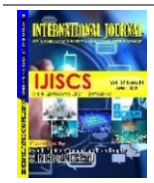

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COMPARISON OF MOVING AVERAGE AND EXPONENTIAL SMOOTHING METHODS IN ANALYZING KWH METER STOCK EXPENDITURE DATA

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Abstract
A common problem that occurs in a company is how to predict future production by utilizing historical data that has been previously recorded, to minimize errors in providing a stock of goods and increasing production efficiency so as not to waste more costs. This research aims to identify and analyze the results of production forecasting using the moving average and exponential smoothing methods in the forecasting calculation process to determine the future stock of goods. Data processing using rapidminer programming, from the prediction results using both methods states that the exponential smoothing method with an alpha value of 0.9 is superior to the moving average method with a request result of 23661.5 MAD = 70.7 and MSE = 12387.9987 smaller than other methods.

1.0 INTRODUCTION

Forecasting is an art and knowledge that is very important in the process of planning effective production and making policies that are focused on the future. In the context of forecasting, it is important to determine the time an event occurs and the significant impact it will produce. The forecasting process includes collecting previous data and processing that data using various forecasting methods. The results of this data analysis can then be used as a guide to make the right decisions in various contexts.

According to Erfanda Andrianto and colleagues in their research entitled "Application of the Stock Availability Forecasting System in the Abadi Jaya Furniture Store Using the Single Moving Average and Exponential Smoothing Method" This research aims to make predictions about sales of goods in the coming period, based on historical data as previously recorded, this prediction has a significant impact on decision making by company managers, especially in determining the amount of goods production that will be carried out. The result of this research is the development of an application using the single moving average and exponential smoothing method which can predict the amount of demand for goods that is expected to occur in the next one-month period [1].

PT. PLN Persero (State Electricity Company) is one of the State-Owned Enterprises (BUMN) which operates in the electricity sector. PT PLN (Persero) Bumi Abung Customer Service Unit (ULP) on Jl. Soekarno Hatta No. 149, Tj. Safe, District. Kotabumi, North Lampung Regency, Lampung 34511, Indonesia. This company is engaged in serving the needs of the community in the field of providing electricity. Where are the services for submitting electricity installations, applying for voltage increases, checking PLN electricity bills, electricity payments, and even customer complaints regarding electricity usage?

The KWH meter is one of the most important electronic meters and has the widest use in an electric power system because the KWH meter is used as a measuring tool in electrical power transactions. The need for electricity for each customer always increases from time to time. Because population growth is increasing and followed by economic growth which is getting higher and higher every day, this can cause customers' electricity needs to increase rapidly. So it is necessary to provide and distribute appropriate electricity, both from a technical and economic perspective. [2]

By comprehensively summarizing this background, the research conducted is expected to make a significant contribution to the field of KWH stock management. It is used to emphasize the relevance and potential benefits of this research. An in-depth comparison of forecasting methods against KWH stock release data can provide valuable insights for decision-making, helping organizations optimize stock management processes, reduce the risk of stock shortages or excess inventory, and increase operational efficiency and overall company profitability.

2.0 THEORETICAL

The method used to calculate kwh meter stock production forecasting uses a type of quantitative forecasting, namely the moving average method and the exponential smoothing method.

2.1. Moving Average

The single moving average method uses several new actual demand data to generate forecast values for future demand. This method has two special properties, namely that making a forecast requires historical data over a certain period, the longer the moving average, the smoother the moving average will be [3]. Moving Average is a forecasting method that is carried out by taking a group of observation values, and looking for the average value as a prediction for the future period. Where the Moving Average method has characteristics, namely:

1. To determine a forecast for the future period requires historical data over a certain period. For example, with a 3-month moving average, the forecast for the 5th month will only be made after the 4th month is finished. If the 7th-month moving average can only be created after the 6th-month ends.
2. The longer the moving average period, the more visible the smoothing effect is in the forecast or produces a smoother moving average [4].

