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Optimization of supply and demand of bread sales as an over production solution in Hani Cake and Bakery

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ABSTRACT

Monte Carlo simulations are used to model the probability of different outcomes in a process that cannot easily be predicted due to the intervention of random variables. In this case, Monte Carlo develops several policies to optimize income costs at Hani Cake & Bakery. Hani Cake & Bakery have a problem with bread demand. Sometimes, demand is low that will pile up bread stock while causing the remaining bread to expire, and sometimes the demand is high, causing the bread stock not to meet customer demand. These problems will have an impact on income costs. In this simulation, the input data needed are cake supply, demand, and sweetbread return data in Hani Cake & Bakery, which will later determine the expired rate. The simulation obtained 30 replications with an expiration rate of 119 bread with an inventory cost of Rp. 413.000. The next policy will be determined by making a new policy in scenarios 1 and 2 by reducing the supply level by 20% and 35%. These results obtained a policy that can be applied to Hani Cake & Bakery with a benchmark of income costs.

ABSTRAK

Simulasi Monte Carlo digunakan untuk memodelkan unsur probabilitas dari data yang berbeda dalam proses yang tidak dapat diprediksi hasilnya karena menggunakan variabel dan data acak. Dalam kasus ini, Monte Carlo digunakan untuk mengembangkan beberapa kebijakan yang digunakan untuk mengoptimalkan biaya pendapatan pada Hani Cake & Bakery. Hani Cake & Bakery memiliki rmasalah dengan permintaan roti. Dimana terkadang permintaan rendah dan membuat stok roti menumpuk sehingga menyebabkan roti kedaluwarsa dan terkadang permintaan tinggi sehingga menyebabkan stok roti tidak dapat memenuhi permintaan pelanggan. Masalah-masalah tersebut akan berdampak pada biaya pendapatan. Dalam simulasi ini, data input yang dibutuhkan adalah data persediaan kue, data permintaan, dan data retur roti manis di Hani Cake & Bakery yang nantinya akan digunakan untuk menentukan tingkat kadaluwarsa. Dari hasil simulasi yang telah dilakukan diperoleh 30 replikasi dengan tingkat kadaluwarsa 119 roti menghasilkan biaya persediaan Rp. 413.000. Penetapan kebijakan selanjutnya akan ditentukan dengan membuat kebijakan baru pada skenario 1 dan 2 dengan menurunkan tingkat rantai pasok sebesar 20% dan 35%. Dari hasil tersebut akan diperoleh kebijakan yang dapat diterapkan pada Hani Cake & Bakery dengan tolak ukur biaya pendapatan.

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1. Introduction

Since March 11, 2020, WHO has declared that Corona Virus Disease 2019 (Covid-19) is a pandemic due to epidemics in various countries, including Indonesia. Covid-19 is a virus discovered at the end of December 2019 in Wuhan, China, that infects the human respiratory system [1]. Following up on the spread of this virus, the Indonesian government imposed Large-Scale Social Restrictions or called PSBB, based on Minister of Health Regulation No. 9 of 2020. These social restrictions, of course, will have an impact on several aspects, one of which is the economy. Based on [2], various countries will experience losses to Gross Domestic Product (GDP) due to the economy being affected by the COVID-19 outbreak that has hit the world one of these countries is

Indonesia. According to [3], Indonesia experienced a GDP loss of 2.41 percent in the first quarter of 2020 with a growth rate of 2.97 percent. This loss is due to a contraction in the business field. Business fields in Indonesia are dominated by small and medium enterprises, where the number of small and medium enterprises units reaches 99.9 percent of the total number of businesses in Indonesia. Then, there were around 37,000 small and medium-sized businesses reporting on the impacts experienced during the Covid-19 pandemic, namely 56 percent experienced a decline in sales, 22 percent experienced problems in the cost aspect, 15 percent experienced problems in distributing goods, and 4 percent experienced problems in obtaining raw materials [4].

