Production Planning to Meet Maximum Demand with Forecasting and Aggregation Methods

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Abstract. Production carried out by small industries still needs to be improved and classified as insufficient compared to the consumer demand. The company's production traditionally relies on sunlight in the drying process. This is the main factor in the limited production process that can be carried out. This study aims to overcome the maximum demand, which is still an obstacle for the industry to meet their demands. To overcome this, demand forecasting is carried out to determine the demand forecast in advance, and production adjustments are made to meet maximum demand with aggregate planning. Data collection techniques in this study used 1) interview methods and 2) collection of request history data. Data analysis techniques use tools, namely forecasting and aggregate methods. The stages carried out in this study are 1) identification of demand patterns, 2) quantitative forecasting calculations, 3) error analysis, and adjustment of production quantities. This study shows that the maximum consumer demand can be met by procuring supplies in preparation for peak demand.

1 INTRODUCTION

Regarding economic relations, Indonesia is currently classified as an industrial country. According to the Ministry of Industry of the Republic of Indonesia, the industrial sector significantly contributes to the national economy, with more than 20% [1]. Posisi Indonesia lebih besar dari Rusia serta sejajar dengan Brasil dan Inggris. This makes Indonesia one of the top 10 in the manufacturing value-added category, more significant than Russia and on par with Brazil and England. [2].

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The most significant factor in the development of the national economy is manufacturing. The world now views manufacturing as an essential industry. This has been agreed at the World Economic Forum, which states that industry is a process that includes pre-processing and post-processing as one unit. For example, in the second quarter of 2021, the manufacturing sector contributed 17.34% to Indonesia's national GDP. The two most significant industrial sectors that contribute to Indonesia's GDP, with a total of 8.62%, are the food and beverage industry, the chemical and pharmaceutical industry at 6.66%, and pharmaceuticals at 1.96% [3]. The Indonesian government is focusing on national economic recovery through developing the industrial sector.

Industry is the most effective indicator for assessing a country's economic resilience, where the manufacturing industry is currently one of the backbones of Indonesia's national economy. Apart from manufacturing, small industries also contribute to the Indonesian economy, especially helping provide employment opportunities [4]. Indonesia's small industries currently reach 62.9 units with different locations and sectors. This resulted in a 2-fold increase in small industry GDP from 2010 to 2017. Apart from increasing GDP, the small industry also contributed a total investment of 58.18% in 2018 [5]. The significant growth of small industries can support Indonesia's economic growth [6]. Therefore, increasing competitiveness is necessary for the sustainability business [7].

Rengginang Barokah is a small industry that has been established for generations and is engaged in the food production process. Currently, the production process carried out by the small sector still needs to be improved and is considered insufficient when compared to the demand received from consumers. This is because the company carries out production traditionally by relying on sunlight in the drying process. This is the main factor in the limited production process that can be carried out. Meanwhile, [8] explains that fulfilling strategies to meet market needs can be done by completing the number of requests and product quality. Even though consumer demand is uncertain and fluctuating, companies must still be able to meet this demand. Several factors can influence demand fluctuations, such as consumer interest, suppliers, raw material prices, and competitors [9]. Currently, the company still needs to maximize its inventory management system properly to meet consumer demand so that inventory can be too much or too little, plus the production process carried out by the company is not by the pattern of incoming demand. Therefore, forecasting is necessary for companies to predict sales and use of products at the right amount [10] so that uncertainty can be minimized and make production quantity policies more effective. In its implementation, forecasting can be seen based on the period, such as short-term, medium-term and long-term [11], depending on the level of the need.

This research aims to overcome maximum demand, which is still an obstacle for the industry to fulfill their demand. As a solution, demand forecasting is carried out to determine future demand estimates and production adjustments are made to meet maximum demand with aggregate planning. Forecasting is carried out to predict and anticipate a significant increase in demand. This is in line with the objectives of Sustainable Development Goals (SDGs) numbers 8 and 9 concerning economic and industrial growth as well as SDGs number 4 regarding the quality of education by applying science in society, solving problems that occur related to community life activities, one of which is in terms of production activities in small industry.

2 METHODOLOGY

The research approach used in this research is quantitative research. Existing data was analyzed using a quantitative approach method. The study's scope focuses on the small industry's internal and external environment and production process strategies to fulfill consumer demand. The type of data used in this research is primary data obtained from the

company's historical data. The data collection technique in this research uses 1) interviews and 2) collecting request history data. Data analysis techniques use tools forecasting and aggregation methods. The stages carried out in this research are 1) identification of demand patterns, 2) quantitative forecasting calculations, 3) error analysis, and adjustment of production quantities.

