JURNAL TEKNOLOGI DAN OPEN SOURCE
Vol. 5, No. 2, December 2023, pp. 170~178
e-ISSN: 2622-1659, accredited Four Grade by Kemenristekdikti, Decree No: 36/E/KPT/2019
DOI: 10.36378/jtos.v6i2.3378

Monte Carlo Simulation to increase the efficiency of Gas Distribution in Padang City

Zulfitri Yani, Nurmaliana Pohan, Devi Gusmita, Eva Rianti

[1,3,4] Departement of Information System, Universitas Putra Indonesia "YPTK" Padang
[2] Departement of Technical Information, Universitas Putra Indonesia "YPTK" Padang

Article Info

Article history:

Received 11 02, 2023
Revised 12 15, 2023
Accepted 12 28, 2023

Keywords:

Data
Gas
Prediction
Simulation
Monte Carlo

ABSTRACT

PT. Cahaya Hermes Indo Abadi is one of the largest non-subsidized gas distributors in the city of Padang. Gas is a necessity in society. It is necessary to pay attention to the availability of gas to meet consumer needs, the state of gas stocks can affect the level of sales revenue. Sales relate to consumer desires for goods and services that they want to fulfill. Increasing the amount of gas demand can generate a large income. In predicting gas needs, a method is needed that is able to overcome society's gas needs. One of the methods used in this research is the Monte Carlo Method. This method is able to overcome further gas needs so data is needed to overcome this problem. The data used is 12 Kg non-subsidized gas sales data for three years, namely Gas Sales Data for 2021, 2022, and Gas Sales Data for 2023. The level of prediction accuracy in 2022 is 86.9% and in 2023 the accuracy is 86.6%. Based on the gas distribution simulation that has been carried out, the average is 86.75%. By obtaining a greater level of accuracy, this method is suitable for use and implementation in predicting future gas demand, making it easier for companies to make decisions in the future.

Corresponding Author:
Zulfitri Yani
Departement of Information System,
Universitas Putra Indonesia "YPTK" Padang
Padang, West Sumatra
Email : zulfitriyani08@gmail.com

1. Introduction

Technological developments are currently increasingly rapid, with this sophisticated technology it is able to make people think more advanced. With the human ability to consider all possibilities before taking decisions and actions. One of them is the problem of managing availability. Inventory is a number of commodities to meet future needs. Having a stable supply of goods can make sales run smoothly. PT Cahaya Hermes Indo Abadi is one of the largest non-subsidized gas distributors in the city of Padang. The gas sold is very diverse, starting from 5.5 kg gas, 12 kg gas, and 50 kg gas. Gas is one of the needs that exist in society. Gas is widely used in everyday life, apart from functioning as vehicle fuel, gas is also used for household needs.

In managing current gas demand, companies still find it difficult to predict gas demand in the future, so one method is used that is able to solve demand problems according to consumer needs, namely by using a prediction. Prediction is the process of estimating possible outcomes. will occur in the future systematically based on facts obtained from the past to minimize the chance of an error occurring [1]. The facts obtained are

in the form of information that is relevant and in accordance with the need to find a picture that can make it easier to carry out the investigation [2]. The existing facts are in the form of past data which is used as a reference in estimating future demand. The data used is sales data for 2 consecutive years. Sales are the number of goods purchased or requested at a certain unit price [3]. In predicting demand for goods, a model is needed. A model is an explanation or picture that cannot be seen directly. A model can also be interpreted as creating an imitation of an object or system into the form of an object whose form will later resemble the original form of the system itself.[4]. The method used to make predictions/estimates is the Monte Carlo method [5]. Simulation is a computer program (software) that functions to imitate the behavior of a certain real system (reality). The purpose of a simulation is training, study of behavior systems, entertainment, or games.

