Forecasting Chestnut Production and Export of Turkey Using ARIMA Model

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A R T I C L E   I N F O

A B S T R A C T

Turkey is one of main producers and exporter countries of chestnut in the world. It is essential to assess scientifically the accurate future production and export potentials of chestnut on the basis of past trends. This study focuses on forecasting the chestnut production and export of Turkey up to the year 2021 using Autoregressive Integrated Moving Average (ARIMA) model. The time series data for the chestnut production and export of Turkey were obtained from the Food and Agriculture Organization of the United Nations (FAO). Annual data for the period of 1961-2016 was used for the study. The study revealed that the best models for forecasting the chestnut production and export were ARIMA (1, 1, 1) and ARIMA (1, 2, 1), respectively. The ARIMA model showed that while the chestnut production of Turkey in 2021 would be 64.183 tonnes with lower limit of 38.946 tonnes and upper limit of 89420 tonnes. However, Turkey's chestnut export in 2021 would be 7.962 tonnes with lower limit of 563 tonnes and upper limit of 15362 tonnes. The study concluded that Turkey's chestnut production and export will increase in the forecasted years. The stakeholders of chestnut sector should take account these projections in their production and marketing decision.

1. Introduction

Fruits are an important part of the human diet. They contain vitamins and other nutrients that help keep the body healthy. Chestnut is one of the important fruit species that has been a rich source of vitamin C, vitamins of the B group and minerals such as potassium, iron and magnesium. In 2016, the total chestnut land and production in the world were 546.796 hectares and 2.176.776 tonnes, respectively. China has 59.71% of the chestnut areas of the world and provides 86.32% of the world chestnut production. Turkey is one of the main chestnut producer and exporter country in the world. Turkey has a substantial production potential and is quite suitable for the cultivation of chestnut in terms of climate and soil. Thus, Turkey has 7.13% of the total plantation area and provides 2.97% (63.762 tonnes) of the total production (Table 1) [1]. Aydın province was the biggest producer province with a share of 38.6% (24.304 tonnes) in Turkey [2]. In 2016, the chestnut export quantity and value in the world were 125.118 tonnes and over USD 350 million, respectively. China accounted for 26.3% and 22.1% of the world's chestnut export quantity and value. However, Turkey accounts for about 6.6% and 7.1% of the world's chestnut export quantity and value, respectively [1]. Turkey is a net exporter country on the external trade of chestnut.

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Table 1. Chestnut Area and Production in the World [1]

Country	Area (ha)	Area (%)	Production (tonnes)	Production (%)
China	326479	59.71	1879031	86.32
Spain	42754	7.82	16185	0.74
Turkey	39000	7.13	64750	2.97
Portugal	35718	6.53	26780	1.23
Republic of Korea	32642	5.97	56244	2.58
Italy	22333	4.08	50889	2.34
Japan	19300	3.53	16500	0.76
Greece	9093	1.66	31557	1.45
France	8004	1.46	8642	0.40
Others	11473	2.10	26198	1.20
Total	546796	100.00	2176776	100.00

Many studies had been carried out on technical issues such as biological control of cancer disease and selection of disease-resistant species in chestnut [3, 4, 5, 6, 7]. Some studies focus on production of the countries, developments of chestnut markets, opportunities and problems [8, 9, 10, 11, 12, 13]. Also there is quite a limited number of studies about the analysis of competitive markets, chestnut producers [14, 15] and, cost-profit analysis of chestnut farming [16,17]. There is an absence of research on forecasting of chestnut production and export in literature.

Forecasting the future has an important role in the management of agriculture [18]. Univariate time series analysis is used to forecast the productions and exports of crops or products. During the last decades, many sophisticated statistical forecasting models have been developed due to the availability of advanced computers [18]. One of such models includes the ARIMA models [19]. There have been many the time series studies used ARIMA model in order to forecast the production, export, area, yield and prices of agricultural crops and products [20, 21, 22, 23, 24, 25, 26].

