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FORECASTING PRODUCTION OF SOME OIL SEED CROPS IN TURKEY USING EXPONENTIAL SMOOTHING METHODS

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ABSTRACT

The aim of the investigation was to forecast annual production of some oil seed crops (sesame, sunflower and soybean) in Turkey for the years 2016 through 2025 using annual production data for the period 1950-2015 and to give solid recommendation on production for producers, consumers and input providers. For this aim, three exponential smoothing methods, Holt, Brown and Damped Trend were executed to economically model the time series data. Goodness of fit criteria such as stationary R^2, R^2 and BIC criteria were adopted in the comparison of these exponential smoothing methods. Soybean, sunflower and sesame production amounts for the period 2016 -2025 were forecasted with high accuracy by using Holt exponential smoothing method with two parameters, which yielded the best result among exponential smoothing methods. Forecasted production amounts of soybean, sunflower and sesame from the period 2016- 2025 ranged from 162.878 to 179.784, 1.692.269 to 1.879.521 and 18.212 to 15.318 tons, respectively. We hope that the results from the time series data will provide baseline information for sustaining production and for guiding agricultural policy and exports of Turkey in terms of the above-mentioned plants in forthcoming years.

Key Words: Production Forecasting, Exponential Smoothing, Time Series Data, Oil Plants.

INTRODUCTION

With the accelerating population growth rates, feeding a growing human population becomes an important global issue. Currently, one of the biggest challenges of policymakers is providing food security. It has been projected that the world demand for food from every available nutritional source will be increased in 2050, with the demand for oilseeds in 2050 to be increased by 74% in comparison to that in 2015 (Table 1). Therefore, it is important to have well-estimated projections for production of oil seeds in order to formulate sound macro-level policies for food security. Future strategies based on time series modeling techniques should be developed to meet the demand for oil seed crops, which are rich sources of energy and protein for human nourishment and important feedstuff for livestock and aquaculture, as well as being a source for biodiesel (Masuda and Goldsmith, 2009).

Forecast assessments of agricultural production are important for efficient planning and direction of agricultural policy throughout the world. From this point of view, time series modeling provides an indispensible tool for forecasting.

Table 1. Population and Types of Food Demand, projection for 2050

	2015	2050	Change (%)	Annual Increase (%)
Population (Billions)	7.5	9.5	27	0.68
Protein Demand from Animal Sources (Million tons)	550	805	46	1.1
Demand for Cereals (Billion tons)	2	2,83	41.5	1.1
Demand for Oil Seeds (Million tons)	530	924	74	1.6

Source: Compiled by Senkoylu, 2016 using FAO and IGC data.

Several studies have been conducted to forecast the amounts or prices in agricultural production (Oliveira *et al.,* 2012; Kumar and Kumar, 2012; Amin *et al.,* 2014; Sing and Mishra, 2015; Aydogan *et al.,* 2015). However, a limited number of studies focused on forecasting production of sunflower, soybean and sesame oil crops. With compound growth rate and least squares method, Shah *et al.* (2005) analyzed time series data of area and production of sunflower in Pakistan. Sibel *et al.* (2006) evaluated the monthly data from the period January 1994 - December 2005 with the aim of forecasting monthly sunflower oil prices in Turkey for 2006-2007 using ARIMA model. Semerci and Ozer (2011) developed a useful model for sunflower production using data from the period 1988-2009 to forecast the post-2010 production. In another study, Suresh *et al.* (2012) specified high-order autoregressive (AR) models to forecast livestock feed sources such as groundnut, soybean, and sunflower for the following 20 years. Borkar (2016) used ARIMA (0,1,1) as the ideal forecasting model on groundnut production data from the period of 1950-1951 to 2013-2014 in India.

An empirical review on production, yield and marketability of soybean was reported for Ethiopia by Bekabil (2015). Using an exponential smoothing method with a damped trend, Masuda and Goldsmith (2009) carried out long-term projections for global production of soybean, which is one of the most valuable crops in the world in terms of nutrition. However, the best of our knowledge, there is still a lack of information on exponential smoothing time series modeling for forecasting production amounts of sesame, sunflower and soybean in the World and in Turkey. Thus, the current work was undertaken to forecast annual production amounts of sesame, sunflower and soybean in Turkey for the period 2016-2025 using annual production data of these oil plants from 1950 to 2015 by means of Holt, Brown and Damped Trend exponential smoothing methods. Forecasting results obtained by exponential smoothing methods would be useful in establishing domestic requirements and agricultural policies for oil plants investigated in this study. Information on exponential smoothing methods is presented in materials and methods section.

MATERIALS AND METHODS

Agricultural data of soybean, sunflower and sesame production for the period 1950- 2015 evaluated in the study were taken from “Statistical Indicators” book published by TUIK (2014). Similarly, data from the subsection “cereals and other herbal products/oil seeds” of Agricultural Statistics in TUIK database were also utilized (TUIK, 2015). Time series data of these crops were exposed to Holt, Brown and Damped Trend exponential smoothing methods, respectively.

