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MODELING AND FORECASTING OF LOG PRODUCTION IN TURKEY

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ABSTRACT

In this study, modeling of log production using moving average, single exponential smoothing, double exponential smoothing and winters (multipcaltive and additive) methods and forecasting of monthly log production for 2017, 2018, 2019 and 2020 by means of the highest performing method was aimed. The data used in this study were obtained from the General Directorate of Forestry in Turkey. The data was monthly and included periods 2011-2016. Minitab 16 programme was used for determining best model. Comparisons of models are based on error criteria such as Mean Absolute Deviation (MAD), Mean Absolute Percent Error (MAPE), and Mean Square Deviation (MSD). Forecasts were made by the method, which it has the lowest error criterion values. When the results of accuracy forecasting of applied methods are examined, it was found that winters's multipcaltive-seasonal exponential smoothing method has the highest accuracy forecasting among the obtained methods.

Key words: Log production, Winters, Moving average, Exponential smoothing

INTRODUCTION

Due to positive economic developments in the General Directorate of Forestry and growth potential in the construction sector in Turkey. There has been an increase in the wood raw material production by the General Directorate of Forestry in Turkey (Anonymous, 2016).

Regarding wood raw material in Turkey, log, wire pole, mine pole, industrial wood and firewood are produced. Log production, which is one of the main products of forests, is as follows: Firstly, the trees are cut, the branches of it are removed, the shells of it are peeled. Then, the defects in tree trunk are cleared. Finally, trees are made of logs (Acar et al., 1996; Yenilmez, 2010).

According to 2016 data in Turkey, the log production constitutes 34% of the wood raw materials regarding production quantity (URL-1, 2017). According to 2016 data, the export of log in Turkey is 2.6 million$ and regarding the export of log, Turkey is the 86th in the world. The leading countries of export of log are United States of America, New Zealand, Russia Federation and Canada, respectively. The import of log in Turkey is 62 million$ and regarding the import of log, Turkey is the 24th in the world. The leading country of import of log is China (URL-2, 2017). When the ratio of log production in industrial wood is considered, the production forecasting studies to be done in this area can contribute to the production, consumption, export and import activities in a planned way.

In this study, the log quantities produced by General Directorate of Forestry in Turkey in 2011-2016 were taken as data, and moving average, single exponential smoothing, double exponential smoothing and winters (multipcaltive and additive) methods were compared. Thus, it is aimed that finding the most appropriate time series method for the data set and forecasting of log production in the between January 2017 and December 2020 using this method.

MATERIAL AND METHODS

Material

For data, the log quantities produced by General Directorate of Forestry in Turkey were used. The data included January 2011 and December 2016 periods. These data were obtained monthly from the official website of the General Directorate of Forestry (URL-1, 2017). The data was taken as thousand m^3.

Moving Average

The moving average method uses the most recent k data values in the time series for the netx period's forecast. "k" is a constant value, and there is no general rule about what "k" will take. "k" is determined by trial and error. In this study, different values were given to "k" by trial and error. Mathematically, the formula of the moving average is as follows:

$$F_{t+1} = \frac{Y_t + Y_{t-1} + \cdots + Y_{t-k+1}}{k}$$

Where, F_{t+1} is forecast of the times for period t+1, Y_t is actual value of the time series in period t and k is the number of data to include in the moving average (URL-3, 2017; Soysal et al., 2010).

In the method, each new data model is included and the oldest data is removed from the model. The disadvantage of this method is that it is not suitable for seasonal and trend data (Hanke et al., 2008; .Soysal et al., 2010).

Single Exponential Smoothing

Exponential smoothing method is a collection of methods that give different weights for past period data (Önder et al., 2009). Three basic variations of exponential smoothing are used: simple exponential smoothing; double exponential smoothing; winters method (Billah et al., 2006).

