Analyzing the Suitability of Time Series and Associative Forecasting Methods for Cotton Bud Product

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Abstract. At PT DBAS, the main problem is the problem of BABY-GRADE-A supply/demand. If a production shortage occurs, the company loses sales leading to overwork and costs. Likewise, suppose there is overproduction, even though the product is durable with a more extended expiration date. In that case, warehousing problems may arise, such as limited warehouses, higher inventory costs, damaged products, and environmental issues. Thus, this study is conducted to discover a suitable forecasting method for BABY-GRADE-A to forecast its future demand and sales figures of BABY-GRADE-A in 2021. This research uses a quantitative descriptive method by comparing the measurement of sales data errors in the time series and polynomial regression methods. To conclude, the most suitable forecasting method for BABY-GRADE-A is Polynomial Regression. MSE and MAPE resulting from the technique are 6,103.18 and 9.07%, respectively. Then, the forecast demand in 2021 is predicted to be 11,426 cartons. Significantly, several aspects should be considered by the company and future researchers, such as market change, marketing strategy, inventory management, and other operations activities.

Keywords: Forecasting · Forecasting Error · Moving Range Chart · Polynomial Regression

1 Introduction

PT DBAS's first business was a cotton bud. In 2013, the owner expanded the business into a self-production cotton product by establishing a manufacturing facility in Ibun, Kab. Bandung. The company is a limited liability company, namely PT DBAS, which involves the production of cotton products both upstream and downstream. Supply and market demand are the biggest concern for PT DBAS as a manufacturing company. One essential skill that keeps the business alive is manufacturing the correct number of products to avoid lost sales and additional costs. So, the company can get a maximum profit because an accurate forecast may lessen the risk of overproduction and shortage of

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Table 1. MAPE for Cotton Bud Product Extension

Cotton Bud Product Extension	MAPE
BABY-GRADE-A	17.8%
BABY-GRADE-B	9.9%
REGULAR-GRADE-A	11.2%
REGULAR-GRADE-B	10.3%

Source: Data Processing (2021)

products that may cause economic waste [1]. According to Diebold [2, p. 9], forecasting aims more to guide decision-making.

Currently, PT DBAS is using a straight assumption for its forecasting method. The company sets the number of productions by adjusting monthly forecasts for 10–30% to the previous year's requirements. Current techniques allow companies to reach their goals and meet demand in most cases. Most product lines have few errors in forecasting. The product type with many forecast errors is the BABY-GRADE-A cotton bud product. They use the company's current forecasting method, and its historical production results in a minor mistake for the three out of four cotton bud product extensions. BABY-GRADE-A, however, resulted in the most forecasting error number, as much as 17.8%, rather than the other three product extensions that have less than 12%. Table 1 shows the Mean Absolute Percentage Error (MAPE) for each cotton bud product extension.

Since the BABY-GRADE-A cotton bud product extension has the most MAPE number, this research analyses, and forecasts the BABY-GRADE-A cotton bud product extension.

2 The Business and the Problem

In PT DBAS production, the common problems are shortage and overproduction. The impact of shortage production is that the company loses sales because it cannot meet the demand that appealed to overtime work to overcome the unmet need and prepare more products. The result is a more significant expenditure to pay overtime labor. Most of the time, the company piled the excess product averagely of IDR135,000,000/period and spent the extra work approximately IDR9,600,000/day. Likewise, even though the product is durable with a more extended expiration date, overproduction lets the company place excess production in the limited warehouse, delaying inventory turnover, higher inventory costs, damaging products, and environmental problems like havoc on the production floor. Therefore, this research is conducted to discover a suitable forecasting method for BABY-GRADE-A to forecast its future demand and sales figures of BABY-GRADE-A in 2021.

3 Research Methods

Heizer et al. [3] define forecasting as the art and science of predicting future events. The opinion of Handoko et al. [4] is that forecasting predicts something that will happen in

the future. The forecast or forecasting function is seen when making decisions. A good decision is based on what will happen when the decision is implemented [5]. The data pattern is collected in forecasting the BABY-GRADE-A cotton bud product demand. It lets us see apparent trends and repeated patterns [6]. It also allows BABY-GRADE-A cotton bud sales to be affected by seasonal elements or not.

Ahmad's [7] research in determining forecasting methods in the production of part New Granada Bowl ST at PT X compares the numbers of Moving Average, Exponential Smoothing, and Linear Regression. The data employed in this research is the mean and highest load of New Granada Bowl ST Jan–Dec 2018. The research summary is that the Linear Regression forecasting method is recommended for New Granada Bowl ST production because it has MAPE in the lowest value.

