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The Analysis of the Relation between Production and Price in Sunflower by Koyck Model

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Abstract

Purpose: The sunflower supply deficit in Turkey is met by imports. Therefore, sunflower production should be increased. In this research, it is aimed to explain the relationship between sunflower production and price in Turkey with the Koyck model.
Design/Methodology/Approach: Distributed Lagged Koyck Model was applied to reveal the relationship between sunflower production and price. At this stage, data for the period 2000-2020 (21 years) were used. A model was developed by Koyck in order to eliminate drawbacks in distributed lag models. Based on the assumption that the independent variable lags affect the dependent variable with a certain weight and that the lag weights decrease geometrically in the Koyck model, the regression equation is estimated by making the model reduced.
Findings: The 10% increase in the sunflower price in the current year is expected to increase the production amount one year later by 2.06% and the production amount two years later by 1.22%. The results show that the change in the lagged values of prices has a positive effect on production and this effect is gradually decreasing.
Originality/Value: Sunflower production is also affected by the lagged value of the average price in the market. The Koyck model is a suitable model to reveal these lagged values. Thanks to this model, which is used to measure the lagged effects of the price variable in successive periods in terms of production, it will be able to shed light on the effective policies that can be applied for sunflower production.
Key words: Sunflower growing, sunflower marketing, Koyck model, distributed lag model.

Ayçiçeğinde Üretim ve Fiyat Arasındaki İlişkinin Koyck Modeli ile Analizi

Özet

Amaç: Türkiye'de ayçiçeği arz açığı ithalatla karşılanmaktadır. Bu nedenle ayçiçeği üretiminin arttırılması gerekmektedir. Bu araştırmada, Türkiye'de ayçiçeği üretimi ve fiyatı arasındaki ilişkinin Koyck modeli ile açıklanması amaçlanmaktadır.
Tasarım/Metodoloji /Yaklaşım: Ayçiçeği üretimi ve fiyatı arasındaki ilişkiyi ortaya koymak için Dağıtılmış Gecikmeli Koyck Modeli uygulanmıştır. Bu aşamada 2000-2020 dönemine (21 yıl) ait veriler kullanılmıştır. Gecikmesi dağıtılmış modellerdeki sakıncaları gidermek için Koyck tarafından bir model geliştirilmiştir. Koyck modelinde bağımsız değişken gecikmelerinin bağımlı değişkeni belirli bir ağırlıkla etkilediği ve gecikme ağırlıklarının geometrik olarak azaldığı varsayımından hareketle, model indirgenmiş hale getirilerek regresyon denklemi tahmin edilmektedir.
Bulgular: Cari yılda ayçiçeği fiyatındaki %10'luk artışın üretim miktarını bir yıl sonra %2.06, iki yıl sonra ise %1.22 artırması beklenmektedir. Sonuçlar, fiyatların gecikmeli değerlerindeki değişimin üretim üzerinde olumlu bir etkiye sahip olduğunu ve bu etkinin giderek azaldığını göstermektedir.
Özgünlük/Değer: Ayçiçeği üretimi de piyasadaki ortalama fiyatın gecikmeli değerinden etkilenmektedir. Koyck modeli bu gecikmeli değerleri ortaya çıkarmak için uygun bir modeldir. Fiyat değişkeninin üretim açısından ardışık dönemlerdeki gecikmeli etkilerini ölçmek için kullanılan bu model sayesinde ayçiçeği üretimi için uygulanabilecek etkin politikalara ışık tutulabilecektir.
Anahtar kelimeler: Ayçiçeği yetiştiriciliği, ayçiçeği pazarlaması, Koyck modeli, gecikmesi dağıtılmış model

1.INTRODUCTION

Oilseeds have an important place in the nutrition of humans and animals by being used as raw materials in various fields such as food, feed and energy sector due to the high oil, protein, carbohydrate and various mineral substances they contain (Arıoğlu, 2016; Kadakoğlu and Karlı, 2019; Kıllı and Beycioğlu, 2019; Aydın Can et al., 2021; Gündüz, 2021). When it comes to oilseed plants around the world; soybean, sunflower, peanut, rapeseed, sesame, safflower, olive, corn, palm seed, coconut, oil flax and castor oil plants are understood (Kadakoğlu and Karlı, 2019; Semerci and Durmuş, 2021).