Exponential smoothing methods involve updating the estimates by taking account of the last change and spikes in the time series data. These spikes can occur by random changes, unexplained effects, or unpredictable developments ignored (Kadilar, 2009). These methods are combined methods giving different weights to the time series data at the previous period (Orhunbilge, 1999; Sharpe *et al.,* 2010). Exponential smoothing models produce successful results in the short term (Yaffe and McGee, 2000). Holt method, one of the exponential smoothing methods, is used in the estimation of the series with trends (Makridakis et *al.,* 1998; Hanke and Wichern, 2008). In the Holt model, two coefficients, such as α and β, used as smoothing coefficients for estimating the trend are employed. The Holt model is formulated as follows:

$$L_t = \alpha Y_t + (1-\alpha)(L_{t-1} + T_{t-1})$$
$$T_t = \beta(L_t - L_{t-1}) + (1-\beta)T_{t-1}$$
$$\bar{y}_{t+p} = L_t + pT_t$$

Where,

L_t: New smoothed value,

α: Smoothing coefficient, ($0<\alpha<1$)

Y_t: Actual value at period t

β: Smoothing coefficient for trend estimation, ($0<\beta<1$)

T_t: Trend predicted value

p:Number of forecasting periods

$\bar{y}_{t+p}$: Forecasting value after p period

Brown’s linear exponential smoothing method with one parameter is another exponential smoothing method. The Brown model is more suitable for increasing or decreasing trends in time series data. Start equation at the model is written as follows (Armutlu, 2008):

$$y_t^1 = \alpha y_{t-1} + (1-\alpha)y_{t-1}^1$$
$$y_t^2 = \alpha y_t^1 + (1-\alpha)y_{t-1}^2$$

where $y_t{}^1$ is the value obtained by single exponential smoothing and $y_t{}^2$ is the binary exponential flatted value. a_t and b_t statistics are calculated from here as: $a_t = y_t^1 + (y_t^1 - y_t^2) = 2y_t^1 - y_t^2$

$$b_t = \frac{\alpha}{1-\alpha} + (y_t^1 - y_t^2)$$

The model for estimation after m periods is expressed as $\hat{y}_{t+m} = a_t + b_t m$ (Orhunbilge, 1999). The damped trend exponential smoothing models are taken into account to perform an excellent forecasting. The forecast error variance is calculated based on ARIMA model (Sbrana, 2012). The damped method is expressed in the following equations (Gardner and McKenzie, 1985).

$$S_t = \alpha Y_t + (1-\alpha)(S_{t-1} + \varphi T_{t-1})$$
$$T_t = \gamma(S_t - S_{t-1}) + (1-\gamma)\varphi T_{t-1}$$
$$Y_t(m) = S_t + \sum_{i=1}^{m} \varphi^i T_t$$

Grander and McKenzie (1985) clarify that if $0<\varphi<1$, then the trend is damped and the forecasts approach an asymptote given by the horizontal straight line $S_t + T_t\varphi/(1-\varphi)$. If $\varphi = 1$, the method is identical to the standard Holt method.

The predictive accuracy of the methods applied in the study was measured by Stationary R^2, coefficient of determination R^2, and BIC, respectively. It is strongly recommended to employ model fit statistics on BIC (Pektas, 2013), with a penalty 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.

$BIC = ln(\hat{\sigma}_e^2) + k\,ln(n)/n$ Where, $\hat{\sigma}_e^2$ is the error variance.

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

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

Where, ΔY is the simple mean model for the differenced transformed series, which is equivalent to the univariate baseline model ARIMA (0,d,0)(0,D,0).

RESULTS AND DISCUSSION

Soybean Production: Figure 1 presents the time series of soybean production for the period 1950- 2015, and it can be seen from the graph that a stochastic trend was obtained by the series. In order to infer the trend more precisely, autocorrelation (ACF) and partial autocorrelation functions (PACF) of the time series were examined.

ACF and PACF graphs of soybean production are illustrated in Figures 2 and 3, respectively. Due to the fact that a vast number of terms of the series in ACF graph exceeded confidence limits, a trend is existent in the series. In order to obtain stationary state of the series, first differences of the series are considered. ACF and PACF graphs of the first-difference series created for providing the stationary state are shown in Figures 4 and 5, respectively, and the graphs produced evidence of the stationary state.

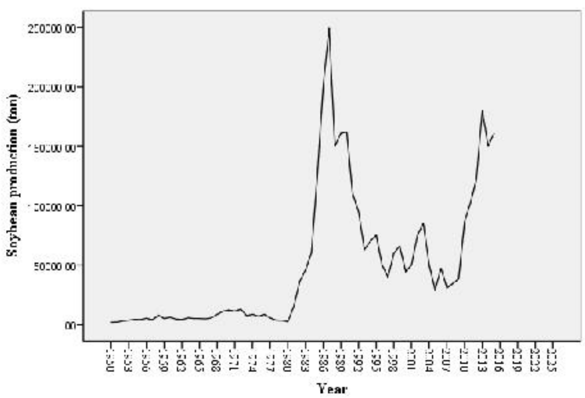

Figure 1. Soybean production, 1950-2015 (tons)