The sales decline also occurred in Hani Cake & Bakery, a bakery company located in Yogyakarta. Hani Cake & Bakery provides various kinds of cake, bread, and tart products with various shapes and flavors. The decline in sales was due to a government regulation that limited the movement of people, especially in public places such as supermarkets, which is one of the best seller distribution places for Hani Cake & Bakery. Hani Cake & Bakery products are distributed through supermarkets and grocery stores around Sleman. The sales decline is indicated by the number of products being returned to the store after four days of being displayed at the distributor's place. The returned products were usually displayed again at the main store of Hani Cake & Bakery to resell by being given a price cut of 50 percent, but even though it has sold do price cuts, these products often remain until they expire so that they become unfit for consumption and are finally throw away, so Hani Cake & Bakery gets a loss. It is necessary to re-plan production considering that the products sold by Hani Cake & Bakery are perishable products or often called products with a limited lifetime, so it is important to do better production planning so as not to cause losses due to the many stale products.

In Hani Cake & Bakery, the problems are complex because they cannot be solved only by mathematical methods and analysis. After all, the demand and supply of bread are uncertain (stochastic) and occur repeatedly, and the amount cannot be determined. On this basis, the researcher chose to solve the problem using the simulation method as an alternative problem solving because simulation offers a reliable approach to studying and evaluating inventory system models with stochastic and dynamic characteristics. Simulations allow users to emulate inventory management that varies over a long period with detailed results based on quantifiable variables [5]. Simulation is a process to model a real system, and experiments are conducted on models to understand the behavior or development of models that have been made with various strategies and policies that can be operated in real systems [6].

One of the most widely used simulation methods is the Monte Carlo simulation. Monte Carlo simulation can be defined as a statistical sampling technique used to estimate solutions to quantitative problems [7]. The Monte Carlo method is a numerical analysis method that involves sampling random number experiments. This method provides a solution to the problem based on a randomization process involving a probability distribution of the data variables collected based on historical data and theoretical probability distributions. These random numbers explain random events and sequentially follow changes that occur in the simulation process [8]. The nature of the random number is uniform in every set of random numbers generated, and the probability of getting a random number is not affected by the previous number [9]. Monte Carlo simulations have been applied to various fields, including project management, transportation, computer design, finance, meteorology, biology, and biochemistry [10]. Monte Carlo can simulate fluctuating cases [11], such as the demand for bakery products which is currently uncertain due to social restrictions. The Monte Carlo simulation can also help solve everyday problems, one of which is the problem at the grocery store to simulate the sales model to estimate the number of sales of goods in the next period [12].

Study [11] used the Monte Carlo simulation to calculate the optimal total production in a bakery shop that had problems determining the total number of products due to product demand that fluctuated every day. The simulation is carried out using the total sales data of traditional cakes, which are then processed using Microsoft Excel and Matlab Programming to obtain the optimal solution. Another study was conducted by [13], who used the Monte Carlo simulation to simulate the supply of food products to help managers manage their business, especially the problem of production quantity in a more planned manner in a more structured and optimal production system. Another Monte Carlo study to determine EOQ [14] was conducted due to lead time and demand uncertainty. Monte Carlo is also used to predict the number of product purchases to reduce large losses and save the budget [15].

Another research was carried out by Andriana [16], who uses monte Carlo to predict the inventory of tempe chips production. The study used Monte Carlo to complete the model for supplying mineral water products, also a perishable product. In this study, the average demand for mineral water was obtained annually, which became the company's benchmark in determining the amount of production [17]. From these results, it can be concluded that the Monte Carlo simulation can be applied to solve processed food products with a fairly short expiration date. This research that will be carried out is a Monte Carlo simulation to find out the optimal number of products to be distributed to distributors so that not many products are wasted, by relating it to data on sales, demand, and the number of products returned. This research expects Hani Cake & Bakery to calculate and minimize possible losses caused by the inaccurate quantity of production.

