YYÜ TAR BİL DERG
(YYU J AGR SCI)
2017, 27(2): 252-258

Geliş Tarihi (Received): 18.04.2017
Kabul Tarihi (Accepted): 19.06.2017

Araştırma Makalesi/*Research Article (Original Paper)*

Zaman Serisi Analiz Yöntemlerini Kullanarak 2016-2025 Dönemi Türkiye Avokado Üretiminin Belirlenmesi

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Özet: Bu çalışmanın başlıca amacı, 1988-2015 yılları avokado üretim FAOSTAT verilerini kullanarak 2016-2025 dönemi için Türkiye'deki avokado üretimini modellemektir. 1988-2015 dönemi avokado üretimine ait zaman serisi verilerinin durağan olmadığı belirlenmiştir. Durağanlık, zaman serilerinin ilk derece farkının alınmasıyla sağlanmıştır. Avokado üretimini tahminlemede üç üstel düzleştirme (Holt, Brown ve Damped) yöntemi kıyaslanmıştır. Brown üstsel düzleştirme modeli, avokado üretimini tahminlemede en uygun yöntem olarak tanımlanmıştır. Türkiye'deki avokado üretiminin 2016-2025 dönemi için 2004 tondan 3156 tona yükseleceği tespit edilmiştir. Bu araştırmadan elde edilen sonuçların, Türkiye'de gıda güvenliği için makro seviyede politikaların geliştirilmesine ve avokado üretiminin gelecekte daha iyi bir şekilde planlanmasına yardımcı olacağı düşünülmektedir.

Anahtar kelimeler: Avokado, Brown yöntemi, Üstsel düzleştirme, Üretim tahminleme, Zaman serileri

Predicting Avocado Production in Turkey for 2016-2025 Period Using Time Series Analysis

Abstract: The main aim of this study was to model avocado production in Turkey for 2016-2025 period using 1988-2015 years FAOSTAT data. Avocado production time series data for the 1988-2015 period was found non-stationary. Stationarity was obtained after taking the first difference of the time series. Three Exponential Smoothing (Holt, Brown and Damped) methods were compared to model avocado production. Brown exponential smoothing model was the most appropriate forecasting model for avocado production. We forecasted that the avocado production in Turkey will show increase from 2004 tons to 3156 tons for the 2016-2025 period. The results of this study could help policy makers to develop macro-level policies for food safety and more powerful strategies for better planning avocado production in Turkey for the future.

Keywords: Avocado, Brown method, Exponential Smoothing, Production forecasting, Time Series

Introduction

Avocado (*Persea americana*) is a very nutritious fruit. Therefore, it shows increasing popularity worldwide. Avocado is very rich in fatty acids, dietary fiber, protein, vitamins, antioxidants and minerals. The fruit contains essential nutrients and phytochemicals with potential health benefits. However, the peel and seed are also very good source of phenolics showing high antioxidant capacity important for health (Zhang et al. 2013; Calderon et al. 2016). Therefore, it is essential to establish good policies for food security and sustainability for healthy diet of the next generations. Turkey avocado production was 300 tons in 2000 year, and reached 1824 tons in 2014 (FAOSTAT 2017). Increasing avocado production would provide better nutritious diet for the people in Turkey and enhance the income of native farmers. Avocado is a valuable fruit with many health benefits and by increasing local production it will be more accessible for the consumers. It is important to establish policies for increasing avocado production for future sustainability, export incomes and food safety, as well as structuring good price for the country. Therefore, projection studies are very useful tool for predicting future prospects of avocado productions by using past trends, as well as to determine appropriate macro-level policies.

There is still lack of information on forecasting production amounts of important horticultural crops (Masuda and Goldsmith 2009; Semerci and Ozer 2011; Suresh et al., 2012; Celik et al. 2013; Hamjah 2014;Borkar 2016; Celik et al. 2017; Karadas et al. 2017a, b). To our knowledge, there is no study on forecasting avocado production in Turkey. Therefore, the objective of this study was to model avocado production in Turkey using 1988-2015 period data trend in order to predict avocado production for the next 2016-2025 period.