This study aimed to forecast the chestnut production and export of Turkey up to the year 2021 using ARIMA model. This kind of analysis could find out useful results and concluding remarks for both decision makers in the stakeholders in chestnut sector.

The remainder of this article is structured as follows. Section 2 explains the material and method for this research. Section 3 presents the results and discussions. Finally, section 4 concludes.

2. Material and Methods

The data were obtained from the Food and Agriculture Organization (FAO) for the period of 1961-2016. Box and Jenkins linear time series model was used to forecasting the future production and export quantities [19]. Box-Jenkins model is also known as ARIMA. ARIMA models allow each variable to be explained by its own past or lagged values, and stochastic error terms [27]. ARIMA (p, d, q) models have three parameters: p is the order of the autoregressive model, d is the degree of difference, and q is the order of the moving average model. The model is given in Equation 1.

$$Z_t = \delta + a_t - \theta_1 a_{t-1} - \theta_2 a_{t-2} - \ldots - \theta_q a_{t-q} \tag{1}$$

Here, a_t; a_{t-1}; a_{t-2}; …; a_{t-q} are random shocks that are assumed to have been randomly selected from a normal distribution that has zero mean and constant variance. Furthermore, the random shocks are assumed to be statistically independent. θ_1; θ_2; θ_3; …; θ_q are unknown parameters that must be estimated from sample data. δ is a constant term and it can be proved that for the moving average model of order q, $\delta = \mu$.

The estimation methodology of the model consists of three steps: (i) namely identification, (ii) estimation of parameters and, (iii) diagnostic checking [23]. The identification step involves the use of the techniques for determining the value of p, d, and q [23]. These values are determined by using ACF, PACF and Augmented Dickey-Fuller (ADF) test [23].

Considerable skill is required to choose the actual ARIMA (p, d, q) model so that the residuals estimated from this model are white noise. The derived model must be checked for adequacy by considering the properties of the residuals whether the residuals from an ARIMA model is normal and randomly distributed [24]. These may also be judged by Ljung-Box statistic under the null hypothesis that the autocorrelation coefficient is equal to zero [18].

In order to realize the ARIMA model based on Equation (1), a plot of the 56-year chestnut production and export data was run using Minitab program. After the plot, the data was investigated for stationarity, using the plots of the autocorrelation functions (ACF) and Partial Autocorrelation Functions (PACF). And finally, to test if residuals are white noise, the ACE of residuals and the Ljung and Box (1978) statistic were used [28].

3. Results and Discussion

The autocorrelation function is a very constructive tool to find out whether a time series is stationary or not. Both ACF and PACF are also used to determine auto-regression and moving average orders of the models [23]. In the ACF graph for chestnut production, it was determined that the delays exceed the confidence limit, namely, they are not stationary. In this case, the first difference was applied to the series and the series was tried to be cleared from the trend. When the ACF and PACF graphs of the chestnut production series with the first difference are examined, it is seen that the series has become stationary (Figure 1).

