DOI:10.14421/ijid.2024.4663 IJID (International Journal on Informatics for Development), *e-ISSN: 2549-7448*
Vol. 13, No. 1, June 2024, Pp. 448-459

Comparison of Single Exponential Smoothing and Double Moving Average Algorithms to Forecast Beef Production

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Article History
Received July 25th, 2024
Revised August 22nd, 2024
Accepted September 10th, 2024
Published October, 2024

***Abstract*— Beef is considered a high-value commodity as it is an important source of protein. Interest in beef continues to rise. Beef production has risen sharply in the past decade, but declined by 7,240.68 tons in 2020 amid coronavirus lockdowns. After that, in 2021, production reached 16,381.81 tons and continued to increase in 2022 and 2023. A precise method is required to forecast beef production. One way to predict beef production in Jakarta is using the Single Exponential Smoothing and Double Moving Average methods. The two algorithms are compared to get the lowest error rate. The methodology used in this research is the SEMMA (Sample, Explore, Modify, Model, and Assess) methodology. According to SAS Institute Inc., there are five stages in developing a system using the SEMMA methodology. After analyzing using MAPE, it is found that the algorithm with the smallest error value is the Single Exponential Smoothing algorithm with a percentage in the monthly period of 16% while for the annual period, it is 27% compared to other algorithms. The forecasting is quite accurate because the MAPE value for each algorithm used has an error of less than 31%.**

Keywords*—beef; double moving average; forecasting; MAPE; single exponential smoothing

1 INTRODUCTION

The authors addressed this topic due to the lack of research on predicting beef production in Jakarta despite its significance in the country's food security and economic sector. To ensure food supply for the population, the agriculture sector plays a vital role and is always a top priority on the national economic growth agendas. As Indonesia's population continues to grow, the nation will increasingly face challenges related to food shortages. One of the most in-demand animal products right now is beef—thanks to their soaring popularity and healthy fat and protein content [1]. In both agricultural and economic sectors, beef production is a crucial component. It contributes to the development of rural areas, creates employment opportunities for farmers, and significantly boosts the nation's revenue and food security [2]. It is anticipated that beef self-sufficiency will be achieved to strengthen national security [3].

Jakarta, which covers a total area of 662.33 km², has five administrative regions and one administrative district. The North, West, and South Jakarta areas are 48.13 km², 146.66 km², and 129.54 km², respectively. Additionally, 8.70 km² is the area of the Thousand Islands managerial rule [4]. It is reasonable to assume that beef output is relatively high in Jakarta due to the city's population and location. The BPS predicts that meat production in Jakarta will generally follow a rising tendency. Despite a dramatic increase in output during the last decade, the coronavirus pandemic lockdown in 2020 caused a reduction in production to 7,240.68 tons. However, production rebounded later that year, peaking at 16,381.81 metric tons, and continuing to increase into 2022 and 2023.

We need data on the future of beef production in Jakarta, so we can monitor and manage the beef supply. An accurate prediction of beef production calls for a tested method, model, or strategy. With traditional forecasting methods failing to construct a model capable of consistently predicting future values, data mining becomes increasingly important in stock market prediction [8] [9] [10]. Information retrieval, databases, statistics, machine learning, and artificial intelligence are all parts of data mining, a multidisciplinary field. It is typically defined as the act of extracting meaningful information from a wide variety of data sources, including but not limited to text, photos, audio, video, and so on. The term "information mining" encompasses a wide range of activities [5] [6] [7].

One of the numerous strategies available for predicting Jakarta beef production is the Double Moving Average (DMA) and Single Exponential Smoothing (SES) approach. Unstable time series are the basis of the SES technique, which incorporates quantitative prediction methods and trends in historical data. This method obtains the exponential term by using weighting, a smoothing parameter derived from earlier eras that influenced the exponential. Constantly improving forecasting, the SES approach reduces (exponentially) averages of previous values of time series data [11] [12] [13]. The moving average model uses fresh real request data to produce forecast values for future requests. For the moving average approach to work, it is expected that product demand in the market will remain constant over time. If you want to know what the future holds, you need historical data from a certain time. For example, the third month must have passed to predict the fourth month using the three-month moving average technique, and so on. The DMA approach was determined to be superior to the simple average and single-moving average methods, completely overcoming their drawbacks. Furthermore, the DMA method handles trends better. The DMA approach is based on calculating the second moving average [14] [15] [16].

A study by Hidayatullah Himawan and Parasian DP Silitonga is cited in this research to bolster the credibility of this study. The single exponential smoothing approach yields the best forecast at 0.9 parameter values and an MPE of 0.0239. In contrast, the double exponential smoothing method produces the best forecast at 0.8 parameter values and an MPE of 0.1172. When α and β are both equal to 0.6 and 0.9, and the MPE is 0.0161, the triple remarkable smoothing procedure yields the best estimates [17].

In addition, there is research conducted by Julinia Nur Aziza that is used as a reference in this research. PT Petrogas Prima Services is a company that focuses on repairing and maintaining LPG gas cylinders. In that study, forecasting was carried out on the demand for LPG gas cylinders, because since 2020, PT Petrogas Prima Services has experienced fluctuations due to a decrease in SPP from PT Pertamina, which made material planning less optimal. The methods used to solve this problem are the Moving Average Method, the Single Exponential Smoothing Method, and the Double Exponential Smoothing Method, for the Moving Average Method shows the results of MAPE of 5, MAD of 4583 and MSE of 58679412. For the Single Exponential Smoothing Method shows the MAPE result of 4, MAD of 3803, and MSE of 34190219. For the Double Exponential Smoothing Method shows the MAPE result of 4, MAD of 3968, and MSE of 35979235. The most effective and efficient method for forecasting the demand for LPG gas cylinders is the Double Exponential Smoothing Method because the data obtained is a type of trend data, which means that demand rises in certain months and falls in certain months. Forecasting results from the Moving Average Method in September were 74151.5, December 74151.5, and January 2022 74151.5. The forecasting results of the Single Exponential Smoothing Method for November 71652.1, December 69344.6, and January 2022 670037 [18].