Materials and Methods

FAOSTAT avocado annual production for the 1988-2015 period was used to forecast production for the next 2016-2025 years. Holt, Brown and Damped Exponential Smoothing methods were compared.

Exponential smoothing methods include updating the estimates by taking account the last change and spikes within the time series. 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 methods show efficient results for short terms (Yaffe and McGee 2000). Time series showing trend use Holt exponential smoothing (Makridakis et al. 1998; Hanke and Wichern 2008). The following two coefficients (α and β) are smoothing coefficients for estimating the trend in the Holt model. Formulas of the Holt method:

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

Where:

L_t: New smoothed value,

α: Smoothing coefficient (0<α<1),

Y_t: Actual (observed) 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.

Another exponential smoothing method is Brown's linear exponential smoothing method with one parameter. The Brown model is reported to be more convenient for increasing or decreasing trends in time series data. Start equation of the model is expressed as follow (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 for single exponential smoothing and y_t^{2} is the binary exponential flatted value. Here, a_t and b_t statistics are estimated as follows

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

The model for the 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<φ<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 φ= 1, the mentioned method is the same to the standard Holt method.
To select the best model, model fit statistics were calculated:

Root Mean Square Error, $$RMSE = \sqrt{\frac{\sum_{i=1}^{n}\left(Y_i - \hat{Y}_i\right)^2}{n}}$$

Mean Absolute Percentage Error, $$\text{MAPE} = \frac{\sum_{i=1}^{n}\frac{\left|Y_i - \hat{Y}_i\right|}{Y_i}}{n}$$

Maximum Absolute Percentage Error, $$\text{MaxAPE} = \max_i\left(\left|\frac{y_i - \hat{y}_i}{y_i}\right|\right)*100, \quad i=1,2,\ldots,N$$

Mean Absolute Error (MAE), $$\text{MAE} = \frac{1}{n}\sum_{i=1}^{M}\left|y_i - \hat{y}_i\right|$$

Time series analysis was performed with IBM SPSS program (version 23).

Results and Discussion

In the current projection study, 1988-2015 period annual avocado production data was analyzed using exponential smoothing methods. A trend in avocado production time series was noticed (Figure 1). Time series graphs of autocorrelation function (ACF) and partial autocorrelation function (PACF) were generated to reveal time trend (Figure 2).

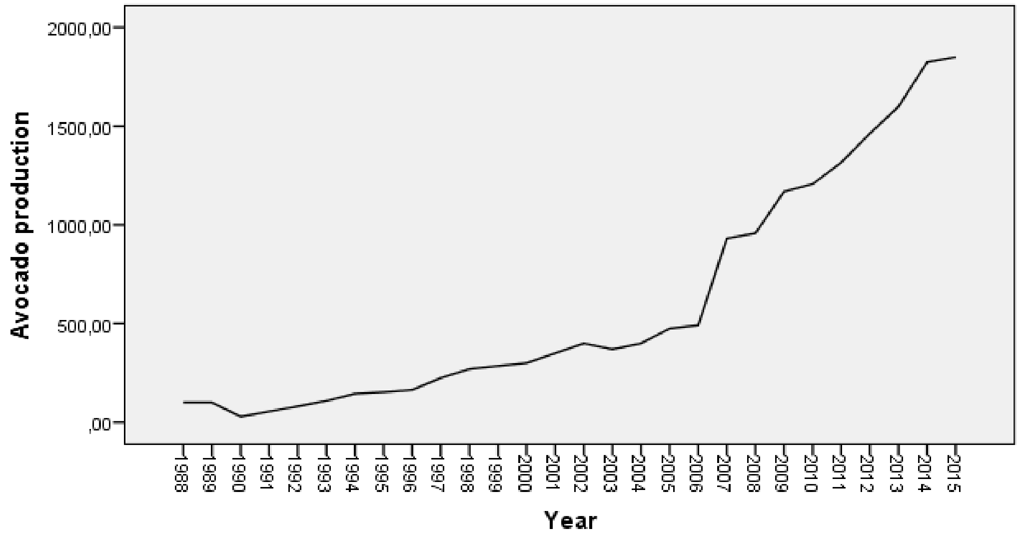

Figure 1. 1988-2015 period annual avocado production.