The model is determined by looking at the ACF and PACF graphs for chestnut production of the stationary series. Accordingly, while the ACF graph decreased rapidly, it was determined that the PACF graph decreased more slowly. So, the model used in this case is ARIMA (1, 1, 1) to forecast chestnut production.
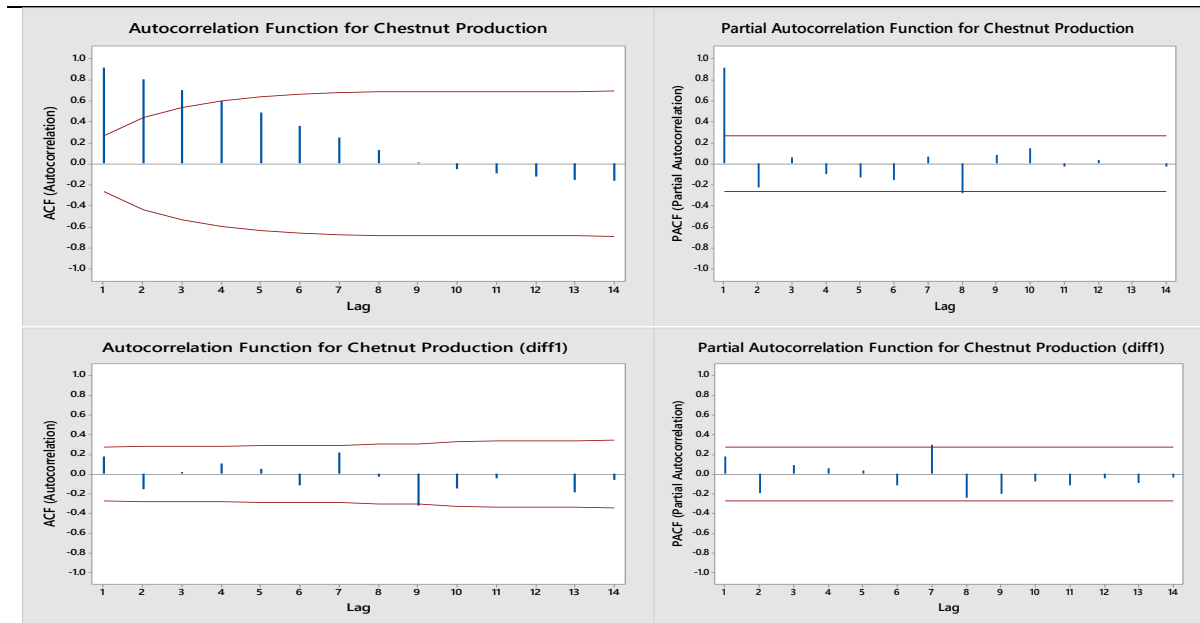

Figure 1. The Autocorrelation (ACF) and Partial Autocorrelation (PACF) Plots of Chestnut Production

The ACF and PACF plots illustrated that the 1st differenced time series of chestnut production is stationary, but chestnut export is not stationary. So, in order to became the time series of chestnut export stationary, the difference of the time series should be taken (Figure 2). To choose ARIMA model, while ACF graph decreased rapidly, PACF graph decreased more slowly. So, the model used in this case is ARIMA (1, 2, 1) to forecast chestnut export.
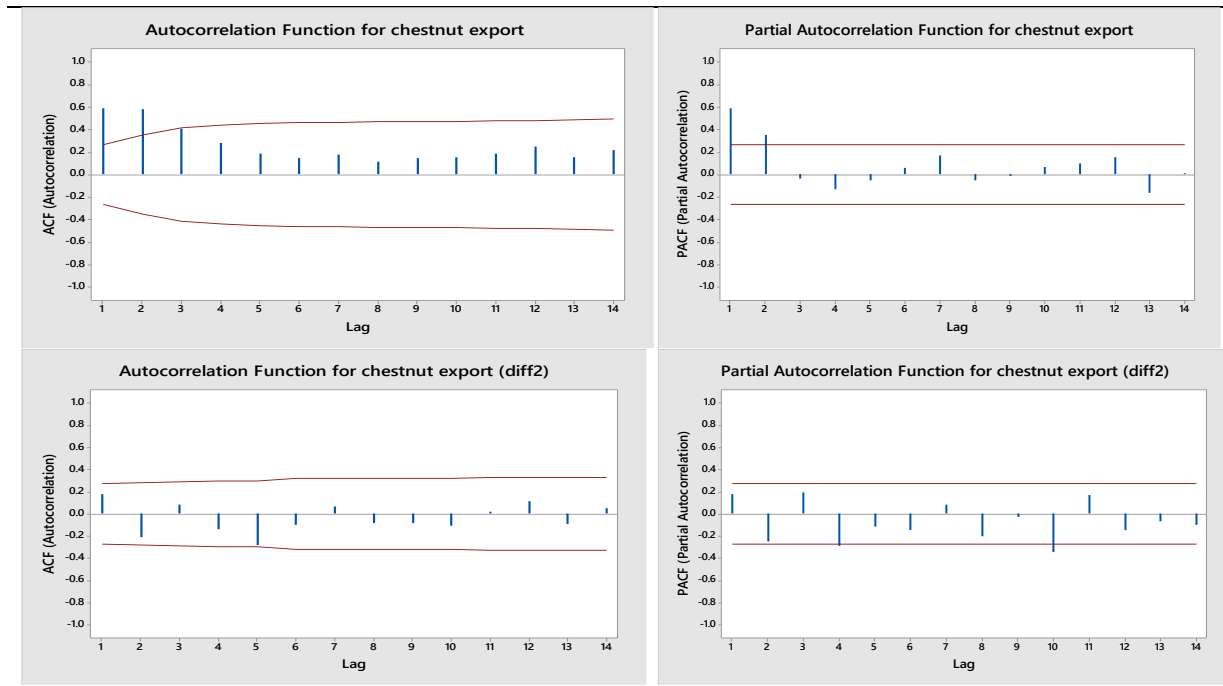
Figure 2. The Autocorrelation (ACF) and Partial Autocorrelation (PACF) Plots of Chestnut Export