Mesach Habel Wiyono Pranataningtyas, Yosep Agus Pranoto, and Deddy Rudhistiar conducted the final piece of research. The results of these two methods' predictions of future vehicle volumes will be shown to consumers by comparing the data's accuracy. Among many (outright), the most common rate mistake is the Mean Outright Rate Error (MAPE). As a statistical metric for estimating (prediction) accuracy, the Mean Absolute Percentage Error is utilized in forecasting approaches. Results for accuracy with an average MAPE of 30.124 per cent were obtained using the Double Moving Average method, whereas results with an average MAPE of 5.368% were obtained using the Double Exponential Smoothing method [19].

Despite the existence of three studies, no one has yet compared the three methods for managing beef production. This investigation was spearheaded by experts using three methods: particular SES, straight relapse, and DMA. By applying these three algorithms, we can compare their error

rates and identify the most accurate ones. Unfortunately, within the given context, neither a solution nor any data can be found to support the prediction of Jakarta's beef production. This project will utilize data mining techniques such as the SES algorithm and DMA to forecast beef output in Jakarta. Furthermore, BPS may benefit from this research outcome to create a prediction system and estimate future beef output.

2 METHOD

2.1 Research Data

This study utilizes quantitative data, especially statistical information on beef production in Jakarta. Data from 2000 to 2023 was obtained from the website of the Central Statistics Agency (BPS) which is publicly accessible. The annual and monthly data on beef production in Jakarta are presented in Table 1 and Table 2.

Table 1. Annual Data

Year	Quantity (Tons)
2000	14282
2001	14888
2002	13719
2003	16610
2004	13045
2005	10060.83
2006	8505.41
2007	7051
2008	8562
2009	5657
2010	6058
2011	9413
2012	12206
2013	18021
2014	19260
2015	20165.99
2016	23125,67
2017	15611.43
2018	15867.13
2019	19194.53
2020	7240.68
2021	16381.81
2022	17617.61
2023	17664.8

Table 2. Monthly Data

Year	Month	Quantity (Tons)
	January	1245
	February	987
	March	445
2000	April	567
	May	1234
	June	1890
	…	…
	January	1238
	February	1367
	March	1148
2001	April	1234
	May	1124
	June	1273
	…	…
	January	1211
	February	1146
	March	1134
2002	April	1166
	May	1167
	June	1040
	…	…
	January	2141
	February	1964
	March	1339
2003	April	1549
	May	957
	June	840
	…	…
	January	1145
	February	1171
	March	1073
2004	April	1189
	May	1147
	June	1075
	…	…
	…	…
…	…	…
	…	…
	January	1210
	February	1117
	March	911
2020	April	774
	May	634
	June	406
	…	…
	January	1645
	February	1564
	March	1300
2021	April	1530
	May	1261
	June	1327
	…	…
	January	1737
	February	1364
	March	1688
2022	April	1283
	May	1131
	June	1652
	…	…
	…	…
	June	1383
	July	1437
2023	August	1269
	September	1482
	October	1356
	November	1259
	December	1545

2.2 Methodology Implementation

In this research, the strategies applied are SES and DMA. Both methods are compared to identify which method has the highest level of accuracy. The statistics data from BPS are used to understand the patterns and trends potentially affecting beef production within the period.

SES and DMA methods are employed to predict the amount of beef production in Jakarta in the future. Hopefully, the data can help related agencies estimate the next beef production and help them in forecasting. This application will be developed and organized following the methodological flow illustrated in Fig. 1.

