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Original Research Paper

Forecasting Production of Some Beans in Turkey Using Holt and Damped Exponential Smoothing Methods

Agriculture

KEYWORDS : Beans, exponential smoothing, first difference, forecasting.

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ABSTRACT

The goal of the investigation was to forecast annual production amounts of some beans produced in Turkey. The data are annual data for the 1961-2015 period. For this, Holt and Damped Trend exponential smoothing methods were carried out for statistical model the time series data. Goodness of fit criteria like stationary R2, R2, RMSE and BIC criteria were approved in the comparison of these exponential smoothing methods. Chickpea, beandry and lentils production amounts for the period 2016 to 2020 were predicted using Holt exponential smoothing method with two parameters, which determined the best one among exponential smoothing methods. Production amounts forecasted in, chickpea, beandry and lentils from the period 2016 to 2020 varied 470899 to 514494, 236778 to 243950 and 374364 to 408174 tons, respectively. The conclusion from the study is that, beans production will be increased in future.

Introduction

Beandry is edible plants the most cultivated and produced in the Turkey and world. Chickpea is edible plants the most second cultivated and produced in the world, one is the first in Turkey (FAO, 2014). The acreage and amount production of lentils are less than chickpeas and beandry.

According to FAO (2014) statistics, India ranks first with 9 880 000 tons, Pakistan is the second with 750 000 tons, and Myanmar is the third with 492 000 tons of chickpea production in the world. Turkey ranks 5th with chickpea production amounts 450 000 tons among the world's countries. Chickpea production amount is 14 239 010 tons in the world. According to FAO (2014) statistics, India ranks first with 4 110 000 tons, Myanmar is the second with 3 737 320 tons, and Brazil is the third with 3 294 586 tons of beandry production in the world. Turkey ranks 20th with beandry production amounts 215 000 tons among the world's countries. Beandry production amount is 25 093 616 tons in the world. According to FAO (2014) statistics, Canada ranks first with 1 987 000 tons, India is the second with 1 100 000 tons, and Turkey were the third with 345 000 tons of lentil production in the world. Lentil production amount is 4 885 271 tons in the world. Chickpea, beandry and production have amounted to 460 000, 235 000 and 360 000 tons in 2015, in Turkey respectively (TSI, 2015).

ARIMA (1,2,1) model was best suited for estimation of chickpea production in India by Gajbhiye et al. (2010). Rahman et al. (2013), revealed that the best models were ARIMA (1,1,1), ARIMA (0,1,0) and ARIMA (1,1,3) for pigeon pea, chickpea and field pea pulse production in Bangladesh, respectively.

The purpose of this study, forecast annual production amounts of chickpea, beandry and lentils plants in Turkey for between the years 2016 and 2020 using annual production data of the beans from 1961 to 2015 by means of Holt and Damped Trend exponential smoothing methods.

Materials and Methods

The study material consists of data regarding production amounts of chickpea, beandry and lentils plants between 1961 and 2015. The data were obtained from Statistical Indicators Book published by the Turkish Statistical Institute. Similarly, the data of the subsection "cereals and other herbal products/dry beans" of Agricultural Statistics in TUIK database were made use of (TUIK 2015).

Time series data of these cereals were used Holt and Damped Trend exponential smoothing methods. Holt method, one of the exponential smoothing methods, is used in the estimation of the series having a trend (Hanke and Wichern, 2008). Holt model is expressed as follows:

$$L_t = \alpha Y_t + (1-\alpha)(L_{t-1} + T_{t-1})$$

$$T_t = \beta(L_t - L_{t-1}) + (1-\beta)T_{t-1}$$

$$\bar{y}_{t+p} = L_t + pT_t$$

Here,

L_t: New smoothed value,: Smoothing coefficient, (0<<1), : Actual value at t. period

β: Smoothing coefficient for trend estimation, (0<), : Trend predicted value

p:Number of forecasting periods, : Forecasting value after p period.

