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Projecting Grape Harvest Area and Production in Turkey Using Time Series Analysis

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Abstract: The objective of this study was to forecast grape harvest area and production in Turkey for 2016-2025 period. For this aim, the FAOSTAT data on grape harvest area and production of 1961-2015 period in Turkey was used. Exponential smoothing models were compared to model grape harvest area and production. Holt model results reflected that a decrease in grape harvest area from 453 985 ha to 382 250 ha was forecasted for the 2016-2025 period. According to the Holt model, the grape production forecasted as 3 819 753 tons in 2016 will increase to 3 944 376 tons in 2025. The projection results of this study could provide useful information for developing good policies for food sustainability, grape production and price structuring in Turkey for the next years.

Keywords: Exponential smoothing, forecasting, grape, Holt method, time series

Türkiye'deki Üzüm Hasat Alanı ve Üretiminin Zaman Serisi Analiz Yöntemleriyle Tahminlenmesi

Öz: Bu çalışmanın amacı, Türkiye'deki üzüm hasat alanı ve üretimini 2016-2025 dönemi için tahminlemektir. Bu amaçla, 1961-2015 dönemine ait Türkiye üzüm hasat alanı ve üretimi FAOSTAT verileri kullanılmıştır. Üzüm hasat alanı ve üretimini modellemek için üstsel düzleştirme teknikleri kıyaslanmıştır. Holt modeli, 2016-2025 dönemi için üzüm hasat alanının 453 985 hektardan 382 250 hektara düşeceğini ve üzüm üretiminin 3 819 753 tondan 3 944 376 tona yükseleceğini öngörmüştür. Bu çalışmadan elde edilen projeksiyon sonuçlarının, gelecek yıllar için Türkiye üzüm üretimi ve fiyat yapılandırılması ile gıda güvenliği ve sürdürülebilirliği konusunda iyi politikalar geliştirilmesi açısından yararlı bilgi sağlayabileceği düşünülmektedir.

Anahtar kelimeler: Üstsel düzleştirme, tahminleme, üzüm, Holt yöntemi, zaman serileri

1. Introduction

Grapes (*Vitis* spp.) are one of the most popular horticultural crops with total worldwide harvest area of 7 124 512 ha and production of 74 499 859 tons in 2014 year. Turkey is one of the leading countries in the grape production with total harvest area of 467 093 ha and production of 4 175 356 tons in 2014 (FAOSTAT, 2017). Grapes are rich source of anthocyanins, flavonoids and phenolic acids with potential health benefits on human health. Grapes contain high amounts of vitamins, minerals, carbohydrates, and fibers which are vital components of the human diet (Eyduran et al., 2015). Therefore, it is important to establish good policies for sustainability of grape production. Time series analyses utilize past trend of a variable to forecast its future value (Hamjah, 2014). There is limited research on projecting harvest area and production of economically important horticultural crops (Masuda and Goldsmith, 2009; Semerci and Ozer, 2011; Celik et al., 2013; Hamjah, 2014;Borkar, 2016; Celik et al., 2017; Karadas et al., 2017a, b).

To our knowledge, there is no research on predicting grape harvest area and production in Turkey. Therefore, the aim of this study was to project grape harvest area and production in Turkey using past trends of grape harvest area and production trend in order to forecast future prospects of grape harvest area and production in Turkey.

2. Materials and Methods

FAOSTAT data on grape harvest area and production in Turkey of the 1961-2015 period was used to forecast grape harvest area and production for the 2016-2025 period. In the present projection study, ARIMA and exponential smoothing methods were applied. ARIMA also known as a generalization of Autoregressive Moving Average (ARMA) model is an abbreviation of Autoregressive Integrated Moving Average model. ARIMA parameters are p (number of time lags or the order of autoregressive model), d (the degree of differencing) and p (the degree of the moving-average model). ARIMA model integrated segment was used to remove the stationarity. The models used were ARIMA (0,1,1), ARIMA (0,1,2) and ARIMA (0,1,3). The time series models constructed through exponential smoothing methods were Holt, Brown, and Damped, which were fitted to the time series data sets. Model fit statistics i.e. stationarity R^2, R^2, RMSE, and BIC were used to select the most appropriate model.

3. Results and Discussion

3.1. Grape harvest area

A time series analysis of grape harvest area in Turkey for the 1961-2015 period was performed. Graph of grape harvest area for the 1961-2015 period is provided in Figure 1. ACF (Autocorrelation Function) and PACF (Partial Autocorrelation Function) graphs are used to examine data trend (Fig. 2).