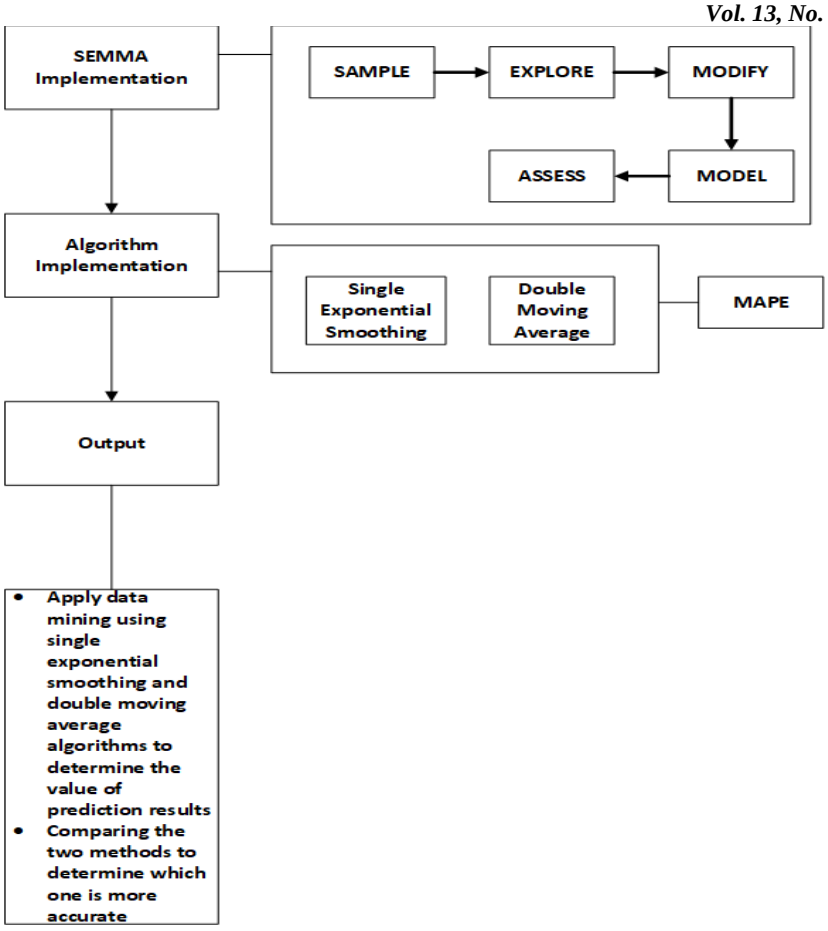

Figure 1. Methodology flow

2.3 Test Design

The SEMMA approach is being used in this study phase. SEMMA is an acronym for "Sample, Explore, Modify, Model, and Assess." According to SAS Institute Inc., there are five stages to developing a system using the SEMMA methodology [20] [21]. The steps of the SEMMA approach that were utilized in this study are as follows:

2.3.1 *Sample Phase:* This stage is the collection of data to contain the information needed in the research. The data collection process is carried out on the website of BPS about beef production in Jakarta from 2000 to 2023. This dataset has a special purpose, which is to support the prediction of beef production in Jakarta. At this stage, in addition to searching for datasets, a literature review is also carried out to identify references from previous research.

2.3.2 *Explore Phase:* Explore is a procedure in data mining that aims to find relevant data sets and obtain information related to unexpected strange patterns. In the exploration stage, data understanding is used to evaluate data and identify problems that might occur. Next, data selection is performed to select data to be used in the mining process while maintaining the actual representation of the data. In data selection, the author sets two attributes, which are the year attribute and the amount attribute in tons.

2.3.3 *Modify Phase:* The modification stage of data mining focuses on changing and adjusting the data and its variables for model selection. At this stage, missing values are eliminated from the data. Data that needs to be corrected is corrected, and inconsistent data is checked for consistency. In this particular situation, since the accessible dataset is only accessible in an annual configuration, the creators also present information in a month-to-month design.

2.3.4 *Model Phase:* At this stage, model building is done using the SES and DMA methods. This stage is also a process in data mining that can be used to build models from data and find prediction results with the three methods mentioned. The system design used uses a website using a MySQL database. After this stage, it will produce predictive values from each method. The formulation of SES can be written as follows [22] [23] [24] :

$$Ft+1 = \alpha * Xt + (1 - \alpha) * Ft \quad (1)$$

Description:
Ft = Forecasting for period *t*
α = Constant
Xt = Actual value of the time series
Ft + 1 = Next period forecasting

The steps taken in the formulation of the DMA are as follows [25] [26] [27] :

$$S't = \frac{Xt + Xt-1 + Xt-2 + \cdots + Xt-k-1 \sum x}{k} \quad (2)$$

$$S''t = \frac{St + St-1 + St-2 + \cdots + St-k-1}{k} \quad (3)$$

$$at = 2S't - S''t \quad (4)$$

$$bt = 2/k\text{-}1\ (S't - S''t) \quad (5)$$

$$ft = at + bt\ m \quad (6)$$

Description:
S't = Single Moving Average (SMA)
S''t = Double Moving Average (DMA)
at = Constant
bt = Trend coefficient

Assess Phase: Section Evaluation of the produced model is performed at this stage. MAPE (Mean Absolute Percentage Error) is used in the evaluation stage. In the comparison of the three approaches' prediction accuracy, the MAPE computation is used. A more precise forecast is made when the MAPE value is lower. This equation formula can be used to compute the MAPE value [28] [29] [30] *:*

$$\text{MAPE} = \frac{\sum(\frac{|Actual - forecast|}{Actual} * 100)}{n} \quad (7)$$

Description:
n = Total period

The effectiveness of MAPE values can be evaluated based on the level of accuracy categorized in Table 3.

3 RESULT AND DISCUSSION

3.1 Annual Prediction

The estimated annual beef production provides a prediction of beef production in DKI Jakarta for 2024. Referring to the SES theory, α = 0.9 and 1-α = 0.1 were determined for annual prediction. The results of the prediction of beef production in Jakarta are presented in Table 4 below.

Table 3. Model accuracy criteria based on MAPE value

MAPE Value	Forecasting accuracy
Less than 10%	Highly accurate forecasting
10 – 20%	Good forecasting
20 – 30%	Feasible forecasting
More than 50%	Bad forecasting

It was found that the prediction result in January 2024 using the SES algorithm was 17639.74 tons, with the resulting MAPE value of 27%. The trend of the production prediction graph with actual production is shown in Fig. 2.

Table 4. Prediction using SES

Year	Quantity (Tons)	Prediction	MAPE
2000	14282	14282	-
2001	14888	14282	4%
2002	13719	14827.4	8%
2003	16610	13829.84	17%
2004	13045	16331.98	25%
2005	10060.83	13373.7	33%
2006	8505.41	10392.12	22%
2007	7051	8694.081	23%
2008	8562	7215.308	16%
2009	5657	8427.331	49%
2010	6058	5934,033	2%
2011	9413	6045.603	36%
2012	12206	9076.260	26%
2013	18021	11893.026	34%
2014	19260	17408.202	10%
2015	20165.99	19074.820	5%
2016	23125.67	20056.873	13%
2017	15611.43	22818.790	46%
2018	15867.13	16332.166	3%
2019	19194.53	15913.633	17%
2020	7240.68	18866.440	161%
2021	16381.81	8403.256	49%
2022	17617.61	15583.9546	12%
2023	17664.8	17414.24	1%
2024		17639.74	
	MAPE		27%

Next, the researchers also used DMA. Referring to the DMA theory, *k*=3 was determined for prediction. The results of the prediction of beef production in Jakarta are presented in Table 5.

