

The Usage of Monte Carlo Simulation to Predict The Sales of Sustainable Batik Products in Small Medium Enterprise

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Abstract--As an intangible cultural heritage, Indonesian Batik continues to develop and is increasingly in demand by domestic and foreign people. In the current era, the concept of making batik that is sustainable or more environmentally friendly has emerged, one of the efforts is in terms of coloring that uses natural dyes. This innovation produces softer batik colors aka soil colors, besides that the manufacturing process is longer than using chemical dyes, so the price is more expensive. With these changes, analyzing the development of sustainable batik sales is important to identify an increase in sales. This study aims to determine the prediction of sustainable batik sales with Monte Carlo simulations precisely and accurately. The data processed is batik production using natural dyes, then converted into probability distributions in the form of compulsive frequencies and then generated random numbers to obtain random numbers. After that, group the interval limit of the random number that has been obtained and continue with the simulation process so that it gets the simulation results and the percentage of accuracy using the Monte Carlo method. The results of the study on data processing from 2020 to 2021 have an accuracy of 90%. So this research is very appropriate for predicting sales for the next year.

Keywords: *Simulation, Monte Carlo, Identification, Batik, Sustainable*

I. INTRODUCTION

Batik is increasingly in demand by domestic and foreign people at various levels

and ages (Titisari et al., 2022). As a cultural heritage recognized by the world, Indonesian batik is growing and must be preserved, including improving the way it is made so as not to damage the environment. This is also to answer issues related to batik dyeing which is considered less environmentally friendly because it uses excessive chemical dyes and bleaches to produce carcinogenic waste. For this reason, it is necessary to have a solution to dealing with these problems by using environmentally friendly alternatives to change the method of making unhealthy batik.

The emergence of the concept of making batik that is sustainable or more environmentally friendly, one of which is in terms of coloring that uses natural dyes. This innovation produces softer batik colors, namely the colors of the soil. In addition to being believed to be more durable, does not fade easily, the manufacturing process with this natural dye is longer than using artificial dyes so it affects the more expensive price. When buying batik, people will choose and tend to compare based on price, motif, color, and design (Titisari et al., 2022).

Some studies examine the waxing process, there are also about the utilization of natural dyes, and several studies on wastewater from chemical dyes. Overall, sustainable batik production is still lacking, both in terms of quantity and innovation (Indarti et al., 2020). This is important of batik producers must participate in educating their consumers to be more aware of environmental issues related to batik making so that they can increase the production and sales of sustainable batik.

The uncertain market demand for sustainable batik products makes it difficult for Batik X SMEs to estimate the number of products that must be provided based on

market demand. Forecasting sales is the activity of estimating the number of sales of goods or services. When sales are accurately predicted, the fulfillment of consumer demand can be sought on time and can overcome the problem of stockouts so that they can meet consumer needs and satisfaction. When that happens, it is expected to increase batik sales in the future.

Based on these problems, it is necessary to simulate the number of sales in Batik X SMEs. Monte Carlo is a method used to produce the outcome of a probability distribution. The random process in Monte Carlo uses random numbers. This random number is a set of numbers whose probability of occurrence is the same (the probability of the number arising is the same) and the pattern of numbers that arise cannot be identified. The random numbers used in the Monte Carlo simulation are generated by computers (Nizar Nasution, 2016).

Monte Carlo simulations have a stochastic nature based on the use of random numbers and the possibility of identifying a problem. This method was previously used to solve quantitative problems with physical processes. Such as dice roll or card matching to derive samples (Dedrizaldi et al., 2019). Sufficient inventory is useful to minimize the capital that has been invested into such inventory. To find out the stock inventory in the future to avoid losses, a simulation process is needed that can predict the number of stocks of goods in the future (Manurung & Santony, 2019). A random number is a number that cannot be predicted to occur, a random number can be generated with a certain pattern called a distribution following a specified distribution function. Many algorithms or distribution methods can be used to generate random numbers. Random numbers are widely used in cryptography (data security). This *Monte Carlo* provides practical solutions to transport emerging problems in visual effects, feature animation, architectural design, and product visualization, and is currently widely used to render images in suitable industries (Novák, 2018). The basis of the Monte Carlo method is the experimentation of various possible elements using a random sample. The advantage of the Monte Carlo method is that it is a powerful numerical calculation tool for

simulating statistical data, this simulation obtains accuracy values accurately from the physical form of the observable system (Liu et al., 2019).

II. RESEARCH METHODOLOGY

The stages of research are:

1. Identify and understand the problem, then set research objectives
2. Observation of the location to make direct observations of activities at Batik X SMEs as well as data related to the material needed in the research.
3. Interviews or questions and answers with relevant parties to dig up information.
4. Literature study by collecting data and information by reading and studying books and research journals related to research.
5. Implementation by calculating to predict batik income specifically for sustainable products in the future with a web-based simulation application using the PHP & MySQL Database programming language by applying the Monte Carlo method calculation algorithm.
6. Testing the results by matching the results of the manual calculation of the Monte Carlo method with the results of the Monte Carlo method calculation.
7. Analyze the results to determine the accuracy of the results obtained from calculations in the application of the Monte Carlo method.

III. RESULT AND DISCUSSION

In building a simulation model several steps must be done:

3.1 Setting the Probability Distribution

Establishing the probability distribution can be done by dividing each frequency by the total frequency that exists. Then the formula for determining the probability distribution will be:

$$P = F/J \quad (1)$$

Where:

P = Probability Distribution;

F = Frequency;

J = Total frequency.