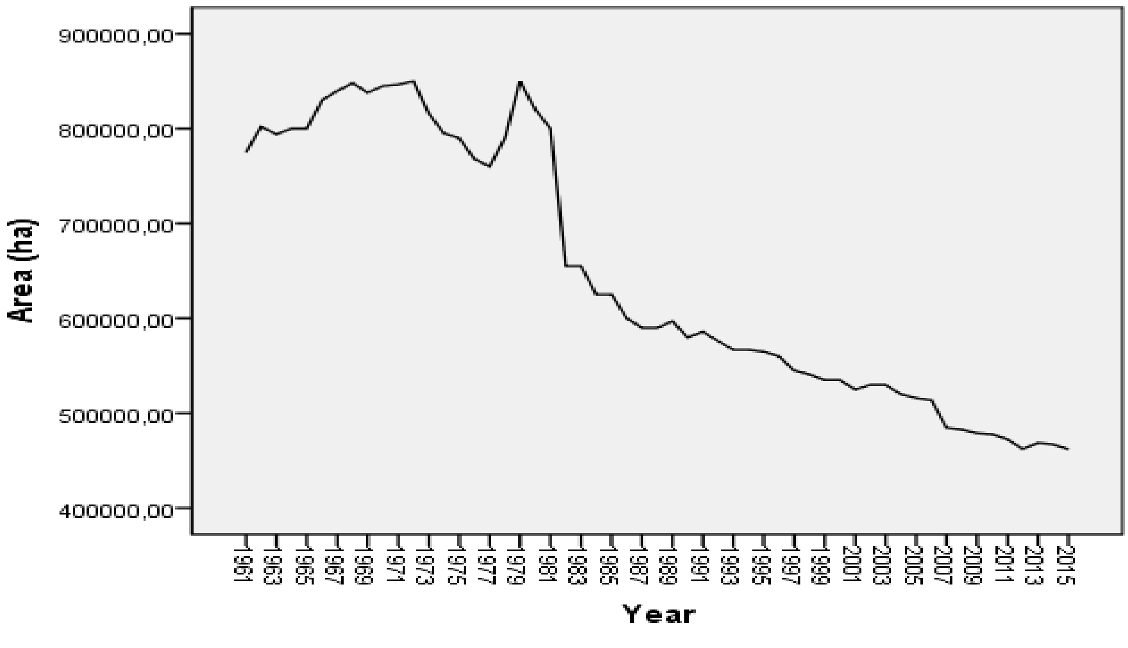

Figure 1. Graph of grape harvest area for the 1961-2015 period
Şekil 1. *1961-2015 yılları arasındaki döneme ait üzüm hasat alanı (ha) grafiği*

There was a trend in grape harvest area within the time series, because many of the terms found in the series in ACF graph exceeded confidence limit (Fig. 2). The first-degree difference of the time series was applied to make the data stationary and remove the trend. ACF and PACF graphs of the time series first difference are presented in Figure 3. The first difference was a stationary time series as seen from ACF and PACF graphs (Figure 3). Model fit statistics (Stationary R^2, R^2, RMSE and BIC) were compared for some ARIMA and exponential smoothing methods. Results of model fit statistics for each method were summarized in Table 1. Model parameters consisting of Holt model smoothing coefficients are presented in Table 2. BIC criterion was suggested to select the most appropriate model (Pektaş, 2013).

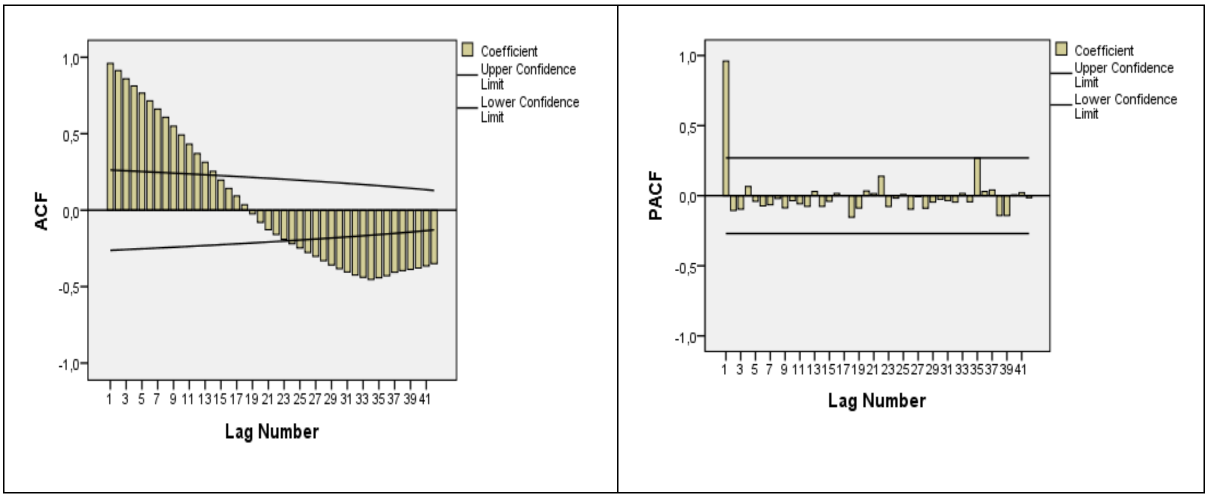

Figure 2. ACF and PACF graphs of grape harvest area (ha)
Şekil 2. *Üzüm hasat alanı (ha) ACF ve PACF grafikleri*