Modeling and simulation are tools that are often used by management in studying or analyzing the work behavior of a system or process [6]. Monte Carlo Simulation Monte Carlo simulation is a type of probabilistic simulation to find solutions to problems by sampling from random processes [7]. The random process is carried out by generating numbers randomly, and the resulting numbers are varied so that the resulting numbers can help determine future demand. In Monte Carlo simulation a model is built based on a real system. Each variable in the model has a value that has the probability of each variable [8]. Monte Carlo simulations (Monte Carlo experiments) are a broad class of computational algorithms that use random sampling to obtain numerical results, usually carrying out the simulation many times to obtain the distribution of unknown probabilistic entities [9]. The basis of the Monte Carlo method is the experiment of various elements of probability using random samples. The advantage of the Monte Carlo method is that it is a powerful numerical calculation tool for simulating statistical data, this simulation obtains accurate values accurately from the physical form of the system that can be observed [10]. Prediction of sales levels with a very good average level of accuracy in the following year [11]. The advantage of the Monte Carlo method is that it makes it easier to predict forecasting in the form of numerical data and is also useful in analyzing costs and scheduling [12]. In Monte Carlo simulation, random numbers are used. Random numbers in Monte Carlo can be generated by generating these numbers according to the distribution of sample data [13].

Monte Carlo simulation has the advantage that it is easy to apply and the results are close to actual values [14]. To make it easier to identify obstacles and problems by using the technique used in predicting data with Monte Carlo simulation, namely by presenting the problem on a knowledge Base basis [15]. The Monte Carlo algorithm will determine choices based on probability and density so that it will determine the best choice [16]. Because this algorithm requires very complex calculations and repetitions, this method generally uses various computer simulation techniques and is carried out using a computer. The Monte Carlo algorithm is a numerical method used to find solutions to mathematical problems (consisting of many variables) that are difficult to solve, such as integral calculus or other numerical methods [17]. The Monte Carlo method can also be used as a tool to analyze and solve existing problems in mathematical form with several random statistical examples [18].

Monte Carlo is able to simulate a system repeatedly by assigning random numbers to each variable from its probability distribution [19]. Other previous research in applying the Monte Carlo method was a simulation in increasing sales of Tiens sharia calcium products. The data used in this research is calcium sales data from 2018 to 2019. The results obtained in this research show an accuracy level of 91% and 93% and are able to predict demand for goods and sales in the following year. The results of predicting the number of requests and sales revenue can help leaders in making decisions [20]. In research conducted by Hasanah, W.P., et al in 2020. Based on the results of a Monte Carlo simulation with 30 replications, it is known that the total minimum storage cost for PRC blood components for blood type AB is IDR 31,390,500 and there is a decrease in shortage from 18 blood bags to 4 blood bags with service level of 99.02% [21]. In research conducted by Simangunsong, A, in 2023, data obtained from Putri Deli Elementary and Middle School can be processed by applying the Monte Carlo method to obtain results with an accuracy level of around 77% to 93%, wherewith this level of accuracy it can predict stationery supplies. in the following year[22]. In research conducted by Triananda, et al. Inventory control performance is reviewed from total inventory costs and service level attainment. The results of the 1518512 spare parts simulation show that the total inventory cost has decreased from Rp. 127,129,418.59 to Rp. 38,615,585.93 and service level achievement has increased from 97.83% to 98.71% [23]. In research conducted by Efendi, G. et al., Simulation results for January 2023. The optimal level of blood supply based on blood groups A, B, AB, O, respectively, is 27, 27, 4, and 46 bags. For February 2023, blood groups A, B, AB, O are 28, 27, 5 and 45 bags respectively. The level of accuracy of this data processing is the prediction of the average demand for each blood type with a percentage of 90% for January 2023 and 81% for February 2023 [24]. In research conducted by Sari. I,Y. et

al,. simulations in predicting demand and use of blood components as well as accuracy values can be increased to be greater so that the average accuracy percentage is 93.1% [25]. With this research, the author aims to help PT. Cahaya Hermes Abadi to solve problems regarding gas availability. The author uses the Monte Carlo method to solve the problem because implementing this method can help the company estimate product availability in the future, and get accurate results based on the level of accuracy produced. The results of this research are expected to be a consideration for companies in determining the amount of gas inventory for 2024, based on data from the previous 3 years. This research is expected to provide information about gas availability in the future.

