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AN ANALYSIS OF PRODUCTION AND PRICE RELATIONSHIP FOR POTATO IN TURKEY: A DISTRIBUTED LAG MODEL APPLICATION

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Abstract

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In this study, the relationship between prices and amount of potato produced and distributed under free market conditions in Turkey were studied using Koyck model of distributed lag models. According to the results, potato production in Turkey has been influenced by the lag value of average price formed in the market. The most striking result of the study is that the time required for the changes in the potato prices in Turkey to have an effect on potato production is 12.33 years. This result shows that the farmers are very enthusiastic for growing this crop, which is largely grown as a staple crop.

Key words: potato production, potato prices, distributed lag model, Koyck model

Introduction

Agricultural activities are largely carried out under natural conditions. Therefore, agriculture is the sector with the highest risk and unpredictability. Problems in weather conditions, pests and diseases, floods etc. negatively affect the production. Besides, problems in crop pricing also negatively affects the production since the prices of agricultural produces are generally determined under market conditions without the effect of the producers. For this reason, farmers have to take the prices formed by the market as data and to make production plans accordingly. Prices in the market are formed based on supply and demand principles rather than production costs. Low supply elasticity of agricultural produces in short term makes the demand critical factor to determine the price.

Agricultural enterprises in Turkey are small. Farmers are not well organized in input and produce markets. Education level of farmers is low. All these factors make price uncertainties for the farmers. Farmers consider the previous years' price when planning the production. Such a planning causes big price and production fluctuations in agricultural production markets. This is called Cobweb theory in economy literature, often encountered in agricultural production and has been the subject of the investigations about production amount and price relationships.

Because of this structural feature of agricultural produces, relationship between the amount produced

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and the price can be studied using distributed lag model. In the regression models in which time series data is used, if the model uses not only the present values but also the delayed past) values of the defining variable, this model is defined as distributed lag model (Gujarati, 2001). Two major problems arise in distributed lag models. One of them is multicolinearity and the other is the increasingly lowered degrees of freedom as lag length increases. In order to overcome these problems, Koyck model has been developed for the estimation of parameters in distributed lag models.

Potato ranks first among the tuber crops in Turkey for acreage, production and trade. Of all acreage of tuber crops, 67.4 % belongs to potato (TURKSTAT, 2007). It is a significant crop in that it provides raw material for agricultural industry. However, there is not an effective organization in the production and marketing of potato in Turkey. Price of potato crop is formed in free market conditions depending upon the supply. Because of this fact, potato producers often face with significant uncertainties for the price of the potato produce.

In this study, we aimed at studying the production amount and price relationship of potato, a staple crop to a large extent in Turkey, using Koyck model. We measured the sensitivity of potato farmers to prices. Establishing the interaction between agricultural production and price via a distributed lag model, such a model can significantly contribute to the literature. Indeed, we have not come across with such an investigation into the subject.

In a study conducted by Yurdakul (1998) in Turkey, relationship between the production and price of cotton crop in 1985-1997 period was studied using Koyck approach. In another study by Dikmen (2005), production and price relationship for tobacco crop in 1982-2003 periods was analyzed using Koyck model. (Eraktan et al., 2004) used Koyck model to investigate the relationship between Direct Income Support, a financial support paid by government to the farmers based on their agricultural land in Turkey, and value added produced. The study by Erdal (2006) dealt with the production and price in tomato crop in 1975-2004 period using Koyck approach. Another study by Ozcelik and Ozer (2006) studied wheat production and price relationship in 1973-2004 period using Koyck approach. Study conducted by Erdal and Erdal (2008) analyzed the relationship between dry onion production and price in 1975-2006 period via Koyck approach.

Materials and Method

Data about potato production amounts and prices were obtained from records and yearbooks of Turkish Statistical Institute (TURKSTAT, 2007). Data about EU and world, on the other hand, were obtained from FAOSTAT (2008) records.

Potato production and price data were arranged yearly and belong to 1975-2006 period. These data were subjected to regression analyses using Koyck model, one of the distributed lag models.