The first activity carried out was interviews with the industry. The data obtained are production activities, consumer demand, and customer service. In this case, it was found that the customer's order quantity request still could not be fulfilled. The small industry still produces using the traditional method, such as by drying the product in the sun. The second activity is observation to get an overview of the production process. From historical data, the numbers obtained from interviews will be processed using the approaches 1) Moving Average, 2) Single Exponential Smoothing (SES), and 3) Linear Regression by using forecasting software PoM QM. Further analysis by comparing 1) Mean Error, 2) Mean Absolute Deviation (MAD), 3) Mean Squared Error (MSE), 4) Standard Error, and 5) Mean Absolute Percent Error (MAPE).

3 RESULTS AND DISCUSSION

From the results of interviews with the Rengginang Barokah industry and looking for historical data on production capacity and demand for reneging products during 2022, data was obtained that can be used as a reference in predicting the production in 2023 at Rengginang Barokah industry. The data and information obtained are presented in the following table:

Table 1. The data demand of the customer

Month	Rengginang Requests Per Month
January 2022	3400
Febuary 2022	3060
March 2022	3130
April 2022	8610
May 2022	3635
June 2022	3430
July 2022	4815
August 2022	3280
September 2022	3010
Oktober 2022	3090
November 2022	3250
Desember 2022	3410
Average	3843

The data above is data on demand for rengginang products during 2022. The following are comparative data between demand and production capacity for rengginang in 2022.

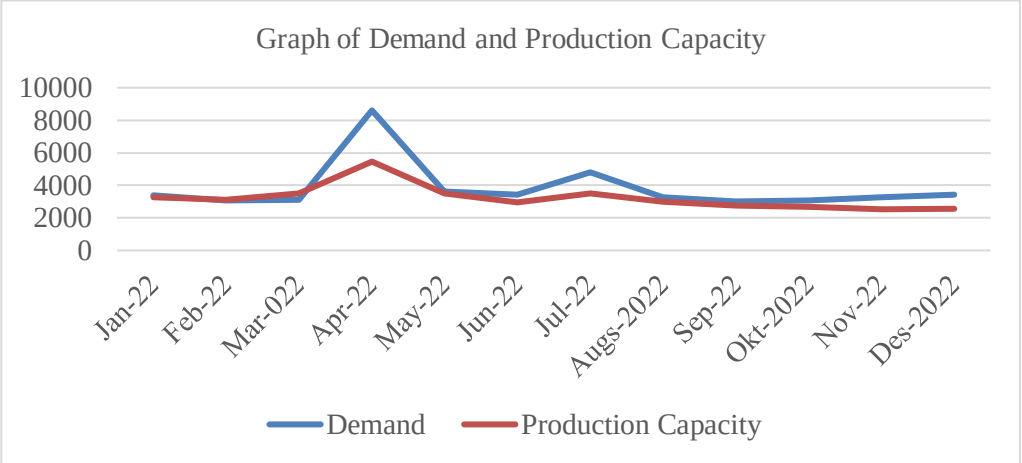


Fig. 1. Rengginang Product Production and Demand Graph

Figure 1 above shows that the average monthly demand for rengginang is around 3843 packs, only able to meet the demand for 3236 packages. This happens because of limiting factors, production capacity and production processes that depend on the weather. If the weather is rainy, the drying process will take two days longer than under normal weather conditions.

From the graph above, it can be seen that there are fluctuations between the amount of demand and production capacity. Demand for products experiences an increasing trend in certain months; this occurs due to factors celebrating holidays such as Eid al-Fitr and Eid al-Adha. On the other hand, production capacity is experiencing a downward trend because the production system is manual and relies on the weather.

The small industry must find solutions to reduce losses from limited product stock. Solutions that can be provided include creating and implementing a consumer demand forecasting system and changing production methods to become more modern.

Below is comparative data between demand and production capacity, presented in graphical form.