The damped trend exponential smoothing models are taken into account to perform an excellent forecasting (Sbrana, 2012).The damped method is expressed in the following equations (Grander and McKenzie, 1985).

$$S_t = \alpha Y_t + (1-\alpha)(S_{t-1} + \varphi T_{t-1})$$

$$T_t = \gamma(S_t - S_{t-1}) + (1-\gamma)\varphi T_{t-1})$$

$$Y_t(m) = S_t + \sum_{i=1}^{m} \varphi^i T_t$$

The predictive accuracy of the methods applied for the study was measured by Stationary R^2, coefficient of determination R^2, RMSE and BIC, respectively. It is propounded to employ model fit statistics on BIC (Pektas, 2013), with a recompense which eliminates the advantage of the model that has more parameters.

Bayesian information criterion (BIC) was developed by Gideon E. Schwarz (1978), who gave a Bayesian argument for adopting it.

$$BIC = ln(\hat{\sigma}_e^2) + kln(n)/n$$

Here $\hat{\sigma}_e^2$ is the error variance.

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Stationary R-Squared statistic was used by Harvey (1989).

Stationary R-Squared

$$R_s^2 = 1 - \frac{\sum_t (Y_t - \hat{Y}_t)^2}{\sum_t (\Delta Y_t - \overline{\Delta Y})^2}$$

as defined. Where ΔY is the simple mean model for the differenced transformed series.

RMSE (Root Mean Square Error): The square root of mean square error. RMSE was calculated for each time series from the N available data. RMSE,

$$RMSE = \sqrt{\frac{1}{N}\sum_{t=1}^{N}(Y_t - \hat{Y}_t)^2}$$

where Y_t: is the production at time t, and $\hat{Y}_t$: the fitted production value obtained at the same time with the model adjusted for all available data.

Result

Chickpea Production

For infer the trend clearer, autocorrelation (ACF) and partial autocorrelation functions (PACF) of the time series are investigated. ACF and PACF graphs of the chickpea production were showed in Figures 1. Trend is existent in the series. To comply stationary state of the series, the difference of the series was taken at the first degree. ACF and PACF graphs of the first difference series carve out for supplying the stationary state are given in Figures 2.

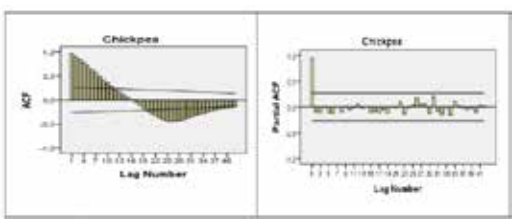

Figure 1. ACF and PACF graph of chickpea production series

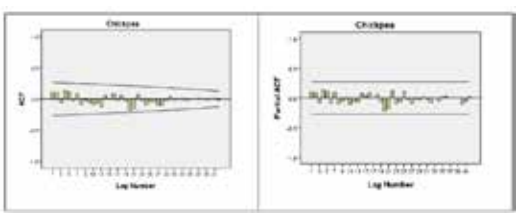

Figure 2. ACF and PACF graph of first differences of chickpea production series

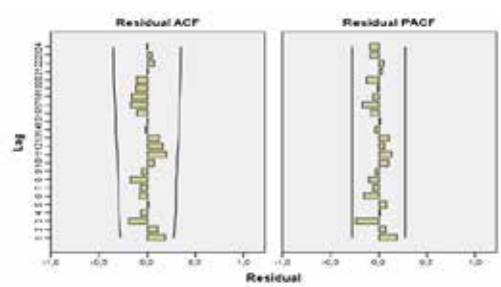

Figure 3. ACF and PACF graphs of residuals of chickpea production

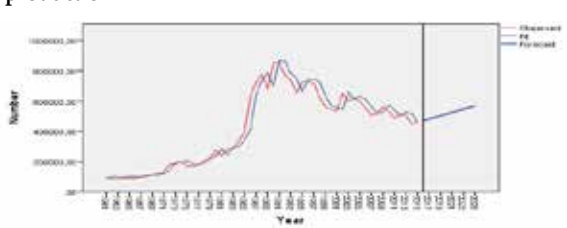

Figure 4. Chart of chickpea production series and forecasting series

Following these results, model fit statistics such as stationary R^2, R^2, RMSE and BIC criteria which were appreciated by Holt and Damped Trend smoothing methods were given in Table 1.