Also, research by Pratama et al. [8] used five methods to forecast the demand for sugar raw materials. The methods are Linear Regression, Moving Average, Weighted Moving Average, Exponential Smoothing, and Exponential Smoothing with the trend. The data is sales of sugar from 2013 to 2018. The analysis shows that the sugar industry of PT. XYZ may use a linear regression method for its forecasting method since MAD, MSE, and MAPE rates are the lowest values compared to other methods.

Thus, this research uses a quantitative descriptive method with supply/demand data using time series and polynomial regression formulas. Then, MRC and Paired Sample t-Test are to verify the selected mode. The research population and sample are BABY-GRADE-A product and BABY-GRADE-A 2019–2020 supply/demand.

4 Result and Findings

4.1 Plot Data

Figure 1 shows sales from January 2019 to December 2020.

4.2 Regression Test

The regression test indicates a trend element in the sales data. The regression test of the dependent variable (sales) and independent variable (monthly period) results in a coefficient constant of 611.163 and a regression coefficient of 7.317 (Table 2).

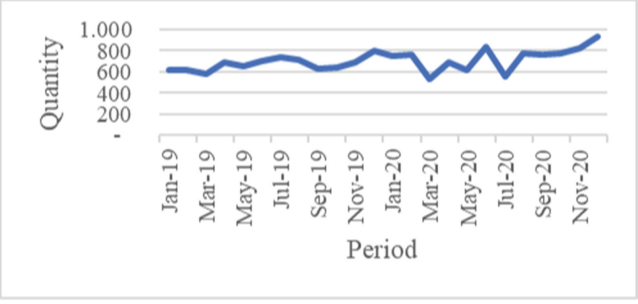

Fig. 1. BABY-GRADE-A Cotton Bud Sales Jan 2019–Dec 2020

Table 2. Regression Test

Coefficients						
Model		Unstd. Coefficients		Std. Coefficeints	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	611.16	35.246		17.340	<.001
	Month	7.317	2.467	.534	2.966	.007

Source: Data Processing (2021)

Table 3. Kolmogorov-Smirnov Test

Sales		
N		24
Normal Parameters	Mean	702.625
	Std. Deviation	96.7996
Most Extreme Differences	Absolute	.088
	Positive	.088
	Negative	−.063
Test Statistic		.088
Asymp. Sig. (2-tailed)		.200

4.3 Normality Test

A normality test is utilized to decide whether a data collection is well-modeled by a normal distribution and to register how reasonable it is for a random variable fundamental to the data set to be normally distributed [9]. Also, this research must proceed with polynomial regression analysis, which is necessary to use customarily distributed data. The hypotheses of the normality test are:

H_0: Data is usually distributed.
H_1: Data is not normally distributed.
If the Sig. (p) $\geq$ 0.05; therefore, H0 is accepted. Otherwise, it is not accepted.

To interpret the Kolmogorov-Smirnov test in Table 3, asymptote significance (two-tailed) is 0.200. The value is more significant than Sig. (p) $\geq$ 0.05. Therefore, the null hypothesis (H_0) is accepted. In other words, the sales data of BABY-GRADE-A cotton bud is usually distributed.

Table 4. Forecasting Methods Error Comparison

No	Forecasting Method	MAD	MSE	MAPE
1.	Naïve	87	13,740	12.85%
2.	Moving Average	72.09	9,034	10.53%
3.	Weighted Moving Avg.	75.27	10,043	11.04%
4.	Single Exponential ($\alpha = 0.55$)	70.44	9,046	10.26%
5.	Holt's Exponential ($\alpha = 0.1$; $\beta = 0.1$)	68	8,299	10.26%
6.	Holt's Winter Exp ($\alpha = 0.7$; $\beta = 0.47$; $\gamma = 0.1$)	114.43	22,847.15	17.80%
7.	Trend Projection	58.84	6,691.96	9.53%
8.	Polynomial Regression	60.58	6,103.18	9.07%

