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Autoregressive Integrated Moving Average (ARIMA) Model of Forecast Demand in Distribution Centre

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Abstract. Demand forecasting is very important to be done in order to meet the demand for nail products that are available in every DC. This article tries to present the basic method of time series analysis and forecasting performance of Autoregressive Integrated Moving Average (ARIMA) Model. The study uses this ARIMA model because this model can include the variables used and the type of time series data. Calculation of forecasting errors to be used is Mean Square Error (MSE). From the results of data processing analysis, the best ARIMA model for DC Aceh demand forecasting is ARIMA (3,0,2) with 63,578 units of nails, DC Padang is ARIMA (3.0,3) with a forecasting result of 59,853 units of nails, DC Pekanbaru is ARIMA (1,0,2) with forecasting results of 53,043 units of nails, DC Palembang is ARIMA (3.0,1) with forecasting results of 57,682 units of nails, and DC Medan is ARIMA (2.0,1) with results forecasting 63,699 units of nails.

1. Introduction

Development of the industrial world, consumers demand high-quality products, and the company certainly do various ways to increase customer satisfaction. Consumers feel satisfied when sending product demands in an appropriate and right number. Demand forecasting is necessary to predict the possibility of a decrease or increase in sales in the next period by using accurate information and the companies prepare the strategic taken to face the real conditions [1]. Based on the statement, a forecasting system is needed to project how the sales coming. Forecasting is an important tool in effective and efficient production planning.

The time series approach to forecasting is one such approach which depends on the past data pattern in a time series to forecast the future data [2]. Time series approach are analyzed to understand behavior of the past data pattern and to forecast the future values, enable to analyze or decision makers to make a clear information to others [3]. An excellent review of time series methods in forecasting. There are exponential smoothing, moving average, etc, but one of the complex method that can be used in many data pattern form is Box and Jenkins or ARIMA. All the time series methods are used to predict future data and the autoregressive integrated moving average (ARIMA) model has been successfully implemented to solve forecasting problems e.g. consumer demand, econometrics, social sciences, and other problems [4].

Many time series forecasting methods, one of them is the ARIMA model. ARIMA Model has advantages compared to other time series methods, which is accept all types of data models [5]. Although the process must be stationary first. ARIMA models are both used to predict past data in a short period of time, has a rapid change and or have qualitative parameters. Forecasting is made by



looking at the past data to estimate future events to support their decision-making activities and tactical operations. ARIMA model also used on manufacturing industry [6]. ARIMA time series model able to forecast the trend of changes in qualitative parameters [7]. For example ARIMA can be used to forecast the London daily gold price [4][8] and primary energy demand on fossil fuel [9]. ARIMA Model has been implemented to asses seasonal variability macrobenthic assemblages [10]. The Autoregressive Integrated Moving Average (ARIMA) method is able to capture the information needed with change of quickly and able to handle of instability. This paper describes the ARIMA model of demand estimation at each Distribution Center (DC) and DC demand fulfilled on time. This paper uses the ARIMA Model in forecasting the demand of each Distribution Center because it is well used for short term and medium term forecasting and it is suitable for various data patterns form. Each DC request is carried out in the short term, therefore the ARIMA model is chosen. Until now there has been commonly found on the demand forecasting distribution center conducted using ARIMA model.

2. Methodology

This study was carried out on one of the industrial factories in Medan city that produces building materials. The object examined in this study is the demand for production from nail products. The process stages in overcoming the problem of unmet production demand begins with forecasting demand. Forecasting is done to estimate the number of nail requests from each distribution center in the next period. The forecasting calculation is used the time series method and consider the error estimation. The estimated demand for the future period will be carried out at each Distribution Center (DC), namely Aceh, Padang, Pekanbaru, Palembang, and Medan. The forecasting method commonly used is Autoregressive Integrated Moving Average (ARIMA) or Box-Jenkins. The model is written in the form of ARIMA (p, d, q), where p is the order of the auto regressive process, d is the order of the data stationary and q is the order of the moving average process [11].