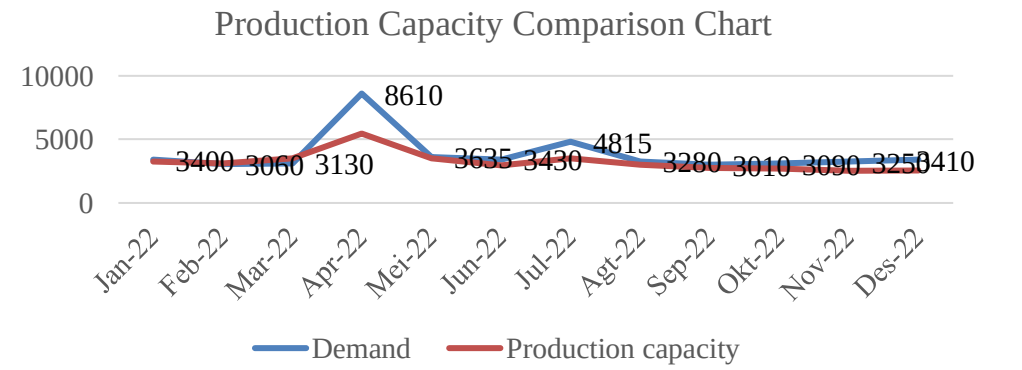


Fig. 2. Production Capacity Comparison Chart

From the graph above, information is obtained that production by using machine capacity is more stable than manual production. In some months, orders are fulfilled optimally so that small industries do not experience losses due to lost opportunities to sell products. Even though it can meet demand in certain months, in some months, it experiences overproduction, which can cause losses. The industry needs to forecast so they don't experience losses.

Forecasting techniques are essential for industry by predicting the amount of demand from consumers. Previously, the small sector needed to learn forecasting techniques to indicate the number of consumer requests. They only estimate by looking at product stock availability and produce larger quantities when facing holidays such as Eid al-Fitr and Eid al-Adha. Knowledge of small industry forecasting techniques can make better preparations by predicting future demand.

Based on historical data on demand for rengginang products in 2022, forecasting demand for the next period is calculated. The analysis results using the Moving Average method and PoM QM software show the following data.

QM for Windows - [Data] Results

PERMINTAAN RENGGINANG UMKM RENGGINANG BAROKAH

Measure	Value
Error Measures	
Bias (Mean Error)	0,909
MAD (Mean Absolute Deviation)	1332,727
MSE (Mean Squared Error)	5395318
Standard Error (denom=n-2=9)	2567,933
MAPE (Mean Absolute Percent Error)	28,779%
Forecast	
next period	3410

Fig. 3. Moving Average Method Demand Forecasting

The second demand forecasting method is the Exponential Smoothing method, which uses PoM QM software. In calculating the Exponential Smoothing method, the α value is 0.75. The following are the calculation results of the Exponential Smoothing method.

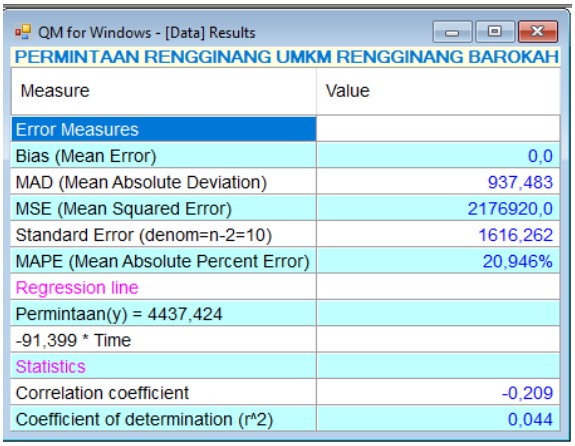
QM for Windows - [Data] Results

PERMINTAAN RENGGINANG UMKM RENGGINANG BAROKAH

Measure	Value
Error Measures	
Bias (Mean Error)	-4,723
MAD (Mean Absolute Deviation)	1263,626
MSE (Mean Squared Error)	4322545,0
Standard Error (denom=n-2=9)	2298,502
MAPE (Mean Absolute Percent Error)	27,249%
Forecast	
next period	3361,033

Fig. 4. Demand Forecasting Single Exponential Smoothing (SES) Method

The final forecasting method is the Linear Regression method. Forecasting calculations use the Linear Regression method using QM for Windows software and show the following results:


QM for Windows - [Data] Results

PERMINTAAN RENGGINANG UMKM RENGGINANG BAROKAH

Measure	Value
Error Measures	
Bias (Mean Error)	0,0
MAD (Mean Absolute Deviation)	937,483
MSE (Mean Squared Error)	2176920,0
Standard Error (denom=n-2=10)	1616,262
MAPE (Mean Absolute Percent Error)	20,946%
Regression line	
Permintaan(y) = 4437,424	
-91,399 * Time	
Statistics	
Correlation coefficient	-0,209
Coefficient of determination (r^2)	0,044

Fig. 5. Linear Regression Method Demand Forecasting

The choice of forecasting technique must be appropriate and suitable to be applied to the small industry; each method will be compared by looking at the Error Measures component such as 1) Mean Error, 2) Mean Absolute Deviation (MAD), 3) Mean Squared Error (MSE); 4) Standard Error and 5) Mean Absolute Percent Error (MAPE). A comparison of the three forecasting techniques can be seen in Table 2.