2. Research Method

The method that will be used in this research is the Monte Carlo method. Several stages will be carried out to overcome the problem. The steps that will be taken in solving the problem can be seen in the research framework in Figure 1

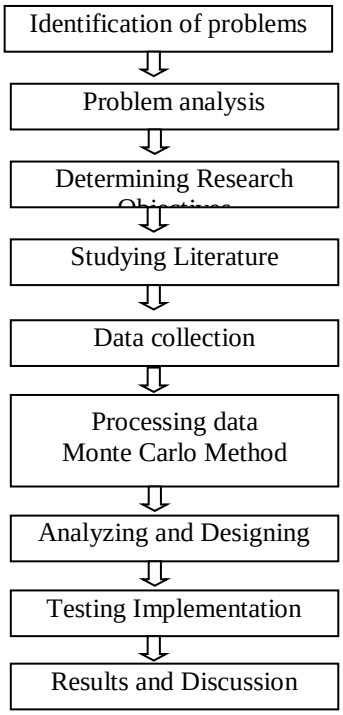

Figure 1. Research Framework

2.1. Identifying Problems

This step is the first step to determine the formulation of the problem that occurs at PT. Cahaya Hermes Indo Abadi, namely the implementation of the Monte Carlo method in determining predictions of future gas demand.

2. 2 Analyzing the Problem

The next step is to analyze the problem to understand the problems that have been determined in the previous scope or limitations. In this problem analysis, we describe the process for estimating gas demand that will be faced in the future based on past data that has been collected.

2.3.Determining Research Objectives

Research objectives are something that must be achieved in a study. The aim of this research is the ideal final result that is expected to be achieved after the research is carried out. At this point, it provides an indication of the direction in which the search is to be conducted or what data and information should be gathered from the search. This step clarifies the scope and boundaries of the problem. Determine what goals will be achieved at the end of the research, so that the research is more focused and useful.

2.4. Studying Literature

To achieve the objectives, several literatures were studied which were used to support this research. This literature is selected which will be used in the research. Literature is taken from various sources, namely in

the form of scientific works, articles, proceedings on the Monte Carlo method and other supporting reading materials.

2.5.Data collection
The data collected in the research is gas sales data for two consecutive years. The data is used as a reference in making predictions using the chosen method. The data obtained is real data. The data needed is gas sales data for 2 years.

2.6. Processing Data Using the Monte Carlo Method
At this stage, the data that has been collected will be processed. The data to be processed is data obtained from observations. Steps taken in the Monte Carlo method:

a.Create a probability distribution
b. Construct a cumulative probability distribution
c. Determine the random number interval
d. Generate random numbers
e. Carrying out simulation experiments

2.6 Analyzing and Designing
At this stage, analysis and design of existing problems will be carried out based on the data collected.

2.7 Implementation and testing
At this stage, implementation and testing of the processed data have been carried out using a programming language. It is hoped that the designed model will be useful for users so that the application of the Monte Carlo simulation method can predict possible future gas demand.

2.8 Results and Discussion
At this stage, the results of processing and testing data are presented to obtain prediction results. The results are compared with real data to see the percentage (%) accuracy. Gas sales data for 2021 is used as test data to predict gas sales in 2022, then 2022 data is used as test data to predict gas sales in 2023. Data for 2023 is used as a test to predict gas sales in 2024.