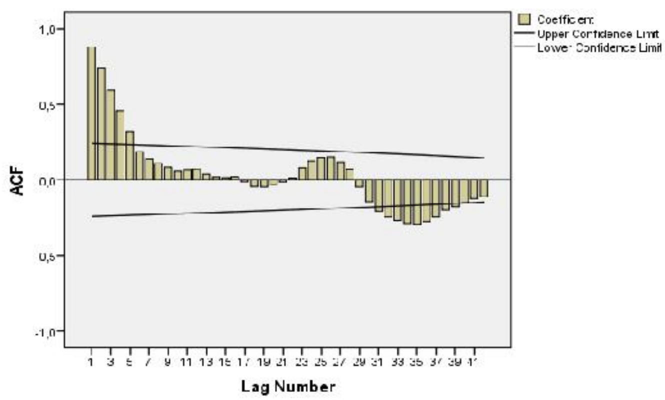

Figure 2. ACF graph of soybean production series

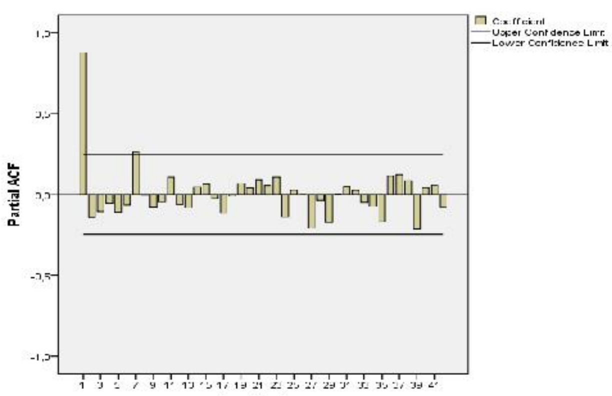

Figure 3. PACF graph of soybean production

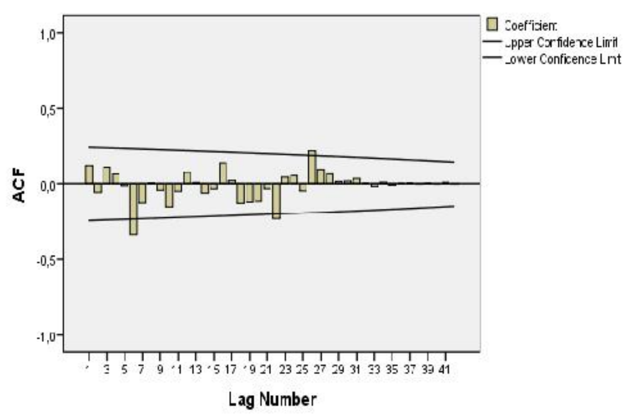

Figure 4. ACF graph of first differences of soybean production

After this, results of model fit statistics Stationary R^2, R^2, MAPE and Normalized BIC criteria evaluated by using Holt, Brown and Damped Trend smoothing methods are summarized in Table 2.

Table2. Model fit statistics.

Fit Statistics	Holt	Brown	Damped Trend
Stationary R-squared	0.428	0.314	0.007
R-squared	0.825	0.790	0.827
BIC	20.359	20.462	20.431

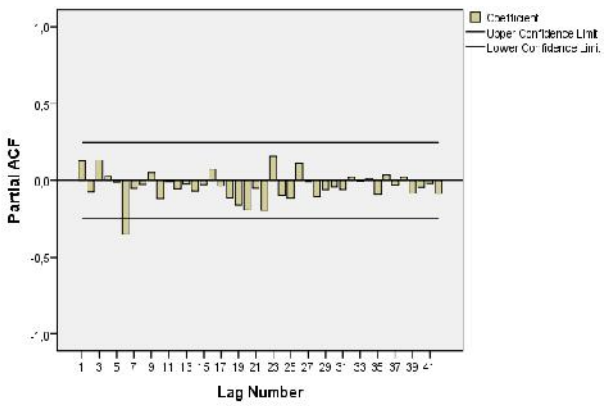

Figure 5. PACF graph of first differences of soybean production.

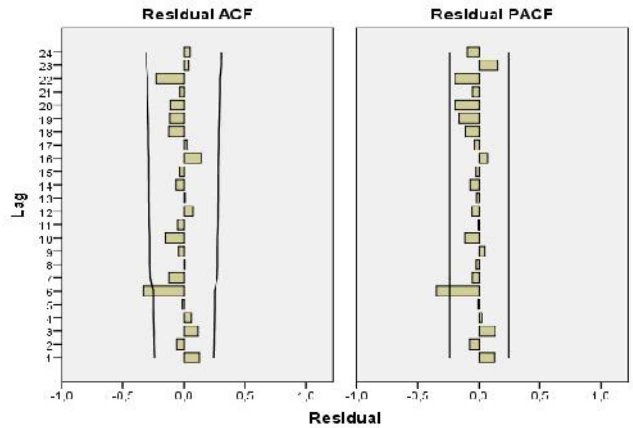

Figure 6. ACF and PACF graphs of residuals of soybean production

In the statistical comparison of the models, it is meaningful to use statistics like BIC (Pektas, 2013). From Table 3, it is well-understood that Holt smoothing method that yielded the lowest BIC value was the best method. Coefficients of Holt smoothing method were estimated as $\alpha = 1$ and $\gamma = 0.001$, respectively. ACF and PACF graphs of the residuals are presented in Figure 6.

Table3. Exponential Smoothing Model Parameters (Holt).

