesia. Tujuan dari penelitian ini adalah untuk mengembangkan sistem prediktif dalam menentukan jumlah produksi berdasarkan permintaan pasar dan tingkat persediaan, sehingga dapat mengatasi permasalahan kelebihan dan kekurangan stok. Data diperoleh dari catatan produksi Marem.id selama periode Januari hingga April 2024, yang mencakup variabel permintaan, persediaan, dan produksi. Pemodelan fuzzy dilakukan dengan tiga variabel, yaitu dua variabel input (permintaan dan persediaan) serta satu variabel output (produksi). Sistem ini mengintegrasikan proses fuzzifikasi, inferensi, dan defuzzifikasi untuk menghitung tingkat produksi yang optimal. Hasil penelitian menunjukkan bahwa pada bulan April 2024, jumlah produksi yang disarankan adalah sebanyak 92.432 unit untuk memenuhi permintaan dan menjaga tingkat persediaan yang efisien. Pendekatan ini mampu meningkatkan efisiensi operasional, menurunkan biaya, serta meningkatkan daya saing di pasar lokal maupun internasional.*

***Kata kunci**: Fuzzy Tsukamoto, manajemen persediaan, kerajinan tempurung kelapa, optimasi produksi*

## INTRODUCTION

The craft industry is a business or activity that is able to manage raw materials or raw materials into finished goods, one of which is craft products. To process raw materials or raw materials requires a qualified creativity and creativity so that the craft products made are able to have a selling value and be able to compete in the market. According to Law Number 5 of 1984, Industry is an economic activity that processes raw materials, raw materials, semi-finished goods, and finished goods into goods with higher value for their use, including industrial design and engineering activities(Industri et al., 2022). Coconut shell handicrafts are one of the mainstay products in the small and medium enterprise (SME) sector in Bantul Regency, Pajangan District, Kampung Santan. This product has a fairly high level of demand in local and international markets. However, artisans often face challenges in managing stock. Excess stock can lead to increased storage costs, while shortages can result in lost sales opportunities.

To achieve optimal stock management, a system capable of predicting stock requirements based on factors such as market demand and raw material availability is required. The Tsukamoto Fuzzy method was chosen because this fuzzy logic approach is able to overcome data uncertainty. Tsukamoto fuzzy was first introduced by Tsukamoto. Each consequent (conclusion) in each IF-THEN rule must be represented with a fuzzy set with a monotonous membership function. As a result, the inference output from each rule is given in a crisp manner based on a-predicate, then calculates the weighted average(Mahendra & Siahaan, 2024). This research aims to develop a system that can help determine the stock of coconut shell craft goods using the Fuzzy Tsukamoto method. This system is expected to increase the efficiency of stock management, reduce operational costs, and increase product competitiveness in local and international markets. In addition, with better stock management, the craftsmen can focus on improving product quality and design innovation, thus expanding their business opportunities.

## METHOD

The scope of the research was conducted at the Marem.Id shell craft shop regarding the determination of the stock of sales items. The limitations of this research focus on using Tsukamoto fuzzy with 3 variables, namely: 2 input variables, Demand, Inventory variables, while the output has 1 variable, namely: Production. These variables will show the results for the amount of production that will be used as demand and inventory to complete the stock needs of goods optimally.

The following flowchart Figure 1 of the stages of the research method used is as follows:

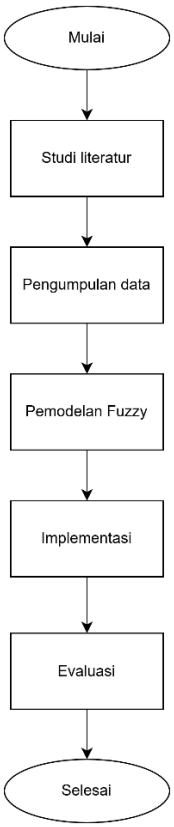


Figure 1. Flowchart tahapan penelitian

1. Literature Study

   Another definition of literature study is to look for theoretical references that are relevant to the case or problem found. These references can be sought from books, journals, research report articles, and sites on the internet. The output of this literature study is the collection of references that are relevant to the problem formulation (Pilendia, 2020).
2. Data Collection

