RESEARCH ARTICLE

Analysis of Correlation of Pistachio Production and Income with the Koyck Models in Turkey

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ABSTRACT

In this research, we aimed to determine the correlations between pistachio production and producer income in Turkey. All producers make a decision looking at price levels 2.7 years ago. Pistachio production was effected from the lagged value of average price. We used the Koyck model at the calculation of lagged value. At this model, pistachio production (dependent) and pistachio prices (independent) were taken into consideration as variables between 1980 and 2019. Previously calculated elasticities of supply and demand were used in calculating the change in future producer income. According to calculations, it was estimated that there will be a decrease of 0.01% to 32.28% in the producer income between 2020-2023.

Introduction

The homeland of the pistachio (*Pistacia vera L.*), the formation and growth center of its culture varieties and the most important gene pool is the Near-East Region, which includes the high parts of Asia Minor, the Caucasus, Iran, and Turkmenistan (Ayfer 1990). In Turkey, it is intensively cultivated particularly in Gaziantep, Şanlıurfa, Adıyaman, Siirt and Kahramanmaraş provinces. In recent years, there is pistachio cultivation also in Aydın and İzmir provinces, although to a lesser extent (Aksoy, 2002). The composition of pistachio contains on average 53.2% fat, 19.6% protein, 19.0% carbohydrate, 5.6% water, and 2.6% ash (Rastgeldi, 2015). It has been used extensively in the dessert sector in recent years. In addition to being consumed in the dessert sector, pistachio is mostly used as an appetizer (dried or roasted salted), and in the pharmacy sector (Gezginç and Duman, 2004).

Turkey, which has an important share in world pistachio production, ranks third after Iran and America.

Thanks to its precious fruits, pistachio provides great profits to its producer, whereas it is a world-renowned important phytonutrient. It is a popular product especially in the Middle East countries where it grows as its homeland. An average 90% of the world's total pistachio production is produced by Iran, the USA, and Turkey (FAO, 2020).

In Turkey, particularly the Southeastern Anatolia Region has an important place in terms of pistachio production. It is one of the favorite products that farmers grow in the Southeastern Anatolia Project (GAP) region, where the most fertile land in Turkey is located, especially in the provinces of Şanlıurfa, Gaziantep and Siirt (Eldoğan and Şahin, 2015). Although Turkey has favorable ecological conditions and lands for pistachio cultivation, due to the fact that cultivation in Turkey is carried out in dry conditions, there is a significant fluctuation in the production amount of pistachios, which has a tendency to periodicity, from year to year (Ertürk et al., 2015).

When the studies in the literature are examined, it is seen that there are studies on the production cost and economic analysis of pistachio (Dilmen, 1976; Janis and Mohn, 1997; Şen and Sandal, 2015; Sandal and Yurddaş, 2019; Temel and Aksoy 2020). It was found that there are many studies

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examining the production-price relationship using the Koyck model in Turkey. The Koyck model was used in the analyses of following relationships by following researchers: the relationship between cotton production and cotton prices between 1985-1997 (Yurdakul (1998)); the relationship between tobacco production and its price in the period 1982-2003 (Eraktan et al. (2004)); tomato production-price relationship in the period 1975-2004 (Erdal (2006)), the relationship between wheat production and its price by (Özçelik and Özer (2006)); potato production-price relationship (Doğan et al. (2014)); and production-price relationship in sheep milk production (Çelik (2015)).

Within the scope of the study, it was aimed to know the relationship between production and price in the pistachio sector, which has an important share in Turkey's economy, to determine the lag in the time of reflection of the change in price to supply and to estimate the future producer income.

Materials and Methods

The data used in the Koyck model were obtained from the database of the Turkish Statistical Institute (TSE). A single source was chosen as the data set to ensure consistency between variables. In the model, all variables that could have an impact on the pistachio sector between 1980 and 2018 were taken into account. Because it creates a trend on the price variable, real prices are used by clearing prices from inflation.