The steps to adopt ARIMA method are [1]:

a. Model identification

The ARIMA model can only be used on stationary time series data. For this reason, the first step that must be done is to investigate whether the time series data is stationary or not. If the data is not stationary, it must be checked the difference and how much data will be stationary.

b. Identification of parameters (ACF and PACF)

To use the ARIMA model the value of d (stationery data) must be determined, the number of residual lag values (q) and the dependent lag value (p) used in the model. The main tools used to identify q and p are ACF and PACF (Partial Auto Correlation Function), and correlation which shows the plot of ACF and PACF values for lag. The partial auto correlation coefficient measures the degree of closeness of the relationship between X_t and X_{t-k} , while the lab effect times 1, 2, 3, ..., k-1 are considered constant.

c. Selection of the best ARIMA model

From the results of stationary identification and identification of ACF and PACF, there will be several alternative models of ARIMA. Hereafter, estimate the auto regressive parameters.

d. Forecasting

After the best model is obtained, forecasting for the future period can be done. In various cases, forecasting with this method is more reliable than forecasting with other time series methods.

3. Result and Discussion

3.1. Historical Product Demand

Nail products manufactured by one of the building materials industry in Medan markets its products through five distribution centers namely the Medan DC, Padang DC, Palembang DC, Pekanbaru DC, and Aceh DC. Each distribution centre order directly to the company. Each distribution center orders separately each period based on market demand. To forecast nail product demand for 12 months, can be done by looking at the historical data demand. The actual product demand of nail in a year from each distribution centre can be seen in Figure 1.

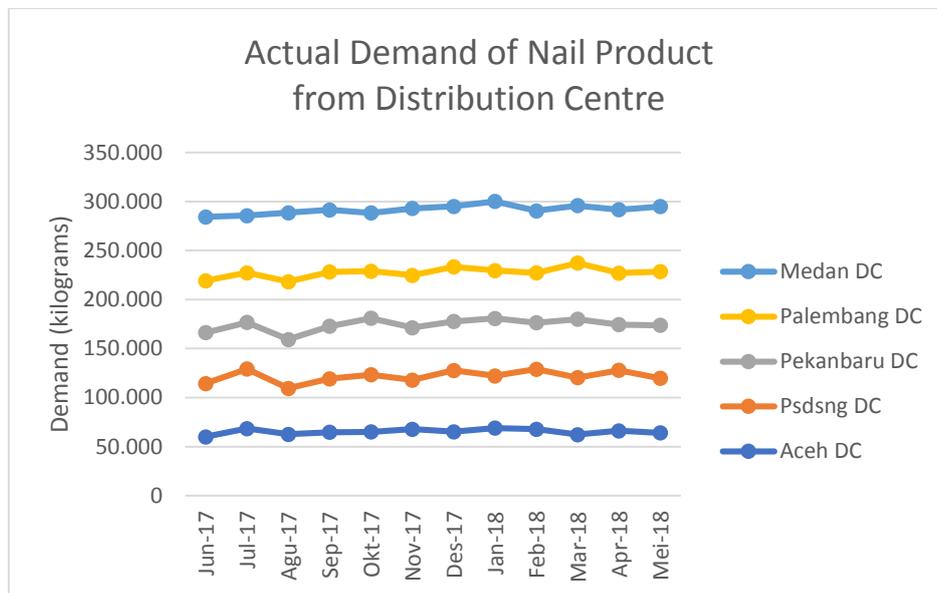


Figure 1 Actual demand of nail product

Based on Figure 1, it can be seen that the number of requests for nail products has small fluctuations. The fluctuations in demand for each Distribution Centre have a similar pattern, for example increasing in July 2017 except DC Medan.

3.2. ARIMA forecasting

After the data is obtained, then the ARIMA process is applied according to the steps in the application of the ARIMA process. The ARIMA process in this study using the Minitab 16 software. The forecasting steps carried out based on the ARIMA model are:

- Setting a goal to forecast demand for nail product 12 months ahead on each DC namely Aceh, Medan, Pekanbaru, Padang, and Palembang.
- Stationary testing of the data in variance is carried out. The result of stationary testing in each distribution centre can be seen in Table 1.