3. Result and Discussion

3.1. Analysis and Design Stages

In this research, the data used is gas sales data from 2021 to 2023. The gas sales data was processed using the Monte Carlo method. Gas sales data for 2021 is used as test data to predict gas sales in 2022, then 2022 data is used as test data to predict gas sales in 2023. Data for 2023 is used as a test to predict gas sales in 2024.
Gas sales data in 2021-2023 are presented in Table 1.

Table 1. Gas sales data for 2021-2023

No	Month	Frequency (Years)		
		2021	2022	2023
1	January	630	750	900
2	February	1700	1400	1100
3	March	450	800	1250
4	April	1150	1150	1200
5	May	550	750	900
6	June	1400	450	1552
7	July	1600	1600	1300
8	August	1.450	1450	1440
9	September	900	1250	1440
10	October	1300	1300	998
11	November	950	1350	1227
12	December	870	1100	990
Total		12.950	13.350	12.857

Based on the data in Table 1, it is then analyzed using the Monte Carlo method with the following stages:

a. Determining Probability Distribution (DP)

The probability distribution is obtained from dividing the variable by the total number of frequencies. with Equation:

Dp= Fr/Tf (1)

Where Dp is the probability distribution, Fr is the frequency, and Tf is the total frequency. Gas Probability Distribution in 2021-2023 is presented in Table 2.

Table 2 Cumulative Probability Distribution for 2021-2023

No	Month	Distribusi Probabilitas		
		2021	2022	2023
1	January	0.05	0.06	0.09
2	February	0.13	0.10	0.09
3	March	0.04	0.06	0.10
4	April	0.09	0.09	0.06
5	May	0.04	0.06	0.07
6	June	0.11	0.03	0.05
7	July	0.13	0.12	0.09
8	August	0.11	0.11	0.09
9	September	0.05	0.09	0.10
10	October	0.10	0.10	0.07
11	November	0.08	0.10	0.10
12	December	0.07	0.08	0.09
Total		1	1	1

b. Determining the Cumulative Probability Distribution

Cumulative distribution is the second step carried out in the Monte Carlo stage. In implementing this second step, it can be used as a reference or guideline in finding cumulative distribution results. Cumulative distribution is obtained by adding the probability distribution with the next cumulative distribution. but not for the first value, because the first value of the cumulative distribution is its own value.

Table 3 Cumulative Probability Distribution for 2021-2023

No	Month	Year 2021		Year 2022		Year 2023	
		DP	DK	DP	DK	DP	DK
1	January	0.05	0.05	0.06	0.06	0.09	0.09
2	February	0.13	0.18	0.10	0.16	0.09	0.18
3	March	0.04	0.22	0.06	0.22	0.10	0.28
4	April	0.09	0.31	0.09	0.31	0.06	0.34
5	May	0.04	0.35	0.06	0.37	0.07	0.41
6	June	0.11	0.46	0.03	0.40	0.05	0.46
7	July	0.13	0.59	0.12	0.52	0.09	0.55
8	August	0.11	0.70	0.11	0.63	0.09	0.64
9	September	0.05	0.75	0.09	0.72	0.10	0.74
10	October	0.10	0.85	0.10	0.82	0.07	0.81
11	November	0.08	0.93	0.10	0.92	0.10	0.91
12	December	0.07	1	0.08	1	0.09	1
Total		1		1		1	

c. Determining Random Number Intervals

The third step in the Monte Carlo method is to determine the random number interval. The random number interval value is obtained from the cumulative probability number value in the previous stage. The function of the random number value is to limit the value between one variable and another variable which functions as a reference value for the simulation results. As for determining the limiting value for the random number variable, it is:

a. The initial limit value for the first variable starts with the value 1.
b. The final limit value is determined by multiplying the cumulative probability value of each variable by the number 100 and rounded then reduced by the number 1.
c. The initial limit value for the second variable and so on is obtained from the final limit value of the previous variable. Random Number Interval Results are presented in Table 4 for 2021, 2022 and 2023.