The prediction results in January 2024 using the DMA algorithm amounted to 21503.92 tons, with a MAPE value of 31%. Figure 3 shows the trend of prediction using the DMA with actual production.

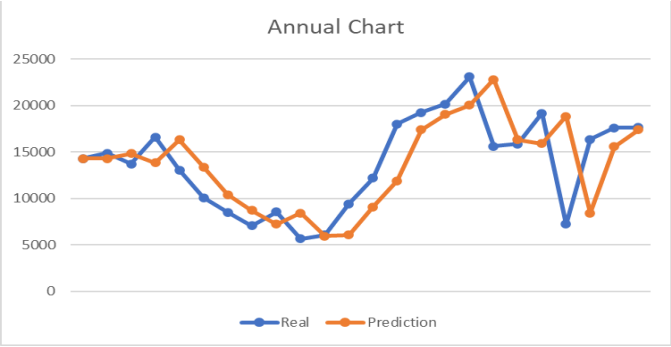

Figure 2. Trend graph of predicted production and actual production by SES (Annual)

Table 5. Prediction using DMA

Year	Quantity (Tons)	SMA	DMA	Prediction	MAPE
2000	14282				
2001	14888				
2002	13719	14296.33			
2003	16610	15072.33			
2004	13045	14458	14608.89		
2005	10060.83	13238.61	14256.31	14156.22	41%
2006	8505.41	10537.08	12744.56	11203.20	32%
2007	7051	8539.08	10771.59	6122.11	13%
2008	8562	8039.47	9038.54	4074.06	52%
2009	5657	7090	7889.51	6041.32	7%
2010	6058	6759	7296.16	5490.97	9%
2011	9413	7042.67	6963.89	5684.69	40%
2012	12206	9225.67	7675.78	7200.22	41%
2013	18021	13213.33	9827.22	12325.44	32%
2014	19260	16495.67	12978.22	19985.56	4%
2015	20165.99	19149	16286	23530.56	17%
2016	23125.67	20850.55	18831.73	24874.99	8%
2017	15611.43	19634.36	19877.97	24888.18	59%
2018	15867.13	18201.41	19562.1	19147.15	21%
2019	19194.53	16891.03	18242.3	15480.01	19%
2020	7240.68	14100.78	16397.7	14188.55	96%
2021	16381.81	14272.34	15088.1	9506.86	42%
2022	17617.61	13746.7	14039.9	12640.92	28%
2023	17664.8	17221.41	15080.1	13160.22	26%
2024				21503.92	
		MAPE			31%

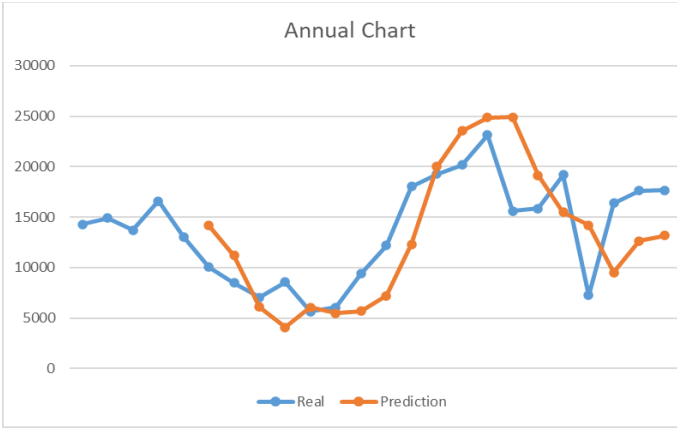

Figure 3. Trend graph of predicted production and actual production based on DMA (annual)

3.2 Monthly Prediction

The monthly beef production forecast will predict the production for January 2024. Referring to the SES theory, α = 0.9 and 1-α = 0.1 were determined for monthly prediction. The prediction of beef production in Jakarta is presented in Table 6 below.

Table 6. Prediction using SES

Year	Month	Quantity (Tons)	Prediction	MAPE
	January	1245		
	February	987	1245	26%
	March	445	1012.8	128%
2000	April	567	501.78	12%
	May	1234	560.48	55%
	June	1890	1166.65	38%
	…	…	…	…
	January	1238	4230.40	242%
	February	1367	1537.24	12%
	March	1148	1384.02	21%
2001	April	1234	1171.60	5%
	May	1124	1227.76	9%
	June	1273	1134.38	11%
	…	…	…	…
	January	1211	1331.12	10%
	February	1146	1223.01	7%
	March	1134	1153.7	2%
2002	April	1166	1135.97	3%
	May	1167	1163.00	0%
	June	1040	1166.60	12%
	…	…	…	…
	January	2141	1277.88	40%
	February	1964	2054.69	5%
	March	1339	1973.07	47%
2003	April	1549	1402.41	9%
	May	957	1534.34	60%
	June	840	1014.73	21%
	…	…	…	…
	January	1145	1311.42	15%
	February	1171	1161.64	1%
	March	1073	1170.06	9%
2004	April	1189	1082.71	9%
	May	1147	1178.37	3%
	June	1075	1150.14	7%
	…	…	…	…
	January	884	1034.77	17%
	February	753	899.08	19%
	March	807	767.61	5%
2005	April	971	803.06	17%
	May	761	954.21	25%
	June	934	780.32	16%
	…	…	…	…
	January	792	749.36	5%
	February	859	787.74	8%
	March	549	851.87	55%
2006	April	827	579.29	30%
	May	657	802.23	22%
	June	607	671.52	11%
	…	…	…	…
	January	689	762.09	11%
	February	557	696.31	25%
	March	622	570.93	8%
2007	April	686	616.89	10%
	May	599	679.09	13%
	June	548	607.01	11%
	…	…	…	…
	January	612	550.84	10%
	February	576	605.88	5%
	March	841	578.99	31%
2008	April	595	814.80	37%
	May	786	616.98	22%
	June	698	769.10	10%
	…	…	…	…
	January	545	614.40	13%
2009	February	467	551.94	18%