3.2 Building a Compulsive Probability Distribution

The Compulsive Probability Distribution can be sought from the summation of probability distributions and compulsive distributions by summing the numbers on the probability distribution by the previous sum. The formula is:

$$DPK = AK + JA \quad (2)$$

Where:

DPK = The Compulsive Probability Distribution;

AK = Numbers on the Probability;

JA = The Previous Sum.

3.3 Determining random number intervals

Random number intervals can be determined based on the probability of occurrence and the cumulative probability obtained in the previous step. The determination of random number intervals is carried out on each variable. The function of this random number interval is to determine the boundary between one variable and another.

3.4 Generating Random Numbers

The generation of random numbers will result in a sequence of numbers and the result will later be able to know the probability. To generate random numbers in this study, the Mixed Congruent Method was used. Here's the formula from the Mixed Congruent Method:

$$Z_{i+1} = (d * Z_i + c) \text{ mod } m$$

Where:

d = multiplier constant ($d < m$);

c = shift constant ($c < m$);

m = modulus constant ($m > 0$);

Z_i = prefix number (integers $0, Z_0 < m$).

3.5 Simulating the Monte Carlo Method

Simulation of the Monte Carlo Method is carried out by comparing and calculating random numbers that have been generated in the previous step with random number intervals.

The following are the stages of Monte Carlo Analysis in predicting an increase in sustainable batik sales in Batik X SMEs:

3.6 Grouping Sales Data

The data used to predict the increase in batik sales is sales data. One of the sales data is the sales data of sustainable batik products in 2020 in Table 1:

Table 1. Data on The Number of Sales In 2020

No	Month	Sum
1	January	256
2	February	255
3	March	186
4	April	182
5	May	229
6	June	271
7	July	197
8	August	223
9	September	292
10	October	193
11	November	198
12	December	185
Total		2657

From Table 1, there are 2,667 batik products sold, which are grouped to be able to conduct Monte Carlo Simulation in predicting an increase in sales at Batik X SMEs.

3.7 Calculating the Probability Distribution

Here is Table 2 which presents the probability distribution calculations based on the data presented in Table 2.

Table 2. Probability Distribution Data in 2020

No	Month	Frequency	Probability Distribution
1	January	256	0,10
2	February	255	0,10
3	March	186	0,07
4	April	182	0,07
5	May	229	0,09
6	June	271	0,10
7	July	197	0,07
8	August	223	0,08
9	September	292	0,11
10	October	193	0,07
11	November	198	0,07
12	December	185	0,07
Total		2667	1

The calculation of the probability distribution is obtained from the frequency divided by the total frequency.

3.8 Calculating the Cumulative Distribution

Here is the calculation of the compulsive distribution presented in Table 3.

Table 3. Cumulative Probability Distribution Data in 2020

No	Month	Frequency	Probability Distribution	Cumulative Probability
1	January	256	0,10	0,10
2	February	255	0,10	0,20
3	March	186	0,07	0,27
4	April	182	0,07	0,34
5	May	229	0,09	0,43
6	June	271	0,10	0,53
7	July	197	0,07	0,60
8	August	223	0,08	0,68
9	September	292	0,11	0,79
10	October	193	0,07	0,86
11	November	198	0,07	0,93
12	December	185	0,07	0,99
Total		2667	1	1

3.9 Determining the interval of a random number

Here is a table that presents random number intervals:

Table 4. Random Data Number Interval in 2020

No	Month	Frequency	Cumulative Probability	Random Number Interval	
				First	Last
1	Januari	256	0,10	1	10
2	Februari	255	0,20	11	20
3	Maret	186	0,27	21	28
4	April	182	0,34	29	35
5	Mei	229	0,43	36	44
6	Juni	271	0,53	45	53
7	Juli	197	0,60	55	60
8	Agustus	223	0,62	62	68
9	September	292	0,68	70	79
10	Oktober	193	0,79	80	85
	November	198	0,86	86	94
12	Desember	185	0,93	95	100
Total		2667	1		

3.10 Calculate and generate random numbers

To determine the interval of random numbers calculated from the number sold of batik products after calculating the random interval, then perform a random number calculation. The calculation of random numbers is carried out by the mixed congruential generator method. Known value: $d=18, z=20, c=25, m=99$

Table 5. Random Numbers

No	Random Numbers
1	9
2	78
3	4
4	60
5	15
6	91
7	88
8	33
9	37
10	52
11	40
12	13

78, 4, 60, 15, 91, 88, 33, 37, 52, 40, and 13.

3.11 Simulation Results

The following are the results and simulations to predict the increase in sales of batik products.

Table 6. Prediction Simulation Results in 2021

Bulan	Random Numbers	Simulation Results
January	9	236
February	78	255
March	4	136

While Table 7 shows the results of the simulation of the prediction of the number of sales in the first 3 months of 2022 based on data in 2021

Table 7. Prediction Simulation Results in 2022

Bulan	Random Numbers	Simulation Results
January	9	282
February	78	276
March	4	285

IV. CONCLUSION

Monte Carlo simulations have been successfully applied to estimate sales of Batik X SME batik products in the dating period based on sales data in the past. The level of accuracy of comparison between simulation results and real data is obtained, namely 88% for 2021 and 90% for 2022.

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