Table 4 Distribution of Random Number Intervals for 2021-2023

No	Month	Year 2021		Year 2022		Year 2023	
		Beginning	End	Beginning	End	Beginning	End
1	January	1	5	1	6	1	9
2	February	6	18	7	16	10	18

3	March	19	22	17	22	19	28
4	April	23	31	23	31	29	34
5	May	32	35	32	37	35	41
6	June	36	46	38	40	42	46
7	July	47	59	41	52	47	55
8	August	60	70	53	63	56	64
9	September	71	75	64	72	65	74
10	October	76	85	73	82	75	81
11	November	86	93	83	92	82	91
12	December	94	100	93	100	92	100

d. Generating Random Numbers

The fourth step in Monte Carlo is by generating random numbers. At this stage several random numbers will be generated to carry out a simulation. The method used is the Linear Congruent Generator (LCG) method. This method is very suitable for use in simulations. This method requires 4 parameters whose values must be set first, namely a, zi, c and m. These 4 parameters are integer. To generate random numbers, use the formula in equation (2).

$Zi + 1 = (a * Z1 + c)\ mod\ M$ (2)

Where :

a = Multiplier number (a < m),

c=Displacement number (c < m,

m= Modulus number (m > 0)

Zi = Initial number (integer ≥ 0, Z0< m). Where i starts from 0.

Table 5 Random Numbers

I	value
1	94
2	79
3	88
4	43
5	70
6	34
7	16
8	7
9	52
10	25
11	61
12	79

Based on the table above, several random numbers are obtained, where these random numbers or numbers will be used as a reference or guideline for carrying out the simulation process.

e. Prediction and Testing Simulation

The final step in the simulation process is to create a series of simulations based on random numbers and random number intervals. The results of these simulations are presented in Table 7 for 2021, Table 8 for 2022, and Table 9 for 2023. The data in Table 7 is used to make a comparison of predicted data with real data.

Table 7 Comparison of Simulation Results and Presentation of Accuracy Levels 2022

No	Month	Accurate	Real Data	Accuracy (%)
1		870	750	86
2	January	1300	1400	93
3	February	950	800	84
4	March	1400	1150	82
5	April	650	750	93
6	May	550	450	82
7	June	1700	1600	94
8	July	1700	1450	85
9	August	1600	1250	78
10	September	1150	1300	88

11	October	1450	1350	93
12	November	1300	1100	85
Total		15420	13350	86.9

Based on the table above, the real data for 2021 is 13,350 gas cylinders. After carrying out simulation experiments, the results obtained in 2022 are 15,420 products, with an accuracy level of 86.9%.

Table 8 Comparison of Simulation Results and Presentation of Accuracy Levels 2023

No	Month	Accurate	Real Data	Accuracy (%)
1	January	950	900	93
2	February	1300	1100	93
3	March	900	1250	80
4	April	1600	1200	72
5	May	850	900	93
6	June	1050	1552	85
7	July	1400	1300	93
8	August	1400	1440	97
9	September	1600	1440	86
10	October	1150	998	90
11	November	1450	1227	80
12	December	1300	990	78
Total		15650	13350	86.6

Based on the table above, the real data for 2022 is 13,350 gas cylinders. After carrying out simulation experiments, the results obtained in 2023 are 15,650 products, with an accuracy level of 86.6%.

Table 9 Prediction Simulation Results for 2024

No	Month	Random Numbers	Simulation Result
1	January	94	1227
2	February	79	998
3	March	88	1227
4	April	43	680
5	May	70	1440
6	June	34	900
7	July	16	1250
8	August	7	900
9	September	52	1552
10	October	25	1250
11	November	61	1400
12	December	79	998
			13.822

The results in Table 9 are for 2024 and the accuracy cannot be found, because there is no real data for 2024. The results obtained are predictions of what will happen to sales. The results of this prediction become a reference for PT Cahaya Hermes Indo Abadi in preparing for future gas demand.