	March	418	475.49	14%
	April	445	423.75	5%
	May	427	442.87	4%
	June	473	428.59	9%
	…	…	…	…
	January	488	532.60	9%
	February	542	492.46	9%
	March	471	537.05	14%
2010	April	549	477.60	13%
	May	567	541.86	4%
	June	478	564.49	18%
	…	…	…	…
	January	839	558.03	33%
	February	782	810.90	4%
	March	697	784.89	13%
2011	April	714	705.79	1%
	May	747	713.18	5%
	June	769	743.62	3%
	…	…	…	…
	January	1206	874.84	27%
	February	910	1172.88	29%
	March	1240	936.29	24%
2012	April	876	1209.63	38%
	May	812	909.36	12%
	June	987	821.74	17%
	…	…	…	…
	January	1345	1215.45	10%
	February	1464	1332.05	9%
	March	1616	1450.80	10%
2013	April	1654	1599.48	3%
	May	1764	1648.55	7%
	June	1548	1752.45	13%
	…	…	…	…
	January	1264	1351.30	7%
	February	1729	1272.73	26%
	March	1212	1683.37	39%
2014	April	1272	1259.14	1%
	May	1567	1270.71	19%
	June	1635	1537.37	6%
	…	…	…	…
	January	1775	1595.53	10%
	February	1673	1757.05	5%
	March	1512	1681.41	11%
2015	April	1544	1528.94	1%
	May	1765	1542.49	13%
	June	1826	1742.75	5%
	…	…	…	…
	January	1981	1664.85	16%
	February	1838	1949.39	6%
	March	1783	1849.14	4%
2016	April	1924	1789.61	7%
	May	1862	1910.56	3%
	June	1646	1866.86	13%
	…	…	…	…
	January	1108	1978.52	79%
	February	1174	1195.05	2%
	March	1350	1176.11	13%
2017	April	1138	1332.61	17%
	May	1551	1157.46	25%
	June	1334	1511.65	13%
	…	…	…	…
	January	1188	1387.48	17%
	February	1554	1207.95	22%
	March	1634	1519.39	7%
2018	April	1109	1622.54	46%
	May	1353	1160.35	14%
	June	1173	1333.74	14%
	…	…	…	…
	January	1440	1337.81	7%
	February	1544	1429.78	7%
	March	1633	1532.58	6%
2019	April	1592	1622.96	2%
	May	1653	1595.10	4%
	June	1665	1647.21	1%
	…	…	…	…
	January	1210	1441.09	19%
	February	1117	1233.11	10%
	March	911	1128.61	24%
2020	April	774	932.76	21%
	May	634	789.88	25%
	June	406	649.59	60%
	…	…	…	…
	January	1645	378.55	77%
	February	1564	1518.35	3%
	March	1300	1559.44	20%
2021	April	1530	1325.94	13%
	May	1261	1509.59	20%
	June	1327	1285.86	3%
	…	…	…	…
	January	1737	1324.73	24%
	February	1364	1695.77	24%
	March	1688	1397.18	17%
2022	April	1283	1658.92	29%
	May	1131	1320.59	17%
	June	1652	1149.96	30%
	…	…	…	…
	…	…	…	…
2023	October	1356	1462.336	8%
	November	1259	1366.634	9%
	December	1545	1269.763	18%
2024	January		1517.476	
		MAPE		16%

Meanwhile, the prediction results for January 2024 using a monthly period using the SES algorithm amounted to 1517.476 tons, with a MAPE value of 16%. The trend of the production prediction graph with actual production is shown in Fig. 4.

Next, the researchers also applied DMA. Referring to the DMA theory, k=3 was determined for prediction. The prediction of beef production in Jakarta is presented in Table 7 below.

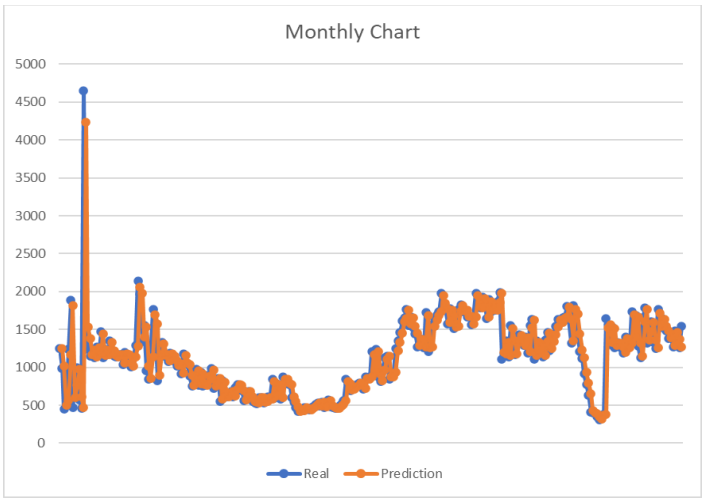

Figure 4. Trend graph of predicted production with actual production based on SES (monthly)