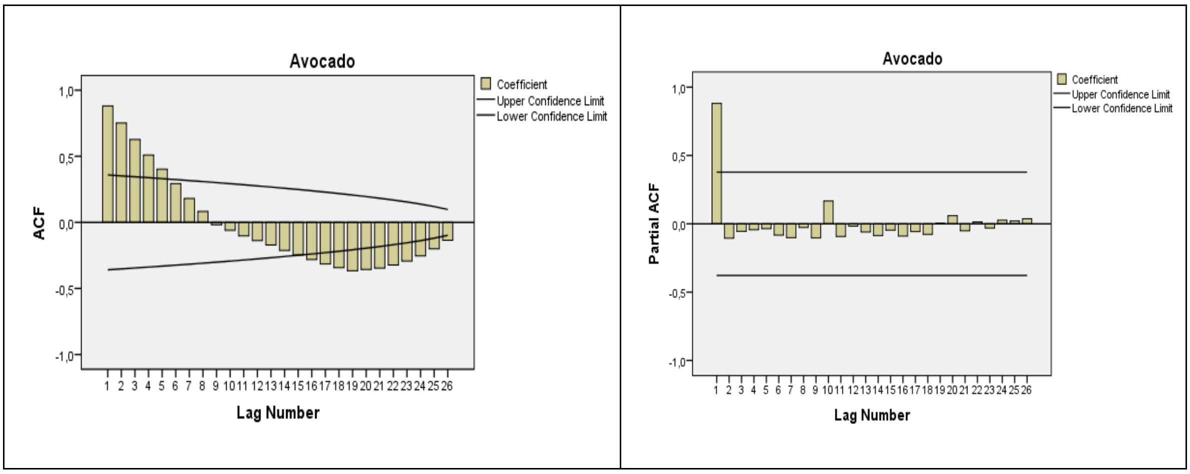

Figure 2. 1988-2015 period avocado production ACF and PACF graphs.

Many terms in ACF graph exceeded confidence limits, which is an indicator of time series trend (Figure 2). The first degree difference was taken to remove the trend from the times series.

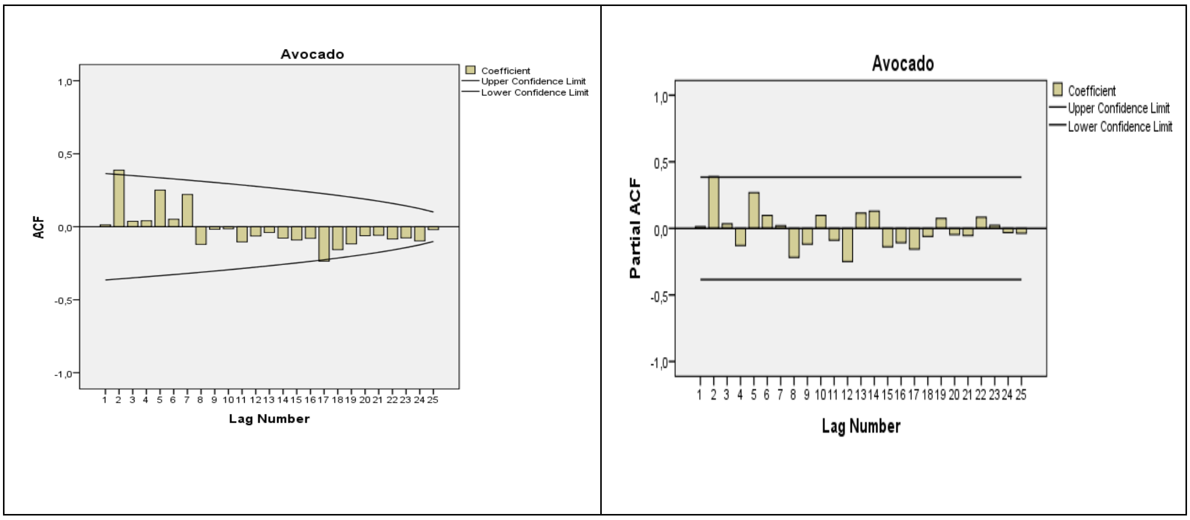

Figure 3. First difference series ACF and PACF graphs

As seen from ACF and PACF graphs, the first difference time series was stationary (Figure 3). Performances of Holt, Brown and Damped trend exponential smoothing methods were compared by using model fit statistics such as Stationary R^2, R^2, RMSE, MaxAE and BIC. Results of model fit statistics for the methods are shown in Table 1. Brown exponential smoothing method was the most appropriate one (Table 1).