The homeland of sunflower, one of the most important oil crops of today, is known as North America. B.C. it started to be produced in the 3000s. It was grown as an ornamental plant in gardens in Spain in the 1500s. As an oil plant of sunflower, it was first produced in Russia and then spread all over Europe. After the World War II, in the 1945-50s, sunflower entered our country thanks to the seeds brought by our citizens who immigrated to our country from Romania and Bulgaria and started to be cultivated. Its production, which first started in Thrace, then spread more or less all over Turkey. However, the main increase in production and cultivation area has been with the introduction of hybrids into our country after the 1980s. In addition, the sunflower plant is also known by the names of sunflower, solstice and sunflower in different regions of our country (Kaya, 2018; Meral, 2019; Tüfekçi, 2019).

According to United Nations Food and Agriculture Organization's (FAO) 2020 data, 50.5 million tons of sunflowers were produced in 27.7 million hectares of land in the world. Russia constituted 52% of the world production with 13.3 million tons and Ukraine with 13.1 million tons. Turkey had a share of 4.2% in the world in the same year with its production of 2.1 million tons. On the other hand, 20.6 million tons of sunflower oil was produced in the world in 2020. Turkey has a 5.3% share in world sunflower oil production (FAOSTAT, 2022).

Sunflower, one of the most important oil crops in the world, is also the oilseed plant with the largest cultivation area and production amount in Turkey, and the country obtains 53% of its vegetable oil need from sunflower (Meral, 2019; Yüksek, 2019; Semerci and Durmuş, 2021). Sunflower is an important oilseed plant variety that is also used in the production of foods such as pastry, chocolate, bread, cookies, in addition to its use in fields such as snack food and bird seed (Güler et al., 2017). The meal, which is 40-45% obtained as a by-product, contains 30-40% protein and is also used as a valuable feed in animal nutrition (Semerci and Durmuş, 2021). The high percentage of oil (40-55%) in sunflower seeds ensures that the amount of oil obtained from the unit area is high and the quality of sunflower oil is high; therefore, this high quality sunflower oil provides an increase in production demand (Altıntop and Gıdık, 2019; Meral, 2019).

According to Turkish Statistical Institute's (TURKSTAT) 2020 data, 1.9 million tons of oil sunflowers were produced in 650,870 hectares of land in Turkey, and 167,004 tons of sunflowers for snacks were produced on 77,983 hectares of land. In oil sunflower production in 2020; Tekirdağ (353,000 tons), Konya (278,000 tons), Kırklareli (226,000 tons), Edirne (240,000 tons) and Adana (195,000 tons) took the first place and constituted 68% of the production. In the same year, the average oil sunflower price received by the producer was determined as 4.39 TL/kg. Although Turkey exported 115,253 tons of sunflower oil in 2020, it imported 1.2 million tons in the same year.

Effective policies should be implemented in order for Turkey to become self-sufficient in sunflower production and to reduce imports. In the current practice, difference payment support is provided to farmers, and field-based input support is also provided. In many studies conducted to date, the effectiveness of these supports has been investigated, and the appropriateness of price or non-price methods has been discussed (Semerci et al., 2012; Semerci, 2013; Özüdoğru et al., 2015; Taşkaya Top and Özüdoğru, 2016; Türkekul et al., 2016; Konyalı, 2017; Berk, 2017; Abdikoğlu and Unakıtan, 2017; Doğan, 2018; Semerci ve Durmuş, 2021; Kadakoğlu and Yılmaz, 2022).

Due to reasons such as risks in agricultural production, lack of production plan and inadequacy of market organization, farmers generally consider the sales price formed in the previous period in the selection of the products they will produce. Making the production decision based on the price of the previous year causes fluctuations in the product quantity and price. Therefore, the effective factor that determines the equilibrium price of agricultural products is the amount of supply (Özçelik and Özer, 2006). Therefore, sunflower production is also affected by the lagged value of the average price in the market. The Koyck model is a suitable model to reveal these lagged values.

In this study, it is aimed to explain the relationship between sunflower production and price in Turkey with the Koyck model. Thanks to this model, which is used to measure the lagged effects of the price variable in successive periods in terms of production, it will be able to shed light on the effective policies that can be applied for sunflower production.