Single exponential smoothing called as simple exponential smoothing assumes that the data fluctuates around a stable mean (Prajakta, 2004). This method use when time series have no trend changes (Huang et al., 2012) and the formula of this method is as follows (Prajakta, 2004):

$$\bar{y}_t = \alpha y_t + (1-\alpha)\bar{y}_{t-1}$$

Where, $\bar{y}_t$ is forecast value for period t , y_t is actual value in period t, forecast value for period t-1 and α is smoothing parameter.

Double Exponential Smoothing

Double exponential smoothing is used when the data have a trend. This model contains two smoothing parameters: α and β. α is smoothing parameter for the level of the series and β is smoothing parameter for the trend. The level is a smoothed forecast of the value of the data at the end of each period. Trend is a smoothed forecast of average growth at the end of each period (Prajakta, 2004; Everette et al., 2006). The formula for double exponential smoothing is (Everette et al., 2006):

$$L_t = \alpha y_t + (1-\alpha)(L_{t-1} + T_{t-1})$$
$$T_t = \beta(L_t - L_{t-1}) + (1-\beta)T_{t-1}$$
$$\bar{X}_t(m) = S_t + mT_t$$

Where, L_t is smoothed level of the series, which computed after y_t is observed, T_t is smoothed trend at the end of period t, $\bar{X}_t(m)$ is the forecast value in m period and m is the number of periods in the forecast lead-time.

Winters Method

Winters method, which developed by Winters in the 1960s, is used when the data have trend and seasonality. Winter method uses three parameters: α is smoothing parameter for the level of the series, β is smoothing parameter for the trend, and γ is smoothing parameter for the seasonality. In practice, there are two different winters models, based on the type of seasonality: multiplicative seasonal model and additive seasonal model (Soysal et al., 2010; Prajakta, 2004; Çuhadar et al., 2017).

The formula for multiplicative seasonal exponential smoothing is (Çuhadar, 2014):

$$L_t = \alpha \frac{y_t}{S_{t-s}} + (1-\alpha)(L_{t-1} + T_{t-1})$$
$$T_t = \beta(L_t - L_{t-1}) + (1-\beta)T_{t-1}$$
$$S_t = \gamma \frac{y_t}{L_t} + (1-\gamma)S_{t-s}$$
$$\bar{X}_{t+m} = L_t + mT_t + S_{t-s+m}$$

The formula for additive seasonal exponential smoothing is (Çuhadar , 2014):

$$L_t = \alpha(y_t - S_{t-s}) + (1-\alpha)(L_{t-1} + T_{t-1})$$
$$T_t = \beta(L_t - L_{t-1}) + (1-\beta)T_{t-1}$$
$$S_t = \gamma(y_t - L_t) + (1-\gamma)S_{t-s}$$
$$\bar{X}_{t+m} = L_t + mT_t + S_{t-s+m}$$

Where, S is the number of season in one year and S_t is smoothed seasonal at the end of period t.

RESULTS

To understand the properties of the data before comparing the performance of the methods, trend and autocorrelation analyses were performed with Minitab 16 program. Trend and Autocorrelation analyses results were given in Figure 1. According to the trend analysis, it was observed that log production has an increasing trend. The data is not stationary. Looking at the autocorrelation results, the data contains seasonality. The log production was increased, while it was decreased in certain months.