Theoretical Framework

Distributed lag models has a special place in literature of economics in that they can allow the analyzing the behaviors of economical units (consumer, producers, etc.) based on appropriate dynamic models. Studied and used for the first time by Irving Fisher (Isyar, 1999), distributed lag models takes into account not only the present year value but also the previous year values of defining variable. If how far back will be gone for defining variable is not described, this is called an "infinite lag model" and shown as follows:

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

On the other hand, if the number of years to go back is defined as *k* for defining variable, it is called "finite distributed lag model" and has been defined as:

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

In this model, dependent variable Y ($Y_{t \ldots} Y_{t-k}$) is not only influenced by the present day value (X_t) but also by the past values ($X_{t-1 \ldots\ldots} X_{t-k}$) of defining variable. Most often, Y responds to X after some time, and the time to respond is called "lag period" (Dikmen, 2005).

Unknown parameters in distributed lag models (α , $\alpha_{0,}$ …, α_k) can be estimated using the classical least squares method (Alt, 1942; Tinbergen, 1949; Gujarati, 2001). Model-specific estimates in distributed lag models have certain drawbacks (Gujarati, 2001). One of them is the lack of a pre-information in the model about how long the lag period will be. Another is that when a data set that can estimate the lag period is not set up, degree of freedom is increasingly decreased in statistical significance tests of parameters. Yet another, but the most significant, drawback is that variables decided as defining variables are in a multiple linear relationships.

In order to overcome the abovementioned drawbacks, a method was developed by, and named after Koyck (Koyck, 1954). Leendert Marinus Koyck (1918- 1962) was a Dutch economist who studied and worked at the Netherlands School of Economics, which is now called the Erasmus University Rotterdam (Franses and Oest, 2004).

Based on the assumption that lags in independent variable affect the dependent variable to some extent and the weight of these lags decrease geometrically, model is reduced and thus made to estimate the regression equation (Dikmen, 2005).

In order to obtain the reduced model, Koyck assumed that in an infinitely distributed lag model all в's had the same signs and geometrically decrease as shown below:

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

In the Koyck model, a sensible range for λ would be the interval 0*;*1). One possibility, involving the entire distribution over λ would be to consider the class of "sup test statistics", which corresponds to the highest value of the original test statistic within the range for α. This approach is advocated by Davies (1987); see also Hansen (1996) and Carrasco (2002).

β_k is the lag coefficient. Lag coefficient β_k) varies by λ as well as by β_0. The closer λ to 1, the less the decrease in β_k. On the other hand, the closer λ to zero, the greater the decrease in β_k (Gujarati, 2001). In other words, λ values close to 1 mean that values of defining variables in remote past have a significant effect on dependent variable, and λ values close to zero mean that values of the defining variable in the remote past rapidly lose their effects of dependent variable. Mean lag number is the weighted average of all lags and is calculated for Koyck model as shown in Equation (4).

$$\text{Mean lag number} = \frac{\lambda}{1-\lambda} \qquad (4)$$

Mean lag number shows the time period necessary for a one unit change in X defining variable to have a detectable effect on dependent variable Y (Dikmen, 2005). In view of these explanations, infinite lag model is formed using OLS method as shown in Equation (5).

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

Linear regression solution cannot be applied to regression Equation (5) since it has infinite lag and λ coefficients are not linear. In order to solve this problem, the model has been taken one period back and the following regression model has been developed:

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

When the equation 6) is multiplied by λ, the Equation (7) is obtained;

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

When the Equation (7), whose lag is taken one period back, is subtracted from Equation 5), whose lag is infinite, the following Equation is reached:

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

If the Equation (8) is reorganized, Equation (9) is obtained;

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

In Equation 9) $v_t = (u_t - \lambda u_{t-1})$ and, it is the moving average mean of u_t and u_{t-1}.

The procedure explained above is known as Koyck transformation. Equation (9) is described as Koyck model. In Koyck model, variables that consist of lag values of defining variables are not defined. Thus, multiple relationship problems are in a sense solved. On the other hand, while in infinitely distributed lag model it is necessary to predict infinite number of β

using α, in Koyck model distributed lag model can be resolved only through estimating α, β_0 and λ.