4. Conclusion

The results of this research show that the Monte Carlo Method is very optimal in helping PT. Cahaya Hermes Indo Abadi to estimate gas sales based on past sales frequency and help companies in making decisions in the future. The accuracy rate in predicting 2022 is 86.9% and in 2023 with an accuracy of 86.6%. The average level of accuracy obtained from simulation experiments in 2022 and 2023 is 86.75%. The prediction of gas demand in 2021 was then compared with real data in 2022, so an accuracy of 86.9% was obtained. Then, the predicted data for 2022, was compared with real data for 2023, and a percentage of 86.75% was obtained. Based on the percentage obtained, the overall percentage is above 85%, and this Monte Carlo method is very appropriate to use because it produces a high level of accuracy and can be used by companies in predicting future needs.

References

[1] Putra, B. M. (2020). Simulasi Monte Carlo dalam Memprediksi Tingkat Pendapatan Advertising. *Jurnal Informatika Ekonomi Bisnis*, 80-85.

[2] Astia, R. Y., Santony, J., & Sumijan, S. (2019). Prediction Of Amount Of Use Of Planning Family Contraception Equipment Using Monte Carlo Method (Case Study In Linggo Sari Baganti District). *Indonesian Journal of Artificial Intelligence and Data Mining*, *2*(1), 28-36.

[3] Geni, B. Y., & Santony, J. (2019). Prediksi Pendapatan Terbesar pada Penjualan Produk Cat dengan Menggunakan Metode Monte Carlo. *Jurnal Informatika Ekonomi Bisnis*, 15-20.

[4] Dari, R. W. (2020). Simulasi Monte Carlo dalam Prediksi Tingkat Penjualan Produk HPAI. *Jurnal Informatika Ekonomi Bisnis*, 86-91.

[5] Thoriq, M., Syaputra, A. E., & Eirlangga, Y. S. (2022). Model Simulasi untuk Memperkirakan Tingkat Penjualan Garam Menggunakan Metode Monte Carlo. *Jurnal Informasi dan Teknologi*, 242-246.

[6] Mahessya, R. A. (2017). Pemodelan dan Simulasi Sistem Antrian Pelayanan Pelanggan Menggunakan Metode Monte Carlo Pada PT Pos Indonesia (Persero) Padang. *Jurnal Ilmu Komputer*, *6*(1), 15-24.

[7] Santony, J., & Yunus, Y. (2019). Simulasi Monte Carlo untuk Memprediksi Hasil Ujian Nasional (Studi Kasus di SMKN 2 Pekanbaru). *Jurnal Informasi Dan Teknologi*, 1-6.

[8] Apri, M., Aldo, D., & Hariselmi, H. (2019). Simulasi Monte Carlo untuk Memprediksi Jumlah Kunjungan Pasien. *JURSIMA (Jurnal Sistem Informasi Dan Manajemen)*, *7*(2), 92-106.

[9] Zulfiandry, R. (2018). Optimasi Kegiatan Pelatihan Menggunakan Metode Simulasi Monte Carlo (Studi Kasus di Balai Latihan Kerja Dinas Tenaga Kerja dan Transmigrasi Provinsi Bengkulu). *ILKOM Jurnal Ilmiah*, *10*(1), 113-119.

[10] Putra, D. E., & Melladia, M. (2022). Prediksi Penjualan Sprei Kasur Toko Coco Alugada Menggunakan Metode Monte Carlo. *JUTEKINF (Jurnal Teknologi Komputer dan Informasi)*, *10*(2), 115-126.

[11] Syaputra, A. E., & Eirlangga, Y. S. (2022). Akumulasi dan Prediksi Tingkat Penjualan Minuman dengan Menerapkan Metode Monte Carlo. *Jurnal Informasi dan Teknologi*, 148-153.