Parameters	Estimate	SE	T	Sig.
Alpha (Level)	1.000	0.129	7.723	0.000
Gamma (Trend)	0.001	0.062	0.003	0.998

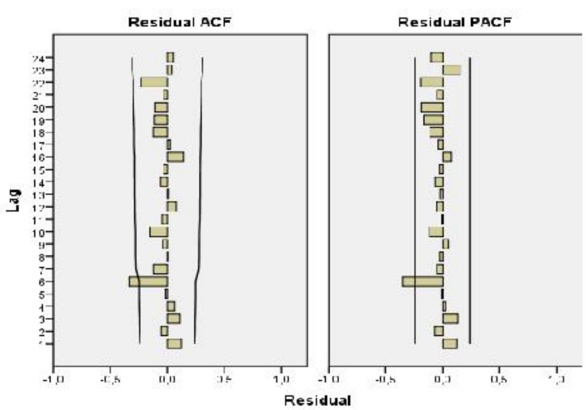

Figure 7. ACF and PACF graphs of residuals of soybean Production

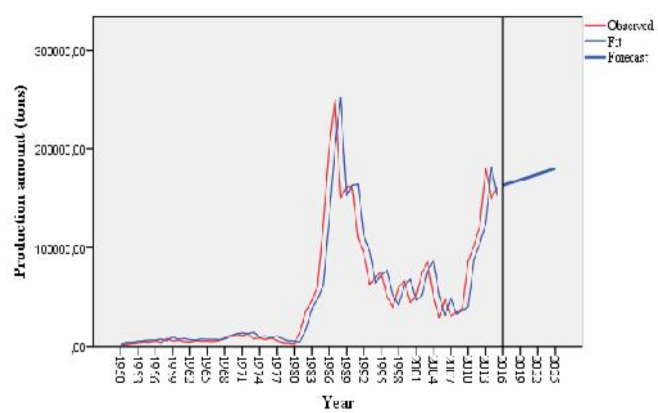

Figure 8. Graph of soybean production series and forecasting

From Figure 7, it can be seen that sixth lag in the ACF and PACF graphs slightly exceeded confidence limit. Thus, results of Box-Ljung test used to find out whether the residuals have white noise are presented in Table 4. In the examination of the test results for the first

20 lags, the residuals comprised white noise since significance levels for all lags were greater than 0.05.

At the next stage, the forecasting series were graphed together with observation values of the original series. Obtained graph is depicted in Figure 8, showing that the original series was compatible with the forecasting series.

After the results obtained above, soybean production can be forecasted. Forecasting results are given in Table 5. An increase in soybean production in the period 2016-2025 is expected, as seen from Table 5.

Table 4. Box-Ljung statistics for the residuals of soybean production data.

Lag	Autocorrelation	Std. Error[a]	Box-Ljung Statistic		
			Value	Df	Sig.[b]
1	.124	.120	1.059	1	.303
2	-.056	.119	1.276	2	.528
3	.113	.118	2.182	3	.536
4	.064	.118	2.479	4	.648
5	-.014	.117	2.494	5	.777
6	-.333	.116	10.809	6	.094
7	-.123	.115	11.962	7	.102
8	.005	.114	11.964	8	.153
9	-.041	.113	12.099	9	.208
10	-.149	.112	13.888	10	.178
11	-.049	.111	14.084	11	.228
12	.076	.110	14.567	12	.266
13	.008	.109	14.572	13	.335
14	-.060	.108	14.888	14	.386
15	-.033	.107	14.982	15	.453
16	.141	.106	16.762	16	.401
17	.021	.104	16.803	17	.468
18	-.125	.103	18.261	18	.439
19	-.118	.102	19.581	19	.420
20	-.113	.101	20.826	20	.407

a. The under lying process assumed is independence (white noise).
b. Based on the asymptotic chi-square approximation.

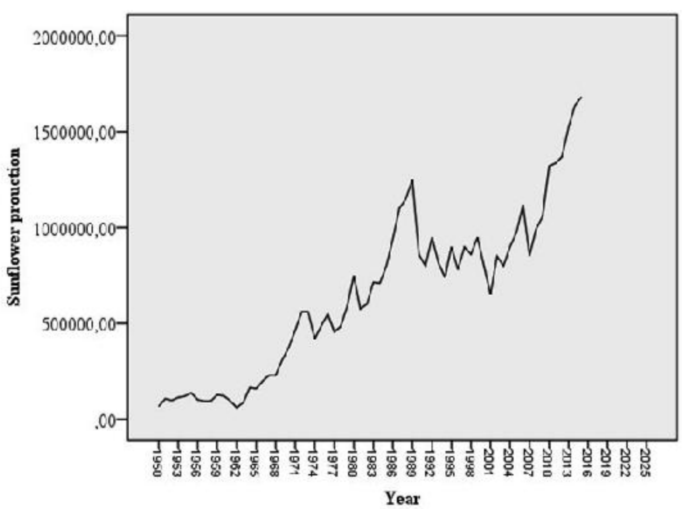

Figure 9. Sunflower production 1950 to 2015 (tons)

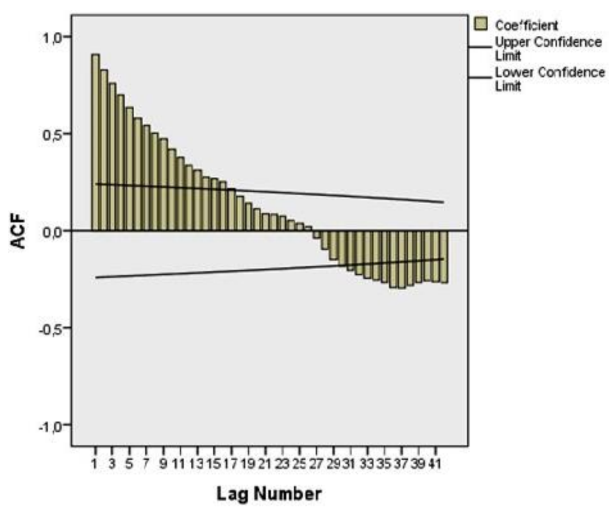

Figure 10. ACF graph of sunflower production

Table 5. Forecasting results for the period 2016 -2025.