2.MATERIAL and METHODS

The main material of this research is the statistical data obtained from FAO and TURKSTAT. In addition, the results of previous studies on the subject were also used.

In the research, Distributed Lagged Koyck Model was applied to reveal the relationship between sunflower production and price. At this stage, data for the period 2000-2020 (21 years) were used. It is seen that similar number of years were used in many studies on plant production in which the Koyck model was created (Dikmen 2006; Çetinkaya, 2012; Doğan et al., 2014; Özbay and Çelik, 2016; Akgül and Yıldız, 2016; Hüsnüoğlu, 2018; Ağazade, 2021).

If the explanatory variables of a regression model containing time series include not only current values but also lagged values, such models are called distributed lag models. In this type of models, if the explanatory variable is given a finite value, they are called finite models, if not, they are called infinite models (Kutlar, 2007; Abdikoğlu and Unakıtan, 2014; Doğan et al., 2014; Çelik, 2015). The model with an infinite lag, that is, the backward length of the lag is not defined, is expressed as follows (Dikmen, 2006; Çetinkaya, 2012; Abdikoğlu and Unakıtan, 2014).

$$Y_t = \alpha + \beta_0 X_t + \beta_1 X_{t-1} + \beta_2 X_{t-2} + \ldots\ldots\ldots\ldots.. + u_t \quad (1)$$

A distributed k-lag model with a finite lag is given in the equation below.

$$Y_t = \alpha + \beta_0 X_t + \beta 1 X_{t-1} + \beta_2 X_{t-2} + \ldots. + \beta_k X_{t-k} + u_t \quad (2)$$

In this model, the dependent variable Y is affected not only by the present value (Xt) of the explanatory variable X, but also by the past values ($X_{t-1}, X_{t-2}, \ldots, X_{t-k}$). Most of the time, Y reacts to X after a while. This elapsed time is called the lag length (Dikmen, 2006; Özçelik and Özer, 2006; Çobanoğlu, 2010; Abdikoğlu and Unakıtan, 2014).

Model-specific estimation of distributed lag models can be made using the ordinary least squares method. (Alt, 1942; Tinbergen, 1949; Dikmen, 2006; Özçelik and Özer, 2006; Çobanoğlu, 2010; Çelik, 2015). However, this way of estimation has some drawbacks (Gujarati, 2001). One of these drawbacks is that there is no information in the model about how long the lag will be. Another drawback is that the variables determined as explanatory variables are in multicollinearity (Kılıçbay, 1983; Erdal, 2006; Abdikoğlu and Unakıtan, 2014).

A model was developed by Koyck in order to eliminate these drawbacks in distributed lag models (Koyck, 1954). Based on the assumption that the independent variable lags affect the dependent variable with a certain weight and that the lag weights decrease geometrically in the Koyck model, the regression equation is estimated by making the model reduced (Dikmen, 2006; Özçelik and Özer, 2006; Erdal and Erdal, 2008). In order to reach the reduced model, it is assumed that all β values have the same sign and these values decrease geometrically in an infinitely distributed model (Dikmen, 2006; Abdikoğlu and Unakıtan, 2014; Ağazade, 2021).

$$\beta_k = \beta_0 \lambda^k \qquad k = 0,1,2,\ldots.. \quad (3)$$

Here, λ ($0 < \lambda < 1$) is the rate of decrease or decrease of the distributed lag, and 1–λ is the rate of adaptation. βk is the value of the lag coefficient (Koyck, 1954; Dikmen, 2006; Abdikoğlu and Unakıtan, 2014; Özsayın, 2017). The closer the value of λ is to 1, the lower the rate of decrease in βk, and the closer λ is to zero, the faster the rate of decrease in βk. The average number of lags gives the weighted average of the lags as follows (Dikmen, 2006; Özçelik and Özer, 2006; Kutlar, 2007; Çobanoğlu, 2010; Güriş et al., 2017).

$$\text{Average lag} = \frac{\lambda}{1-\lambda} \quad (4)$$

The average number of lags indicates the time period required for a one-unit change in the independent variable X to have a noticeable effect on the dependent variable Y (Yurdakul, 1998; Özçelik and Özer, 2006; Abdikoğlu and Unakıtan, 2014; Çelik, 2014). According to these definitions, the following equation is reached to express the infinitely distributed model with lag.