In the study, all outputs that can be made with the current data set are tried to be obtained. In this context, on the other hand, the Koyck model results were run for forecasting purposes and the outputs obtained were given below. In order to create the Koyck model, among the considered lag length Schwartz (SC) criterion data, the lagged value of the pistachio price is needed. In order to determine the lag length in the model, the Schwartz lag length criterion (Schwartz 1978) was used (Yurdakul 1998; Dikmen 2005; Özçelik and Özer 2006). Accordingly, the Koyck model and mean lag length are as follows;

$$Y_t = \alpha + \beta_0 X_t + \beta_1 X_{t-1} + \beta_2 X_{t-2} + \ldots + u_t$$
$$\text{Mean lag} = \lambda/(1-\lambda)$$

Results and Discussion
General Information on Pistachio Sector

Considering the production, planting areas, and yield in the pistachio sector, we revealed the change in the sector by years. When the pistachio production shares are examined by continents, it is seen that the highest production belongs to the Asian continent with an average share of 70%, and it is followed by the American continent with an average share of 27%. It was found that the production in other continentals is scarcely any (Table 1).

Table 1. Pistachio production by continents

Years	Africa	America	Asia	Europe	World
2001	0.5	24.7	70.8	4.0	100.0
2002	0.3	26.5	71.0	2.2	100.0
2003	0.5	11.4	85.8	2.2	100.0
2004	0.6	35.6	61.3	2.5	100.0
2005	0.5	24.9	72.2	2.4	100.0
2006	0.4	16.2	81.7	1.5	100.0
2007	0.4	25.2	72.8	1.5	100.0
2008	0.5	24.0	73.0	2.1	100.0
2009	0.5	29.1	68.0	2.3	100.0
2010	0.4	33.0	64.7	1.9	100.0
2011	0.5	32.3	64.7	2.2	100.0
2012	0.4	36.3	61.6	1.5	100.0
2013	0.6	31.4	65.9	1.9	100.0
2014	0.5	26.3	71.3	1.7	100.0
2015	0.7	14.8	82.4	2.0	100.0
2016	0.5	31.5	66.2	1.6	100.0
2017	0.5	23.9	73.4	2.0	100.0
2018	0.4	32.5	65.5	1.5	100.0

Source: (FAO, 2020).

According to the data of the United Nations Food and Agriculture Organization (FAO), the country that is the leader in pistachio production in the world as of 2018 is Iran. Amirteimoori and Chizari (2008) determined that Iran has a comparative advantage in the pistachio industry. America, where modern techniques are used, has become a rival to Iran by constantly increasing the amount of production. Despite its fluctuating production structure, Turkey with its intense periodicity ranks third after these countries (Table 2).

Table 2. Pistachio production shares by countries (%)

Years	Iran	USA	Turkey	China	Syria	Greece	Italy	Others	World
2001	38.0	24.7	10.1	8.8	12.7	3.2	0.6	1.8	100.0
2002	48.0	26.5	6.8	5.4	10.2	1.7	0.4	1.1	100.0
2003	49.8	11.4	19.0	6.3	10.1	1.7	0.4	1.3	100.0
2004	41.8	35.6	6.8	7.2	4.8	1.8	0.5	1.5	100.0
2005	44.6	24.9	11.6	6.6	8.7	1.7	0.5	1.4	100.0
2006	48.1	16.2	16.5	5.4	11.0	1.2	0.2	1.3	100.0
2007	50.4	25.2	9.8	5.1	6.9	1.1	0.4	1.1	100.0
2008	31.4	24.0	22.9	7.6	10.0	1.6	0.4	2.1	100.0
2009	33.2	29.1	14.8	8.1	11.1	1.5	0.6	1.7	100.0
2010	30.1	33.0	17.8	8.1	8.0	1.1	0.4	1.5	100.0
2011	25.2	32.3	17.9	11.9	8.9	1.3	0.5	2.1	100.0
2012	24.1	36.3	19.8	9.5	7.5	1.1	0.1	1.7	100.0
2013	33.1	31.4	13.0	10.9	8.0	1.0	0.5	2.0	100.0
2014	49.8	26.3	9.0	8.7	3.2	1.0	0.4	1.6	100.0
2015	51.9	14.8	17.4	9.0	3.5	1.2	0.5	1.9	100.0
2016	44.6	31.5	13.2	5.8	2.2	0.9	0.3	1.6	100.0
2017	57.0	23.9	6.8	6.6	2.5	1.0	0.3	1.8	100.0
2018	40.1	32.5	17.4	5.4	2.1	0.6	0.3	1.5	100.0

Source: (FAO, 2020)

In Turkey, pistachio production is widely carried out in the Southeastern Anatolia Region. According to the average of 2001-2019, 88% of pistachio production is provided from Gaziantep, Şanlıurfa, Adıyaman, Siirt, Kahramanmaraş and Kilis provinces (Table 3).