Year	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Forecast	162878	164756	166635	168513	170392	172270	174149	176027	177905	179784

Sunflower production: Figure 9 shows the graph of the time series data of sunflower production from the period 1950- 2015. A trend is existent in the time series. ACF and PACF graphs drawn for observing the trend are depicted in Figures 10 and 11, respectively.

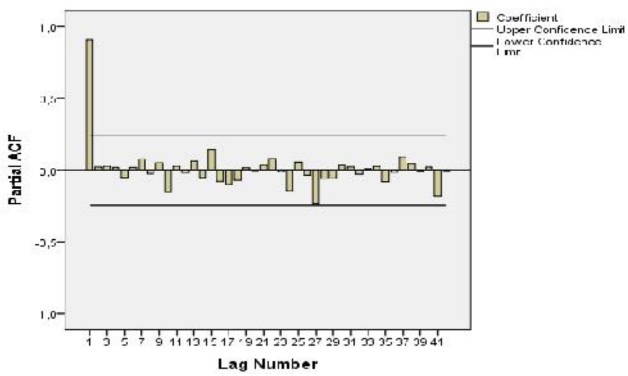

Figure 11. PACF graph of sunflower production

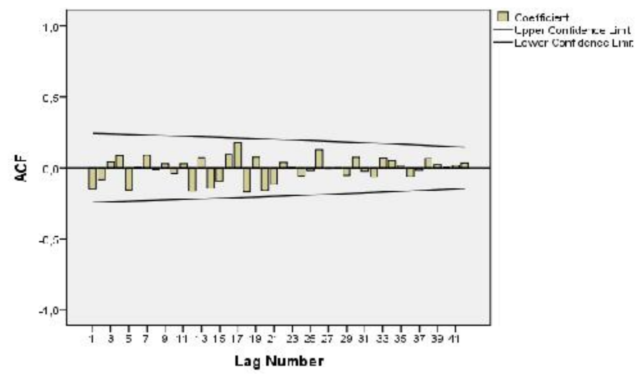

Figure 12. ACF graph of first differences of sunflower production

When ACF and PACF graphs are examined, many terms of the series in ACF graph surpassed confidence limits, and thus the series formed a trend. To transform the stationary state of the series, first degree differences of the series were taken and ACF and PACF graphs of the first degree series are shown in Figures12 and 13, respectively.

Looking at Figures12 and 13, terms of ACF and PACF graphs for the first-difference time series were within confidence limits and thus they produced stationary time series. In the light of this information, the best among Holt, Brown and Damped Trend smoothing methods was selected by using Stationary R^2, R^2, MAPE and Normalized BIC.

As it can be seen from Table 6, the most appropriate method was Holt smoothing method which yielded the lowest normalized BIC value and the greatest values of stationary R^2 and R^2, respectively. Coefficients of Holt smoothing method are presented in Table 7 and were estimated as $\alpha = 0.800$ and $\gamma = 0.0000214$, respectively . ACF and PACF graphs of the residuals for sunflower production are shown in Figure 14.

Table 6. Model fit statistics of the first difference time series of sunflower production.

Statistics	Holt	Brown	Damped Trend
Stationary R-squared	0.575	0.527	0.024
R-squared	0.937	0.930	0.937
BIC	23.326	23.357	23.405

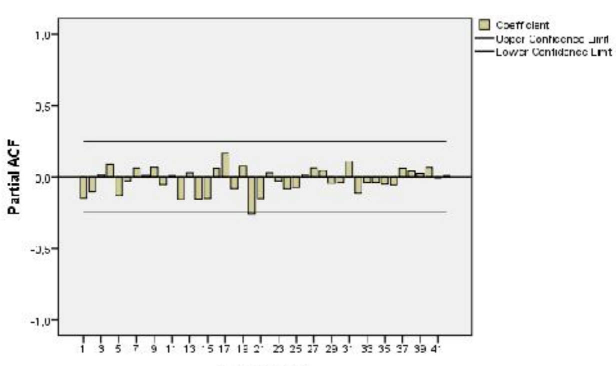

Figure 13. PACF graph of first differences of sunflower production

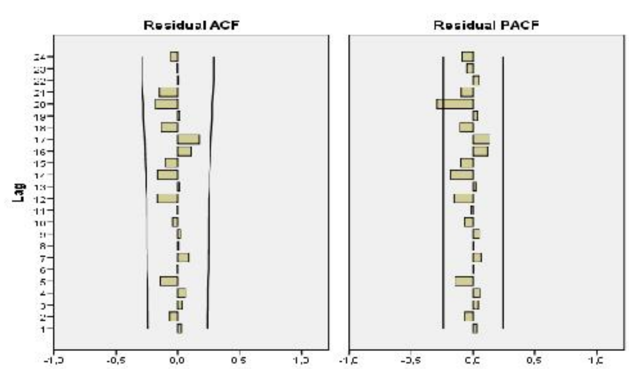

Figure 14. ACF and PACF graphs of residuals of sunflower production

Table7. Exponential Smoothing Model Parameters (Holt) for sunflower production data.