Table 7. Prediction using DMA

Y	M	Quantity (Tons)	SMA	DMA	Prediction	MAPE
	Jan	1245				
	Feb	987				
	Mar	445	892.3			
	Apr	567	666.3			
2000	May	1234	748.7	769.1		
	Jun	1890	1230.3	881.8	707.8	63%
	Jul	467	1197	1058.7	1927.4	313%
	…	…	…	…	…	…
	Jan	1238	2114.3	1559.8	3441.6	178%
	Feb	1367	2417.7	2140.9	3223.4	136%
	Mar	1148	1251	1927.7	2971.2	159%
2001	Apr	1234	1249.7	1639.4	-102.3	108%
	May	1124	1168.7	1223.1	470.1	58%
	Jun	1273	1210.3	1209.6	1059.8	17%
	…	…	…	…	…	…
	Jan	1211	1241.3	1221.3	1282.1	6%
	Feb	1146	1235.3	1241.9	1281.3	12%
	Mar	1134	1163.7	1213.4	1222.2	8%
2002	Apr	1166	1148.7	1182.6	1064.1	9%
	May	1167	1155.7	1156.0	1080.9	7%
	Jun	1040	1124.3	1142.9	1155.0	11%
	…	…	…	…	…	…
	Jan	2141	1527.0	1247.7	1257.1	41%
	Feb	1964	1799.7	1492.2	2085.7	6%
	Mar	1339	1814.7	1713.8	2414.6	80%
2003	Apr	1549	1617.3	1743.9	2016.4	30%
	May	957	1281.7	1571.2	1364.2	43%
	Jun	840	1115.3	1338.1	702.6	16%
	…	…	…	…	…	…
	Jan	1145	1221.7	1174.6	885.0	23%
	Feb	1171	1214.7	1183.1	1315.9	12%
	Mar	1073	1129.7	1188.7	1277.8	19%
2004	Apr	1189	1144.3	1162.9	1011.7	15%
	May	1147	1136.3	1136.8	1107.2	3%
	Jun	1075	1137.0	1139.2	1135.4	6%
	…	…	…	…	…	…
	Jan	884	988.3	1041.1	1140.2	29%
	Feb	753	889.7	988.4	882.8	17%
	Mar	807	814.7	897.6	692.1	14%
2005	Apr	971	843.7	849.3	648.9	33%
	May	761	846.3	834.9	832.3	9%
	Jun	934	888.7	859.6	869.2	7%
	…	…	…	…	…	…
2006	Jan	792	833.3	861.8	820.7	4%
	Feb	859	792.0	824.2	776.4	10%
	Mar	549	733.3	786.2	727.6	33%
	Apr	827	745.0	756.8	627.6	24%
	May	657	677.7	718.7	721.4	10%
	Jun	607	697.0	706.6	595.7	2%
	…	…	…	…	…	…
	Jan	689	742.7	735.0	842.6	22%
	Feb	557	669.0	722.4	758.0	36%
	Mar	622	622.7	678.1	562.1	10%
2007	Apr	686	621.7	637.8	511.8	25%
	May	599	635.7	626.7	589.4	2%
	Jun	548	611.0	622.8	653.7	19%
	…	…	…	…	…	…
	Jan	612	566.0	568.9	539.3	12%
	Feb	576	580.0	569.1	560.2	3%
	Mar	841	676.3	607.4	601.8	28%
2008	Apr	595	670.7	642.3	814.1	37%
	May	786	740.7	695.9	727.3	7%
	Jun	698	693.0	701.4	830.2	19%
	…	…	…	…	…	…
	Jan	545	637.0	717.7	582.1	7%
	Feb	467	536.3	629.9	475.7	2%
	Mar	418	476.7	550.0	349.2	16%
2009	Apr	445	443.3	485.4	330.0	26%
	May	427	430.0	450.0	359.1	16%
	Jun	473	448.3	440.6	390.0	18%
	…	…	…	…	…	…
	Jan	488	512.7	502.2	556.4	14%
	Feb	542	521.7	514.3	533.6	2%
	Mar	471	500.3	511.6	536.3	14%
2010	Apr	549	520.7	514.2	477.9	13%
	May	567	529.0	516.7	533.6	6%
	Jun	478	531.3	527.0	553.7	16%
	…	…	…	…	…	…
	Jan	839	639.3	551.0	580.3	31%
	Feb	782	728.0	630.3	816.0	4%
	Mar	697	772.7	713.3	923.3	32%
2011	Apr	714	731.0	743.9	891.3	25%
	May	747	719.3	741.0	705.2	6%
	Jun	769	743.3	731.2	676.0	12%
	…	…	…	…	…	…
	Jan	1206	976.3	884.4	957.7	21%
	Feb	910	998.0	946.7	1160.1	27%
	Mar	1240	1118.7	1031.0	1100.7	11%
2012	Apr	876	1008.7	1041.8	1294.0	48%
	May	812	976.0	1034.4	942.4	16%
	Jun	987	891.7	958.8	859.1	13%