Table 3. Pistachio production shares by provinces (%)

Years	Gaziantep	Şanlıurfa	Adıyaman	Siirt	Kahramanmaraş	Kilis	Others	Turkey
2001	25.2	30.3	3.2	7.1	8.3	2.3	23.6	100
2002	24.2	34.4	3.2	5.7	9.6	2.1	20.8	100
2003	40.3	33.1	7.7	2.4	5.4	1.1	10.1	100
2004	16.3	27.1	5.7	7.4	13.2	1.7	28.6	100
2005	34.0	31.7	4.8	3.6	8.8	2.0	15.2	100
2006	43.4	38.3	2.6	2.2	4.7	0.6	8.1	100
2007	49.6	18.5	11.8	3.3	4.4	1.2	11.1	100
2008	39.7	37.6	6.4	4.3	2.8	0.9	8.3	100
2009	50.2	17.0	6.0	14.1	3.7	1.1	8.0	100
2010	41.1	30.4	8.5	8.7	3.4	1.2	6.8	100
2011	32.9	32.7	8.3	11.3	4.4	1.2	9.3	100
2012	37.5	32.8	4.8	11.7	3.3	1.2	8.8	100
2013	11.2	34.5	9.5	21.3	5.9	3.5	14.0	100
2014	21.5	26.9	12.1	19.0	3.0	2.9	14.4	100
2015	36.9	33.2	10.7	7.8	1.5	1.6	8.3	100
2016	44.3	28.3	11.0	3.9	3.6	1.3	7.5	100
2017	18.9	36.5	13.4	10.2	4.7	4.1	12.1	100
2018	37.6	41.7	10.0	4.7	1.6	1.8	2.6	100
2019	31.0	37.6	3.1	14.4	1.2	2.6	10.2	100

Source: (TÜİK, 2020)

Again, according to the average of the last five years, 96.8% of the pistachio planting areas are located in these six provinces. The highest increase in planting areas within the period examined is experienced in Siirt province with 465%, followed by Kahramanmaraş with 133% and Kilis with 122%. While Gaziantep province had the most planting area in 2001, it was seen that the most planting area in 2019 was in Şanlıurfa province (Table 4).

Table 4. Pistachio plantation areas by provinces (%)

Years	Gaziantep	Şanlıurfa	Adıyaman	Siirt	Kahramanmaraş	Kilis	Others	Turkey
2001	44.1	34.8	12.1	2.3	1.6	1.4	3.6	100
2002	43.9	34.7	12.2	2.2	1.6	1.5	4.0	100
2003	43.8	35.0	12.2	2.2	1.5	1.3	4.0	100
2004	44.0	35.0	12.1	2.4	1.5	1.4	3.6	100
2005	39.6	32.0	11.1	11.1	1.8	1.3	3.1	100
2006	39.9	31.9	11.0	11.3	1.4	1.3	3.1	100
2007	35.6	34.1	10.6	12.6	2.3	1.4	3.4	100
2008	35.7	34.4	10.5	12.2	2.5	1.4	3.3	100
2009	36.9	35.8	11.0	8.5	2.8	1.5	3.4	100
2010	37.5	35.0	10.6	9.3	2.8	1.4	3.4	100
2011	37.0	36.7	10.3	9.0	2.6	1.2	3.3	100
2012	45.9	30.9	8.6	8.3	2.4	1.2	2.8	100
2013	46.2	31.5	8.7	6.7	2.4	1.9	2.5	100
2014	46.0	31.3	8.8	6.8	2.4	2.1	2.6	100
2015	44.6	33.2	8.7	6.5	2.3	2.0	2.6	100
2016	42.6	36.0	8.3	6.3	2.1	2.1	2.5	100
2017	41.5	38.1	7.8	5.7	2.1	1.9	2.8	100
2018	38.5	39.3	7.4	8.0	2.1	1.8	2.9	100
2019	38.1	38.5	7.4	7.8	2.3	1.9	4.1	100

Source: (TÜİK, 2020)

Although there has been a decrease in pistachio planting areas between 2001-2019 in Turkey, our country has increased in general. In this process, the highest increase in planting areas occurred especially in recent years. This increase was realized in 2019 with an area of 3.662.103 decare (Figure 1). A significant increase in domestic demand in Turkey for pistachio particularly in recent years caused prices to rise. With the increase in domestic demand, this situation led to an increase in the number of pistachio orchards engaged in modern cultivation, especially in the