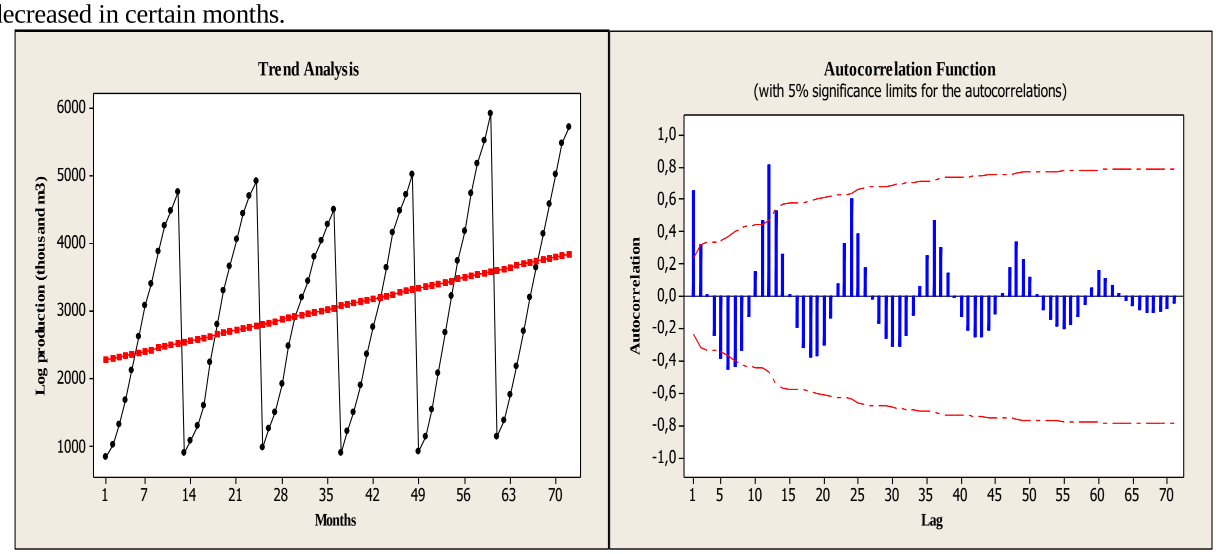

Figure 1. The trend and autocorrelation analyses of log production

After determining the characteristics of the data, four different time series methods (moving average, single exponential smoothing, double exponential smoothing and winters) were applied by using Minitab 15 program. It was conducted that comparisons of models are based on error criteria such as Mean Absolute Deviation (MAD), Mean Absolute Percent Error (MAPE), and Mean Square Deviation (MSD). The formulas of MAD, MAPE and MSD were given below (Göktaş, 2005; Chang et al., 2015):

$$\text{MAD}=\frac{1}{n}\sum_{i=1}^{n}|x_i-\bar{x}| \qquad \text{MAPE}=\frac{100}{n}\sum_{i=1}^{n}\left|\frac{x_i-\bar{x}}{x_i}\right| \qquad \text{MSD}=\frac{1}{n}\sum_{i=1}^{n}|x_i-\bar{x}|^2$$

Where, x_i is the forecasting value of model, $\bar{x}$ is the actual value of model and n is the number of observations.

In the analysis made according to the moving average method, “k” values (the number of data to include in a moving average) were randomly assigned different values such as 1, 3 and 5. The results were given in Table 1. It was determined that the error rate also increases, when the k value increases. This increase is thought due to seasonality and trend. k=1, which given the lowest performance criterion values was obtained.

Table 1. Comparison of k values in moving average method

	MAPE	MAD	MSD
k=1	42	638	1311062
k=3	66	1142	2039518
k=5	75	1446	2694089

In the order the single exponential smoothing and double exponential smoothing methods, the optimal values determined using the Minitab 15 program are used in comparison. In the single exponential smoothing method, α=0.986334 was determined. For double exponential smoothing method, α=1.09752 and β=0.01548 were determined. For multiplicative and additive winters methods, α, β and γ values given the lowest error criteria were determined. For multiplicative and additive winters methods, α = 1, β = 0.4 and γ = 0.1 were determined. According to the MAD, MAPE and MSD results, it was obtained that the multiplicative winters method has achieved the least error criteria than other methods and given in Table 2. A graph of the results of actual and forecasting obtained using the multiplicative winters method is given in Figure 2. In Figure 2, it was seen that the forecasting values are mostly close to the real values.