	Estimate	SE	t	Sig.
Alpha (Level)	0.800	0.127	6.326	0.000
Gamma (Trend)	0.0000214	0.057	0.001	0.999

The degree of relationship between residuals in ACF and PACF graphs were found within confidence limits (Figure 14). In PACF graph, 20th lag value slightly surpassed the confidence limit. Results of Box-Ljung test, which is used to understand this better, are presented in Table 8. Since significance levels were found greater than 0.05, the residuals gave series with white noise. The joint graph of the original series and forecasting series is shown in Figure 15. The original series corresponded to forecasting series (Figure 15).

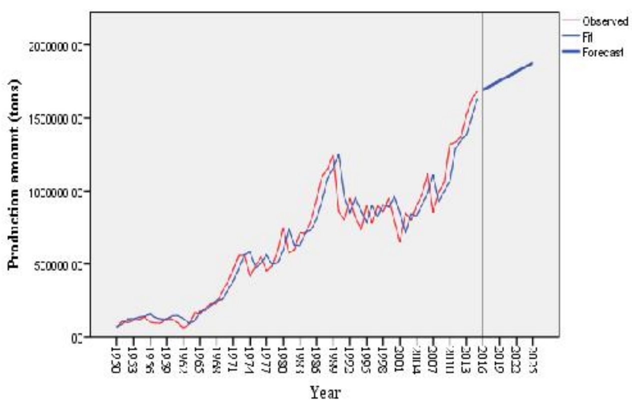

Figure 15. Graph of original and forecasted series in sunflower production

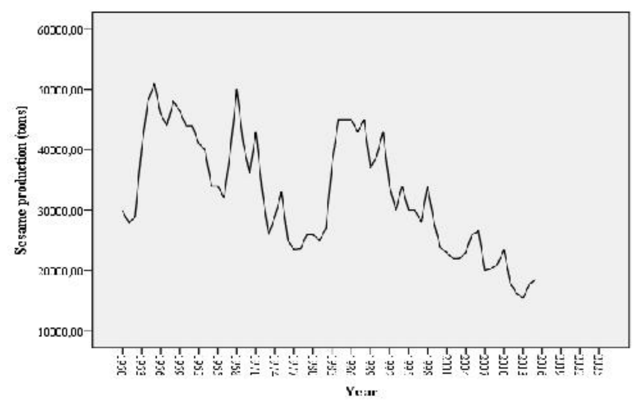

Figure 16. Graph of sesame production (1950-2015)

Table 8. Box-Ljung statistics for residuals (Sunflower).

Series:	Noise residual from sunflower-Model1				
			Box-LjungStatistic		
Lag	Autocorrelation	Std. Error^{a}	Value	df	Sig.^{b}
1	.032	.120	.071	1	.790
2	-.068	.119	.398	2	.820
3	.036	.118	.492	3	.921
4	.064	.118	.791	4	.940
5	-.143	.117	2.305	5	.805
6	-.010	.116	2.313	6	.889
7	.088	.115	2.898	7	.894
8	.007	.114	2.901	8	.940
9	.025	.113	2.951	9	.966
10	-.040	.112	3.081	10	.979
11	-.010	.111	3.090	11	.989
12	-.162	.110	5.277	12	.948
13	.011	.109	5.288	13	.968
14	-.161	.108	7.523	14	.913
15	-.100	.107	8.406	15	.906
16	.112	.106	9.526	16	.890
17	.172	.104	12.228	17	.786
18	-.132	.103	13.852	18	.739
19	.014	.102	13.872	19	.791
20	-.182	.101	17.098	20	.647

a. The underlying process assumed is independence (white noise).
b. Based on the asymptotic chi-square approximation.

Consequently, forecasting results of sunflower production data from the period 2016-2025 are given in Table 9. Forecasting results which point to an increase in sunflower production was illustrated (Table 9), which means a favorable development for the Turkish economy as well.

Sesame production: Graph of sesame production data from the period 1950-2015 is given in Figure 16. A stochastic trend was obtained. ACF and PACF graphs which are more informative on the trend are shown in Figures 17 and 18, respectively.

When ACF graph in Figure 17 was observed, it can be seen that there was a trend. In order to generate the stationary series for sesame production data, the first differences of the data must be obtained. Figures 19 and 20 show ACF and PACF graphs of the first difference (stationary) series for the sesame production data, respectively.

Table9. Forecasting results from the period 2016 - 2025 (Sunflower production).