Table 1. Model fit statistics

Fit Statistic	Holt	Damped
Stationary R-squared	0.439	0.012
R-squared	0.943	0.944
RMSE	59514.199	59558.903
BIC	22.134	22.208

In Table 1, Stationary R-squared values are 0.439 and 0.012 according to Holt and Damped trend methods, respectively. R^2 values are 0.943 and 0.944 according to Holt and Damped trend methods, respectively. According to the these methods, RMSE values are 59514.199, and 59558.903; BIC values are 22.134 and 22.208, respectively. From Table 1, it is well showed that Holt smoothing method that value the less than RMSE and BIC value and the higher Stationary R-squared and R-squared were the best method. In Table 2, parameter coefficients of Holt smoothing method were determined as and, respectively. In the statistical comparison of the models, it is significant to use statistics like BIC (Pektas, 2013). ACF and PACF graphs of the residuals are represented in Figure 3. According to Figure 3, the series is White Noise.

Tablo 2. Holt Exponential Smoothing Model Parameters

	Estimate	SE	t	Sig.
Alpha (Level)	1.000	0.140	7.118	0.000
Gamma (Trend)	0.001	0.033	0.029	0.977

Following the results obtained prior, chickpea production can be forecasted. Forecasting results are shown in Table 3 and Figure 4. An increase in chickpea production amounts from the period 2016 to 2020 is expected.

Table 3. Forecasting results from the period 2016 to 2020

Years	2016	2017	2018	2019	2020
Forecast	470899	481798	492697	503596	514494

Beandry production

A trend is existing in ACF and PACF graphs given in Figures 5. When ACF and PACF graphs are examined in Figures 5, many terms of the series in ACF chart surpassed confidence limits, and the series formed a trend. Stationary of the series, the first degree difference of the series was taken. ACF and PACF graphs of the first degree series were given in Figures 6.