Apart from the graphical methods of using ACF for determining stationarity of a time series, a very popular formal method of determining stationarity is the Augmented Dickey-Fuller (ADF) test [21]. Whether the changes in the chestnut production and export amount or not have a unit root by Dickey and Fuller (1981)'s Generalized Dickey-Fuller (ADF) test. The test analysis illustrated that chestnut production, the 1st differenced time series are stationary but, chestnut export is not stationary. So, chestnut export time series need to be difference to 2nd examine stationary of the series. The ACF and ADF tests indicated that while chestnut production time series is stationary of order one and chestnut export time series is stationary of order two (Table 2). It means the data of chestnut production and export have unit root, which are overcome by taking first and second differences, respectively.

Table 2. Results of Augmented Dickey-Fuller Test

		Chestnut production		Chestnut export	
		Level	1st difference	Level	2nd difference
		-1.5812	-6.0704	-2.1334	-7.8290
Probability:		0.4843	0.0000	0.2328	0.0000
Test critical values:	1% level	-3.5550	-3.5574	-3.5574	-3.5654
	5% level	-2.9155	-2.9165	-2.9165	-2.9199
	10% level	-2.5955	-2.5961	-2.5961	-2.5979

*MacKinnon (1996) one-sided p-values.

ARIMA (1, 1, 1) and ARIMA (1, 2, 1) models were estimated using MINITAB package program and estimation of the models for the chestnut production and export data are given in Tables 3. Accordingly, it was determined that the estimation of parameter is statistically significant ($p<0.05$).

Table 3. Final Estimates of Parameters

Chestnut Production	Coefficient	SE Coefficient	T-Value	P-Value
AR 1	-0.7573	0.1091	-6.94	0,000
MA 1	-0.9715	0.0485	-20.03	0,000
Chestnut Export				
AR 1	-0.5099	0.1238	-4.12	0,000
MA 1	0.9523	0.0762	12.49	0,000

