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Estimation of Turkey hazelnut export quantity and prices with ARIMA model

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Abstract: Hazelnut is of strategic importance for Turkey and is a product subject to international trade. Turkey, which realizes 64% of the world hazelnut production, is also the country that exports the most. It is important to estimate the future hazelnut price, export amount and income from exports to maintain the country's position. Hazelnut export unit price ($/ton), hazelnut export quantity (tons) and hazelnut export value ($) variables in Turkey between 1961 and 2023 were used and forecasted with ARIMA model for 2024, 2025 and 2026. Statistical error evaluation criteria such as mean absolute percentage error (MAPE), mean absolute error (MAE), root mean square error (RMSE), normalized Bayesian information criterion (BIC) etc. were used to test the validity of the ARIMA model, which indicated that the model was reliable. In addition, the augmented Dickey-Fuller test (ADF) and Phillips-Perron test (PP) unit root tests were applied to determine the stationarity levels of the series. The series was stationarity at different levels and the Ljung-Box significance levels of the series were appropriate for the models. It is predicted that export unit price and hazelnut export value will follow an increasing trend in the next three years, while hazelnut export quantity will follow a fluctuating course. In addition, it can be said that the export quantity will continue to follow a fluctuating course over the years with the effect of periodicity in production, while the export unit price and export value will continue its upward trend in a fluctuating manner with the effect of the crisis experienced after 2005.

Keywords: ARIMA model, hazelnut price, hazelnut exports, Türkiye

Türkiye fındık ihracat miktarı ve fiyatlarının ARIMA modeli ile tahmini

Öz: Fındık Türkiye için stratejik öneme sahip olup, uluslararası ticarete konu olan bir üründür. Dünya fındık üretiminin %64'ünü gerçekleştiren Türkiye, aynı zamanda en fazla ihracat yapan ülkedir. Ülkenin bu konumunu sürdürebilmesi için geleceğe ilişkin fındık fiyatı, ihracat miktarı ve ihracattan elde edilen gelirin bilinmesi önemlidir. Çalışmada 1961-2023 yılları arasındaki Türkiye fındık ihracat birim fiyatı ($/ton), Türkiye fındık ihracat miktarı (ton) ve Türkiye fındık ihracat değeri ($) değişkenleri kullanılmış ve Türkiye için 2024, 2025 ve 2026 yıllarına dair ARIMA modeli ile tahminler yapılmıştır. ARIMA Modelinin geçerliliğini sınamak amacıyla MAPE, MAE, RMSE, Normalize BIC vb. istatistiki hata değerlendirme ölçütleri yapılmış ve modelin güvenilir olduğu tespit edilmiştir. Ayrıca serilerin durağanlık seviyelerini tespit etmek amacıyla ADF ve PP birim kök testleri uygulanmıştır. Seriler farklı seviyelerde durağanlık göstermekte ve serilerin Ljung-Box anlamlılık düzeyleri modeller için uygundur. Çalışma sonuçlarına göre Türkiye ihracat birim fiyatı ve Türkiye fındık ihracat değerinin gelecek üç yılda artış trendinde olacağı, Türkiye fındık ihracat miktarının ise dalgalı bir seyir izleyeceği tespit edilmiştir. Ayrıca ihracat miktarının üretimdeki periyodisite etkisi ile yıllar itibariyle dalgalı bir seyir izlemeye devam edeceği, ihracat birim fiyatının ve ihracat değerinin 2005 yılından sonra yaşanan krizin etkisi ile artış trendini dalgalı şekilde sürdüreceği söylenebilir. Fiyatlardaki bu oynaklığın dikkate alınarak uygun politikaların izlenmesi ve üreticilerin fiyat oynaklığından korunması önem arz etmektedir.