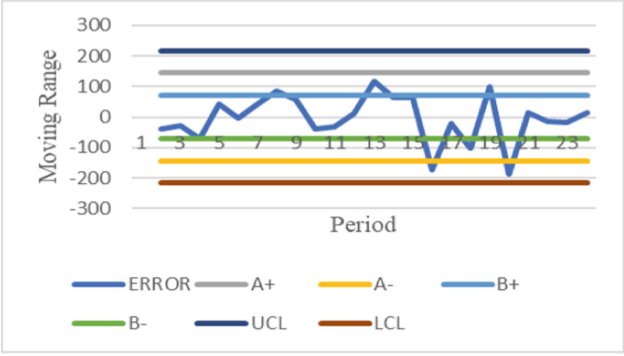

Fig. 2. Moving Range Chart

4.4 Forecast Comparison

After conducting various forecasting methods from time series and associative models, it is applicable to discover the most suitable forecasting method for BABY-GRADE-A cotton bud at PT. DBAS. The value of MSE (Mean Squared Error) is a parameter to compare the plans. At the same time, MAD shows the error by using the same unit as the data to see the absolute number of mistakes to avoid negative error numbers [10].

The Table 4 shows that the least MSE has resulted from the polynomial regression forecasting method with 6,103.18 MSE.

4.5 Moving Range Chart

The result will be verified and validated to show that polynomial regression is a valid method to forecast the BABY-GRADE-A cotton bud.

From Fig. 2, no errors limit the UCL or the LCL, and none of any points violates the control rule. It means that the data are controllable based on the moving range chart.

Table 5. Paired Sample t-Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% CI[a]				
					L	U			
P1	D-F	.04167	79.80	16.28	−33.73	***33.65***	***−.003***	***23***	***.998***

[a] Confidence Interval of the Difference

Table 6. Forecast Demand Jan–Dec 2021

No	Month	Forecast	No	Month	Forecast
1.	Jan-21	838	7.	Jul-21	958
2.	Feb-21	856	8.	Aug-21	981
3.	Mar-21	875	9.	Sep-21	1,005
4.	Apr-21	895	10.	Oct-21	1,029
5.	May-21	915	11.	Nov-21	1,055
6.	Jun-21	936	12.	Dec-21	1,081
TOTAL					11,426

4.6 Paired Sample Test

Paired sample tests employ validation. This validation is carried out by applying the selected forecasting approach to the actual data and then comparing the results of using the method with historical data held by the company. The results to be compared are the real demand with the forecasting result. The validation test in this research uses a paired sample test because paired sample test examines the differences in the average for the two paired or connected samples.

Table 5 shows the significance 2-tailed value of actual demand and forecasted demand is 0.998. It is more significant than 0.05 sig. (p). The meaning is that H_0 will be accepted, and there is no significant difference between the actual demand data and the forecast demand. In this case, the forecasted demand uses a polynomial regression method.

4.7 Forecast Demand

After verification and validation processes, the next step is forecasting the demand for BABY-GRADE-A cotton bud 2021 using polynomial regression. The table below shows the number of forecast demands for January 2021 to December 2021 (Table 6).

4.8 Discussion

Compared to Naïve, Moving Average, Weighted Moving Average, Exponential Smoothing, and Trend Projections, Polynomial Regression has some specific aspects to the

historical sales data of BABY-GRADE-A cotton bud. The characteristics depend on the demand period and fluctuate demand due to COVID-19. And unpredictable seasons, trends, or cycles. Therefore, along with polynomial regression characteristics, the polynomial regression forecasting method suits to forecast the sales data of BABY-GRADE-A cotton bud.

A minor result of error measurements supports the suitability of the polynomial regression method for BABY-GRADE-A cotton bud. The number of errors is utilized to minimize the negative impacts and strategic planning to overcome product shortage or overproduction. After comparing the errors among forecasting methods, the method with minor mistakes (proposed–with polynomial regression method) will be compared to the current method employed by the company (actual). The errors compared are MSE (Mean Squared Error) and MAPE (Mean Absolute Percentage Error). MSE and MAPE are used to compare the fits of different time series models, and smaller values indicate a better fit.

Based on Fig. 3, it is evident that the proposed method could least the MSE up to 26%, from 22,700.96 to 6,103.18 squared errors.