The mathematical equation of a single moving average is as follows:

$$\boldsymbol{Mt = Ft + 1} \quad (1)$$

$$= \frac{\mathbf{Yt+Yt-1+Yt-2+\ldots+Yt-n+1}}{\mathbf{n}} \quad (2)$$

Information:

Mt = Moving Average for period t
Ft+1 = Forecast for the period t + 1
Yt = Real Value of the th period t
n = The number of limits in the moving average

2.2. Exponential Smoothing

This method is a time series forecasting method where the data will continuously improve the past average value, using a decreasing method. The smoothing constant parameter used ranges from 0-1. With information, values close to 1 give the greatest emphasis to the current value, while values close to 0 emphasize the previous data point.

$$\mathbf{St} = \boldsymbol{a} * \boldsymbol{Xt} + (\mathbf{1} - \boldsymbol{a}) * \boldsymbol{St} - \mathbf{1} \quad (3)$$

The formula for Simple exponential smoothing is as follows:

Where:

St = Forecasting for the period t
Xt + (1-a) = Actual value of time series
Ft-1 = Forecasting at time t-1 (previous time)
a = The smoothing constant is between 0 and 1

2.3. Forecasting Errors

The forecast error rate provides a measure of accuracy and a yardstick for comparing alternative methods that may be used. The level of forecasting error can be calculated by Mean Absolute Deviation and Mean Squared Error. Mean absolute deviation (MAD) is the average absolute value of forecast errors, regardless of the positive or negative sign.

$$\mathbf{MAD} = \sum|\mathbf{At} - \mathbf{Ft}| \quad (4)$$

$\sum$ = Amount
At = Observation data for period t
Ft = Forecast period t

Meanwhile, Mean Squared Error (MSE) is the average of the squared differences between predicted values and observed values. MSE provides a penalty for larger errors or strengthens the influence of large error numbers but reduces the numbers. [5]

Forecast error

$$\mathbf{MSE} = \sum(\mathbf{At} - \mathbf{Ft})\,\mathbf{2} \quad (5)$$

$\sum$ = Amount
At = Amount
Ft = Forecast period t

3.0 METHODOLOGY

Collection of actual request data obtained from the company by referring to orders received by officers. Following are consumer demands starting from January 2020 - December 2021:

Table 1 Consumer Demand 2020-2021

Year	Month	Consumer Demand
2020	January	334
	February	172
	March	322
	April	611
	May	524
	June	380
	July	0
	August	1395
	September	0
	October	1206
	November	5213
	December	3788
2021	January	2473
	February	1413
	March	987
	April	1503
	May	560
	June	544
	July	402
	August	376
	September	678
	October	785
	November	899
	December	1553