Table 2. The comparison of methods according to error criteria values

Forecasting Methods	MAPE	MAD	MSD
Moving average method	42	638	1311062
Single exponential smoothing method	42	630	1292625
Double exponential smoothing method	41	530	1330914
Additive winters method	11	147	119904
Multiplicative winters, method	4.6	83	17422

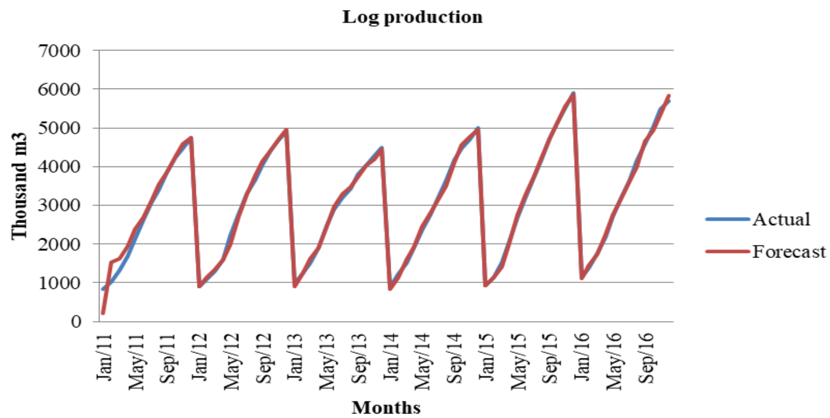

Figure 2. The actual and forecast values for log production in 2011-2016

In Table 3, the forecasting values were included for log produced by General Directorate of Forestry in Turkey in the between January 2017 and December 2020.

Table 3. The forecasting values for log production in 2017-2020 (thousand m^3)

	2017	2018	2019	2020
January	1068	1085	1102	1119
Februray	1337	1358	1380	1401
March	1675	1702	1729	1755
April	2128	2162	2196	2230
May	2739	2783	2827	2870
June	3289	3341	3393	3446
July	3786	3846	3906	3966
August	4220	4287	4354	4421
September	4743	4818	4893	4968
October	5151	5232	5314	5395
November	5486	5573	5660	5746
December	5796	5887	5979	6070

CONCLUSIONS

In this study, different forecasting methods (moving average, single and double exponential smoothing and winters) were used for forecasting of log produced by the General Directorate of Forestry in the future in Turkey. These methods was compared. For this, the data in 2011 -2016 were obtained monthly from the official website of the General Directorate of Forestry. Comparisons of models were made based on performance criteria such as MAPE, MAD and MSD. According to the performance criterion, the log production values for 2017-2020 were predicted using the multiplicative winters exponential smoothing method, which have the lowest values.

Models are classified according to the MAPE value: (1)If MAPE ≤ 10%, it is high accuracy forecasting; (2)If 10% < MAPE ≤ 20%, it is good forecasting; (3)If 20% < MAPE ≤ 50%, it is reasonable forecasting; (4)If MAPE > 50%, it is inaccurate forecasting (Lewis, 1982; Hu et al., 2004). When classification is considered, it seems that the multiplicative winters exponential smoothing model (MAPE=4.6) is a high accuracy forecasting model. The results are similar to studies in the literature. In this study, which aims at analyzing the serum consumption of Süleyman Demirel University Hospital with estimation methods and determining the most appropriate prediction model and predicting the serum consumption for future periods, were used moving average, exponential smoothing, holt-winters and linear regression methods. Methods were compared. As a result of comparison, it was determined that the method with the lowest

MAPE and MAD values is the holt-winters method (Yiğit, 2016). An another study, using the number of tourists, it was estimated that in 2008, the number of tourists who came to the facilities with operation certificate in Turkey for six months. For this, it was used moving average, single exponential smoothing, holt and winters methods. Forecasts were made with the winters method, which has the lowest error performance values (Soysal et al., 2010).

Forecasts may partly remove uncertainties in the decision-making process. To authorized persons provide fast, accurate decisions, they must use the most appropriate technique. For the forecasting of production, consumption, exports and imports of forest products, different forecasting methods can be used by the General Directorate of Forestry. Thus, forecasting studies on forestry activities can lead on the strategic planning to be done for forestry.

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