Table 2. Comparison of Three Forecasting Techniques

Perbandingan	***Moving Average***	***Single Exponential Smoothing***	***Linear Regression***
ME	0,909	-4,723	0,0
MAD	1332,727	1263,626	937,483
MSE	5395318	4322545	2176920
SE	2567,933	2298,502	1616,262
MAPE	28,779%	27,249%	20,946%

From Table 2, the comparison results of forecasting techniques that are appropriate and suitable for the small industry are the Linear Regression method. The Linear Regression method was chosen because this method has a smaller error value than the other two methods, so errors in the forecasting process can be avoided. The Linear Regression method has the smallest Mean Absolute Percent Error (MAPE) value than the three previous methods; the MAPE value for the Linear Regression method is 20.946%.

The Linear Regression method is the appropriate and suitable method for forecasting small industries. Below are the results of forecasting for the next year using the Linear Regression method in PoM QM software, which can be seen in Figure 6.

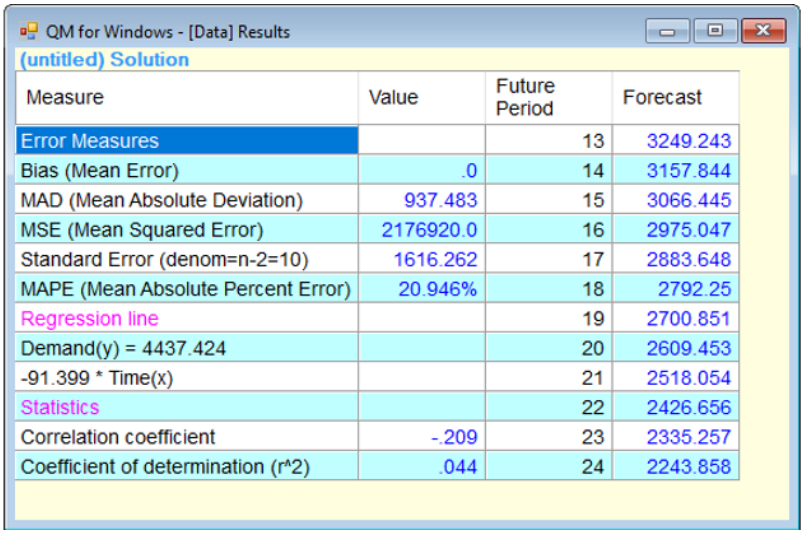


Fig. 6. Linear Regression Method Forecasting Results

The forecasting results using the Linear Regression method and PoM QM software show that the estimate for the next period, January 2023, is 3249,243 products. This amount of demand can be met by industry, and this is because small industry production capacity is traditionally 3843 products, and modern machines use 3500 products.

The forecasting results using the Linear Regression method and PoM QM software show that the forecast for the next period from January to July 2023; it can be seen in Table 3 that from the forecasting results, production will be increased so that monthly demand can be met and excess production will be stored to be accumulated to meet significant increases in product demand such as those that occurred in April and July. By carrying out excess production, the company can meet the substantial increase in demand.

Table 3. Aggregate production

Use of overtime	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**
Peak Demand				8610			4815
Unit Produced	4658	4567	4475	4384	3589	3496	3406
Sales Forecast	3249	3158	3066	2975	2884	2792	2701
Inventory (end of month)	1409	2818	4227	5636	705	1410	2115

4 CONCLUSION

The current problem in the Rengginang Barokah industry is that they cannot meet consumer demand. This is due to the company's limited production capabilities. The amount of production is determined by the presence of major holidays such as Eid al-Fitr and Eid al-Adha. If there are significant holidays, the small industry immediately increases output by 2-3 times compared to the usual amount. The production process also uses traditional methods by relying on the weather, so during the rainy season, the production process runs slower, and the number of products produced is small. By implementing production forecasting,

companies are better prepared to meet consumer demand, where production is increased to be accumulated according to aggregate production.

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