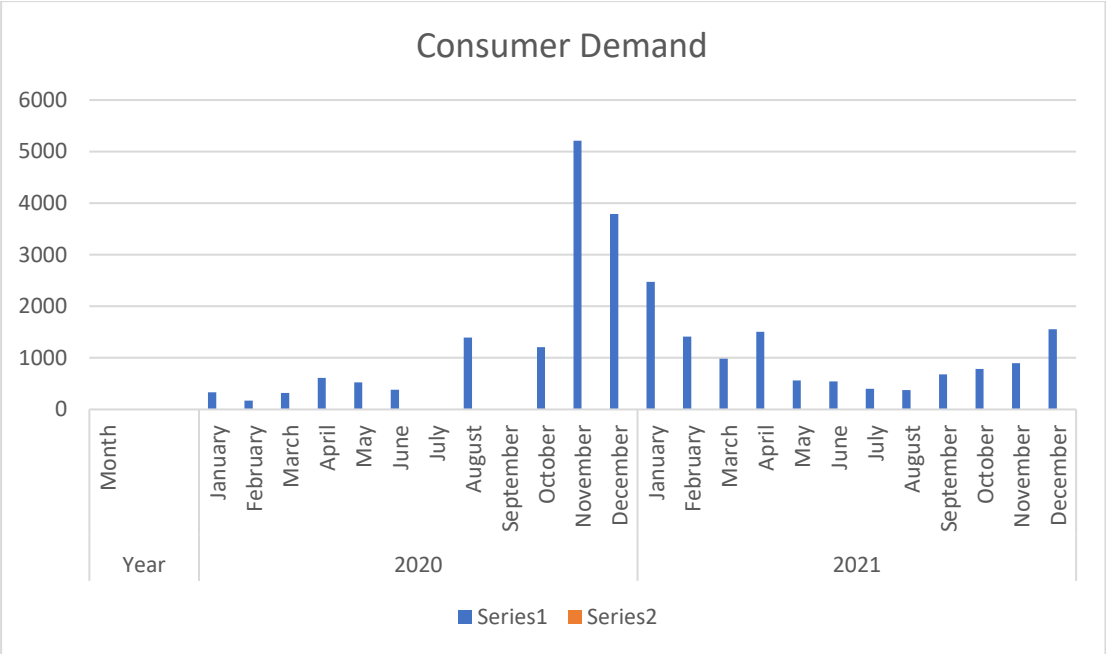

Figure 1 Consumer Demand in 2020-2021

Consumer demand data is very volatile in 2020-2021. Next, the data will be predicted using two forecasting methods that may be used in analyzing the data. The two methods are: Moving average and exponential smoothing. The Moving Average uses 3 monthly and 5 monthly, Exponential Smoothing with a = 0.1; a = 0.5; and a = 0.9.

Forecasting using the 3-month Moving Average method. This method is calculated by: every time new actual data is obtained, a new average can be calculated by removing the old period data and entering the latest period data. The new average is used as a forecast for the coming period.

$$F_{t+1} = \frac{\sum_{t-n+1} x_i}{N}$$

$$= \frac{X_t + X_{t-1} + \ldots + X_{t-N+1}}{N}$$

Information:

X1 = Observation data for period t
N = Number of time series used (5 months)
Ft+1 = Forecast value for period t +1 (next)

Forecasting using the 3-month Moving Average method
Consumer demand forecast for January 2022

F January 2022

$$F_{t+1} = \frac{334 + 172 + 322}{3}$$

$$= \frac{828}{3}$$

$$= 276$$

Table 2 Results of 3-month Moving Average Consumer Demand Forecasting

Year	Month	Consumer Demand	Forecasting
2020	January	334	-
	February	172	-

	March	322	-
	April	611	276
	May	524	368,3333333
	June	380	485,6666667
	July	0	505
	August	1395	301,3333333
	September	0	591,6666667
	October	1206	465
	November	5213	867
	December	3788	2139,666667
2021	January	2473	3402,333333
	February	1413	3824,666667
	March	987	2558
	April	1503	1624,333333
	May	560	1301
	June	544	1016,666667
	July	402	869
	August	376	502
	September	678	440,6666667
	October	785	485,3333333
	November	899	613
	December	1553	787,3333333
			1079

The results of the consumer demand forecast for January 2022 using the 3 Month Moving Average method are 1079.

Forecasting using the 5 monthly Moving Average method
Consumer demand forecast for January 2022
F January 2022

$$Ft + 1 = \frac{334 + 172 + 322 + 611 + 524}{5}$$

$$= \frac{828}{3}$$

$$= 276$$

Table 3 Results of 5-month Moving Average Consumer Demand Forecasting

Year	Month	Consumer Demand	Forecasting
2020	January	334	-
	February	172	-
	March	322	-
	April	611	-
	May	524	-
	June	380	392,6
	July	0	401,8
	August	1395	367,4
	September	0	582
	October	1206	459,8
	November	5213	596,2
	December	3788	1562,8
2021	January	2473	2320,4

	February	1413	2536
	March	987	2818,6
	April	1503	2774,8
	May	560	2032,8
	June	544	1387,2
	July	402	1001,4
	August	376	799,2
	September	678	677
	October	785	512
	November	899	557
	December	1553	628
			858,2

The results of the consumer demand forecast for January 2022 using the 3 Month Moving Average method are 858.2

Forecasting using the Exponential Smoothing method.

The reason for using a is because the a area is between 0 and 1, a = 0.1 represents the beginning of the data, a = 0.5 represents the average, a = 0.9 represents the final data.