Year	2016	2017	2018	2019	2020
Forecast	1692269	1713075	1733881	1754687	1775492
Year	2021	2022	2023	2024	2025
Forecast	1796298	1817104	1837910	1858716	1879521

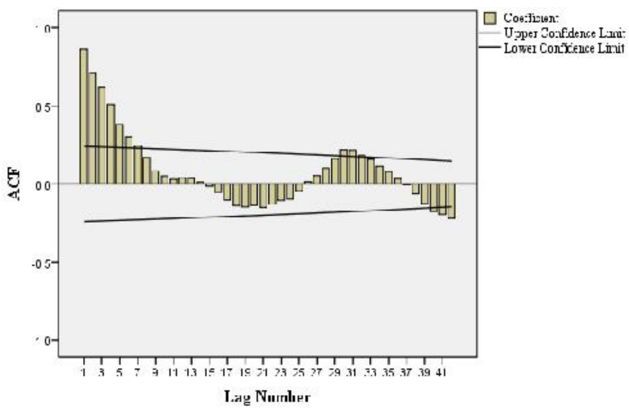

Figure 17. ACF graph of sesame production

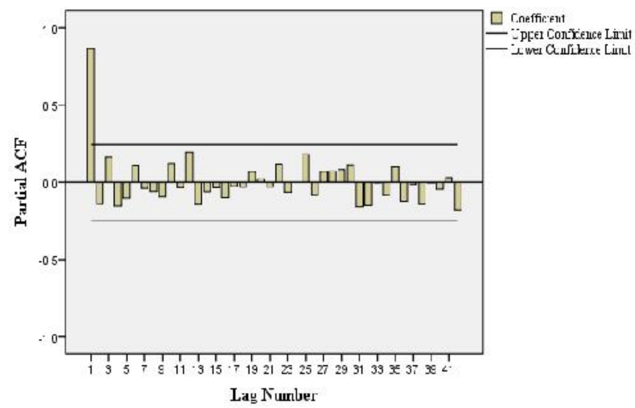

Figure 18. PACF graph of sesame production

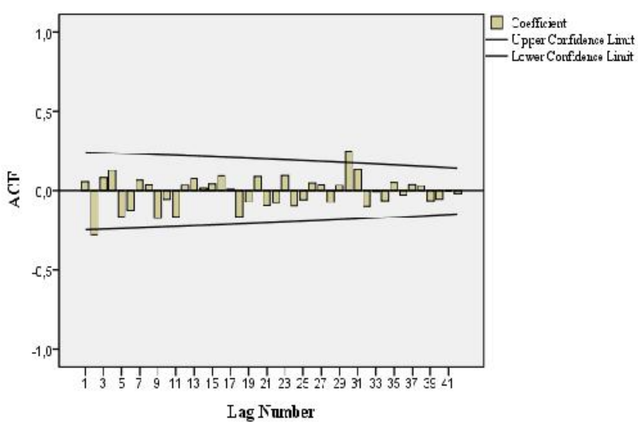

Figure 19. ACF graph of first differences of sesame production

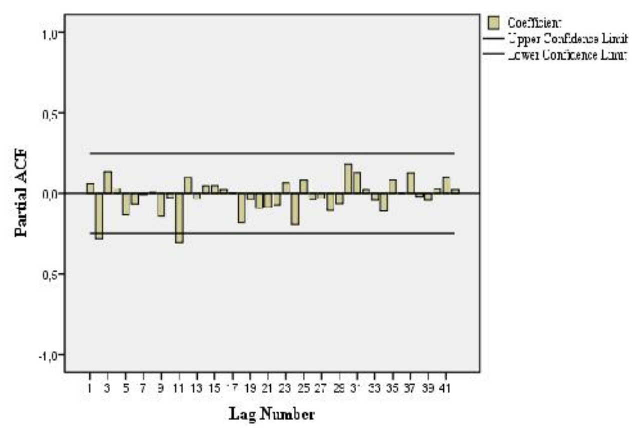

Figure 20. PACF graph of first differences of sesame production

Results of model fit statistics for the exponential smoothing methods are presented in Table 10, and demonstrated that Holt exponential smoothing method yielded a better fit due to its lower normalized BIC and greater stationary R^2 when compared with other methods. Parameter coefficients of the Holt smoothing model are presented in Table 11, and became equal to $\alpha = 1$ and $\gamma = 0.001$, respectively. ACF and PACF graphs of the residuals are given in Figure 21.

With Figure 21, it is clear that relationship of the 2^{nd} lag in ACF and PACF graphs slightly passed the confidence limit. Box-Ljung test results are shown in Table 12. Box-Ljung test results for the first 20 lags in Table 12 produced evidence of being white noise series since all the lags were greater than 0.05.

Table10. Model fit statistics for the sesame production data.

Fit Statistics	Holt	Brown	Damped Trend
Stationary R-squared	0.468	0.340	0.002
R-squared	0.760	0.697	0.761
BIC	17.069	17.224	17.144

Table11. Exponential Smoothing Model Parameters of sesame production (Holt model).