[12] Amalia, E. L., Yunhasnawa, Y., & Rahmatanti, A. R. (2022). Sistem Prediksi Penjualan Frozen Food dengan Metode Monte Carlo (Studi Kasus: Supermama Frozen Food). *Jurnal Buana Informatika*, *13*(02), 136-145.

[13] Noviani, R., Nasution, Y. N., & Rizki, N. A. (2017). Klasifikasi Persediaan Barang Menggunakan Analisis Always Better Control (ABC) dan Prediksi Permintaan dengan Metode Monte Carlo. *EKSPONENSIAL*, *8*(2), 103-110.

[14] Ferdinal, D., Defit, S., & Yunus, Y. (2021). Prediksi Bed Occupancy Ratio (BOR) Menggunakan Metode Monte Carlo. *Jurnal Informasi dan Teknologi*, 1-9.

[15] Dwika, R. (2022). Penerapan Metode Monte Carlo pada Simulasi Prediksi Jumlah Calon Mahasiswa Baru Universitas Muhammadiyah Bengkulu: Penerapan Metode Monte Carlo Pada Simulasi Prediksi Jumlah Calon Mahasiswa Baru Universitas Muhmammadiyah Bengkulu. *Jurnal PROCESSOR*, *17*(2), 74-81.

[16] Irwanto, M. R., Widiyaningtyas, T., & Arifin, M. Z. (2017). Implementasi algoritma monte carlo pada sistem informasi penerimaan peserta didik baru (ppdb) secara online. *Teknologi dan Kejuruan: Jurnal teknologi, Kejuruan dan Pengajarannya*, *40*(1), 69-78.

[17] Rambe, M. R., & Nasution, K. R. P. (2023). Penerapan Metode Monte Carlo pada Penjadwalan Proyek Gedung PuskesmasPadangMatinggiKotaPadangsidimpuan. *STATIKA*, *6*(1), 87-98.

[18] Hutahaean, H. D. (2018). Analisa simulasi monte carlo untuk memprediksi tingkat kehadiran mahasiswa dalam perkuliahan (studi kasus: STMIK pelita nusantara). *Journal Of Informatic Pelita Nusantara*, *3*(1).

[19] Yani, Z. (2021). Simulasi Algoritma Monte Carlo dalam Memprediksi Pendapatan Penjualan Produk Kalsium Tiens Syariah. *Jurnal Informatika Ekonomi Bisnis*, 8-15.

[20] Wijaya, F. S., & Sulistio, H. (2019). Penerapan Metode Monte Carlo Pada Penjadwalan Proyek Serpong Garden Apartment. *JMTS: Jurnal Mitra Teknik Sipil*, 189-198.

[21] HASANAH, W. P. (2022). Manajemen Persediaan Darah Komponen Packed Red Cell (Prc) Menggunakan Simulasi Monte Carlo (Studi Kasus: Palang Merah Indonesia Sleman

[22] Simangunsong, A. (2023). Penerapan Metode Monte Carlo Dalam Simulasi Pengelolaan Persediaan Alat Tulis Kantor. *Jurnal SAINTIKOM (Jurnal Sains Manajemen Informatika dan Komputer)*, *22*(2), 280-289.

[23] Triananda, M. I., & Tantrika, C. F. M. (2022). *Analisis Pengendalian Persediaan Bahan Baku Dengan Model Persediaan Probabilistik (Studi Kasus Waroeng Spesial Sambal)* (Doctoral dissertation, Universitas Brawijaya).

[24] Efendi, G., & Zahmi, A. (2023). Optimalisasi Optimalisasi Persediaan Darah Dengan Metoda Monte Carlo (Studi Kasus UTD PMI Solok): Metode Simulasi Monte Carlo. *Journal of OperationSystem*, *1*(2),99-113.

[25] Sari, I. Y., & Maulana, F. (2021). Simulasi Terbaik Dalam Persediaan Komponen Darah Menggunakan Metode Monte Carlo. *JITA (Journal of Information Technology and Accounting)*, *4*(1),24-33.