Southeastern Anatolia region. When Figure 2 is examined, it is striking that there is a periodicity-induced constant fluctuation in yield over the years. Looking at the general trend between 2001-2019, it can be said that there is an increase in yield although to a lesser extent.
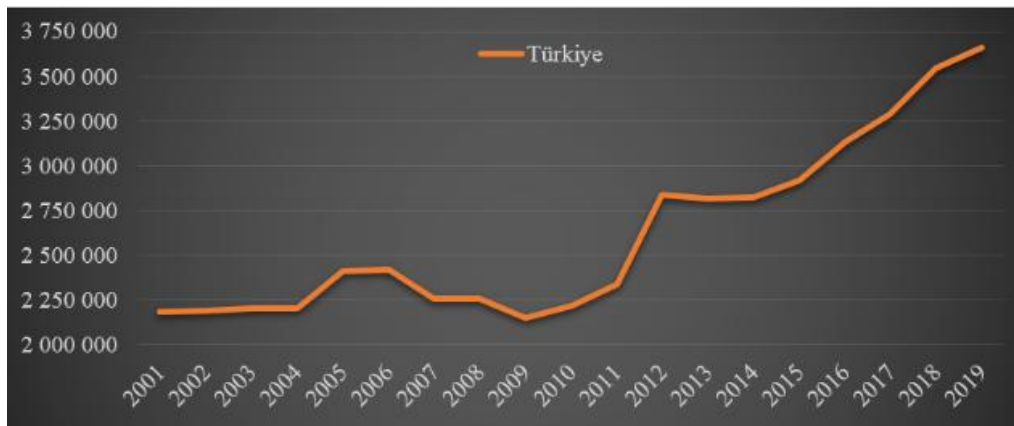

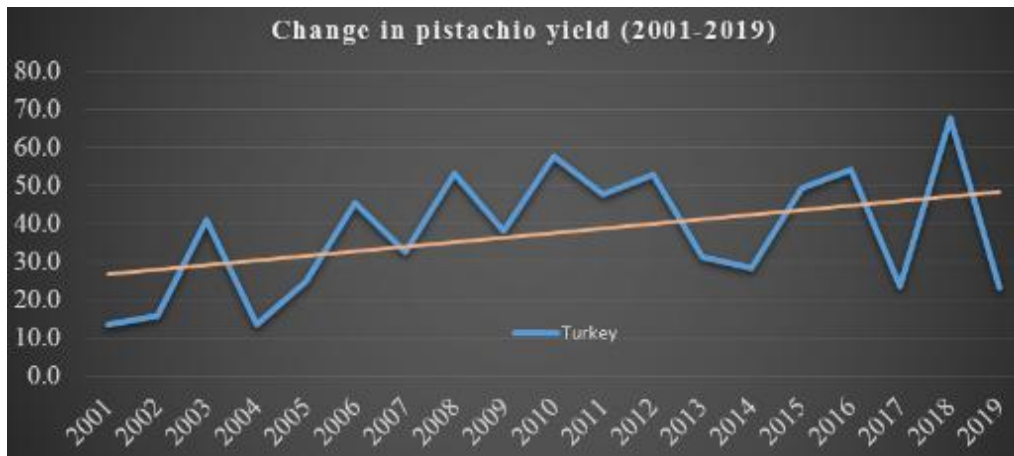**Figure 1.** Pistachio planting areas in Turkey (decare)

Figure 2. Pistachio yield in Turkey (kg/da)

The Koyck Model

Its Short-Run and Long-Run Effect

In the Koyck model, the pistachio price in the supply function was taken with a lag. Therefore, in the Koyck model, P_{t-1} was used instead of P_t (Table 5). The model has a 65%-expressiveness rate.

Table 5. Supply Function of the Koyck Model

Variables	Coefficient	Std. Error	T-Ratio
Constant	-57362.7	34807.4	-1.648
$RANF_{t-1}$	975309	283054	3.446***
ARZ_{t-1}	0.73469	0.10073	0.000***
R^2	0.653		
F(2, 33)	84.0111 P(F)=1.13e-13		
Rho	-0.2619		

When the Koyck model is written in equation form;

$$SUPPLY_t = a_0 + a_1 P_{t-1} + \lambda SUPPLY_{t-1}$$

Variables in the model:

$SUPPLY_t$: Pistachio production (TON)

P_t: Real producer prices of pistachio (TL/KG)

$SUPPLY_t = -57362.7 + 975309 P_{t-1} + 0.734694 SUPPLY_{t-1}$

Accordingly:

Correction rate (λ) = 0.73

Mean lag = $\lambda/(1-\lambda)$ = 0.73/(1-) = 2.70

Permanent effect (Median lag) = -log 2/log λ =-log 2/log 0.73 = 2.2

The mean lag is 2.70 years. Accordingly, to reflect the change in pistachio price noticeably on supply, it should take an average of 2.70 years. Adding 1 lag, a lag of 3.7 years is encountered. Here, the median lag to be 2.2 years means that it takes 2.2 years for 50% of the change in supply caused by a one-unit permanent change in price to occur. Here again, adding 1 lag can be said to be 3.2 years.

Since the Koyck model enables to calculate the long-run effect, the short-run effect of price on supply is the predictor of the price variable in the Koyck equation. Accordingly, the short-run marginal effect of price on supply is 975309. Its long-term effect, on the other hand, is as follows:

$$b_1[1/(1-\lambda)] = 975309[1/(1-0.73)=3612255.6.$$

In terms of future producer income forecast, % change elasticities in the equilibrium price of pistachio for 2020 are calculated as follows, by taking from Aksoy (2002):

Elasticity of supply: 0.66

Elasticity of demand: -0.35 -> 0.35

In 2020, supply increased by 58% compared to the average supply of the last 10 years. Accordingly, the % change in the equilibrium price of pistachio can be measured as follows:

$$\% \text{ change in equilibrium price} = -\frac{\% \text{ change in supply}}{E_s + E_D}$$

$$\% \text{ change in equilibrium price} = -\frac{0.58}{0.66 + 0.35} = -0.57$$

So, it is understood that the equilibrium price of pistachio will decrease by 57% (Miran, 2018).

Change in Producer Income

A 57% decrease in the price of pistachio means that the price fell from 1 to 0.43.

So if P_0 is the introductory price and P_1 is the new price, then:

$$P_1 = (1-0.57)P_0$$
$$P_1 = 0.43 \times P_0$$

If Q_0 is the introductory supply and Q_1 is the new supply, since supply increases by 58%, then:

$$Q_1 = 1.58 \times Q_0$$

Producer income was initially as:

$$TR_0 = P_0 \times Q_0$$

After the new case in supply and price, producer income will be around:

$$TR_1 = P_1 \times Q_1$$

In TR_1 when we place P_1 and Q_1:

$$TR_1 = 0.43P_0 \times 1.58Q_0$$
$$TR_1 = 0.6794 \times P_0\, Q_0$$
$$TR_1 = 0.6794 \times TR_0 = \%67.94\ TR_0$$

As can be seen, in the new case, the producer gets 67.94% of his previous income. In other words, producer income has fallen by about 32%. Table 6 shows similar calculations for the years 2020-2023. As a result of the above calculations, it draws attention that there will be a continuous decrease in the producer income of pistachio.

Table 6. Change in producer income of pistachio for the years 2020-2023

Year	Forecast	Increase in supply compared to the average of the last 10 years (%)	Decrease in equilibrium price (%)	New price level (%)	Change in producer income (%)
2020	201037	58.00	57.1	42.86	-32.28
2021	129839	2.04	2.0	97.99	-0.01
2022	192363	51.18	50.4	49.57	-25.05
2023	146061	14.79	14.6	85.43	-1.94

Conclusion

As a result of the study, it is seen that there has been a continuous increase in pistachio plantation area and yield in recent years. According to the Koyck model result, it was seen that the signs of the coefficients belonging to the variables used in the model were significant and they were statistically significant. The short and long-run effects were calculated using the Koyck model. It was concluded that accordingly, it takes an average of 2.70 years for the change in the price of pistachio to be reflected in the supply significantly.

In the projection of income, depending on the periodicity and with the fluctuation in production, it is estimated that the equilibrium price will decrease by 2% to 57% between 2020-2023 and as a result, there will be a decrease of 0.01% to 32.28% in the producer income. Analyzes show that domestic consumption will not be sufficient to meet the increasing supply in the pistachio sector in recent years. In order to prevent damage to the Southeastern Anatolia producers who live off by this sector, policymakers are required to develop policies to increase almost negligible exports of Turkey, which ranks third in production.

Authors' Contributions

ÜA: Colected the data set and wrote the itroduction

AA: Plannig the paper, deign of the econometric model and the writing of results.

Conflict of Interest

The authors have no conflict of interest.

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