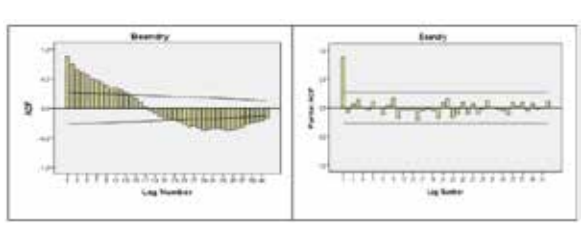

Figure 5. ACF and PACF graph of beandry production series

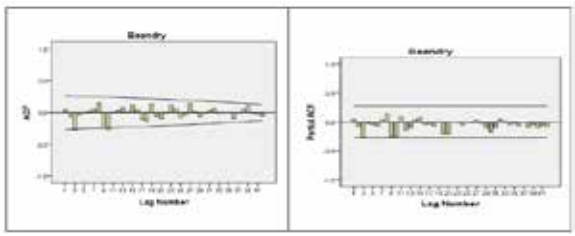

Figure 6. ACF and PACF graph of first differences of beandry production series

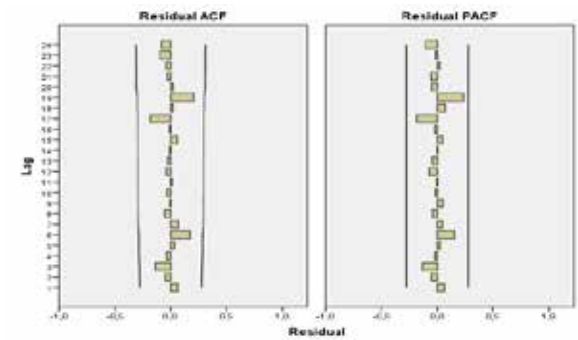

Figure 7. ACF and PACF graphs of residuals of beandry production

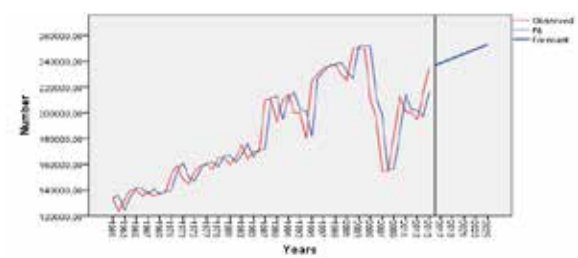

Figure 8. Graph of beandry production series and forecasting series

When Figures 5 was examined, in terms of ACF and PACF charts for the first difference time series were within confidence limits because of being produced the stationary time series. In this case, the best smoothing one among Holt and Damped Trend smoothing methods was selected by using Stationary R^2, R^2, RMSE, MAPE and BIC.

Table 4. Model fit statistics of the series of beandry production

Fit Statistic	Holt	Damped
Stationary R-squared	0.475	0.000
R-squared	0.825	0.825
RMSE	15590.784	15740.632
MAPE	5.593	5.579
BIC	19.455	19.547

As can be seen from Table 4, generally the most appropriate method was Holt smoothing method. Because Stationary R-squared and R-squared values are more than, RMSE and BIC values are less than in Holt method. Coefficients of Holt smoothing method are showed in Table 5 was estimated as alpha and gamma, respectively. The ACF and PACF graphs of the residuals for beandry production are reported in Figure 7.

Table 5. Exponential Smoothing Model Parameters (Holt) for beandry production data

	Estimate	SE	t	Sig.
Alpha (Level)	0.999	0.146	6.830	0.001
Gamma (Trend)	5.246E-05	0.096	0.001	0.999

In figure 7, the degree of relationship between the residuals in ACF and PACF graphs were found within confidence limits. Hence, series has white noise. The common graph of the original series and forecasting series is given in Figure 8. Forecasting results of beandry production amount data from the period 2016 to 2020 are presented in Table 6.

Table 6. Forecasting results from the period 2016 to 2020 (beandry production)

Years	2016	2017	2018	2019	2020
Forecast	236778	238571	240364	242157	243950

Lentils production

A trend was shown in ACF and PACF charts given in Figures 9. When ACF and PACF charts are examined in Figures 9, many terms of the series in ACF chart surpassed confidence limits, and the series formed a trend. Stationary of the series, the first degree difference of the series was taken. ACF and PACF graphs of the first degree series were given in Figures 10.

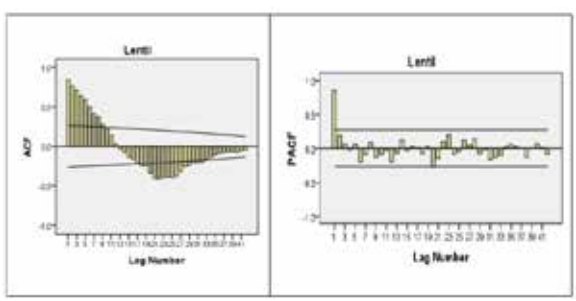

Figure 9. ACF and PACF graph of lentils production series

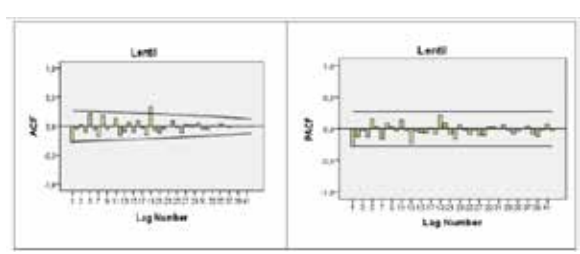

Figure 10. ACF and PACF graph of first differences of lentils production series

When ACF graph in Figure 9 was observed, it could be seen that there was a trend in this place. To produce the stationary series for lentil production amount data, the first difference of the data must be created. Figures 10 report ACF and PACF graphs of the first difference series obtained by the lentil production data.