Anahtar kelimeler: ARIMA modeli, fındık fiyatı, fındık ihracatı, Türkiye

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1. Introduction

Hazelnuts are a strategically important product for Turkey. Turkey accounts for 64.0% of global hazelnut production and 57.4% of global hazelnut exports, ranking the country first worldwide in both production and export. Hazelnuts and hazelnut products are among Turkey's leading agricultural export commodities, constituting 9% of the country's annual agricultural exports and 2% of its total exports (Anonymous, 2024). Hazelnuts serve as a raw material in various industries, including snacks, confectionery, chocolate, halvah, and baking, which further underscores their strategic significance in terms of imports and exports (Kırsahanoğlu, 2022). Consequently, the future trajectory of hazelnut prices and export volumes is of critical importance for Turkey, which holds the top position in global exports. Although Turkey ranks first in the world in hazelnut production and export, the entry of countries such as Italy, Chile, Azerbaijan, and Georgia into the market in recent years has affected Turkey's share in this sector. Chile increased its hazelnut production from 180 tons in the 1990s to 62 thousand tons by 2022, and Azerbaijan increased its hazelnut production from 7 to 8 thousand tons in the 1990s to 72 thousand tons in 2022. These countries are gaining a more prominent position in hazelnut production, with South American nations, particularly Chile, increasing their output thanks to favorable climatic conditions. Moreover, countries like Georgia, Azerbaijan, Iran, and some Middle Eastern nations are gaining a competitive advantage due to low labor costs. These developments highlight the need for further economic analysis regarding how Turkey's hazelnut production and exports might be impacted (Aydoğan & Meral, 2024). Turkey's production of 765,000 tons (64% of global output) clearly demonstrates the country's dominant position in this sector. Italy and Azerbaijan follow as the second and third largest producers, with 98,670 tons and 72,105 tons, respectively. These top three producers are followed by the United States, Chile, Georgia, China, Iran, France, and Poland. The total global hazelnut production amounts to 1,195,732 tons. Turkey's contribution to 64% of global production is driven by both domestic market dynamics and international competitive conditions, providing a significant indicator of how global production strategies are evolving. The entry of South American countries and China into hazelnut production exemplifies this trend.

Table 1. The countries producing the most hazelnuts in the World (2022).

Countries	Import Quantity (tonnes)	Countries	Import Value ($)
Germany	69 493	Germany	484 964 426
Italy	58 163	Italy	375 986 506
France	23 068	France	152 327 672
Canada	17 419	Canada	121 868 984
Switzerland	9 627	Brazil	73 864 055
Brazil	7 949	Switzerland	64 181 739
Holland	5 469	Poland	45 011 606
Poland	5 211	Holland	37 716 626
Austria	3 320	Austria	23 154 370
Belgium	2 838	Belgium	20 476 157
Others	22 092	Others	232 770 897
World	224 648	World	1 632 323 038

Table 2. Top ten countries in world export quantity and export value (2022).

Countries	Export Quantity (tonnes)	Countries	Export Value ($)
Turkey	153 678	Turkey	995 330 274
Holland	26 059	Chile	231 925 106
Azerbaijan	21 947	Italy	185 781 832
Italy	21 617	Azerbaijan	119 555 427
Georgia	13 167	USA	99 078 251
USA	12 552	Georgia	74 188 441
Germany	7 542	Germany	59 352 976
Czechia	1 005	Holland	43 885 353
Spain	943	Czechia	6 955 466
Armenia	905	Spain	6 687 167
Others	8 154	Others	29 627 236
World	267 569	World	1 852 367 529

In 2022, Turkey ranked first globally in hazelnut exports with an export volume of 153,678 tons. The Netherlands and Germany, despite having no domestic production, are among the top ten countries in export volume and value due to their role as re-export hubs. Globally, the total hazelnut export volume reached 267,596 tons, with an export value of $1,852,367,529.