Potato in Turkey

Potato is the fourth food source in the world following rice, wheat and corn. It is high yielding crop and can be grown in many environments. As a food, it is nutritious and easy to digest. Besides, it can be used in many forms. Because of these facts potato is grown and consumed in almost every country of the world. Potato production in the world continuously increases as parallel to the population increase. Potato production in 1990's is 260-270 million tons while in 2006 this figure is about 315 million tons (FAOSTAT, 2008). Major potato producing countries in the world are China, Russia, India, USA and Ukraine. Turkey ranks 12th for acreage and 13th for production. In 2006, Turkey produced about 1.4 % of total world potato production. Tuber crops occupy 13.5 % of the cultivated area in Turkey, and 67.4 % of this land belongs to potato only (TURKSTAT, 2007). Total potato production in Turkey was 4.4 million tons in 2006.

Potato production in Turkey is conducted in Mediterranean, Aegean and Black Sea regions using early cultivars. Potato is also heavily grown in Middle-Anatolian and East-Anatolia regions. The leading potato producing provinces are Nigde, Nevsehir, Izmir, Bolu and Afyon. These five provinces make up about 60 % of Turkey's total potato production (Yilmaz et al., 2006).

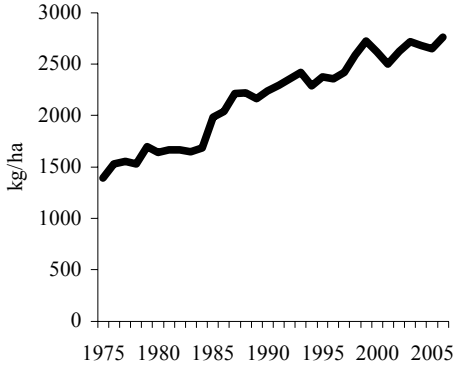

Fig. 1. Potato yields in Turkey in 1975-2006 period

Potato yield in Turkey was 28.50 t/ha in 2006. This yield is higher than both world average 17.73 t/ha) and EU average 25.09) FAO, 2008). Potato yields in Turkey are on a continuous increase (Figure 1).

Considering the potato trade of Turkey, 127 000 tons of potato was exported in 2006. Most of this export was to Middle Eastern and African countries. Iraq, Azerbaijan, Georgia, Senegal and Pakistan were leading countries as export destinations. Turkey imports only seed potato, which is as low as 9-10 000 tons yearly.

Potato is one of the crops in Turkey whose price fluctuate the most (Yilmaz et al., 2006). Forming of price and trade of potato in Turkey occurs under free market conditions. There is not any subsidiary policy applied for potato in Turkey. Changes in the potato prices result in fluctuations in the production. At the period studied in the present study, potato production and real potato prices in Turkey is given in Figure 2.

Potato wart disease, caused by *Synchytrium endobioticum* fungus, that appeared in 2004 have caused decreases in potato acreage since that year. A subsidy of 110 YTL (about 10 US $) was paid to farmers who could not grow potato because of potato wart disease problem in 2007.

Results and Discussion

In order to determine the relationship between potato prices and production at the studied period, a correlation analysis was performed. A correlation coefficient of 0.71 was found, indicating a high level of relationship between the two variables. This result indicated that production amount and price relationship can be studied using Koyck model.

Distributed lag model was formed as follows:

$$Q_t = \alpha + \beta_0 P_t + \beta_1 P_{t-1} + \beta_2 P_{t-2} + \ldots\ldots\ldots + \beta_k P_{t-k} + u_t \quad (10)$$

In the model, Q_t is potato production in period t (ton), P_t is potato price in period t (TL/kg).

In order to form Koyck model, it is necessary to determine lag value of potato price series lag length).