2. Research Methodology

The place of research is Hani Bakery & Cake, with the object of research being bread. There are two types of data used in the study: primary data in bread sales data, bread demand data, and returned bread data. The second is secondary data from previous studies such as journals/proceedings. The method used in this research is Monte Carlo, which predicts the demand for bread in the future. This research methodology will explain the stages that will be carried out to overcome the existing problems. The following are the stages carried out during the research.

2.1. Identfication of Problems

The initial stage was carried out to determine the problems faced by one Hani Cake & Bakery, one of the bread producers in Sleman Yogyakarta. The problem identified is the number of unstable requests that tend to drop due to COVID-19, leading to many slices of bread being used as the foundation.

2.2. Determining Goals and Problem Formulation

The study's objectives were determined at the outset to address the research questions, and the research did not extend beyond the research questions. The study's objective must be very apparent to be beneficial to users.

2.3. Data Collection

Data collection techniques were carried out by direct observation and conducting interviews with the owner of Hani Cake & Bakery to obtain various required data. These data include bread supply, bread demand, bread returns, data on the cost of bread production, the selling price of bread for three months from March-May 2021, and the number of suppliers.

2.4. Data Processing with Monte Carlo Simulation

After the data is collected, data processing will be carried out using the Monte Carlo simulation method to predict future supply and demand. The data processing is carried out using Microsoft Excel software with the following steps:

a. Create a probability distribution.
b. Calculate cumulative probability distribution.
c. Create class intervals for random numbers.
d. Perform simulations with random numbers.

2.5. Validation

After the simulation model is completed, validation will be carried out to ensure whether the model that has been created already represents the real system. If the model is declared invalid, it must repeat the data processing process. The following are the validation results using the average two similarity test and the two variance similarity test.

2.6. Model Analysis, Experiment Design, and Alternative Selection

After being said to be valid, the model will be analyzed to find out the problems faced and some of the variables that cause these problems. Experimental design is carried out in order to make improvements to the existing system and make alternative choices from various experiments that have been carried out and analyze the results of the experimental design.

3. Result and Discussion

3.1. Monte Carlo Simulation

Monte Carlo simulation in this study is designed to provide production strategy to Hani Cake & Bakery so that during the current pandemic the store remains sustain and does not suffer losses due to supply and demand of bread in the market is not appropriate. In pandemic conditions, the store is still conducting bread sales activities. One of its marketing targets is Mirota Gejayan, but the amount of bread delivered is still too much than the demand for bread during the pandemic. By applying Monte Carlo Simulation, Hani Cake & Bakery can also increase profits by minimizing the cost of producing bread. This simulation is done by using Microsoft excel application by generating random numbers. The data used in this study is data on the supply of bread (bread stock/bread made) , demand for bread (demand from customer), return of bread (bread that does not sell and is returned to the shop), data on the cost of production of bread (the cost of making one bread), and the selling price of bread for 3 months from March-May 2021 with marketing targets to Mirota Gejayan. The following is the result of Monte Carlo simulation processing.

Table 1. Probability of bread's supply.

Supply	Frequency	Probability	Cum probability	Lower lim.	Upper lim.
0	71	0.76344086	0.76344086	0	76
28	1	0.010752688	0.774193548	77	78
32	2	0.021505376	0.795698925	79	80
35	1	0.010752688	0.806451613	81	81
36	6	0.064516129	0.870967742	82	87
40	1	0.010752688	0.88172043	88	88
48	11	0.11827957	1	89	100
Total stock supply	911				

Based on Table 1, it can be seen that the total supply of bread for three months is 911 bread, with the frequency of supply being 22 times making deliveries to Mirota Gejayan. The next step is to determine the probability of the demand for bread. Table 2 shows the calculation of the demand for bread. Based on Table 2, it can be seen that the total demand for bread for three months is 494 slices of bread with a total frequency of requests is 22 times. It can be seen that the problems in Hani Cake & Bakery can be seen that there is overproduction. The next step is to calculate the probability of returning sweetbreads. Here is the calculation.

Table 2. Probability of bread's demand.