Germany ranks first globally in both hazelnut import volume and export volume. Germany is followed by Italy, France, Canada, and Switzerland. Except for Italy and France, the other countries do not hold a significant share in hazelnut production, yet their prominent role in imports indicates their re-export activities and a more active involvement in the hazelnut market. Re-export is a form of international trade in which a country exports previously imported goods without changing them. With the re-export method, the above-mentioned countries can determine the market prices for hazelnuts themselves. For this reason, the international market prices of hazelnuts are mostly determined in European stock exchanges. Globally, the total hazelnut import volume amounted to 224,648 tons, with an import value of $1,632,323,038.

Numerous studies have been conducted on hazelnut prices. Özer and Yavuz (2014) used the Box-Jenkins model to forecast hazelnut prices. Şeyranlıoğlu (2022) detailed the relationship between hazelnut prices and exchange rates. Bayyurt and Deveci Kocakoç (2023) employed the NARX technique of artificial neural networks to predict hazelnut production volumes, while Kara (2024) attempted to forecast hazelnut prices in Turkey using artificial neural networks. Bülbül and Tanrıvermiş (1999) examined traditional and organic hazelnut production and export potential in Turkey, linking stock increases to production growth and low domestic and foreign demand. Based on their findings, they proposed recommendations for restructuring hazelnut production and marketing policies. Sarımeşeli and Aydoğmuş (2000) aimed to develop policy alternatives for the global hazelnut market using data from the 1967–1985 period, applying a quadratic programming model. Their results assessed the potential impacts of alternative policies on producer welfare in Turkey.

Table 3. Top ten countries in world import quantity and import value (2022).

Countries	Import Quantity (tonnes)	Countries	Import Value ($)
Germany	69 493	Germany	484 964 426
Italy	58 163	Italy	375 986 506
France	23 068	France	152 327 672
Canada	17 419	Canada	121 868 984
Switzerland	9 627	Brazil	73 864 055
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Belgium	2 838	Belgium	20 476 157
Others	22 092	Others	232 770 897
World	224 648	World	1 632 323 038