Table 1 Results of Box-Cox transformation demand of phase 1

Distribution Centre	Rounded Value	Confidence Level
Aceh	0.04	95%
Medan	0.16	95%
Pekanbaru	-0.92 with transformation	95%
Padang	1.00 with transformation	95%
Palembang	0.43	95%

Because the rounded value is smaller than 1 (≤ 1), it means the data is stationary.

- Do the stationary testing of the data in the first means (Autocorrelation Function). The result of Autocorrelation Function testing in Aceh DC (as example) can be seen in Figure 2.

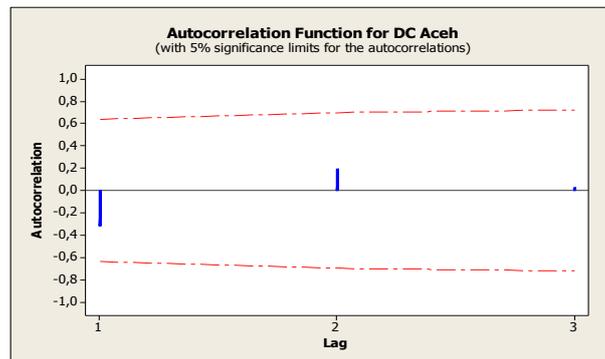


Figure 2 Autocorrelation function results of Aceh DC

- d. Do the stationary testing of data in the second means, PACF (Partial Autocorrelation Function). The result of Partial Autocorrelation Function testing in Aceh DC (as example) can be seen in Figure 3.

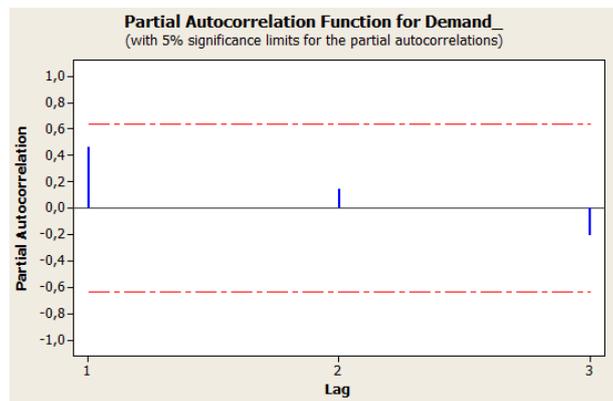


Figure 3 Partial Autocorrelation function results of Aceh DC

- e. Forecasting is based on the ARIMA method. After that, each ARIMA model was tested to get the smallest model with MS (Mean Square). For example ARIMA model (1,0,0) means that *autoregressive = 1, difference = 0, and moving average = 0*. The result of mean square value in ARIMA model (1,0,0) from Aceh DC has mean square value equal to 6230139. Then Forecast demand of nails products are repeated again with other ARIMA models (by trial and error) to get the smallest MS (Mean Square). With the same way in Aceh DC, the same calculation is done for each ARIMA model at the other distribution center. The results of repetition of the ARIMA model in each distribution centre (Aceh, Medan, Pekanbaru, Padang, and Palembang) can be presented in Table 2.

Testing was done based on all ARIMA models using the Minitab software. Based on Table 1, the smallest Mean Square in Aceh DC is the ARIMA Model (3,0,2) equal to 4222190. The smallest Mean Square in Medan DC is the ARIMA Model (2,0,1) equal to 13572762. In Pekanbaru DC, the smallest Mean Square is the ARIMA Model (1,0,2) equal to 15727607. In Padang DC, the smallest Mean Square is the ARIMA Model (3,0,3) equal to 13512774. In Palembang DC, the smallest Mean Square is the ARIMA Model (3,0,1) equal to 4153281.