Demand	Frequency	Probability	Cum probability	Lower lim.	Upper lim.
0	71	0.76344086	0.76344086	0	76
11	1	0.010752688	0.774193548	77	77
12	2	0.021505376	0.795698925	78	80
13	2	0.021505376	0.817204301	81	82
15	1	0.010752688	0.827956989	83	83
16	2	0.021505376	0.849462366	84	85
21	1	0.010752688	0.860215054	86	86
22	1	0.010752688	0.870967742	87	87
23	2	0.021505376	0.892473118	88	89
24	2	0.021505376	0.913978495	90	91
26	1	0.010752688	0.924731183	92	92
27	2	0.021505376	0.946236559	93	95
29	1	0.010752688	0.956989247	96	96
30	1	0.010752688	0.967741935	97	97
32	1	0.010752688	0.978494624	98	98
34	1	0.010752688	0.989247312	99	99
44	1	0.010752688	1	100	100
494	93				

Table 3. Probability returns of bread.

Return	Frequency	Probability	Cum probability	Lower lim.	Upper lim.
0	72	0.774193548	0.774193548	0	77
4	1	0.010752688	0.784946237	78	78
6	1	0.010752688	0.795698925	79	80
9	1	0.010752688	0.806451613	81	81
10	2	0.021505376	0.827956989	82	83
11	1	0.010752688	0.838709677	84	84
13	2	0.021505376	0.860215054	85	86
14	2	0.021505376	0.88172043	87	88
16	3	0.032258065	0.913978495	89	91
17	1	0.010752688	0.924731183	92	92
20	1	0.010752688	0.935483871	93	94
23	1	0.010752688	0.946236559	95	95
24	2	0.021505376	0.967741935	96	97
25	2	0.021505376	0.989247312	98	99
27	1	0.010752688	1	100	100
337	21				

Based on Table 3, it can be seen that the total return of bread for 3 months is 337 breads with a total frequency of requests is 21 times. It can be seen that there is a return rate of bread from Mirota Gejayan to Hani Cake & Bakery. Next is the creation of a Monte Carlo simulation. The following are the results of the Monte Carlo simulation.

3.2. Validation

The developed model is then tested to ensure that it accurately depicts a genuine system or is identical. The following are the results of the validation using the Mean Comparison Test and the Variance Comparison Test. The parameters are the supply of bread, demand for bread, the amount of bread returned.

a. Mean comparison test. The mean comparison test compares the real system's performance with the simulation model from the value of output mean on both population data. Because the data is from two populations, the test used is double-sided.
b. Variance comparison test. The variance comparison test ensures that two populations have the same variance.

Table 4. Monte Carlo simulation.

Day	Rand	Supply	Rand demand	Demand	Return	Rand return	Buy return	Expired
1	24	0	100	0	0	96	0	0
2	75	0	98	0	0	8	0	0
3	28	0	87	0	0	77	0	0
4	21	0	81	0	0	4	0	0
5	78	28	95	27	1	38	0	1
6	63	0	87	0	0	48	0	0
7	88	40	81	13	27	98	25	2
8	67	0	89	0	0	70	0	0
9	2	0	99	0	0	55	0	0
10	81	35	78	12	23	54	4	19
11	81	35	83	15	20	23	0	20
12	13	0	90	0	0	18	0	0
13	6	0	99	0	0	9	0	0
14	19	0	96	0	0	31	0	0
15	69	0	94	0	0	95	0	0
16	66	0	84	0	0	48	0	0
17	55	0	86	0	0	44	0	0
18	91	48	81	13	35	73	4	31
19	66	0	98	0	0	35	0	0
20	76	0	83	0	0	33	0	0
21	9	0	100	0	0	99	0	0
22	32	0	92	0	0	83	0	0
23	80	32	97	30	2	28	0	2
24	54	0	78	0	0	9	0	0
25	97	48	90	24	24	56	4	20
26	16	0	98	0	0	11	0	0
27	51	0	84	0	0	84	0	0
28	96	48	86	21	27	59	4	23
29	5	0	97	0	0	52	0	0
30	70	0	86	0	0	20	0	0

Table 5. Validation of bread's supply.