Reference: FAOSTAT, 2024

Yavuz et al. (2004) carried out a study aiming to provide alternative policies to solve the problems of hazelnut sector in Turkey. In this study, a model was developed for the current situation and problems of the hazelnut sector and applied using the least squares method. Bayramoğlu and Gündoğmuş (2007) analyzed the Dynamics of the World hazelnut market and investigated the effect of Turkey on price formation and price determinants in global markets. Using data for the period 1970-2004, they analyzed the variance decomposition, impulse-response function and Granger Causality tests. The findings of the analyses revealed that the position of countries own currencies against the dollar, the amount of hazelnut production in Turkey and the price of Fındık Tarım Satış Kooperatifleri Birliği (FİKSOBİRLİK) play a determinant role in determining the prices in the world hazelnut market. Usta (2007) examined the distribution of Turkey's hazelnut exports by market and product groups between 1996 and 2005. The findings revealed that the market structure of Turkey's hazelnut exports remained unchanged during this period. The study concluded with a recommendation to preserve surplus hazelnuts under suitable storage conditions and to take new steps toward product development. Erdal and Uzunöz (2008) investigated the causal relationship between hazelnut prices and exchange rates. They analyzed the relationship between Turkey’s hazelnut export prices, European stock market prices, and exchange rates for the period 1995–2007, applying Johansen cointegration and Granger causality tests. The results indicated a long-term relationship among these variables. Based on the findings, it was recommended that Turkey’s hazelnut export prices be made less susceptible to exchange rate uncertainties. Hatırlı et al. (2008) analyzed the price pass-through of hazelnuts from Turkey to Germany. Using monthly data from 1996–2006, the study applied a double-logarithmic model and the GARCH approach. The results attributed to the lack of price pass-through to hazelnuts being a storable product. Akal (2009) examined Turkey's shelled hazelnut exports using simple econometric methods and autoregressive moving averages. Models based on natural logarithms were developed, revealing that the exchange rate elasticity of shelled hazelnut exports was inelastic, while the export revenue elasticity of shelled hazelnut export volumes was elastic. The study predicted an increase in shelled hazelnut export revenues based on these models. Parlaktuna (2009) conducted an empirical study focusing on Turkey's hazelnut exports from 1980 to 2007. The analysis employed a two-stage least squares method and found no strong substitution relationship between hazelnuts and almonds. Additionally, production and stock levels were shown to have a negative impact on export prices. The study concluded that export prices are determined by supply dynamics in the market. Akseki (2012) analyzed price formation in the global hazelnut market and proposed alternative policies for Turkey. The study employed time series and panel data methods for econometric analysis. The results indicated that the purchasing prices set by FİSKOBİRLİK had a significant upward impact on global hazelnut prices. Uçar (2014) examined Turkey's hazelnut export demand during the 2001–2011 period, focusing on data from countries such as Germany, France, Belgium, Poland, Switzerland, Italy, and the Netherlands. Panel data analysis was applied, and the fixed-effects model was identified as the most appropriate approach for the analysis. The findings reveal that the export demand model satisfies the self-interest assumption but not the equal diffusion assumption. Çabaş (2017) examined the effects of hazelnut exports on foreign trade in the post-1990 period, focusing on the Sakarya province. The empirical analysis utilized data from 2004 to 2016 to explore causal relationships between hazelnut exports, Turkey's and Sakarya's GDP, and foreign trade. The study employed the Toda-Yamamoto causality test along with ADF, PP, and Vogelsang-Perron structural break unit root tests. The results revealed unidirectional causality from Turkey's total exports to Sakarya's hazelnut exports and from Sakarya's GDP to hazelnut exports, as well as a unidirectional causality relationship involving exchange rates. Kılıç and Turhan (2020) attempted to explain Turkey's hazelnut exports using the Box-Jenkins method and forecasted future export volumes. The study analyzed hazelnut export data from 1961 to 2018, employing the ARIMA model for projections. According to the findings, Turkey's hazelnut export volume was predicted to reach 162,000 tons in 2019 and 176,000 tons in 2023. Merdan (2024) investigated the factors influencing Turkey's hazelnut export demand using the ARIMA model. The study assessed the impacts of global hazelnut imports, unit prices, and Turkey's export unit prices from 2001 to 2021. The findings indicated that these variables were not significant determinants of Turkey's hazelnut exports. However, the study revealed that global hazelnut export volumes positively influenced Turkey's hazelnut exports.

Despite Turkey being the world's largest hazelnut producer and exporter, the dominance of countries like Germany and the Netherlands in the market due to re-export activities, as well as the increasing production in countries such as Chile, China, and the United States, make the future of Turkey's hazelnut prices and export volumes highly significant. The presence of hazelnut exchanges in Germany and Italy, and their role in determining global hazelnut prices, contributes to Turkey's hazelnut prices not being the primary determinant, despite its leading position in global production. The study examines the future projections of Turkey's hazelnut export unit prices, export value, and export volumes using the ARIMA model. The aim of the study is to analyze how Turkey's hazelnut prices will evolve in the future, and whether new entrants in the hazelnut export market will lead to any changes in Turkey's export volume.

2. Materials and Methods

The main material of the study consists of data obtained from FAOSTAT and UN Comtrade. Turkey hazelnut export quantity (tons), Turkey hazelnut export value ($) and Turkey hazelnut export unit price ($) data for the years 1961-2023 were used. There is no missing data in the series and no data transformation was performed.

The Augmented Dickey-Fuller (ADF) test developed by Dickey and Fuller (1981) and the Phillips-Perron (PP) test developed by Phillips and Perron (1988) are used to determine series trend to determine the stationarity of the series before constructing the ARIMA model.

The ARIMA model can achieve high accuracy rates in short-term forecasts (Akdağ, 2016). For this reason, forecasting is limited to three years to avoid a high margin of error in long-term forecasts. The most striking feature of SPSS in time series analysis is its ability to automatically determine forecasting techniques.

