Forecasting of salt demand using ARIMA model to prevent the bullwhip effect in salt supply chain

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Abstract. The volume of imported salt contributed roughly up to 50.29 percent in Indonesia. However, until the end of 2020, salt from domestic farmers reached 2.89 million tons. Based on these conditions, it is necessary to plan how to expand the distribution of local salt. Not only does distribute the salt to the domestic market, but also exports it, so the stock of salt does not accumulate in the warehouse. The work demonstrated in this article constituted to predict the demand of salt especially exported salt. This research utilized the historical demand data from 2014 to 2019 to predict the market of exported salt in Indonesia. The historical data were used to develop several models of autoregressive integrated moving average (ARIMA). This method was used to analysed how the forecast affected to supply chain and to prevent the bullwhip effect on it. The bullwhip effect could be known as the small fluctuations in retail demand level which could cause progressively larger fluctuation in demand at the distributor and supplier levels. The selected model corresponded to the ARIMA (1,0,1) of the tentative models with the smallest RSME value of 9.566. These results will provide to the manager of salt manufacturing to make decisions related to expand the salt market by exporting it rather than only distributing in domestic market.

1. Introduction

Salt is one of the leading business sectors in Madura. Madura is the largest salt field in Indonesia, which is approximately 15,000 hectares of salt lands. There are Bangkalan, Sumenep, Pamekasan, and Sampang. However, the abundance of salt land is not enough to be an economic support to salt farmers. Salt farmers (*mantong*) are still below the poverty line [1]. The existence of land tenure by salt farmers who have wider lands than farmers who have narrower lands also contributes to the polarization of marginalization among salt farmers [2]. The salt industry community has not been well formed in Madura. The government's policy about imported salt also contributed to the dropping of selling price of salt [3]. Moreover, there was a pandemic condition in 2019 which made the economic condition of salt farmers worse.

Based on the balance sheet in the 2020, the volume of imported salt contributed up to 50.29 percent of the availability salt in that year. Nevertheless, the national salt demand reached roughly 4.46 million tons with industrial needs reaching 83.86 percent or 3.74 million tons. By the end of 2020, salt from domestic farmers reached in 2.89 million tons. The local salt stocks in 2019 reached 2.11 million tons [4]. Given this condition, it is necessary to have an alternative market selection other than the domestic market, so that salt could be distributed to the international market. The purpose of this study is analysing

the forecasting of exports in Indonesia as an alternative market using the ARIMA method to prevent the bullwhip effect. This method was used because the used data was seasonal data type [5]. The bullwhip effect is referred as demand or variance amplification. The effect becomes substantial when the cost fluctuates in production or ordering outweighs the holding cost in inventory. The bullwhip cost plays a crucial role in business. Bullwhip costs could be associated with difficulty in forecasting [6].

2. Methodology

2.1. Data collecting
Used data in this research was exported salt data in Indonesia from 2014 to 2019. The data was derived from Statistic Indonesia (*BPS*).

2.2. Pre-processing
Pre-processing was used for data cleaning. It was purposed to dispose of data which contained noise, and then data was plotted to create a time series and the pattern [7].

2.3. Stationarity test
Stationarity test was used to examine the data both stationary in variance and the mean. If the data was not stationary in variance, then the Box-Cox transformation was carried out. If the data was not stationary in the mean then differencing was carried out (differentiation method) [7].

2.4. ACF/PACF Plotting
This stage was examined to create the ACF (Auto Correlation Function) and PACF (Partial Auto Correlation Function) plots. These plots determined the tentative models or candidates to be selected to perform the best forecasting [7].

2.5. Estimation
This stage was used to perform the Jenkins Box stage by checking the significance of parameters, discarding insignificant parameters, and data overfitting [7].

3. Result and discussion
In this article, the demand forecasting was conducted based on real data. The accuracy and characteristics were studied. This study examined the effectiveness of demand forecasting in exported salt in Indonesia. The model shown in Figure 1 is based on the demand of exported salt in Indonesia from 2014 to 2019.