Validation of bread's supply			
Similarity two average		test similarity two variance	
Z value	−0.53321536	F crit	1.0467
Boundary	± 1.96	Boundary	0.65 < Fcrit < 1.5192
Result	Valid	Result	Valid

Table 6. Validation of bread's demand.

Validation of bread's demand			
Similarity of two averages		Similarity of two variances	
Z value	-1.0092	Fcrit	0.7717
Boundary	± 1.96	Boundary	0.65 < Fcrit < 1.5192
Result	Valid	Result	Valid

Table 7. Validation of bread's return.

Validation of bread's return			
Similarity of two averages		Similarity of two variances	
Z value	0.0733	Fcrit	0.749
Boundary	± 1.96	Boundary	0.65 < Fcrit < 1.5192
Result	Valid	Result	Valid

Based on Table 5, the result of the two statistical tests declares that the model is valid because, in the mean comparison test, the Z value is located between the boundary and the result of the variance comparison test. The amount of data used for invalidation is 30 data. The next step is to validate the other parameters. Bread's demand parameter also declares that the model that has been created is valid. The result of calculation Z value is -1.0092. It is between ± 1.96. Furthermore, from the variance comparison test, Fcrit is 0.7717, also between the statistic boundary.

The result of the two statistical tests declares that the model is valid because, in the mean comparison test, the Z value is located between the boundary and the result of the variance comparison test. Based on Table 7, it is known that the Fcrit and Z test with the parameters of supply, demand, and return of bread for three months stated that there was no difference between the simulation model and the real system, or the model was said to be valid with the statistical test validation technique. After the model has been valid, bread's supply is usually too much than bread's demand because the number of unsold bread must be large and returned to the store. In addition, the profit generated from the spread of bread in Mirota Gejayan is not maximal due to the high

cost of bread production. If there is no improvement to the bread production system, it can cause a very detrimental thing for Hani Cake & Bakery. Therefore, researchers designed a design experiment to improve the bread production system presented in the Monte Carlo simulation.

3.3. Design Experiment

The next step is to make an experimental design to solve the problems that exist in the simulation model. The experimental design designed is to adjust the supply and demand of bread to search the optimum total inventory cost. Here are the results of the experimental design already designed.

a. Design experiment 1. Based on Table 8 and Figure 1, it is known that the supply is always greater than the demand for bread. The fact was not noticed by Hani Cake & Bakery, therefore they tried to design a policy that the supply was reduced to 20%.
b. Design experiment 2. Experimental design 2 is almost the same as experimental design 1, the parameter that is changed is the amount of production or supply of bread. In the experimental design of 2 researchers tried to reduce the amount of production by 35%. The parameter used to compare the initial model with experimental models 1 and 2 is profit. The following are the results of the benefits obtained based on the initial model, experimental design models 1 and 2.

Table 8. Profit comparison between previous model, experiment design model 1 and 2

Previous model	Experiment design model 1	Experiment design model 2
Rp. 413.000	Rp. 599.000	Rp. 649.400

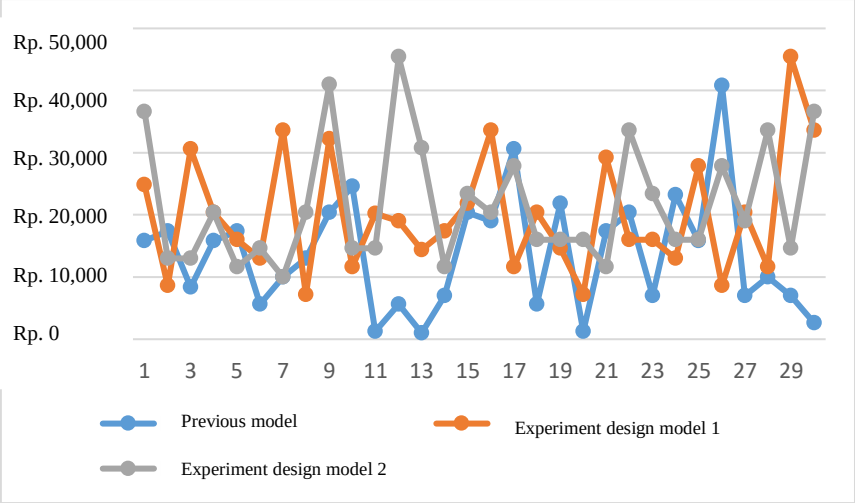

Figure 1. Profit comparison.