   This stage is a data collection activity, searching and studying about materials that produce a set of data to be analyzed to get a picture of the problem so that information is obtained which is then used to analyze the problem being studied(Asy Aria et al., 2023). To fulfill the data needs, interviews were conducted to collect relevant information. The data collected includes Demand (Low, Medium, High), Inventory (Little, Medium, Many), Production (Little, Medium, Many), which was collected during the last 1 month period, namely November 2024.
3. Fuzzy Modeling

   In this step, a fuzzy logic model is designed by applying the Tsukamoto method. The initial step is fuzzyfication, namely the fuzzy set and determination of the membership degree of the crisp input in a fuzzy set. Inference to determine the evaluation of rules, rules, fuzzy rules to produce the output of each rule. Composition to find an aggregation or combination of the outputs of all rules. Defuzzyfication, calculation of crisp output.

4. Implementation

   The implementation stage is carried out by applying the Tsukamoto fuzzy model that has been designed on the system of determining the stock of goods at the Marem.Id shell craft shop. Implementation is done by building a computer-based system that can calculate the optimal amount of production based on demand and inventory data. This system is created using programming software such as Python or MATLAB.

5. Evaluation

   At this stage will determine whether this recommendation system is appropriate or vice versa and perform maintenance on the finished program, if a program error is found, improvements will be made to make the program run smoothly, the results of this evaluation will determine whether the recommendation system is running well or not (Afandi et al., 2022).

## RESULTS AND DISCUSSION

The data needed for this research is coconut shell craft production data, such as demand data, inventory data, and production data table 1 for 4 months. This study took data on the production of coconut shell crafts from January 2024 to April 2024 which was obtained from Marem.id.

Table 1. Production Data of Coconut Shell Handicrafts

| Month | Demand | Inventory | Production |
|---|---|---|---|
| January 2024 | 4130 | 37216 | 79583 |
| February 2024 | 2091 | 37275 | 59008 |
| March 2024 | 6665 | 38714 | 155532 |
| April 2024 | 6224 | 37027 | 171738 |

Based on the data obtained, it is known that Marem.id has a total demand of 6224 and an inventory of 37027, how much should Marem.id produce?

Completion:

From the production data in table 2 obtained from Marem.id, then look for the maximum and minimum data, as in the table below:

Table 2. Maximum and Minimum Values of Demand, Inventory, and Production

| Production Data | Quantity |
|---|---|
| Maximum Demand | 6665 |
| Minimum Demand | 2091 |
| Maximum Inventory | 38714 |
| Minimum Inventory | 37027 |
| Maximum Production | 171738 |
| Minimum Production | 59008 |

The steps of applying the Tsukamoto fuzzy method are:

a. Modeling fuzzy variables (Fuzzification)

There are 3 variables to be modeled, namely Demand, Inventory, and production quantity.

1. Demand variable

Demand consists of 3 fuzzy sets, namely
a little = [0 - 4778]
medium = [ 2091 - 6665 ]
a lot = [ 4778 - ~ ]
To represent and create a function of the demand variable, a shoulder curve is used for the (falling and rising) set and a triangular curve for the (Normal) set.

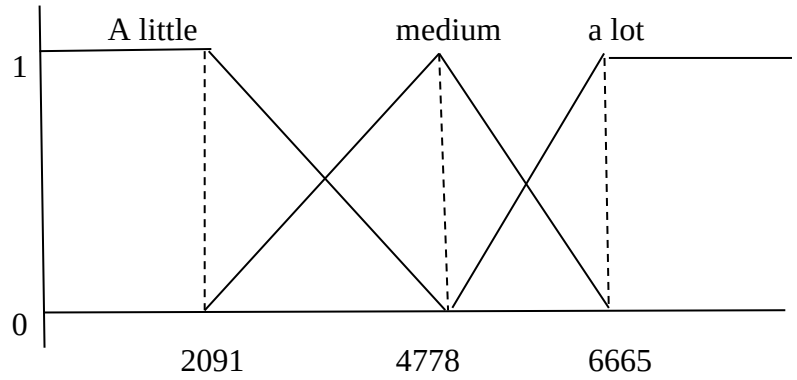


Figure 2. Membership Function of the Demand Variable

From the data obtained, the minimum demand is 2091, the maximum demand is 6665, and the average demand that occurs in each month is 4778. Membership function of the set of few, medium, and many of the Demand variable:

$$\mu\text{little demand} = \begin{cases} 1 & , x \leq 2091 \\ \frac{4778 - x}{4778 - 2091} & , 2091 \leq x \leq 4778 \\ 0 & , x \geq 4778 \end{cases}$$

$$\mu\text{medium demand} = \begin{cases} 1 & , x \geq 2091 \\ \frac{x - 2091}{4778 - 2091} & , 2091 \leq x \leq 4778 \\ 0 & , x \leq 2091 \text{ v } x \geq 4778 \end{cases}$$

$$\mu\text{Lot demand} = \begin{cases} 0 & , x \leq 4778 \\ & , 4778 \leq x \leq 6665 \\ \frac{x - 4778}{6665 - 4778} & \\ 1 & , x \geq 6665 \end{cases}$$

If the number of craft requests is 6224 then the membership value of the set of few, medium, and many of the 6225 demand variable is found by:

μPermintaanTurun[6225]=0
μNormal Demand[6225]= (6665 - 6225) / 4574 = 6663.639047

2. inventory variable

Inventory consists of 3 fuzzy sets, namely
Little = [0 - 37558]
Medium = [37027 - 38714]
Many = [37558 - ~]
To represent and create a function of the inventory variable, using a shoulder curve for the set (few and many) and a triangle-shaped curve for (Medium set).

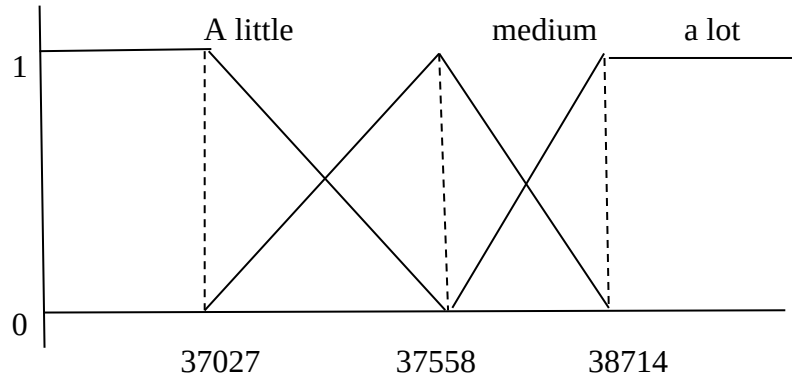


Figure 3. Membership Function of the Inventory Variable

From the data obtained, the minimum inventory is 37027, the maximum demand is 38714, and the average inventory that occurs each month is 37558. Membership Function of the Little, Medium and Many Sets of inventory variables:

$$\mu\text{little inventory}[y]=\begin{cases}1 & ,y \le 37027\\ \frac{37558-y}{37558-37027} & ,37027 \le y \le 37558\\ 0 & ,y \ge 37558\end{cases}$$

$$\mu\text{medium inventory}[y]=\begin{cases}1 & ,y \ge 37558\\ \frac{x-37027}{37558-37027} & ,37027 \le y \le 37558\\ \frac{38714-y}{38714-37558} & ,37558 \le y \le 38714\\ 0 & ,y \le 277 \text{ v } y \ge 38714\end{cases}$$

$$\mu\text{lot inventory}[y]=\begin{cases}0 & ,y \le 37558\\ \frac{x-37558}{38714-37558} & ,37558 \le y \le 38714\\ 1 & ,y \ge 38714\end{cases}$$

If the amount of coconut shell craft inventory is 37027, then the membership value of the set of Few, Medium,

and Many of the 37027 inventory variables are searched by :
μLittleAvailability[37027] = 0
μMedium Availability[37027] = (38714 - 37027) / 1156
=38681,96972
μLarge Availability[37027] = (37027 - 37558) / 1156
= 36994,51038

3. Production Variables

Production consists of 3 fuzzy sets, namely
little = [0 - 116465]
medium = [59008 - 171738]
Many = [1164665 - ~]

To represent and create a function of the production variable, using a shoulder curve for the set (few and many) and a triangular curve for (medium set).