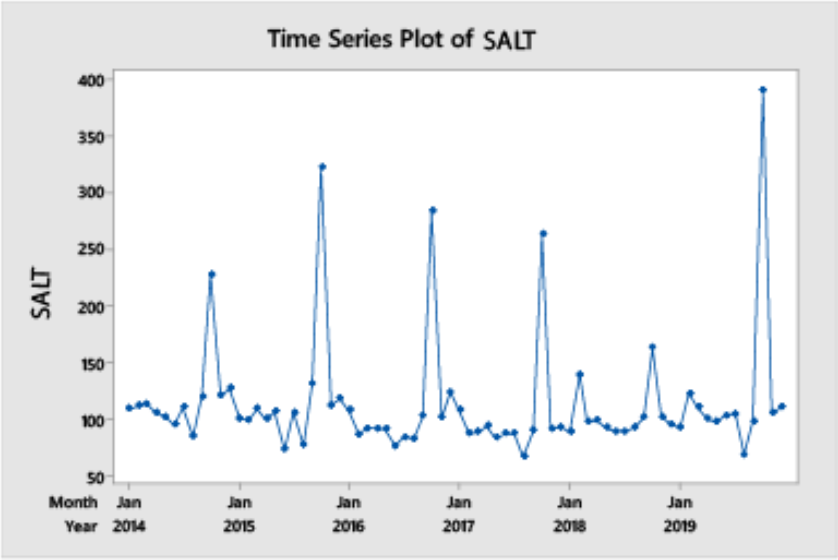

Figure 1. Exported salt data from 2014 to 2019

Looking at the chart, in the 2019 exported salt experienced an increase significantly in around October, then plunged in November. The previous years also described a rising trend that was around October and then plunged in November.

The data at figure 1 showed that the data fluctuated over the years, so that it could be happened because of the typical of salt's business process. Indonesia has two seasons. There are dry season and wet season (monsoon). The salt farmers only work in dry season. However, when it comes the wet season, the salt farmers do not work. Because the salt production in Indonesia is processed using traditional process, so that the processes depend on the sunlight to crystalize the salt.

The dry season in Indonesia is around April to September, so that the reason why the sale of salt arises significantly around October. After harvesting the salt, it is stored in warehouses to be sold in the next months. The salt business owner probably considers this condition. The fluctuated demand of exported salt probably triggers the bullwhip effect. Hence demand forecasting is needed in order to make a better business plan, so that the business owner could decide how to supply and sale the salt in order to arrange the balance of point of sales over the years. It is important to use a prediction model to estimate the data to prevent the bullwhip effect [8]. In this article, the model could be used to predict to expand the salt market not only in domestic market but also in international market. Supply chain effectiveness are influenced by demand unpredictability, particularly in the upstream echelons. The fluctuated demand tends to be intensified moving upstream in the supply chain called the bullwhip effect phenomenon, so that this tends to damage the service level to the final customers [9].

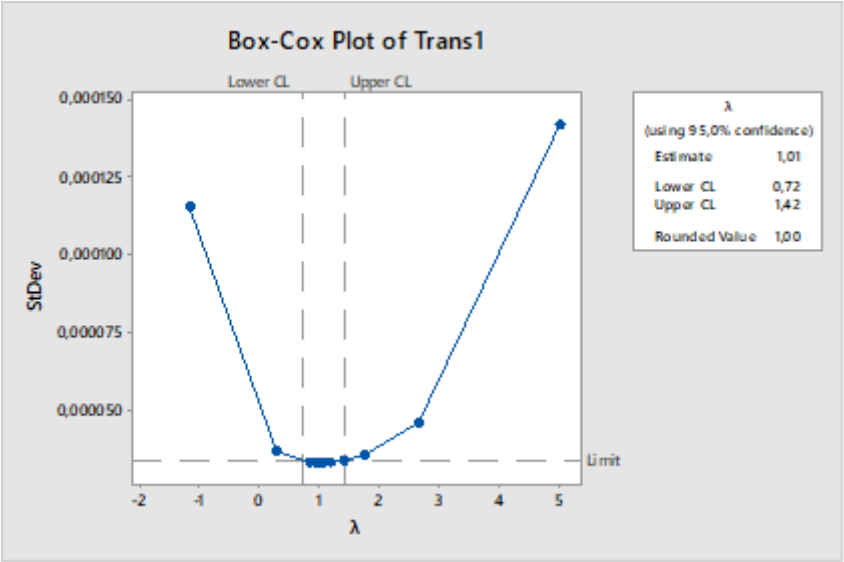

Figure 2. Box Cox plot

The result of *the Box-Cox* analysis was obtained $\lambda = 0$, as the transformation used was Ln. The transformation result was shown in figure 2. Based on figure 2 was obtained a rounded value of 1 with a significance level of 95%. A rounded value was located between the values of Lower CL and Upper CL, so that the data was stationary in variance. Next step was to examine the stationarity in mean using the ACF and PACF plots. The ACF plot result was shown in figure 3, while the PACF plot result was shown in figure 4. Looking at the figures, these figures indicated that the data was stationer visually after experiencing in 1 differencing.