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

Information:

Xt = observation data for period t

Ft+1= forecast value for period t

a = smoothing constant

a = 0.1

Forecastnya, F March 2022

= 0.1 * 172 + (1- 0.1) * 334

= 17,2 + (0.90) * 334

= 17,2 +300,6

= 317,8

F January 2023

= 0.1 * 1553+ (1- 0.1) *899

= 155,3 + (0, 90) * 899

= 155,3 + 809,1

= 964,4

Table 4 Forecasting Consumer Demand Exponential Smoothing a = 0.1

Year	Month	Consumer Demand	Forecasting
2020	January	334	-
	February	172	317,8
	March	322	187
	April	611	350,9
	May	524	602,3
	June	380	509,6
	July	0	342
	August	1395	139,5
	September	0	1255,5
	October	1206	120,6
	November	5213	1606,7
	December	3788	5070,5

2021	January	2473	3656,5
	February	1413	2367
	March	987	1370,4
	April	1503	1038,6
	May	560	1408,7
	June	544	558,4
	July	402	529,8
	August	376	399,4
	September	678	406,2
	October	785	688,7
	November	899	796,4
	December	1553	964,4

The results of the consumer demand forecast for January 2022 using the Exponential Smoothing method a = 0.1 is 964.4

a = 0.1

Forecastnya, F March 2022

= 0.5 * 172 + (1- 0.5) * 334

= 86 + (0.50) * 334

= 86 +3167

= 253

F January 2023

= 0.5 * 1553+ (1- 0.5) *899

= 776,5 + (0, 50) * 899

= 776,5 + 449,5

= 1.226

Table 5 Forecasting Consumer Demand Exponential Smoothing a = 0.5

Year	Month	Consumer Demand	Forecasting
2020	January	334	-
	February	172	253
	March	322	247
	April	611	466,5
	May	524	567,5
	June	380	452
	July	0	190
	August	1395	697,5
	September	0	697,5
	October	1206	603
	November	5213	3209,5
	December	3788	4500,5
2021	January	2473	3130,5
	February	1413	1943
	March	987	1200
	April	1503	1245
	May	560	1031,5
	June	544	552
	July	402	473

	August	376	389
	September	678	527
	October	785	731,5
	November	899	842
	December	1553	1226

The results of the consumer demand forecast for January 2022 using the Exponential Smoothing method a = 0.5 is 1,226.

a = 0.9
Forecastnya, F March 2022
= 0.9 * 172 + (1- 0.9) * 334
= 154,8 + (0.10) * 33,4
= 154,8 +33,4
= 188,2

F January 2023
= 0.9 * 1553+ (1- 0.9) *899
= 1.397,7 + (0, 10) * 899
= 1.397,7 + 89,9
= 1.487,6

Table 6 Forecasting Consumer Demand Exponential Smoothing a = 0.9

Year	Month	Consumer Demand	Forecasting
2020	January	334	-
	February	172	188,2
	March	322	307
	April	611	582,1
	May	524	532,7
	June	380	394,4
	July	0	38
	August	1395	1255,5
	September	0	139,5
	October	1206	1085,4
	November	5213	4812,3
	December	3788	3930,5
2021	January	2473	2604,5
	February	1413	1519
	March	987	1029,6
	April	1503	1451,4
	May	560	654,3
	June	544	545,6
	July	402	416,2
	August	376	378,6
	September	678	647,8
	October	785	774,3
	November	899	887,6
	December	1553	1487,6

The results of the consumer demand forecast for January 2022 using the Exponential Smoothing method a = 0.9 is 1487.6

Forecasting Errors

The MAD measured is simply the magnitude of the absolute error. Where the effects in operations where minor errors are not serious and are smoothed out by demand or additional work hours. Big mistakes are difficult, a few big mistakes are the same as a lot of small mistakes. Consequently, error measurement methods that penalize large errors need to be taken into account. Where MSE is a measurement of error by transferring each forecasting error by its square. With squaring, errors are easier to spot.