$$Y_t = \alpha + \beta_0 X_t + \beta_0 \lambda X_{t-1} + \beta_0 \lambda^2 X_{t-2} + \ldots. + u_t \quad (5)$$

Linear regression analysis method cannot be applied to equation (5), because the model is infinite and λ coefficients are non-linear. The model was withdrawn by Koyck for a period and the following regression model was obtained (Dikmen, 2006; Abdikoğlu and Unakıtan, 2014).

$$Y_{t-1} = \alpha + \beta_0 X_{t-1} + \beta_0 \lambda X_{t-2} + \beta_0 \lambda^2 X_{t-3} + \ldots. + u_{t-1} \quad (6)$$

When both sides of equation (6) are multiplied by λ;

$$\lambda Y_{t-1} - = \lambda\alpha + \lambda\beta_0 X_{t-1} + \beta_0 \lambda^2 X_{t-2} + \beta_0 \lambda^3 X_{t-3} + \ldots\ldots. + \lambda u_{t-1} \quad (7)$$

equation is obtained. When equation (7), whose lag is pulled back one period, is subtracted from equation (5) whose lag is infinite, the following equation is obtained.

$$Y_t - \lambda Y_{t-1} = \alpha(1-\lambda) + \beta_0 X_t + (u_t - \lambda u_{t-1}) \quad (8)$$

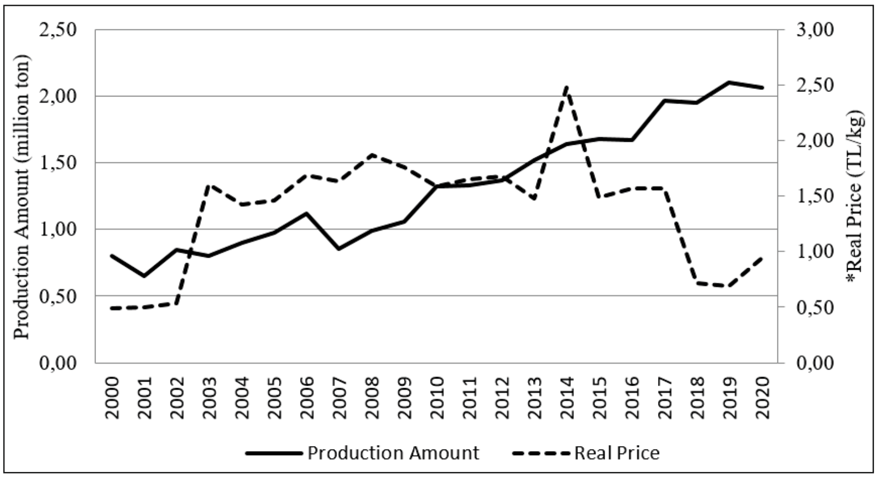
Equation (9) is reached when this equation is rearranged;

$$Y_t = \alpha(1\text{-}\lambda) + \beta_0 X_t + \lambda Y_{t-1} + v_t \quad (9)$$

equality is achieved. Equations (8) and (9) obtained as a result of certain operations are defined as Koyck model. In equation (9), $v_t = (u_t - \lambda u_{t-1})$ is a moving average of ut and λu_{t-1}. In this transformation, which is called the Koyck transformation, a model with three unknowns (α, β0, λ) is obtained from an infinite number of parameters. There is no multicollinearity in the model because Yt-1 value is used instead of X_t, X_{t-1}, …. values (Dikmen, 2006; Özçelik and Özer, 2006; Kutlar, 2007; Abdikoğlu and Unakıtan, 2014).

3.FINDINGS

Turkey's sunflower production amount and sunflower real prices between 2000-2020 are given in Figure 1. Accordingly, while there was a linear increase in sunflower production over the years, significant fluctuations were observed in real prices. The lowest value of the production amount was 650,000 tons in 2001 and the highest value was 2.1 million tons in 2019. The real price of sunflowers, on the other hand, reached the highest value of 2.48 TL/kg in 2014 (Figure 1).