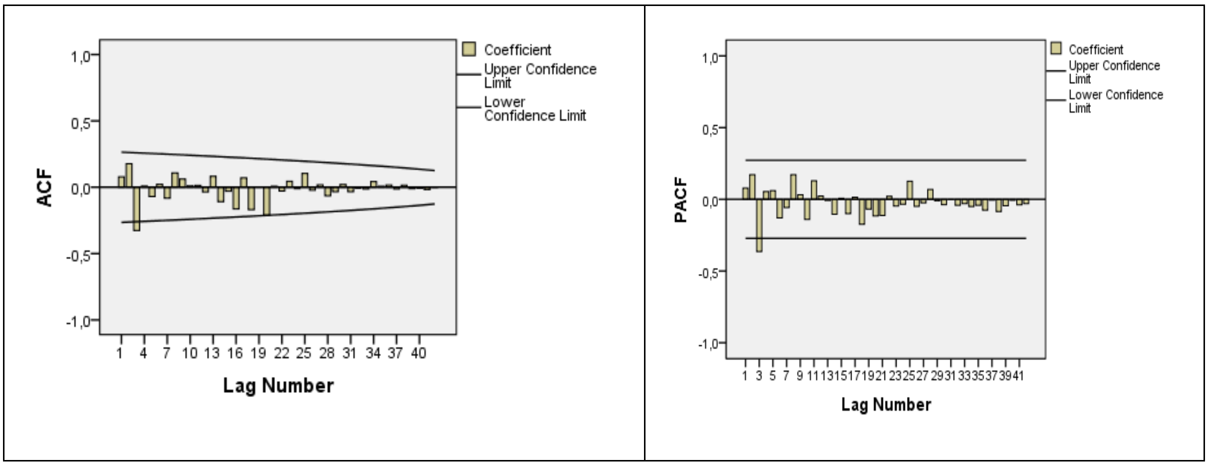

Figure 3. Grape harvest area first difference time series ACF and PACF graphs
Şekil 3. *Üzüm hasat alanı birinci derece fark zaman serilerinin ACF ve PACF grafikleri*

Table 1. Grape harvest area model fit statistics
Tablo 1. *Üzüm hasat alanı uyum testi istatistikleri*

Fit Statistic	Stationary R^2	R^2	RMSE	BIC
ARIMA(0,1,1)	0.004	0.968	25152.566	20.413
ARIMA(0,1,2)	0.091	0.971	24268.140	20.415
ARIMA(0,1,3)	0.202	0.975	22961.667	20.379
Holt	0.463	0.968	25084.555	20.406
Brown	0.326	0.961	27556.125	20.521
Damped	-0.005	0.969	25270.195	20.493

*Ljung-Box Q=17.135 and p=0.377>0.05

Although ARIMA (0, 1, 3) model had the smallest BIC and the highest Stationary R2 and R2 (Table 2), parameter estimates of the model were not significant. Therefore, Holt linear model was selected as the best one. Holt model showed the best R^2 estimates, the smallest BIC and RMSE. Besides, Ljung-Box Q=17.135 and p>0.05 were also selecting criteria for the Holt linear model

Holt linear model parameters $\alpha = 1$ (P<0.01) and $\gamma = 0.001$ were estimated. Based on this model, ACF and PACF residual graphs are provided in Figure 4.

Table 2. Grape harvest area (ha) exponential smoothing model parameters
Tablo 2. *Üzüm hasat alanı (ha) üstsel düzleştirme model parametreleri*

	Estimate	SE	t	Sig.
Alpha (Level)	1	0.136	7.358	0.001
Gamma (Trend)	0.001	0.016	0.066	0.948

The relationship degrees of lags in ACF and PACF residual graphs, used in considering a suitable model, were within confidence limits (Fig. 4). Only 3rd lag slightly exceeded the confidence limits. The residuals were found as white noise (Fig. 4). Fitted and actual (observed) series graph is shown in Figure 5. The fitted series were in agreement with the observed time (Fig. 5).