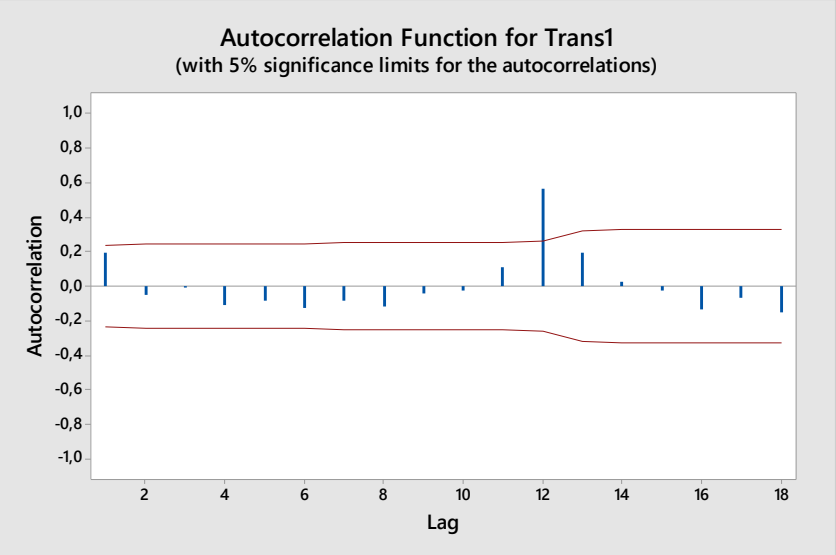

Figure 3. ACF plot

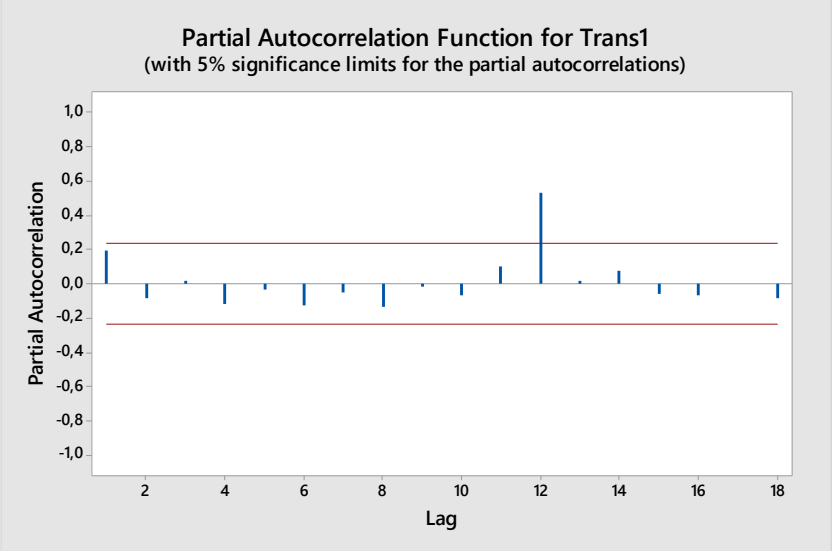

Figure 4. PACF plot

The estimated model for ARIMA can be made from the figures. The ARIMA model can be built by arranging (p, d, q), while the value was derived as follow:
p value = PACF significance lag
d value = differencing
q value = ACF significance lag

Estimated model of ARIMA were (0,0,1), (1,0,0), and (1,0,1). After establishing the estimated model, then the root mean square error (RMSE) of the model was calculated. The model which had the smallest RMSE was chosen [10]. The calculation of RMSE of model was shown in Table 1.

Table 1. RMSE calculation of estimated model

Model	RSME
Model ARIMA (0, 0, 1)	92.21983891
Model ARIMA (1, 0, 0)	50.30306585
Model ARIMA (1, 0, 1)	9.565992145

Looking at the table 1, the smallest RMSE was model ARIMA 1,0,1. Because of having the smallest value, this model was chosen to predict the exported salt for the next period. This result could be used for manager, government, or businessman who need to predict the market. Over the years, the salt farmers suffered from the decreasing sale of salt. With this model, not only can the salt business be expanded its market to the international market, but it also has to be followed by improving the quality of salt product to be suitable to satisfy the international customers.

4. Conclusion

The purpose of this study is analysing the forecasting of exports in Indonesia as an alternative market using the ARIMA method to prevent the bullwhip effect. This method was used because the used data was seasonal data type. The bullwhip effect is referred as demand or variance amplification. The effect becomes substantial when the cost fluctuates in production or ordering outweighs the holding cost in inventory. The bullwhip cost plays a crucial role in business. Bullwhip costs could be associated with difficulty in forecasting. With this model, not only can the salt business be expanded its market to the international market, but it also has to be followed by improving the quality of salt product to be suitable to satisfy the international customers. For the next project, the chosen model could be used to predict the data in the next period by generate codes in SAS.

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Acknowledgments

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