Parameters	Estimate	SE	t	Sig.
Alpha (Level)	1.000	0.126	7.959	0.001
Gamma (Trend)	0.001	0.024	0.031	0.976

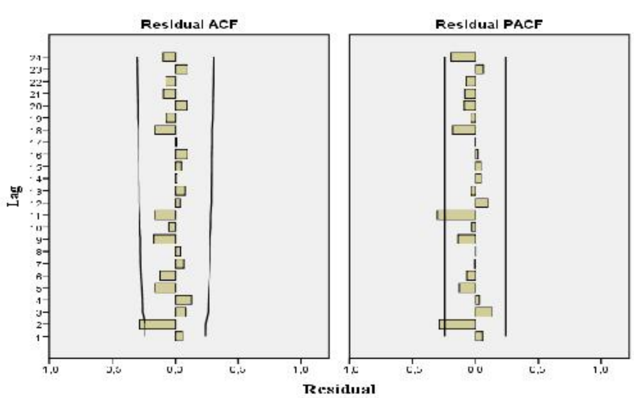

Figure 21. ACF and PACF graphs of the residuals (sesame)

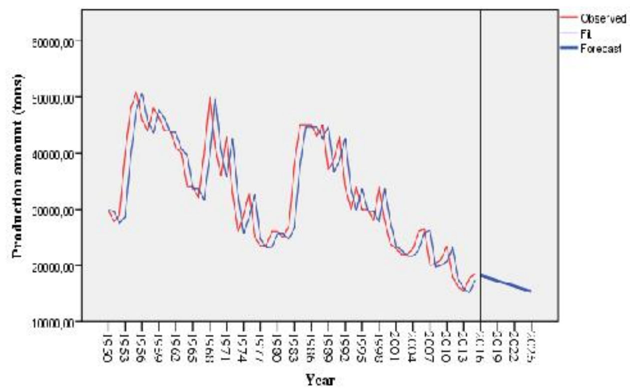

Figure 22. Graph of forecasted series in sesame production

Table12. Box-Ljung test results of the residuals (Sesame).

Series:	Noise residual from sesame-Model_1				
			Box-Ljung Statistic		
Lag	Autocorrelation	Std. Error[a]	Value	df	Sig.[b]
1	.060	.120	.245	1	.620
2	-.281	.119	5.770	2	.056
3	.083	.118	6.255	3	.100
4	.128	.118	7.439	4	.114
5	-.162	.117	9.378	5	.095
6	-.124	.116	10.527	6	.104
7	.069	.115	10.895	7	.143
8	.040	.114	11.019	8	.201
9	-.172	.113	13.361	9	.147
10	-.052	.112	13.575	10	.193
11	-.162	.111	15.728	11	.152
12	.038	.110	15.847	12	.198
13	.078	.109	16.368	13	.230
14	.015	.108	16.387	14	.290
15	.046	.107	16.573	15	.345
16	.095	.106	17.376	16	.362
17	.007	.104	17.381	17	.429
18	-.163	.103	19.878	18	.340
19	-.070	.102	20.346	19	.374
20	.091	.101	21.148	20	.388

a. The underlying process assumed is independence (white noise).
b. Based on the asymptotic chi-square approximation.

The joint graph of forecasting series and original series is shown in Figure 22. Forecasting series was in agreement with the original series. Forecasting results from the period 2016- 2025 are summarized in Table 13. A serious decrease in sesame production is forecasted, as shown in Table 13.

Table13. Forecasting results from the period 2016 - 2025 (Sesame production).

Year	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Forecast	18212	17894	17575	17257	16939	16621	16302	15984	15666	15348

There are not many studies on forecasting soybean, sunflower and sesame production in the recorded literature. With the objective of forecasting annual sunflower production amounts from the period 2010 to 2013, Semerci and Ozer (2011) evaluated the annual sunflower production data from the period 1988-2009, and addressed that the production data were found to be stationary in respect to Dickey-Fuller test results and an increasing trend was obtained for projection between the years 2010 and 2013. In the current study, forecasting results from the period 2016-2025 also showed an increasing trend in sunflower production which is highly dependent on diesel fuel and seeds as inputs. In the light of this information, it is important that farmers must be subsidized in purchases of diesel fuel and seeds for increasing the production.

Forecasting long-term soybean production at national and international levels, Masuda and Goldsmith (2009) projected an increase from 311.1 million metric tons in 2020 to371.3 million metric tons in 2030 through an exponential smoothing method with a damped trend. Similarly, soybean production increased from 2016 to 2025 according to Holt exponential smoothing method. We understood well that more extensive forecasting studies for the investigated oil plants must be performed.

Conclusion: In this study, soybean, sunflower and sesame production in Turkey for the period 2016- 2025 were forecasted with high accuracy by using Holt exponential smoothing method with two parameters, which yielded the best result among exponential smoothing methods on the basis of Stationary R^2, R^2 and BIC. In the forecasted period, soybean production changed from 162.878 tons in 2016 to 179.784 tons in 2025, whereas sunflower production changed from 1.692.269 tons in 2016 to 1.879.521 tons in 2025. The forecasts for these two oil plants mean that their production will increase in the upcoming years, which will play a fundamental role for Turkish economy. Increasing production of soybean and sunflower is an important advantage in terms of meeting domestic demand and increasing exports. In contrast to these oil plants, a significant decrease from 2016 (18.212 tons) to 2025 (15.318 tons) was observed in sesame production. In order to overcome the worrisome case in sesame production, cautionary agricultural policies should be formulated. The decrease in domestic production and consequent increase in sesame prices would be problematic for sesame suppliers in near future, thus giving way to increasing sesame imports and loss of foreign currency. Therefore, necessary measures must be taken to increase domestic sesame production in the future.

In conclusion, the obtained forecasting results are thought to provide an applicable reference for both farmers and policymakers in the future.

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