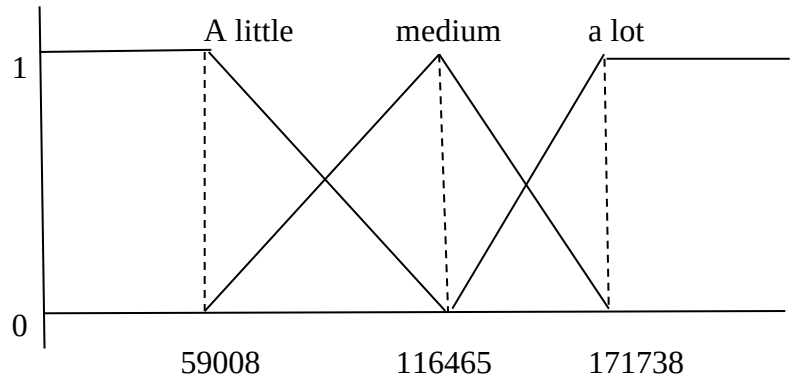


Figure 4. Membership Function of the Production Variable

From the data obtained, there is little production at 59008, a lot of production at 171738, and the average production that occurs in each month is 116465. Membership function of the set of few, medium and many of the production variables

$$\mu\text{little production}[x]=\begin{cases}1 & , x \le 599008\\ \frac{116465 - z}{116465 - 59008} & , 59008 \le x \le 116465\\ & , x \ge 116465\\ 0 & \end{cases}$$

$$\mu\text{medium production}[x]=\begin{cases}\begin{cases}1 & , x \ge 116465\\ \frac{z - 59008}{116465 - 59008} & , 59008 \le x \le 116465\\ \frac{171738 - z}{171738 - 116465} & , 116465 \le x \le 171738\\ 0 & , x \le 59008 \text{ v } x \ge 171738\end{cases}\\ 0 \quad , x \le 116465\end{cases}$$

$$\mu\text{lot production}[x] = \begin{cases} \dfrac{z - 116465}{171738 - 116465} & , 116465 \leq x \leq 171738 \\ 1 & , x \geq 171738 \end{cases}$$

To determine the amount of coconut shell handicraft production for the April period, where the demand is 6224 and the inventory is 37027, 9 fuzzy rules are formed with α-predicates as follows inventory of 37027 then 9 fuzzy rules with α-predicates are formed as follows

[R1] IF Demand Little And Supply Much Then Coconut shell craft production little
α1 = min(0, 155532)
= 0
In the little production function, then to calculate the value of z1:
z1 = 116465 - 0 (116465 - 59008)
= 116465 - 0 (57457)
= 116465 - 0
= 116465
[R2] IF Demand Little And Inventory Medium Then Coconut shell craft production Little
α2 = min(0, 155532)
= 0
In the little production function, then to calculate the value of z2:
z2 = 116465 - 0 (116465 - 59008)
= 116465 - 0 (57457)
= 116465 - 0
= 116465
[R3] IF Demand Little And Inventory Little Then Coconut shell craft production Little
α3 = min(0, 126030)
= 0
In the little production function, then to calculate the value of z3:
z3 = 116465 - 0 (116465 - 59008)
= 116465 - 0 (57457)
= 116465 - 0
= 116465
[R4] IF Demand is moderate And Inventory is plentiful Then Coconut shell handicraft production is low
α4 = min(59008, 171738)
= 59008
In the little production function, then to calculate the value of z4:
z4 = 116465 - 59008 (116465 - 59008)
= 116465 - 59008 (57457)
= 3905 - 3390422656
= -3390306200
[R5] IF Demand Is Moderate And Inventory Is Moderate Then Coconut shell craft production Is Moderate
α5 = min(59008, 171738)
= 59008
In the little production function, because production is moderate then for z5 value:

116465

[R6] IF Demand Is Moderate And Inventory Is Low Then Coconut shell craft production Is High

α6 = min(112239, 162801)

= 112239

On many production functions, then to calculate the value of z6:

z6 = 0 (171738 - 116465) + 116465

= 0 (55273) + 116465

= 0 + 116465

= 116465

[R7] IF Demand Many And Inventory Many Then Production of coconut shell crafts Many

α7 = min(0, 155532)

= 0

In the Increased production function, then to calculate the value of z7:

z7 = 0 (171738 - 116465) + 116465

= 0 (55273) + 116465

= 0 + 116465

= 116465

[R8] IF Demand is High And Inventory is Medium Then Coconut shell production is High

α8 = min(0, 155532)

= 0

In the Many production function, then to calculate the value of z8:

z8 = 0 (171738 - 116465) + 116465

= 0 (55273) + 116465

= 0 + 116465

=116465

[R9] IF Demand is High And Inventory is Low Then Production of coconut shell handicrafts is High

α9 = min (66277, 0.45)

= 0.45

In the Reduced production function, then to calculate the value of z7:

z9 = 0.45 (171738 - 116465) + 116465

= 0.45 (55273) + 116465

= 25149,215 + 116465

= 2929003325

d. Defuzzification

The Tsukamoto method uses centered average defuzzification to determine the output in strict form, as follows

$z$

$$= \frac{\alpha pred1 * z1 + \alpha pred2 * z2 + \alpha pred3 * z3 + \alpha pred4 * z4 + \alpha pred5 * z5 + \alpha pred6 * z6 + \alpha pred7 * z7 + \alpha pred8 * z8 + \alpha pred9 * z9}{\alpha pred1 + \alpha pred2 + \alpha pred3 + \alpha pred4 + \alpha pred5 + \alpha pred6 + \alpha pred7 + \alpha pred8 + \alpha pred9}$$

$$z = \frac{0 * 116465 + 0 * 116465 + 0 * 116465 + 59008 * -3390306200 + 59008 * 116465 + 112239 * 116465 + 0 * 116465 + 0 * 116465 + 0{,}45 * 2929003325}{0 + 0 + 0 + 59008 + 59008 + 112239 + 0 + 0 + 0{,}45}$$

$$z = \frac{0 + 0 + 0 + -200179189616000 + 6872366720 + 13071915135 + 0 + 0 + 1318051496}{230255}$$

$$z = \frac{21262333351}{230255}$$

$$z = 92432$$

So, the results of the calculation using fuzzy tsukamoto above, it is produced that the amount that must be produced by Marem.id in April was 92342 pieces.

The implementation of the Fuzzy Tsukamoto method in this study demonstrates its effectiveness in handling uncertainty in production planning for small industries. This method utilizes linguistic variables such as "high demand" or "low inventory" to convert imprecise input into crisp output using fuzzy rules. The recommended production of 92,432 units for April 2024 was obtained through fuzzification, inference, and defuzzification processes, and aligns with actual needs of the business (Mahendra & Siahaan, 2024; Saputra & Suyono, 2022). This is consistent with previous studies that showed how fuzzy systems help in dynamic decision-making environments where numerical precision is often limited (Darmawan & Puspita, 2021; Rahmawati & Hidayat, 2022).

Fuzzy logic systems are particularly valuable for small enterprises like Marem.id, which lack access to complex forecasting tools. By applying a flexible, rule-based approach, they can avoid overproduction and stockouts while adapting to fluctuating customer demands (Siregar & Utami, 2021; Pilendia, 2020). The model's use of basic programming tools such as Python also makes it accessible and replicable (Nugroho & Rachman, 2023). Moreover, this decision support system enhances the capacity of SMEs to plan production based on realistic market behavior rather than fixed assumptions (Afandi et al., 2022; Asy Aria et al., 2023).