ARIMA is a widely used method in time series analysis and continues to be popular today (Akpınar, 2020). This method makes it possible to predict future trends by examining past data (Kutlar, 2006). SPSS is a frequently preferred software for modeling and data analysis and this software offers the opportunity to automate model an parameter selection processes, to check for seasonality, interruptions and missing data in the data set, and to display goodness-of-fit measures (R^2, RMSE, MAPE, MAE, BIC) (Eşidir & Metin, 2021).The estimated ARIMA models are evaluated based on criteria such as significance of parameter coefficients, constant R-Square, Normalized Bayes Information Criterion (BIC), Root Mean Square Error (RMSE), Mean Absolute Error (MAE) and Mean Absolute Percentage Eror (MAPE). In line with these criteria, the model with the lowest BIC, RMSE, MAE and MAPE values and the highest Constant R^2 value is considered the most appropriate model (Oni & Akanle, 2018; Çelik, 2019). To Show that a model has a successful forecasting performance, the MAPE value is expected to be below 10% and the p-value of the Ljung-Box Q test is expected to be greater than 5%. In addition, the lower the Normalized Bayes Information Criterion (BIC), the better the fit of the model to the series (Pankratz, 1983; Oğhan, 2010; Pektaş, 2013).

ARIMA Model is a combination of AR and MA models. The AR model uses observations from previous time periods to predict the value in the next time period. There may be a relationship between values in different periods. This relationship is called inter-variable correlation if the relationship changes in the opposite direction and a positive correlation if it changes in the same direction. Statistics-based metrics are used to calculate correlation. The AR (p) notation is expressed by equation (1) below.

$$X_t = c + \sum_{i=1}^{p} \varphi_i X_{t-1} + \varepsilon_t \tag{1}$$

In equation (1), c is a constant coefficient. The time series is denoted by X_t and the integer index of the time series is denoted by t. The parameter values of the AR model are denoted by φ_i . P is the number of lags of the model and ε_t is the constant variance error term with zero mean. The MA model is called a Rolling or moving average. For use in data analysis, different subsets, if any, calculate the average of other subsets (Kaya et al., 2020).

$$X_t = \mu + \varepsilon_t \sum_{i=1}^{q} \theta_i \varepsilon_{t-i} \tag{2}$$

μ in equation (2) denotes the mean of the series in the model. The value of the moving average is denoted by θ_i and the order of the average is denoted by q. X_t denotes the time series. The error terms are denoted by ε_t and ε_{t-i} (Kaya et al., 2020). ARIMA both linearly models the next step from the previous steps and combines AR and MA models. In addition, it makes the sequence stationary by combining the preprocessing step. This precess is called integration and is expressed by the following equation (Kaya et al., 2020).

$$X_t = \frac{(1+\sum_{i=1}^{p} \theta_i L^i)\varepsilon_t}{(1-\sum_{i=1}^{p} \emptyset_i L^i)(1-L)^d} \tag{3}$$

The lag operatör used in equation (3) is denoted by L. The Parameter value in the autoregressive model is denoted by Ø, while the parameters of the moving average model are denoted by θ_i. X_t represents the time series, while the error terms are denoted by ε_t (Kaya et al., 2020). The ARIMA (p,d,q) model uses three main variables as input parameters. Among these variables, p represents the number of lags, d represents the degree of differencing and q represents the moving average window size. However, first the time series must be stationary, in which case d=1 is chosen. One of these methods is to examine the autocorrelation function (ACF) and partial autocorrelation function (PACF) graphs. These plots are used to determine the number of AR and MA terms. The also provide information on trend and seasonality. The ACF shows the value of autocorrelation in a series and is important for understanding the relationship between past and current values. The ACF is known as the full autocorrelation function because it analyzes components such as trend, seasonality and noise. In non-stationary time series, the ACF plat shows a decreasing trend over time. The PACF shows the time-varying correlations between two data points and is used to determine the optimal number of terms in the AR model. This number of terms is also a parameter that determines the degree of the model (Akçay, H., Yıltaş-Kaplan, D., 2024).