Table 2 Result of forecast demand of nails product of Aceh DC

Model	MS (Mean Square) of Each DC				
	Aceh	Medan	Pekanbaru	Padang	Palembang
ARIMA (1,0,0)	6230140	15453343	15985373	21540388	11626234
ARIMA (2,0,0)	6534694	13881288	17350505	22300267	7083864
ARIMA (3,0,0)	7342997	13629340	16883172	Not identified	Not identified
ARIMA (1,0,1)	6717948	19498669	17230462	23311498	5452530
ARIMA (1,0,2)	5646975	19793817	15727607	17487930	4225062
ARIMA (1,0,3)	5472635	17713240	17146520	17412958	6796485
ARIMA (2,0,1)	7357481	13572762	19344040	24586523	5167757
ARIMA (2,0,2)	7246419	19230943	18262781	17891704	4326315
ARIMA (2,0,3)	6418482	13872097	19529910	20436836	7428313
ARIMA (3,0,1)	8512141	14670412	17561184	Not identified	4153281
ARIMA (3,0,2)	4222190	19467071	Not identified	19235245	Not identified
ARIMA (3,0,3)	6589172	Not identified	19741884	13512774	Not identified

Based on the smallest Mean Square, forecast the nails product demand in Aceh DC using the ARIMA Model (3,0,2), Medan DC with ARIMA Model (2,0,1), Pekanbaru DC with ARIMA Model (1,0,2), Padang DC with ARIMA Model (3,0,3), and Palembang DC with ARIMA Model (3,0,1). Forecasting demand in each distribution centre for 12 months calculated based on ARIMA model with the smallest mean square value. Errors are obtained by comparing forecast data with actual demand data. The smallest Mean Square give results closer to actual demand forecasting with the smallest error. The forecasting result in each distribution centre with 95% level of confidence can be presented in Table 3.

Table 3 The result of forecasting nail product demand

Period	The Result of Demand Forecasting				
	Aceh ARIMA (3,0,2)	Medan ARIMA (2,0,1)	Pekanbaru ARIMA (1,0,2)	Padang ARIMA (3,0,3)	Palembang ARIMA (3,0,1)
13	63.578	63.699	53.043	59.853	57.682
14	66.266	63.102	53.946	58.574	50.064
15	65.326	65.633	51.950	56.504	52.399
16	64.410	62.867	53.763	59.021	57.230
17	66.076	64.607	52.117	56.331	51.194
18	65.415	64.313	53.611	58.602	51.554
19	64.705	63.496	52.254	56.591	56.767
20	65.840	64.721	53.487	58.220	52.303
21	65.421	63.742	52.368	56.841	51.089
22	64.897	64.134	53.384	57.955	56.123
23	65.675	64.310	52.461	57.026	53.237
24	65.415	63.822	53.299	57.780	50.935

Table 3 shows the results of Nail Product demand forecasting for each distribution center. Forecasting is done in the next 12 periods based on the selected ARIMA model. The ARIMA model

selected for each DC has been verified to have the smallest error compared to other ARIMA models. This paper does not compare the ARIMA model with other time series models, because the ARIMA model can be used on all data models [5] and considered in capable of providing good forecast results. This paper has been succeeded in applying the ARIMA model to predict the demand for each distribution center that changes anytime.

4. Conclusion

Comparison of actual company demand with demand forecasting calculations using the ARIMA model. Based on the results of research on forecasting using Auto Regressive Integrated Moving Average (ARIMA), the best forecasting results are generated using the ARIMA Model (3,0,2) in Aceh DC, ARIMA Model (2,0,1) in Medan DC, ARIMA Model (1,0,2) in Pekanbaru DC, ARIMA Model (3,0,3) Padang DC, and ARIMA Model (3,0,1) in Palembang DC. The forecast demand in 13th period in Aceh DC with ARIMA (3,0,2) equal to 63,578 units of nails, Padang DC with ARIMA (3,0,3) equal to 59,853 units of nails, Pekanbaru DC with ARIMA (1,0,2) equal to 53,043 units of nails, Palembang DC with ARIMA (3,0,1) equal to 57,682 units of nails, and Medan DC with ARIMA (2,0,1) equal to 63,699 units of nails. In the future a comparison between all forms of ARIMA models will be compared to other time series methods. Besides that, the ARIMA model will be further developed in the service industry because the service industry has more complex quality parameters.

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