Table 7 Moving method forecasting error

Year	Month	Consumer Demand	Moving Average			
			3 Month		5 Month	
			Dev. Abslut	Error 2	Dev. Abslut	Error 2
			| At – Ft |	(At – Ft) 2	| At – Ft |	(At – Ft) 2
2020	January	334	-	-	-	-
	February	172	-	-	-	-
	March	322	-	-	-	-
	April	611	335	112.225	-	-
	May	524	156	24.232	-	-
	June	380	106	11.165	13	159
	July	-	505	255.025	402	161.443
	August	1.395	1.094	1.196.107	1.028	1.055.962
	September	-	592	350.069	582	338.724
	October	1.206	741	549.081	746	556.814
	November	5.213	4.346	18.887.716	4.617	21.314.842
	December	3.788	1.648	2.717.003	2.225	4.951.515
2021	January	2.473	929	863.660	153	23.287
	February	1.413	2.412	5.816.136	1.123	1.261.129
	March	987	1.571	2.468.041	1.832	3.354.759
	April	1.503	121	14.722	1.272	1.617.475
	May	560	741	549.081	1.473	2.169.140
	June	544	473	223.414	843	710.986
	July	402	467	218.089	599	359.280
	August	376	126	15.876	423	179.098
	September	678	237	56.327	1	1
	October	785	300	89.800	273	74.529
	November	899	286	81.796	342	116.964
	December	1.553	766	586.245	925	855.625
	∑		17.951	35.085.811	18.871	39.101.733
	MAD & MSE		855	1.670.753	899	1.861.987

Table 8 Exponential Smoothing method forecasting error

Year	Month	Consumer Demand	EKSPONENTIAL SMOOTHING					
			0,1		0,5		0,9	
			Dev. Abslut	Error^2	Dev. Abslut	Error^2	Dev. Abslut	Error^2
			| At – Ft |	(At – Ft) ^{2}	| At – Ft |	(At – Ft) ^{2}	|At – Ft|	(At – Ft)^2
2020	January	334	-	-	-	-	-	-
	February	172	146	21258	81	6561	16	262
	March	322	135	18225	75	5625	15	225
	April	611	260	67652	145	20880	29	835
	May	524	78	6131	44	1892	9	76
	June	380	130	16796	72	5184	14	207
	July	0	342	116964	190	36100	38	1444
	August	1395	1256	1576280	698	486506	140	19460
	September	0	1256	1576280	698	486506	140	19460
	October	1206	1085	1178093	603	363609	121	14544
	November	5213	3606	13005400	2004	4014012	401	160560
	December	3788	1283	1644806	713	507656	143	20306

2021	January	2473	1184	1400672	658	432306	132	17292
	February	1413	954	910116	530	280900	106	11236
	March	987	383	146996	213	45369	43	1815
	April	1503	464	215667	258	66564	52	2663
	May	560	849	720292	472	222312	94	8892
	June	544	14	207	8	64	2	3
	July	402	128	16333	71	5041	14	202
	August	376	23	548	13	169	3	7
	September	678	272	73875	151	22801	30	912
	October	785	96	9274	54	2862	11	114
	November	899	103	10527	57	3249	11	130
	December	1553	589	346450	327	106929	65	4277
	∑		14635	23078842	8131	7123099	1626	284924
	MAD & MSE		636	1003428	354	309700	71	12388

Appropriate Forecasting Methods To find out the most appropriate forecasting method, compare the forecasting errors of each forecasting method.

Table 9 Comparison of forecasting errors

METHOD	MAD	MAP
Moving average 3 Month	854,793651	1670752,92
Moving average 5 Month	898,609524	1861987,27
Exponential smoothing a=0,1	636,3	1003427,89
Exponential smoothing a=0,5	353,5	309699,967
Exponential smoothing a=0,9	70,7	12387,9987

4.0 RESULTS

From the results of forecasting using 2 alternative methods and adding forecast error calculations, it can be concluded that forecasting consumer demand using the Exponential Smoothing method a = 0.9 produces an estimate for consumer demand for the January period of 23661.5 pcs greater than the other methods. and the forecasting error rate MAD = 70.7 and MSE = 12387.9987 is smaller than other methods.

5.0 CONCLUSION

Researchers suggest that companies need to review the methods that will be used to predict future demand after the next four years or more precisely until April 2028. This is due to the addition of the latest historical data which can cause changes in the current value used in this research, so it will also have an impact on the method chosen for subsequent forecasting. Researchers suggest that companies can consider implementing the selected method, namely the exponential smoothing method with an alpha (a) parameter of 0.9 which is relevant for the next four years in predicting the amount of future demand to reduce or minimize fluctuating demand each season. Other researchers who discuss the topic of forecasting should pay attention to several initial things such as data plots and data adequacy tests to see whether the patterns contained in the data are seasonal, constant, trend, or a combination of several patterns. The data adequacy test also determines the authenticity of the data needed as a requirement before a forecast is carried out

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