In the study, the ARIMA model was used for the forecasts of all variables and annual data and three-year (2024, 2025 and 2026) forecast values were analyzed.

3. Results and Discussion

The data set in the study consists of hazelnut export unit price, export quantity and export value. The names of the variables are coded for ease of analysis. Turkey Hazelnut Export Unit Price is coded as THEUP, Turkey Export Quantity (tons) as TEQ and Turkey Export Value ($) as TEV. In the study, Augmented Dickey-Fuller Test (ADF) and Phillips-Perron (PP) unit root tests were applied to test the stationarity of the series.

As mentioned in Equation (3), d=1 was chosen to make the series stationary while constructing the ARIMA model. Table 4 presents the ADF and PP unit root tests of the variables.

Table 4 shows that the series are stationary at different levels. Accordingly, while THEUP and TEV variables are non-stationary at level and constant, they are stationary at level and constant trend. The TEQ variable is stationary at both level and first difference. While all the series are stationary in the first difference, only the TEV variable does not Show stationarity in the ADF unit root test in the first difference but shows stationarity in the PP unit root test in the same first difference.

Figure 1 shows the forecast value, upper limit and lower limit of the unit price of hazelnut exports in Turkey. While forming the unit price between 1961-2023, forecasting was made from 2024 onwards. Except for 1979, the export unit price, which has followed a stable course since 1961, showed a significant increase in 2005 and then followed a fluctuatin graph. During this period, FISKOBIRLIK, the cooperative organization of which hazelnut producers are members, was unable to make payments for some of the products purchased in 2005 and 2006 and faced a financial crisis. This led to a sharp increase in hazelnut prices. As a result of the economic and social problems experienced by producers, the Toprak Mahsulleri Ofisi (TMO) decided to purchase surplus hazelnuts on behalf of the state. After this process, which lasted until 2012, hazelnut prices were left to free market conditions again (Özcüre, 2012). Starting in 2005, price fluctuations continued until 2023.

Table 5 presents the ARIMA (1,2,1) model of Turkish hazelnut export unit price and future forecasts. In the tests for the validity of the model, the R^2 value of the model was found to be 0.787. Since the Ljung-Box Q value is greater than 5% (0.085), it is determined that the model is compatible with the data. The mean absolute percentage error (MAPE) value is 16%, which is between 10% and 20%, indicating that the model has a good level. The normalized BIC (Bayes Information Criterion) was 14.287. As a result of all these tests, Turkey's hazelnut export unit price is predicted to be 6 639,20 $/ton ,n 2024, 6 750,67 $/ton in 2025 and 6 859,97 $/ton in 2026. Accordingly, it can be said that Turkey's hazelnut export unit price will continue its upward trend since 2022.

Figure 2 shows the forecast value, upper limit and lower limit of the projection for Turkey's exports (tons). Since 1961, there has been an increase in the amount of exports, but it still follows a fluctuating course with the increase. The most important reason for this fluctuation is the periodicity effect observed in hazelnut production. In Table 6, the ARIMA (1,2,1) model of Turkey's export volume (tons) and future forecasts are given. In the tests for the validity of the model, the R^2 value of the model was found to be 0.644. The Ljung-Box Q value was found to be 0.189 and since it was greater than 5%, it was determined that the model was compatible with the data. The mean absolute percentage error (MAPE) value is 14%, which is between 10% and 20% indicating that the model is good. The normalized BIC (Bayes Information Criterion) is 20,220. As a result of all these tests, Turkey's export volume (tons) is projected to be 162 433 tons in 2024, 157 819 tons in 2025 and 158 039 tons in 2026. It is estimated that the amount of exports is in line with the general course of the series and that after 2024, there will be a decline in 2025 and then increase again.