Table 1. Model fit statistics results for the tested exponential smoothing methods

Fit Statistic	Holt	Brown	Damped
Stationary R-squared	0.554	0.554	0.130
R-squared	0.976	0.976	0.976
RMSE	92.716	91.031	94.567
MaxAE	406.350	406.270	406.434
Normalized BIC	9.297	9.141	9.456
Ljung-Box Q		Statistics: 12.179 Sig. 0.789	

BIC statistics was recommended for methods comparison (Pektas 2013). Brown exponential smoothing method showed the smallest BIC with Ljung-Box Q=12.179 and p>0.05. Model parameters as smoothing coefficients of the Brown model are provided in Table 2. Brown model parameter coefficient (α = 0.483) was significant (P<0.01).

Table 2. Exponential Smoothing model parameters

	Estimate	SE	t	Sig.
Alpha (Level and Trend)	0.483	0.082	5.885	0.001

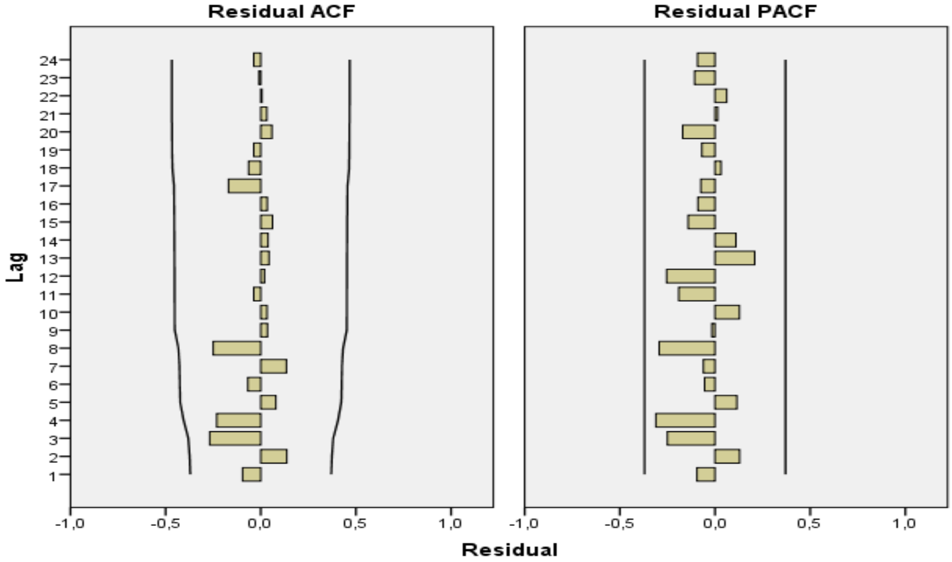

Figure 4. Residuals ACF and PACF graphs.

Residuals lags relationship degrees in the ACF and PACF graphs were found within the confidence limits. The fitted and observed time series on annual avocado production were in agreement (Figure 5).