Diagnostic checking of the models are concerned with the residual plots of ACF and PACF as presented in Figure 3. As all the ACF and PACF are within the confidence bound the model ensures that the errors or residuals possess a white noise.
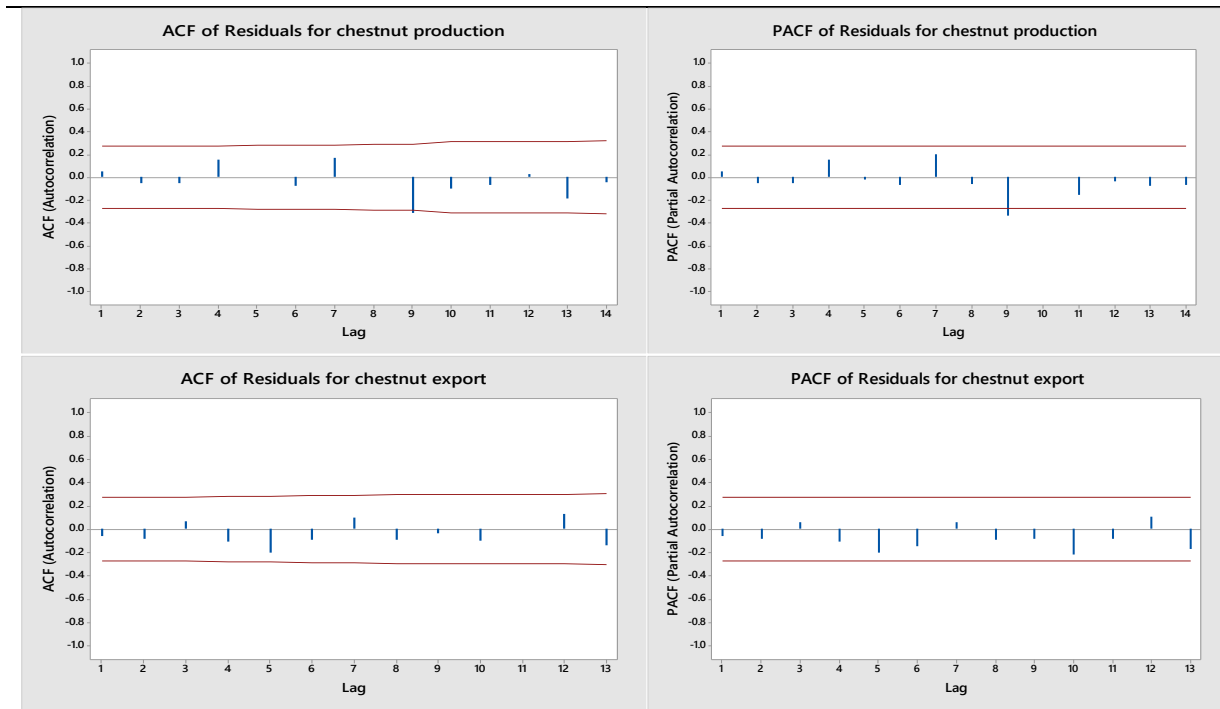

Figure 3. Residual Plots of ACF and PACF of Chestnut Production and Export

ARIMA (1, 1, 1) and ARIMA (1, 2, 1) were taken for 20 years ahead and forecasts for chestnut production and export (Table 4). In Turkey, the total chestnut production increased from 53.814 to 64.750 tonnes in the period of 2006-2016 (Figure 4). However, the chestnut export quantity increased from 3.735 to 8.337 tonnes (Figure 5). The ARIMA model showed that, in 2021, the chestnut production of Turkey would be 64.183 tonnes with lower limit of 38.946 tonnes and upper limit of 89.420 tonnes. However, Turkey's chestnut export would be 7.962 tonnes with lower limit of 563 tonnes and upper limit of 15.362 tonnes.