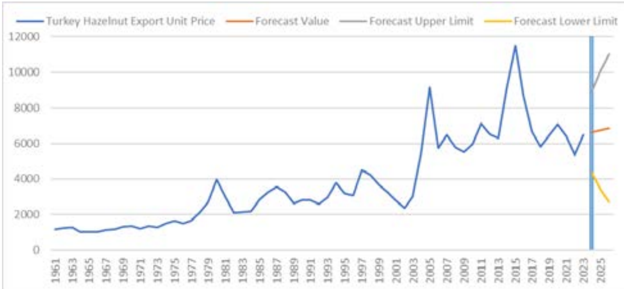

Figure 1. Turkey hazelnut export unit price data and future forecasts

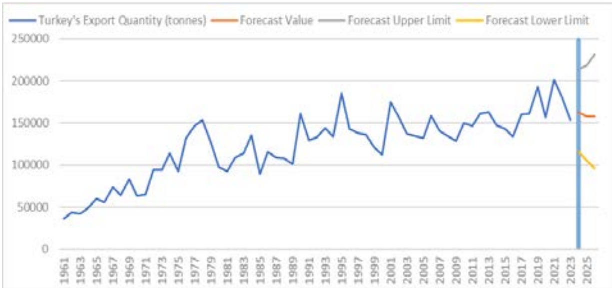

Figure 2. Turkey's export quantity (tonnes) data and future forecasts

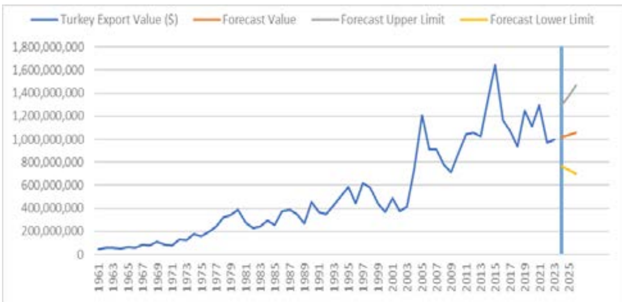

Figure 3. Turkey export value ($) data and future forecasts

Table 4. ADF and PP unit root tests

		Variables	ADF	PP		Variables	ADF	PP
Level	Intercept	THEUP	-1.7852	-1.5881	*1st difference*	THEUP	-7.3379***	-17.0975***
		TEQ	-2.9424**	-2.6908*		TEQ	-11.6752***	-19.7816***
		TEV	-1.4873	-1.2783		TEV	-1.7107	-20.9589***
	Trend and intercept	THEUP	-4.5350***	-3.5704**		THEUP	-7.2721***	-16.8304***
		TEQ	-4.9844***	-4.9844***		TEQ	-11.6352***	-25.9573***
		TEV	-3.9438**	-3.8150**		TEV	-1.2788	-20.5530***

Table 5. ARIMA (1,2,1) results for Turkey hazelnut export unit price

Turkey Hazelnut Price	2024			2025			2026
Forecast Value	6 639.20			6 750.67			6 859.97
Forecast Upper Limit	8 920.38			10 092.99			11 025.65
Forecast Lower Limit	4 358.02			3 408.34			2 694.29
Model	Constant R^2	R^2	RMSE	MAPE	MAE	Normalize BIC	Ljung-Box Q (Sig.)
	0.475	0.787	1144.002	16.322	727.422	14.287	0.082

Table 6. ARIMA (1,2,1) results for export quantity (tonnes)

Export Quantity (tons)	2024			2025			2026
Forecast Value	162 433			157 819			158 039
Forecast Upper Limit	213 600			218 333			231 595
Forecast Lower Limit	116 717			105 001			95 591
Model	Constant R^2	R^2	RMSE	MAPE	MAE	Normalize BIC	Ljung-Box Q (Sig.)
	0.683	0.644	22227.949	14.342	17260.389	20.220	0.189