According to the these methods, RMSE values are

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128204.436 and 129231.731; BIC values are 23.668 and 23.757; Stationary R-squared values are 0.643 and 0.092; R-squared values are 0.752 and 0.753, respectively. From Table 7, it is well showed that Holt smoothing method that value the less than RMSE and BIC value and the higher Stationary R-squared value was the best method (Table 7). Parameter coefficients of the Holt smoothing method are showed in Table 8, and became equal to and , respectively. ACF and PACF graphs of the residuals are given in Figure 11. Accordingly, a series of white noise series.

Table 7. Model fit statistics for the lentils production data.

Fit Statistic	Holt	Damped
Stationary R-squared	0.643	0.092
R-squared	0.752	0.753
RMSE	128204.436	129231.731
BIC	23.668	23.757

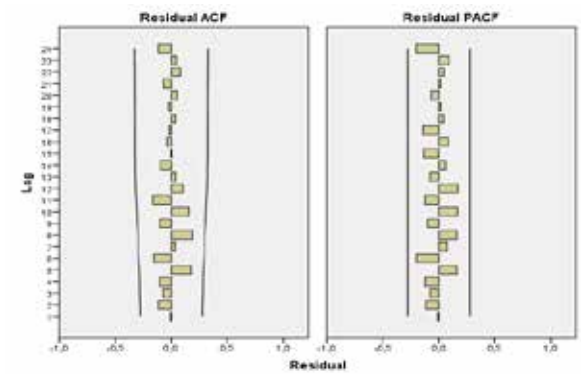

Figure 11. ACF and PACF graphs of residuals of lentil production

Table 8. Holt Exponential Smoothing Model Parameters of lentil production

	Estimate	SE	t	Sig.
Alpha (Level)	0.700	0.135	5.181	0.001
Gamma (Trend)	1.527E-06	0.057	2.657E-05	0.999

The joint graph of forecasting series and original series is shown in Figure 12. Forecasting series was in settlement with the original series. Forecasting results from the period 2016 to 2020 are given in Table 9. A serious increase in lentils production is forecasted.

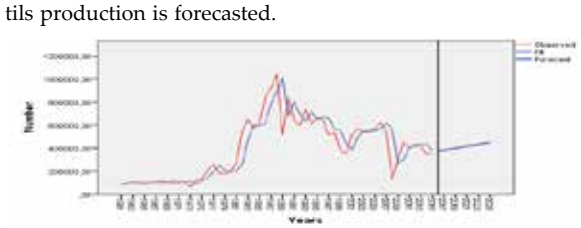

Figure 21. Charts of lentil production series and forecasting series

Table 9. Forecasting results from the period 2016 to 2020 for lentils production

Years	2016	2017	2018	2019	2020
Forecast	374364	382816	391269	399721	408174

In the present study, forecasting results from the period 2016-2020 also displayed an increasing trend in chickpea, beandry and lentils production. It was understood well that more boundless projection works for the researched grains should be performed.

Conclusion

In this study, chickpea, beandry and lentil production amounts in Turkey for the period 2016- 2020 were forecasted with high accuracy by using Holt exponential smoothing method with two parameters, which yielded the best one among exponential smoothing methods on the basis of Stationary R^2, R^2, RMSE and BIC criteria. In estimate between 2016-2020, chickpea productions are from 470899 to 514494 tons, beandry production are from 236778 to 243950 tons, and lentil production are from 374364= to 408174 to. An increase in the forecasting results of beans production was significant a development for economic gains. In conclusion, Holt method yielded better results than Damped method, in the analysis of time series data of some bean production.

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