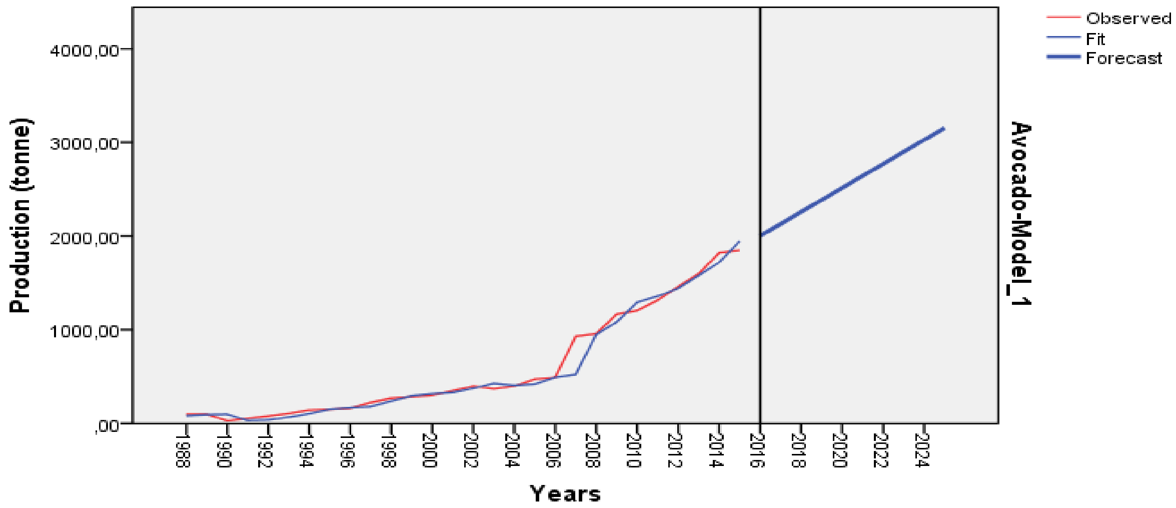

Figure 5. Graph of the fitted and observed time series in avocado production.

Avocado production forecasting results for the 2016-2025 period are provided in Table 3. Avocado production for 2016 year was predicted as 2004 tons and reached to 3156 tons in 2025 year. Avocado production in Turkey is expected to reach to 3156 tons in 2025 year (Table 3). The information is important for policy makers and food industry in developing new agricultural policies.

Table 3. Avocado production (tons) prediction results for the 2016-2025 period

Year	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Forecast (tons)	2004	2132	2260	2388	2516	2644	2772	2900	3028	3156

To our knowledge, there is no study on predicting avocado production in Turkey for the next years to provide security and sustainabiliy of this crop. The studies available on production forecasting of important horticultural crops such as avocado is very limited (Hamjah 2014). In the current study, Brown exponential smoothing model in general predicted increasing avocado production trend in Turkey. Mango, banana and guava production in Bangladesh were forecasted ten years forward using Box-Jenkins ARIMA model. Mango showed initially a downward, after a time stable production and at the end increasing production tendency. Banana was forecasted to have constant production tendency, whereas guava showed upward production tendency in Bangladesh (Hamjah 2014). Increasing maize production trend in Nigeria was predicted using ARIMA model (Badmus and Ariyo 2011). It was reported that the sugarcane production will increase in 2013, then will show downward production tendency in 2014, and afterwards will show upward production tendency in India using Box-Jenkins ARIMA model (Kumar and Anand 2014). Upward soybean production tendency in the world was reported for the 2020-2030 period using Damped exponential smoothing method (Masuda and Goldsmith 2009). Pistachios, walnuts, hazelnuts, almond and chestnuts productions in Turkey were projected for the 2012-2020 period and increasing production tendency was shown using different ARIMA models (Celik 2013). Upward production tendency was projected for groundnut using time series analyses (Celik et al. 2017), Holt exponential smoothing method projected sunflower and sesame upward production tendency in Turkey (Karadas et al. 2017a in press). Cotton lint production was predicted to increase using Holt exponential smoothing method (Karadas et al. 2017b in press).

Conclusion

The time series data of avocado production for the 1988-2015 period were non-stationary, and the original time series data was converted into stationary time series after the first differences of the original data were taken. Three Exponential Smoothing (Holt, Brown and Damped) models were compared and Brown exponential smoothing model was detected to be the most proper forecasting model for avocado production in Turkey. According to the Brown method, avocado production in Turkey will show increase from 2004 tons to 3156 tons for the 2016-2025 period. The projection results obtained from this study can help policy makers to establish better price structure and production strategies for avocado production in Turkey for the next ten years.

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