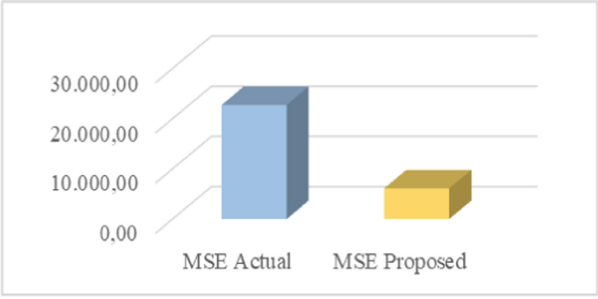

Fig. 3. MSE Comparison

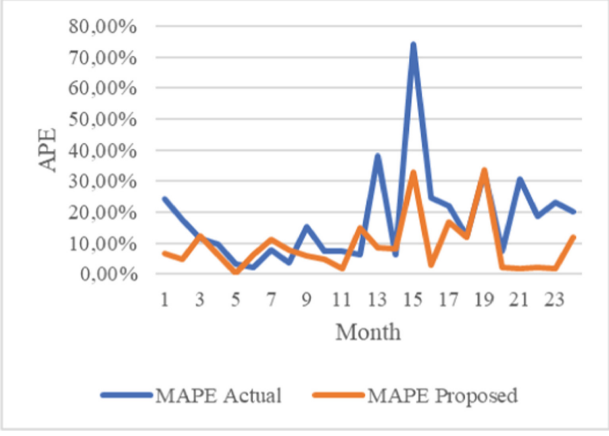

Fig. 4. MAPE Comparison

Figure 4 shows the absolute percentage error for actual data and the monthly proposed method. Generally, the APEs of the proposed method are lesser than the real's. However, there are three months with higher APE, such as Jul 2019, Dec 2019, and Jul 2020.

The least number of error measurements helps the company forecast more accurate forecasting. In other words, a more precise prediction reduces the risk of shortage which leads to employees working overtime and loss in sales or even higher inventory turnover and cost, havoc pollution because of overproduction. So, the company applies suitable decision-making in production and sales effectiveness. This benefit, the decision to produce exact product numbers, may lessen the cost of mismatching supply or demand [11].

Since the result error numbers of polynomial regression are the least among the others, the company should use the method to forecast future demand. It can be proven by comparing polynomial regression and another method to forecast demand and supply in Sep-21 and 2021.

Sep–Oct 2021's forecast by using Holt's Exponential Smoothing is 216 and 158. Meanwhile, the actual sales for the months are 980 and 1,058. If the company used Holt's Exponential Smoothing, which has a MAPE of 10.26%, the company would lack supply. It might cause trouble of shortage.

5 Conclusion and Recommendation

To conclude, MAPE results from each method are varied. The slightest error method is polynomial regression with a MAPE of 9.07%. So, based on the error's comparison, Polynomial Regression is suitable for forecasting BABY-GRADE-A future demands, and the total forecast demand of BABY-GRADE-A cotton bud in 2021 is 11,426 cartons.

Although the polynomial regression forecasting method advantages the company in forecasting BABY-GRADE-A future demand, it does not necessarily mean that it uses polynomial regression for the long-term forecasting method. The company should relate all forms. The company could use the forecasting solution for expanding their operations aspects such as sales & operations plan, inventory management, MRP (Material Requirement Planning), aggregate planning, or even scheduling. In addition, the company should integrate the functions of other departments, such as operations, marketing, and inventory departments, to create a more effective business process.

6 Implication and Significance

From September 2021 to October 2021, the company implemented the number of forecasting sales using the polynomial regression (proposed) method for their production parameter. The company set the number of 1,100 for producing BABY-GRADE-A cotton bud in September and October 2021 since the forecasted demand is 1,005 and 1,029, respectively.

The MAPE does not deviate too large. The two-month polynomial regression policy created 2.62% of MAPE, 26.75 of MAD, and 718.70 of MSE (Table 7).

In addition, as a whole business process, the coordination among departments such as operations, marketing, and inventory departments must be strengthened to improve the

Table 7. Actual-Forecasting Sep–Oct 2021

	Month	Sales	Production	F	|- ^|	|-^|^2	MAPE (%)
1.	Sep-21	980	1,100	1,005	24.9	623	2.55
2.	Oct-21	1,058	1,100	1,005	28.5	814	2.70
Total		2,038	2,200	2,034			
MAD					26.7		
MSE						718	
MAPE							2.62

Source: Data Processing (2021)

quality of the production figures that have been implemented. In operations, for instance, after getting the accurate forecasting number, make sure that the lead time for producing products is on time with a determination of the correct ROP (Re-Order Point). The stock record should be accurate (stock name). The older stock should be placed in a different place from the newest by implementing the FIFO (First-In-First-Out) inventory method to lessen the risk of damaging products. Moreover, to reduce the risk of piled effects for the marketing department, it is better to apply some marketing strategies, such as promotion, discount, bundling package, advertisement, or IMC (Integrated Marketing Communication) strategy.

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