	…	…	…	…	…	…
	Jan	1345	1176.7	1027.2	1151.1	14%
	Feb	1464	1352.0	1182.7	1475.6	1%
	Mar	1616	1475.0	1334.6	1690.7	5%
2013	Apr	1654	1578.0	1468.3	1755.9	6%
	May	1764	1678.0	1577.0	1797.3	2%
	Jun	1548	1655.3	1637.1	1880.0	21%
	…	…	…	…	…	…
	Jan	1264	1331.3	1343.3	1263.1	0%
	Feb	1729	1447.3	1371.1	1307.3	24%
	Mar	1212	1401.7	1393.4	1599.8	32%
2014	Apr	1272	1404.3	1417.8	1418.1	11%
	May	1567	1350.3	1385.4	1377.4	12%
	Jun	1635	1491.3	1415.3	1280.1	22%
	…	…	…	…	…	…
	Jan	1775	1704.7	1762.2	1552.3	13%
	Feb	1673	1674.7	1701.2	1589.6	5%
	Mar	1512	1653.3	1677.6	1621.6	7%
2015	Apr	1544	1576.3	1634.8	1604.9	4%
	May	1765	1607.0	1612.2	1459.4	17%
	Jun	1826	1711.7	1631.7	1596.6	13%
	…	…	…	…	…	…
	Jan	1981	1739.3	1670.7	1600.6	19%
	Feb	1838	1831.3	1736.3	1876.7	2%
	Mar	1783	1867.3	1812.7	2021.3	13%
2016	Apr	1924	1848.3	1849.0	1976.7	3%
	May	1862	1856.3	1857.3	1847.0	1%
	Jun	1646	1810.7	1838.4	1854.3	13%
	…	…	…	…	…	…
	Jan	1108	1656.0	1783.0	1962.6	77%
	Feb	1174	1424.7	1650.3	1402.0	19%
	Mar	1350	1210.7	1430.4	973.3	28%
2017	Apr	1138	1220.7	1285.3	771.1	32%
	May	1551	1346.3	1259.2	1091.3	30%
	Jun	1334	1341.0	1302.7	1520.6	14%
	…	…	…	…	…	…
	Jan	1188	1291.7	1324.0	1304.9	10%
	Feb	1554	1380.0	1335.4	1227.0	21%
	Mar	1634	1458.7	1376.8	1469.1	10%
2018	Apr	1109	1432.3	1423.7	1622.4	46%
	May	1353	1365.3	1418.8	1449.7	7%
	Jun	1173	1211.7	1336.4	1258.4	7%
	…	…	…	…	…	…
	Jan	1440	1337.0	1344.4	1357.0	6%
2019	Feb	1544	1444.0	1375.6	1322.1	14%
	Mar	1633	1539.0	1440.0	1580.9	3%
	Apr	1592	1589.7	1524.2	1737.0	9%
	May	1653	1626.0	1584.9	1720.6	4%
	Jun	1665	1636.7	1617.4	1708.2	3%
	…	…	…	…	…	…
	Jan	1210	1439.3	1562.9	1696.6	40%
	Feb	1117	1246.3	1441.8	1192.2	7%
	Mar	911	1079.3	1255.0	855.4	6%
2020	Apr	774	934.0	1086.6	728.0	6%
	May	634	773.0	928.8	628.9	1%
	Jun	406	604.7	770.6	461.4	14%
	…	…	…	…	…	…
	Jan	1645	798.7	498.4	367.0	78%
	Feb	1564	1196.3	783.1	1399.1	11%
	Mar	1300	1503.0	1166.0	2022.8	56%
2021	Apr	1530	1464.7	1388.0	2177.0	42%
	May	1261	1363.7	1443.8	1618.0	28%
	Jun	1327	1372.7	1400.3	1203.4	9%
	…	…	…	…	…	…
	Jan	1737	1438.3	1347.4	1384.8	20%
	Feb	1364	1477.7	1413.9	1620.1	19%
	Mar	1688	1596.3	1504.1	1605.2	5%
2022	Apr	1283	1445.0	1506.3	1780.8	39%
	May	1131	1367.3	1469.6	1322.3	17%
	Jun	1652	1355.3	1389.2	1162.9	30%
	…	…	…	…	…	…
	…	…	…	…	…	…
2023	Oct	1356	1369	1376	1393.8	3%
	Nov	1259	1365.7	1376.9	1355	8%
	Dec	1545	1386.7	1373.8	1343.2	13%
2024	Jan				1412.4	14%
			MAPE			19%

The prediction for January 2024 using the DMA algorithm in the monthly period is 1,412.44 tons, with a MAPE value of 19%. The trend graph of DMA production prediction with actual production is shown in Fig. 5.

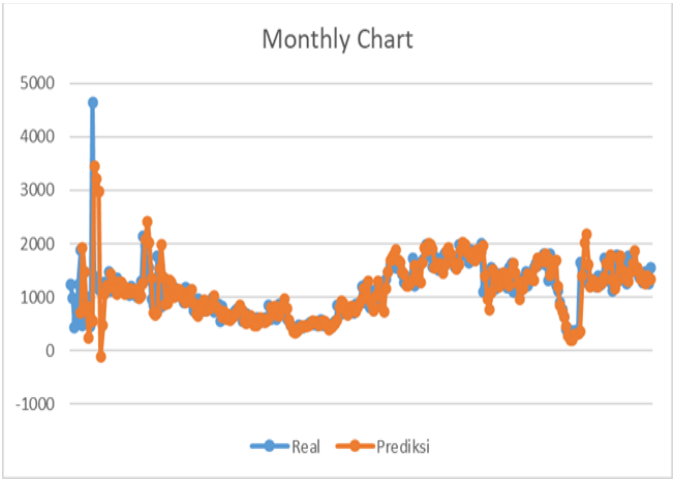

Figure 5. Trend graph of predicted production and actual production based on DMA (Monthly)