For future development, the system can be improved by integrating additional parameters such as pricing data, market seasonality, and supplier lead times. A more user-friendly interface could enable non-technical users to apply fuzzy models easily, particularly in rural artisan communities (Putri & Azizah, 2023). It is also recommended to explore hybrid methods that combine fuzzy logic with machine learning for higher precision in forecasting (Widodo & Putra, 2020; Tim Industri, 2022). These advancements will ensure the system's long-term scalability and impact on local creative industries.

## CONCLUSION

Based on the results of the research obtained by the application of the tsukamoto fuzzy method in determining the amount of production of Coconut Shell handicrafts, starting with the fuzzification process, namely forming a variable then forming a set of shoulder and triangle. set of shoulders and triangles, then carried out the implication process with 9 rules and the last one defuzzification process is carried out to produce an output value that is the amount to be produced by Marem.id, From the results of the calculation of demand 6224 and inventory as much as 37027 which is obtained that the

amount to be produced for the month of the month. It is found that the amount to be produced for April 2024 is 92432 coconut shell handicrafts.

## REFERENCES


Afandi, A., Farida, I. N., & Mahdiyah, U. (2022). Penerapan algoritma apriori dan metode moving average untuk prediksi stok barang. *Prosiding Seminar Nasional Inovasi dan Teknologi (INOTEK)*, 6(2), 421–426.

Asy Aria, T., Julkarnain, M., & Hamdani, F. (2023). Penerapan algoritma K-Means clustering untuk data obat. *KLIK: Kajian Ilmiah Informasi dan Komputer*, 4(1), 649–657.

Darmawan, A., & Puspita, D. (2021). Implementation of fuzzy inference system in forecasting production needs in dynamic markets. *Jurnal Teknologi dan Sistem Komputer*, 9(1), 12–19. https://doi.org/10.14710/jtsiskom.9.1.12-19

Mahendra, Y. P., & Siahaan, R. F. (2024). Penerapan metode fuzzy Tsukamoto dalam menentukan jumlah produksi opak pada home industri Tegar Jaya. *Jurnal Pelita Ilmu Pendidikan*, 2(1), 39–46. https://doi.org/10.69688/jpip.v2i1.60

Nugroho, R., & Rachman, F. (2023). Decision support system for stock prediction using fuzzy logic. *Journal of Computer Science and Artificial Intelligence*, 5(1), 10–17. https://doi.org/10.31098/jcsa.v5i1.244

PILENDIA, D. (2020). Pemanfaatan Adobe Flash sebagai dasar pengembangan bahan ajar fisika: Studi literatur. *Jurnal Tunas Pendidikan*, 2(2), 1–10. https://doi.org/10.52060/pgsd.v2i2.255

Putri, M. F., & Azizah, A. (2023). Hybrid fuzzy and seasonal model to forecast demand in creative industries. *Jurnal Sistem Informasi dan Bisnis Kreatif*, 6(2), 55–62.

Rahmawati, L., & Hidayat, A. (2022). Model prediksi stok berbasis fuzzy-Tsukamoto. *Jurnal Teknologi dan Sistem Informasi*, 6(1), 34–41.

Saputra, F. R., & Suyono, H. (2022). A fuzzy Tsukamoto method approach in determining the optimal stock of raw materials in MSMEs. *Jurnal Ilmiah Teknologi dan Rekayasa*, 25(2), 233–241. https://doi.org/10.31294/jitr.v25i2.15001

Siregar, E. B., & Utami, S. (2021). Fuzzy-based production planning for small industries. *Jurnal Sistem Cerdas*, 4(3), 99–107.

Tim Industri. (2022). Definisi industri berdasarkan UU No. 5 tahun 1984. *Lumbung Inovasi: Jurnal Pengabdian kepada Masyarakat*, 7(2), 82–96. https://journal-center.litpam.com/index.php/linov

Widodo, A., & Putra, M. H. (2020). Penggunaan fuzzy dalam optimasi rantai pasok. *Jurnal Logistik Indonesia*, 3(2), 45–52.