Table 9. Amounts of breads expired comparison

Previous model	Experiment design model 1	Experiment design model 2
119 breads	67breads	49 breads

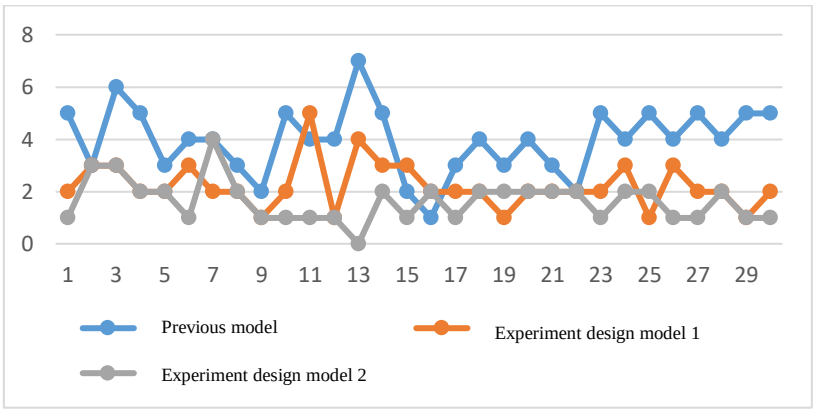

Figure 2. Average amount of breads expired comparison.

The experimental design model can certainly reduce the average number of pieces of bread that are not purchased and become expired. Here is the result of the fix with 30 replications. Based on Figure 3, it is known that the yellow color is experimental model 2, green is the initial model, blue is the experimental model 1. As we know, the amount of bread supply is always greater than bread demand. Then we must adjust supply and demand. The result of alternative 1 managed to increase the profit obtained by Hani Cake & Bakery from Rp. 413.000 to Rp. 599.000 in 1 month for sweet bread. Slain, can also lower the level of bread that expired because consumers do not buy it from 119 bread to 67 pieces of bread. Alternative two also managed to increase the profit earned from Rp. 413,000 to Rp. 599,000. In addition, the number of unsold pieces of bread also decreased from 119 to 49 pieces of bread. Based

on that alternative chosen as the proposed improvement is alternative 2. The results follow [10] that Monte Carlo simulation can be a model used to forecast and produce system improvement policies.

4. Conclusion

This research is expected to know the optimum scenario to decrease the total inventory cost and expired bread. Total inventory cost consists of supply, expired cost (unsold bread), and shortage costs (opportunity lost). It can be identified the problems contained in Hani Cake & Bakery for 30 times of replication in the form of a high expired (wasted) rate of 119 pcs of bread because of a considerable loss due to wasted bread with an analysis of the initial model and an income of Rp. 413,000 is obtained. Waste of bread needs to be minimized so that sales can be more optimal, so from the results of the initial model analysis, a policy was built to reduce the supply of Hani Cake & Bakery type of bread by 20% in scenario one and 35% in scenario two, so the number of expired rates can go down in total 67 pcs of bread with an income of Rp. 599,800 in scenario one and an expired rate of 49 pcs of bread with a total Rp income cost. 649,400. So the bakery can reduce bread production by about 35%, from 911 pieces of bread made to 592 bread. With the simulation results that have been validated, the Monte Carlo model can be used to predict the number of bread making to be sold in the market. So that there are not many products expired and gain high profits. Other bakeries can also use this simulation model besides Hani Cake & Bakery by adjusting the shop's supply, demand, and cost conditions.

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