**Producer Price Index - 2003 base year*
Source: FAOSTAT, 2022; TURKSTAT, 2022.

Figure 1. Turkey's Sunflower Production between 2000-2020 and Sunflower Real Prices

The delayed value of the sunflower price is needed for the Koyck model. It is important to determine the lag length by selecting the model with the smallest Akaike Information Criterion (AIC), Schwartz Bayesian Criterion (SBC), or Hannah-Quinn Criterion (HQ) (Shrestha and Bhatta, 2018). AIC and HQ were used to determine the lag length in the study. Accordingly, the lag length was calculated as 2 (Table 1). In other words, the effect of sunflower price on sunflower production becomes zero by the second year.

Table 1. AIC and HQ at Different Lag Lengths

Lag Length	AIC	HQ
1	27.6199	27.7035
2	**27.5155**	**27.6548**
3	27.6544	27.8495
4	27.6728	27.9236

The Koyck model, which examines the relationship between sunflower production and price, was estimated as follows:

$$Q_t = \alpha + \beta_0 P_t + \lambda Q_{t-1} + u_t \qquad (10)$$

In equation (10);
Q_t = sunflower production in period t (million tons),
P_t = sunflower price in period t (TL/kg),
Q_{t-1} = sunflower production in the period before period t.
The model result for equality is given below.
$Qt = 0,0483 + 0,2064P_t + 0,5939Q_{t-1}$

According to the short-term sunflower production model, the production and price coefficients were found to be statistically significant. Since the logarithms of the variables in the model are used, the coefficients directly give the elasticity. In the short run, a 10% increase in sunflower price will cause a 2.06% increase in sunflower production (Table 2).

Table 2. Distributed Lag Model Results for Sunflower

	Constant	P_t	Q_{t-1}
Coefficient	0.0483	0.2064	0.5939
t statistics	1.6382	2.4809	3.6665
p	0.1197	0.0239	0.0019
$R^2 = 0.91$	F = 82.82	p = 0.000	LM Test = 0.13

The long-term elasticity was calculated as 0.51, and it was determined that a 10% increase in price would cause an increase of 5.1% in sunflower production in the long run.

Long-run elasticity $= \beta 0 \,[1/(1-\lambda)] = 0.2064\,[1/(1-0.5939)] = 0.51$

Breusch-Godfrey LM test was performed to check whether there is autocorrelation in the model. According to the obtained LM Test value (0.13), it was determined that there was no autocorrelation in the model.

Based on the model findings, the average lag length was calculated with the following formula:

Average lag $= \lambda/(1-\lambda) = 0.5939/(1-5939) = 1.46$

Accordingly, the time required for the change in sunflower price to have a significant effect on production is 1.46 years. Considering the average lag length, the distributed lag model showing the effect of the 2-year lagged price was calculated using equation 11.

$$Q_t = \alpha + \beta_0 P_t + \lambda Q_{t-1} \qquad (11)$$

According to this;

$\alpha_0 = \alpha/(1-\lambda) = 0.0483/(1-0.5939) = 0.1189.$

The coefficients β_1 and β_2 were calculated using the equation $\beta_i = \lambda_i \beta_0$:

$\beta_1 = \lambda^0 \beta 0 = (0.5939)^0.(0.2064) = 0.2064$

$\beta_2 = \lambda^1 \beta 0 = (0.5939)^1.(0.2064) = 0.1226$

When the regression equation derived from the Koyck model is rewritten with the results obtained, the following equation is obtained:

$Q_t = 0.1189 + 0.2064P_{t-1} + 0.1226P_{t-2}$

Accordingly, the 10% increase in the sunflower price in the current year is expected to increase the production amount one year later by 2.06% and the production amount two years later by 1.22%. The results show that the change in the lagged values of prices has a positive effect on production and this effect is gradually decreasing.

4.DISCUSSION and CONCLUSION

In this study, the relationship between sunflower production amount and prices was analyzed using Koyck model, which is one of the distributed lag models. According to the Koyck model results obtained, it was determined that the time required for the change in sunflower prices to have a significant and perceptible effect on sunflower production is 1.46 years. In addition, it is predicted that a 10% increase in the price of sunflower will increase the production amount one year later by 2.06% and the production amount two years later by 1.22%. The results show that the change in the lagged values of prices has a positive effect on production and this effect is gradually decreasing. In another study investigating the relationship between sunflower production and price with the Koyck model, according to the model estimates, the sunflower price affected only the prices of the previous year and it took 0.1885 years for the change in sunflower prices to have a significant effect on sunflower production (Berk, 2017).