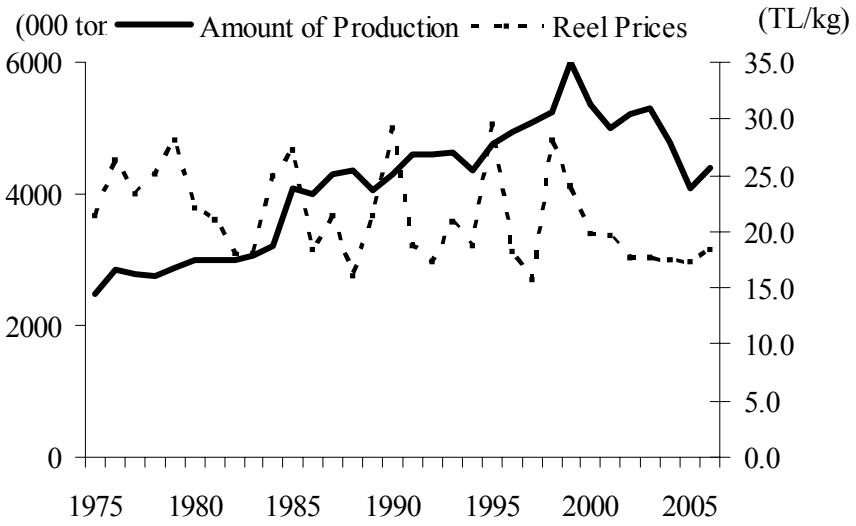

Fig. 2. Potato production and real prices of potato in Turkey in 1975-2006 period

In a distributed lag model, Schwarz criterion is used to determine the lag length (Dikmen, 2005).

Schwarz proposes reduction of Equation (11) to the lowest:

$$SK = \ln \sigma^2 + m \ln n \qquad (11)$$

Here, σ^2 is the highest probability estimate of $\sigma^2 = (KKT/n)$, m is length of the lag, n is the number of observations. In summary, a regression model is used along with some lag values (=m), and m value that makes the value of Schwarz criterion the lowest is selected (Gujarati, 2001). At this stage, without making any limitation to the form of the distributed lag, a very large k value length of the lag) is used at the start. Then, when the duration of lag is shortened, whether the model goes wrong is checked (Davidson and Mackinnon; 1993).

Values for Schwarz criterion determined at different lag lengths for Equation (10) is given in Table 1.

As can be seen from Table 1, the lowest Schwarz value was obtained from lag length k=2. Thus, effect of potato prices on potato production is zero after two years. According to the determined lag lengths, the relationship between potato production and price has been estimated using the classical least squares method given in Equation (10). The results of the model are given in Table 2.

According to the results given in Table 2, potato prices in the period t and one period earlier (t-1) has positively affected the potato production while potato prices two periods earlier (t-2) negatively affected the production. Partial regression coefficients in the model except ($в_1$) have been statistically significant. Model, as a whole, is also statistically significant. Multiple determination coefficient of the model is 0.38, which means that 38% of the changes in potato production can be explained through changes in potato price and its distributed log values.

Although statistically significant as a whole, the model has to be questioned in terms of reliability for two points related to distributed lag models. The first is the multiple relationship problems as a result of the fact that lag values of price variable was used in the model. The second problem is the loss of observations occurred in lag value set. If the number of data in formed series is not large, estimated values can be inconsistent due to lags.

In order to overcome these two major problems, estimations were made using Koyck model. Estimation results of regression equation given in Table 2 based on Koyck model are given in Table 3.

Table 1
Lag length values based on Schwarz criterion

Lag length	Schwarz values
k=1	30.22
k=2	30.2
k=3	30.26
k=4	30.29
k=5	30.33

Koyck model given in Table 3 was statistically significant at 1 % level of probability. According to model results, a 1 YTL increase in potato price increased the potato production by 0.529 ton. An increase of 1 ton of potato production in the previous period increased the potato production by 0.925 ton.

According to mean lag number, the time required for changes in potato prices to have a significant and detectable effect on potato production was 12.33 years. This result shows that Turkish farmers, who most often grow potato as a staple crop, are very enthusiastic for growing potato.