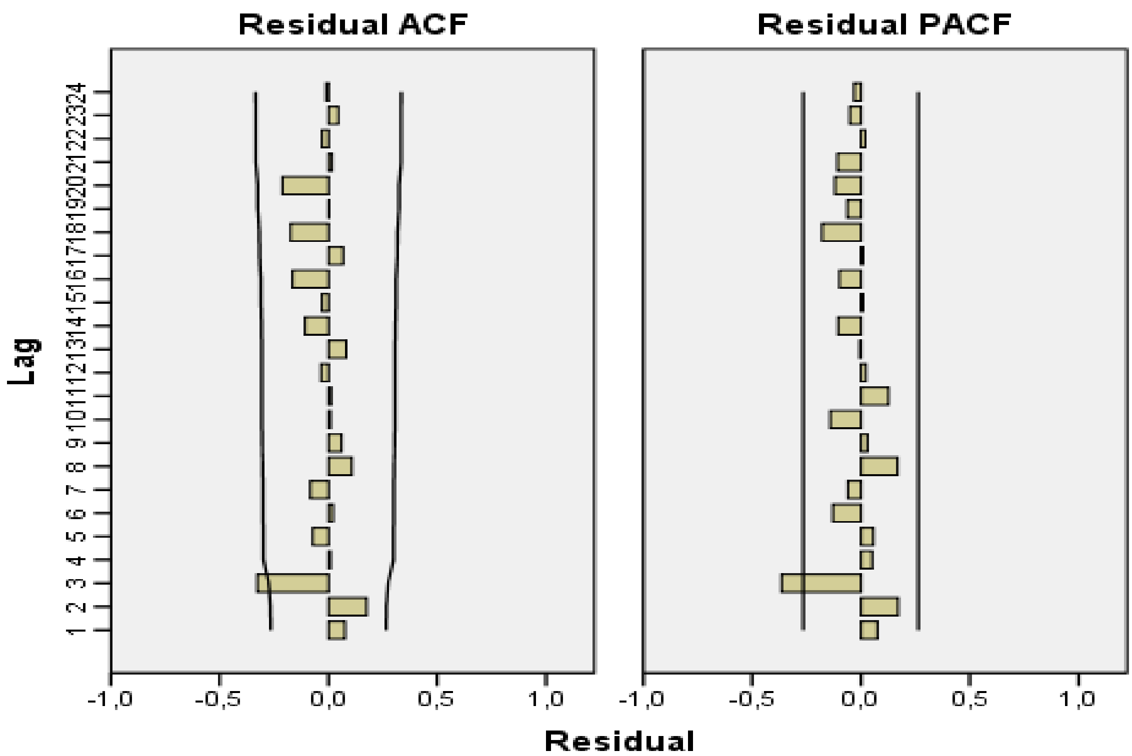

Figure 4. Grape harvest area ACF and PACF residual graphs
Şekil 4. *Üzüm hasat alanı ACF ve PACF hata terimleri grafikleri*

The grape harvest area (453 985 ha) forecasted for 2016 year was higher than the forecasted subsequent years. We can say that a decrease in grape harvest area (from 453 985 ha to 382 250 ha) was forecasted for the 2016-2025 period (Table 3).

Table 3. Grape harvest area (ha) forecasting results for 2016-2025 period
Tablo 3. *2016-2025 yılları üzüm hasat alanı (ha) tahmin sonuçları*

Year	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Area (ha)	453 985	446 015	438 044	430 074	422 103	414 133	406 162	398 191	390 221	382 250

3.2. Grape production amount

Grape production (tons) in Turkey for the 1961-2015 period was analyzed using time series analysis. Grape production graph for the 1961-2015 period is provided in Figure 6. Grape production ACF and PACF graphs used to determine the time series data trend are presented in Figure 7.

The first three terms in the ACF graph exceeded confidence limit, implying a time series trend (Fig. 7). The first-degree difference of the grape production time series was taken to make the series stationary. ACF and PACF graphs of the first difference time series for grape production are presented in Figure 8.

To better understand stationarity, a unit root test was applied. Results of unit root test are presented in Table 4. Null hypothesis on existing unit root for grape production series was accepted and showed non-stationarity. ADF test was used to reveal whether the first difference time series of grape production was stationary.