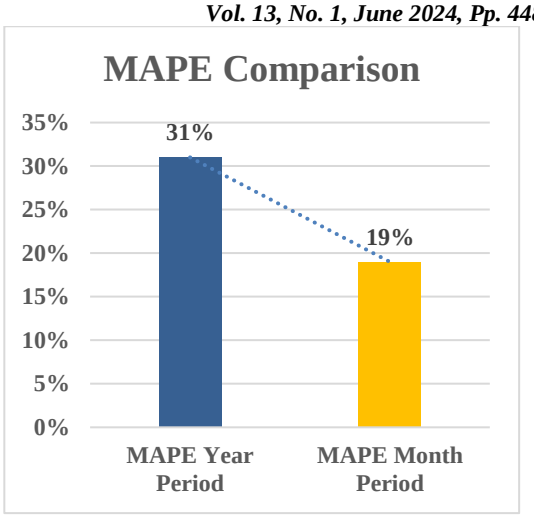

Figure 7. Comparison of MAPE value of DMA for yearly and monthly periods

3.3 Algorithm Comparison Analysis

A bar chart of the MAPE results was created to facilitate analysis identifying the most suitable algorithm for beef production in Jakarta among the three algorithms used. The initial plan was to combine the prediction results in each algorithm's monthly and yearly periods. Based on Fig. 6 and Fig. 7, the MAPE value for the monthly period is smaller than the annual period based on the three algorithms. A comparison of MAPE results shows that monthly periods, which have more data points, produce more accurate values than yearly periods, which have fewer data points.

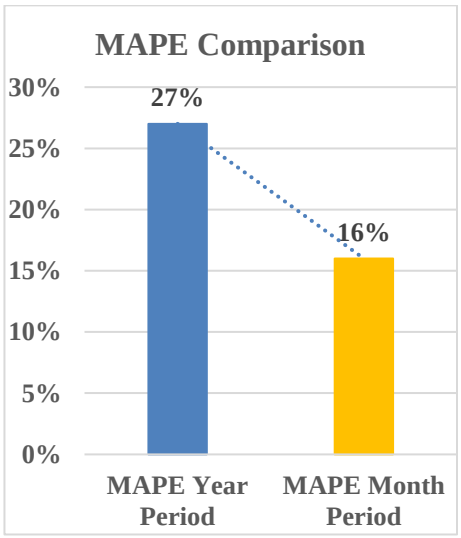

Figure 6. Comparison of MAPE value of SES for yearly and monthly periods

The next concept is to join all prediction results from the two algorithms obtained from both monthly and annual periods. Based on Fig. 8, the smallest MAPE value is obtained using the SES algorithm for monthly or yearly periods, where the MAPE results are 16% and 27%. Thus, the SES algorithm is more suitable to solve the problem of beef production in Jakarta.

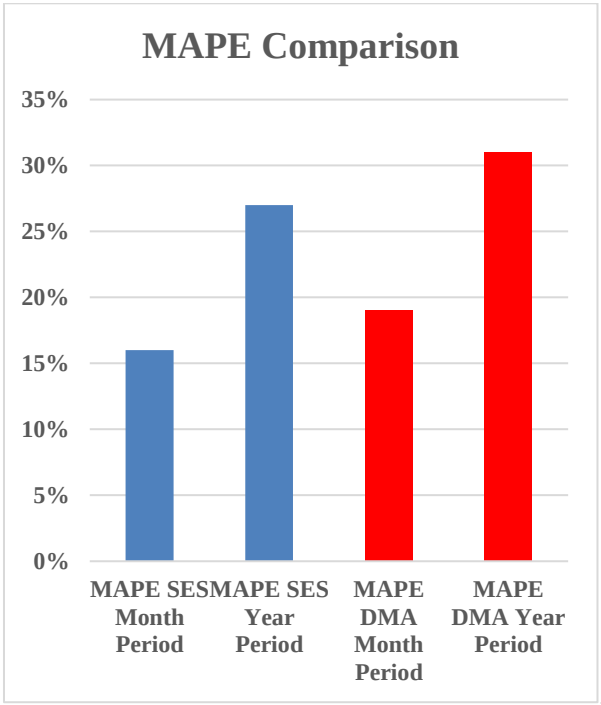

Figure 8. Comparison of MAPE of each algorithm

4 CONCLUSION

Predictions of beef production in Jakarta using the SES and DMA methods yielded the following results in January 2024: a year-end prediction of 17639.74 and a month-end prediction of 1517.476; predictions based on the DMA algorithm's output of 21503.92 and 1412.444, respectively. It

can be drawn from this research that both methods can be used to forecast beef production in Jakarta. The SES algorithm outperforms the other one in terms of error value. According to MAPE analysis; it has a monthly percentage of 16% and a yearly percentage of 27%. Meanwhile, the DMA algorithm produces a MAPE value of 31% in the annual period and 19% in the monthly period. Future researchers and relevant stakeholders can consider using different values of α and b to lower the MAPE value, or they can compare the study's results with those of the various values of α and b.

AUTHOR'S CONTRIBUTION

As a contributing writer, Rachmat Hidayat Insani conducted research under the supervision of the first author, Tundo. Rasiban and Untung Suropati contribute to the research content by providing theoretical insights and guidance on writing methods.

COMPETING INTERESTS

This article does not contain any conflicts of interest (COI) or competing interests (CI), as the authors Tundo, Rachmat Hidayat Insani, Rasiban, and Untung Suropati have declared under this journal's publication ethics.

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