In Turkey, the need for vegetable oil increases in parallel with the per capita consumption amount and population growth, but the production cannot be realized at a level to meet the oil need. When the data of the 2020 production year in Turkey are examined, it is seen that the sunflower agriculture production area decreased by 3.1% and the production amount decreased by 1.6% compared to the previous production period, and Turkey's sunflower sufficiency level was 62.5% (TURKSTAT, 2022). Only a part of the total vegetable oil demand can be met with domestically produced sunflower. For this reason, the increasing significant oil deficit is met through the import of seeds and crude oil, and the vegetable oil industry is mostly dependent on foreign sources in terms of raw materials. When the 2020 production year data in Turkey is examined, sunflower oil production is approximately 1 million tons and consumption is approximately 1.2 million tons (MAF, 2022; USDA, 2022). For this reason, it is necessary to determine appropriate policies for sunflower production and to encourage farmers in this direction.

A lot of research has been done so far on which support model might be more suitable for sunflower production. In a study examining the effects of agricultural supports for sunflower production in Turkey, the effects of diesel-fertilizer support, import prices and diesel-fertilizer prices, which are among the supports applied in sunflower production, on sunflower growing areas were found to be statistically significant. It has been determined that the diesel-fertilizer support rather than the premium support given to the farmers is more effective on the growing areas. The reason for this is the decrease in real premium support prices, especially in recent years (Kadakoğlu and Yılmaz, 2022). On the other hand, in another study, it was determined that the most important factor taken into consideration by sunflower farmers in order to continue their production was good price and the second factor was appropriate premium. This situation reveals that the difference payment supports are an important factor in terms of the sustainability of production. According to sunflower farmers, the most important factor in a support policy to be implemented is the good price. Here, what is meant by a good price is the high amount of unit support given to the product. In addition, the fact that input (diesel, fertilizer, seeds, pesticides, etc.) supports are weighted, provides yield increase and is based on premiums comes to the fore (Özüdoğru et al., 2015).

According to the results obtained in another study using Granger Causality Test and Johansen Cointegration Test, the effect of difference payment supports on sunflower farmer decisions was found to be statistically significant (Doğan, 2018). In another study, it was determined that the most important factor in increasing the farmer income or reducing the product cost in oil sunflower production was the application of difference support. According to the research, in order to increase oil sunflower production throughout the country; the differential support for oil sunflower production should be increased, especially in regions other than Thrace (Semerci and Durmuş, 2021).

It has been determined that as the premium amount increases in the difference payment support of sunflower producers, the probability of preferring this support increases. When the premium amount in the difference payment support increases by 10 kr, the probability of preferring the difference payment support increases by 15.8%. However, it has also been determined that input supports are an important support element among agricultural supports for farmers (Özüdoğru et al., 2015).

Although sunflower growing areas did not change much in the examined period, yield and production increased depending on the seeds, fertilizers and water used in production. It has been determined that the amount of premium and input support, which is an important support tool for sunflower production, has decreased in real terms over the years. While the input prices used in the production process increase, insufficient supports may lead the farmers to either produce a different product or to produce sunflowers by reducing the inputs. This may adversely affect sunflower production. For this reason, it is important and necessary to sustain agricultural supports in sunflower production, where there is a shortage of supply.

It is extremely important to meet Turkey's sunflower and oil needs with domestic resources, and it has become a necessity to implement policies to increase production in sunflower, which is a serious import item. This situation makes sunflower production and support more privileged than other products. The agricultural support policies being implemented should be at a level that can compete with the world conditions. Despite the decreasing effect of sunflower price on sunflower production, it is possible to explain the increase in sunflower production with premium payments. In order for the income of oil sunflower farmers not to fall below a certain level, the difference payment support paid to the farmers should be increased and the input support should be continued by increasing it.

Contribution Rate of Researchers Declaration Summary

The authors declare that they have contributed equally to the article and have not plagiarized.

Conflict of Interest Declaration

The authors of the article declare that there is no conflict of interest between them.

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