Table 7. ARIMA (1,1,0) results for export value ($)

Export Value ($)	2024			2025			2026
Forecast Value	1 014 954 574			1 036 040 574			1 056 728 305
Forecast Upper Limit	1 291 938 847			1 374 163 654			1 467 071 244
Forecast Lower Limit	763 859 756			735 122 921			699 179 261
Model	Constant R^2	R^2	RMSE	MAPE	MAE	Normalize BIC	Ljung-Box Q (Sig.)
	0.448	0.936	106623541.8	14.780	77047442.63	37.302	0.510

The timeline of Turkey's export value ($) is given in figure 3. Since 1961, the value of exports has followed a normal course, while in 2005 it increased with an increase similar to the export unit price and it can be said that it fluctuates. Table 7 presents the ARIMA (1,1,0) model of Turkey's export value ($) and future forecasts. For the validity tests of the model, the R^2 value of the model was found to be 0.936. The Ljung-Box Q value was found to be 0.510 and since it was greater than 5%, it was determined that the model was compatible with the data. The mean absolute percentage error (MAPE) value is 14%, which is between 10% and 20%, indicating that the model has a good accuracy level. The normalized BIC (Bayes Information Criterion) is 37,302. As s result of all these tests, Turkey's export amount (tons) is predicted to be 1 014 954 574 USD in 2024, 1 036 040 574 USD in 2025 and 1 059 728 305 USD in 2006. It can be said that the export value will continue the upward trend that it has achieved in 2022 for three years. Even if the amount of hazelnut production and exports fluctuate slightly for the next 3 years, the hazelnut export unit price continues its upward trend. This shows that hazelnut prices are not affected much by small changes in supply and that the stock exchanges are dominant over prices.

4. Conclusion

Hazelnut is a strategic agricultural product for Turkey and has a great importance in terms of both economic and international trade. For this reason, future projections of hazelnut foreign trade are important. Turkey's leading position in the World and the continuation of this position in the coming years in an increasingly competitive environment is important in terms of dominating the market. However, as mentioned before, although Turkey is the leading exporter in the market, it does not have a say in the stock market prices. Projections made with the ARIMA model show that Turkey's hazelnut export unit price will be in an increasing trend between 2024 and 2026. Accordingly, hazelnut export unit price is expected to reach 6 639,20 $/tons in 2024 and 6 859,97 $/tons in 2026. Although the export amount follows a fluctuating course, it is expected to reach 162 433 tons in 224 and 158 039 tons in 2026. Turkey's hazelnut export value will continue to increase in the same period and is estimated to reach 1 059 728 305 USD by 2026. Different policies created over the years, acting with government policy instead of state policy have led to the formation of different problems in hazelnut in different periods. The excess supply caused by the rapid increase in hazelnut areas and the rise in hazelnut prices in 2005 are examples of this. For this reason, it can be said that sudden price changes can be prevented with fixed production planning and need-oriented agricultural policies. This situation causes the hazelnut price to play a more active role especially in European-based stock exchanges. The same care shown to produce hazelnuts should also be applied to the market structure, and hazelnut prices should be organized by the producing country within the framework of free competition conditions through the stock exchanges established in Turkey. These findings show that although Turkey maintains its leading position in the world hazelnut market, it needs to develop more careful strategies against increasing international competition conditions and fluctuations in the domestic market. Turkey should both invest in production technologies and diversify its export markets to ensure sustainable growth in hazelnut production and exports. In addition, measures should be taken against Halyomorpha Halys, which has caused serious damage to hazelnuts in recent years. The pest, which significantly reduces the yield rate in hazelnuts, affects the production of quality hazelnuts, and this problem has the potential to damage the value of hazelnuts produced in Turkey in the international market.

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Conflict of interest

The authors declare no conflicts of interest.

Authorship contribution statement

K.K and A.Ç: The authors declare that they have contributed equally to the article.

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