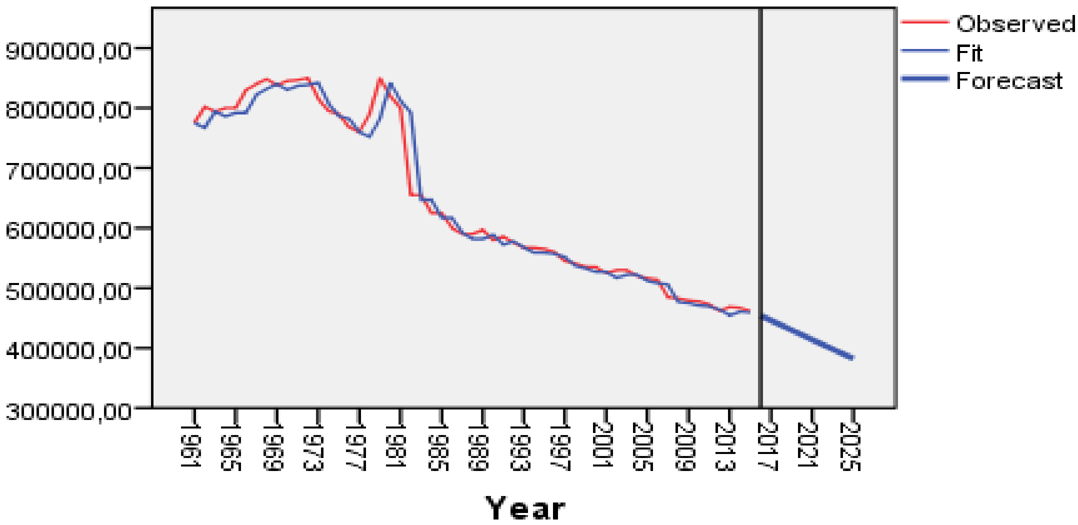

Figure 5. Grape harvest area fitted and observed time series graph
Şekil 5. *Üzüm hasat alanı gözlenen ve tahminlenen zaman serilerinin grafikleri*

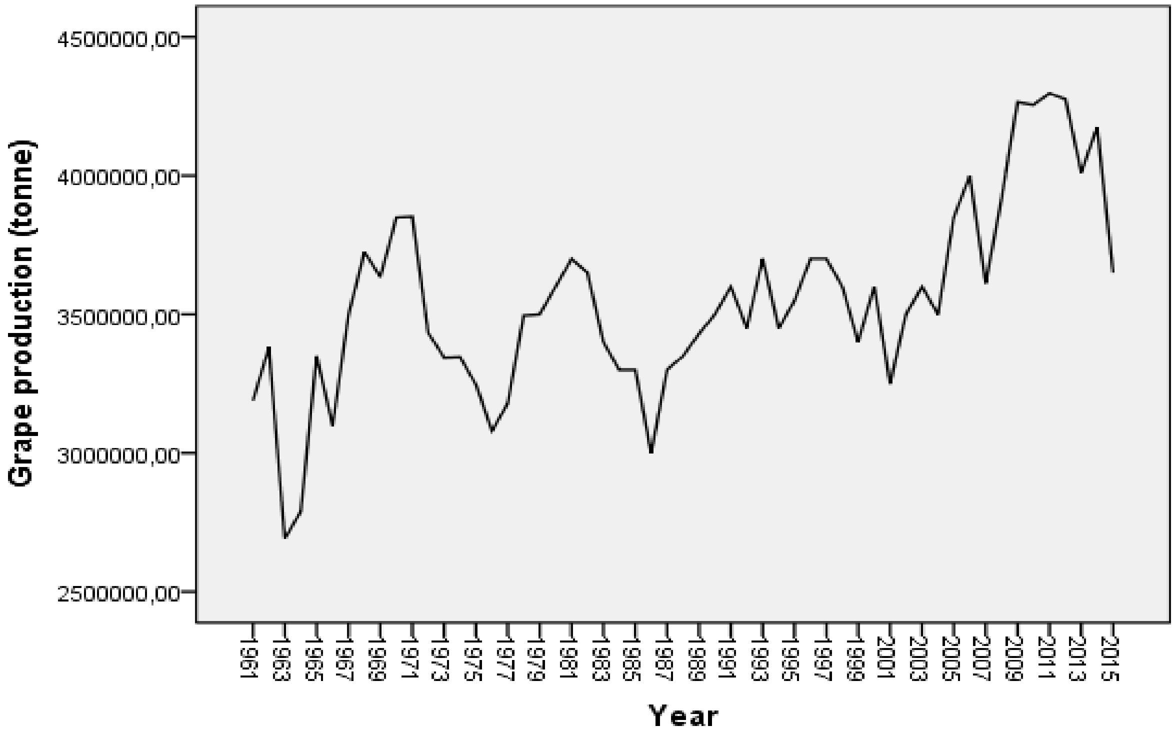

Figure 6. Grape production (tons) graph for the 1961-2015 period
Şekil 6. *1961-2015 yılları arasındaki döneme ait üzüm üretimi (ton) grafiği*