Table 4. Chestnut Production and Export Forecasts from 2017 to 2021 by ARIMA

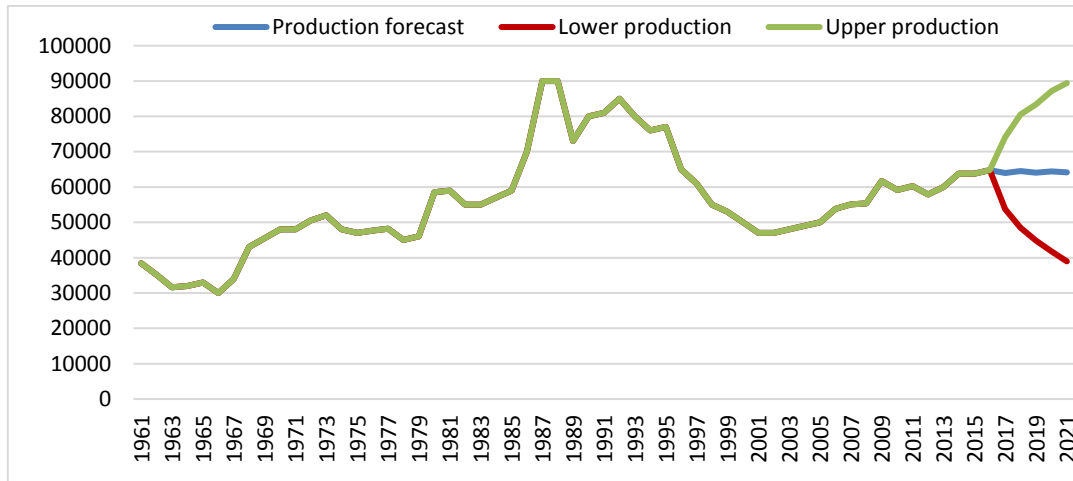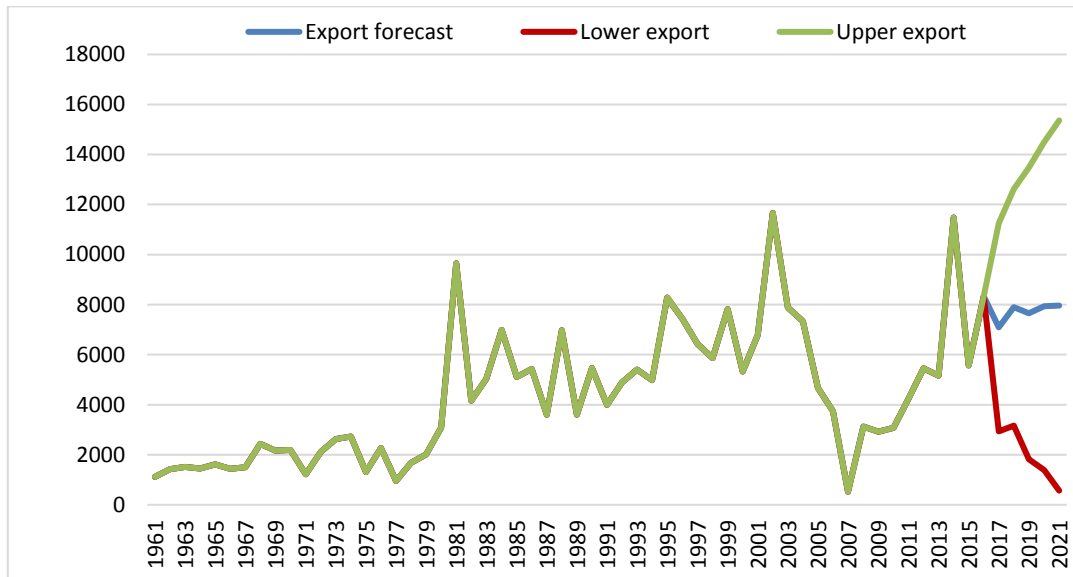| Year	Chestnut production			Chestnut export		
	Forecast	**Lower**	**Upper**	**Forecast**	**Lower**	**Upper**
2017	63952.5	53760.7	74144.2	7091.9	2931.2	11252.6
2018	64556.4	48524.7	80588.1	7894.3	3170.2	12618.3
2019	64099.1	44812.5	83385.6	7652.5	1822.5	13482.5
2020	64445.4	41744.3	87146.6	7943.2	1380.5	14506.0
2021	64183.1	38946.1	89420.1	7962.4	563.3	15361.6

Figure 4. Chestnut Production Forecast (tonnes)

Figure 5. Chestnut Export Forecast (tonnes)

4. Conclusion

In this study, Turkey's chestnut production and export amounts were estimated for the period of 2017-2021 using the models of ARIMA(1, 1, 1) and ARIMA (1, 2, 1) respectively. For the time series of chestnut production, ARIMA (1, 1, 1) model was found to be the best-fitted model whereas for the time series of chestnut export, ARIMA (1, 2, 1) was found to be the best fitted one. According to the model results, while chestnut production would be almost stable, the export quantity would fluctuate in the following years. To protect the current position of the country, it is recommended that the government should give enough support to increase chestnut production and export in Turkey. The projections of agricultural commodities play a vital role in the adjustments of supply and demand in the future. The stakeholders of the chestnut sector should take account these projections in their production and marketing decision.

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