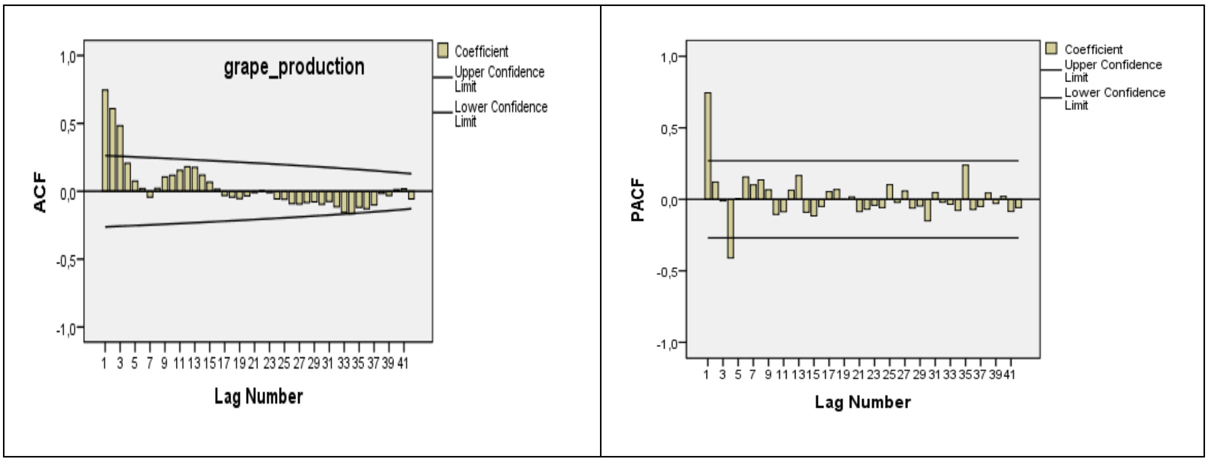

Figure 7. Grape production (tons) ACF and PACF graphs
Şekil 7. Üzüm üretimi (ton) ACF ve PACF grafikleri

ADF unit root test results are shown in Table 4. The first difference time series stationarity (I(1)) was significant ($P<0.01$) (Table 4).
ARIMA models and exponential smoothing methods model fit statistics were compared (Table 5). Since Holt exponential smoothing model showed the highest stationary R^2, R^2, and the smallest BIC estimates, it was selected as the most suitable model (Table 5). BIC was recommended as a good fit criterion (Pektas, 2013). Ljung-Box Q=20.375 and p=0.204 (>0.05)

were also used for the suitability of the Holt linear model.

Holt linear model parameter coefficients were α = 0.700 and γ=0.00006. Only α parameter was found significant (P<0.01) (Table 6). The Holt model ACF and PACF residuals graphs are presented in Figure 9. The relationship degrees of ACF and PACF residual lags of the Holt model were within confidence limits (Fig. 9). Therefore, the residuals were considered white noise.

The fitted and observed series graph is shown in Figure 10. The fitted and observed series were in agreement with each other (Fig. 10).

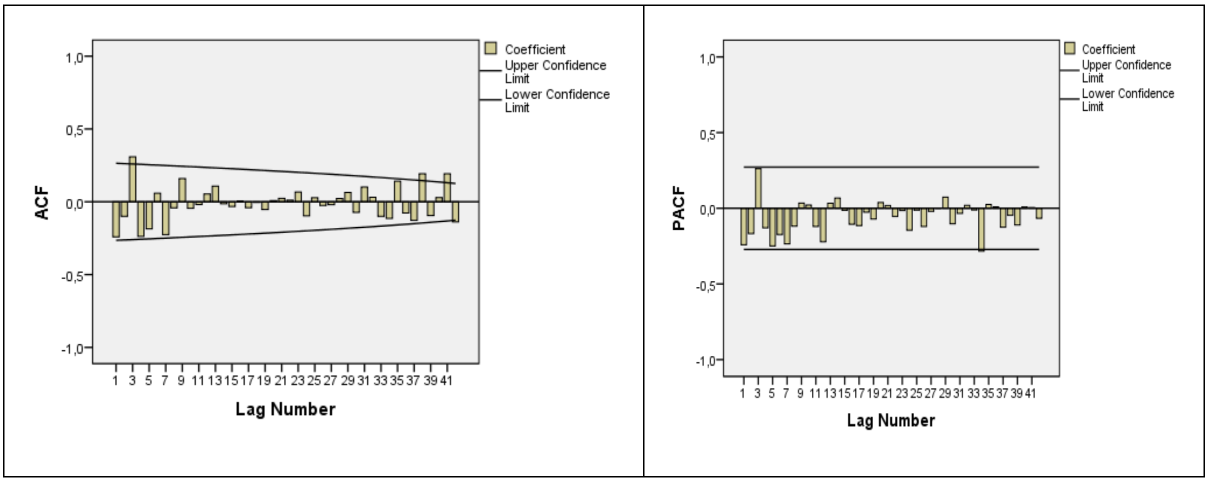

Figure 8. Grape production ACF and PACF graphs of the first difference time series
Şekil 8. Üzüm üretimi birinci derece fark serilerinin ACF ve PACF grafikleri

Table 4. Grape production (tons) ADF unit root test results
***Tablo 4.** Üzüm üretim miktarı (ton) ADF birim kök testi sonuçları*

Variable	ADF values		
	Level	1. different	Result
Grape production	-2.810	-8.943**	I(1)

*The first difference of the time series was not a unit root at an alpha level of 5%.
**The first difference of the time series was not a unit root at an alpha level of 1%.
MacKinnon critical values at alpha levels of 1, 5 and 10% were –3.560, -2.917 and –2.597.

Table 5. Grape production (tons) model fit statistics
Tablo 5. Üzüm üretim miktarı (ton) uyum testi istatistikleri

Fit Statistic	Stationary R^2	R^2	RMSE	BIC
ARIMA(0,1,1)	0.073	0.538	236834.812	24.898
ARIMA(1,1,1)	0.142	0.573	230038.141	24.914
ARIMA(1,1,0)	0.064	0.533	238037.551	24.908
Holt	0.615	0.548	234396.355	24.875
Brown	0.540	0.460	253962.170	24.963
Damped	0.074	0.548	236718.365	24.968

*Ljung-Box Q=20.375 and p=0.204>0.05

Table 6. Grape production (tons) exponential smoothing model parameters
***Tablo 6.** Üzüm üretimi (ton) üstsel düzleştirme model parametreleri*

	Estimate	SE	t	Sig.
Alpha (Level)	0.700	0.138	5.065	0.001
Gamma (Trend)	0.00006	0.060	0.001	0.999

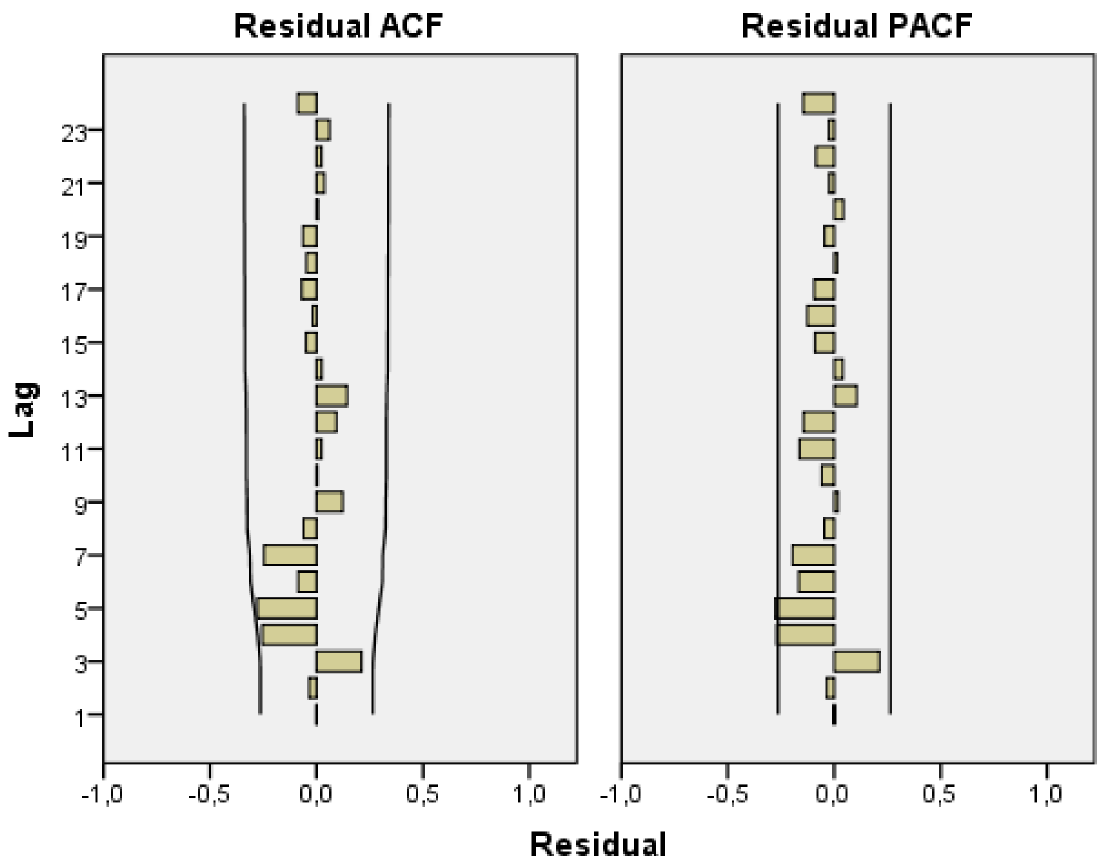

Figure 9. Grape production (tons) ACF and PACF residual graphs for the Holt model
Şekil 9. *Holt modeli için üzüm üretimi (ton) ACF ve PACF hata terimleri grafikleri*

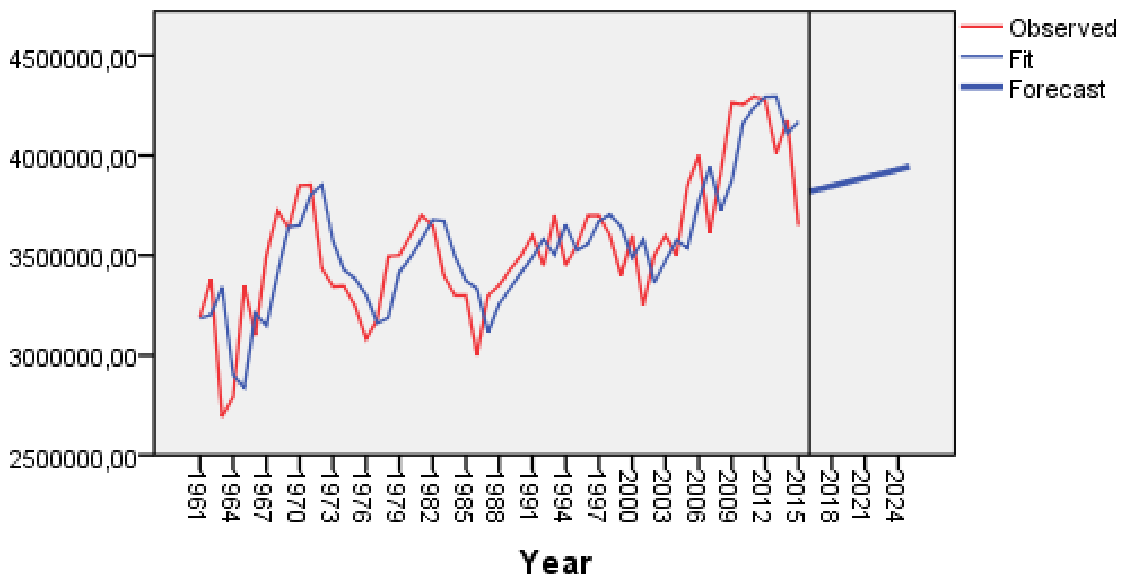

Figure 10. Grape production (tons) fitted and observed series graph
Şekil 10. *Üzüm üretimi (ton) gözlenen ve tahmin edilen seri grafiği*

It is expected that the grape production forecasted as 3 819 753 tons for 2016 will increase to 3 944 376 tons in 2025 with the proportion of 103 % (Table 7).

Table 7. Grape production (tons) predictions for the 2016-2025 period
Tablo 7. *2016-2025 dönemi için üzüm üretimi (ton) tahmini*

Year	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Forecast (tons)	3 819 753	3 833 600	3 847 447	3 861 294	3 875 141	3 888 988	3 902 835	3 916 682	3 930 529	3 944 376

4. Discussion

To our knowledge, there is no research on forecasting grape harvest area and production in Turkey for the future to establish good policies of grape sustainability. The investigations available on predicting harvest area and production of important horticultural plants is limited (Hamjah, 2014). Although in our study, Holt linear model forecasted grape harvest area to decrease, the model predicted in general increase in grape production in Turkey for the next years. Box-Jenkins ARIMA model was used to predict mango, banana and guava production in Bangladesh for the subsequent ten years. Mango was predicted to show downward production trend for the first years, after a few years later the production was stabilized and for the last years showed upward production tendency. Banana was predicted to show stable production, whereas guava was forecasted to show increasing production in Bangladesh (Hamjah, 2014). ARIMA model predicted an increase in maize production in Nigeria for the future years (Badmus and Ariyo, 2011). Box-Jenkins ARIMA model forecasted sugarcane production in India to increase in 2013, then to show a decrease in 2014, and at the end to increase again (Kumar and Anand, 2014). Damped exponential smoothing method predicted an increase in soybean production in the world for the 2020-2030 period (Masuda and Goldsmith, 2009).

Pistachios, walnuts, hazelnuts, almond and chestnuts productions in Turkey were forecasted for the 2012-2020 period and upward production tendency was demonstrated by applying various ARIMA models (Celik, 2013). Groundnut increasing production was predicted using time series projections (Celik et al., 2017). Holt exponential smoothing method forecasted increase in sunflower and sesame production in Turkey (Karadas et al. 2017a in press). Upward cotton lint production tendency was defined by Holt exponential smoothing method (Karadas et al., 2017b in press).

5. Conclusion

This projection study aimed to forecast grape harvest area and production in Turkey for the 2016-2025 period. Grape production (tons) forecasted for the 2016-2025 period was 3 819 753 tons for 2016 and increased to 3 944 376 tons in 2025, whereas grape harvest area showed a decrease from 453 985 ha to 382 250 ha for the next year. This could be due to the fact that, grape cultivars with higher yield were planted and better cultural practices were applied.

This study was the first one to forecast grape harvest area and production in Turkey. The results found here could help policymakers to establish better macro-level policies for food security and sustainability, as well as to plan more effectively grape planting area and production in Turkey.

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