Table 2
The results of distributed lag model

$Q_t = 392255.0 + 15.620P_t + 0.449P_{t-1} - 18.470P_{t-2}$				
Lag length				
	Constant	t	t-1	t-2
Coefficient (β)	3922550.0	15.620	0.449	-18.470
t- values	23.988	1.619	0.024	-1.636
Probability	0.000	0.117	0.980	0.113
R^2 = 0.38	F = 5.32	p=0.005		

Table 3
The results of Kocyk model

$Q_t = 411803.5 + 0.529\ P_t + 0.925\ Q_{t-1}$			
Lag length			
	Constant	P_t	Q_{t-1}
Coefficient	α) 411802.5	ß) 0.529	λ) 0.925
t- values	1.447	1.032	12.951
Probability	0.159	0.310	0.000
R^2 = 0.88	F = 102.25	p = 0.000	
Average lag Number Average lag Length λ / 1 1-λ) = 0.925 / 1 1-0.925 = 12.33			

Note: Q_t is potato production in period t, P_t is potato price in period t and Q_{t-1} is potato production in one period earlier than t.

In Turkey for different crops the time required for the prices to have considerable changes is 1.19 years for tobacco (Dikmen, 2005) 18 years for tomato (Erdal, 2006), 0.83 years for wheat (Ozcelik and Ozer, 2006) and 1.19 years for dry onion (Erdal and Erdal, 2008).

In Koyck model

$Q_t = \alpha + \beta_0 P_t + \lambda Q_{t-1} + u_t$ and $\beta_k = \lambda^k \beta_0$

Since $0 < \lambda < 1$, using the following calculations Equation (10) is reached;

$\beta_k = \lambda^k \beta_0$

$\beta_0 = \lambda^0 \beta_0 = (0.925)^0 (0.529) = 0.529$
$\beta_1 = \lambda^1 \beta_0 = (0.925)^1 (0.529) = 0.489$
$\beta_2 = \lambda^2 \beta_0 = (0.925)^2 (0.529) = 0.453$
$\alpha_0 = \alpha / 1- \lambda) = 411803.5 / 1- (0.925) = 5490713.3$

When the regression formulae derived from Koyck model is rewritten using this results, Equation (12) is obtained;

$$Q_t = 5490713.3 + 0.529 P_t + 0.489 P_{t-1} + 0.453 P_{t-2} \quad (12)$$

In Equation (12), which represents a distributed lag model derived from Koyck model, it is seen that lag potato prices have a decreasing effect on potato production, since $0 < \lambda < 1$. Decreasing effects of lag price parameters result from the fact that л coefficient exerts an effect which was limited in the model.

According to Equation (12), a one-unit increase in potato prices in Turkey increased the production by 0.529 tons in that year while a one-unit increase in the previous year increased the production by 0.489 tons. In addition, a one-unit price increase two years ago increased the production by 0.453 tons. Although the changes in lag values of the prices had a positive influence on production, this influence was getting smaller.

Conclusions Results and Suggestions

In this study, relationship between amount of potato produced and marketed, and price of potato, all under full market economy conditions, were studied. This relationship was studied using Koyck model, one of distributed lag models. Amount of potato produced was dependent variable, and potato price and lag values of potato production were defining variable in the model. The study dealt with 1975-2007 period.

At the studied period, there was a correlation of 71 % between amount produced and the price. This coefficient showed that Koyck model was appropriate for studying the relationship between production amount and price of potato crop.

For the estimation of unknown parameters in the model, lag length determined using Schwarz criterion was calculated as 2. This means that potato production is influenced by the prices of up to past two years in Turkey, based on the data from studied period. On the other hand, according to Koyck model, the time required for the changes in potato prices to have a significant and detectable effect on potato production was calculated as 12.33 years.

For the studied period, a one-unit increase in potato prices increased the potato production by 0.529 tons in that year; while a one-unit increase in the previous year increased the production by 0.489 tons. In addition, a one-unit increase in the prices of two years ago increased potato production by 0.453 tons. Thus, it can be said that each additional lag value results in a smaller effect on potato production.

In conclusion, potato is one of the major staple crops in Turkey. Considering the average lag number, it can be stated that potato producers in Turkey is very enthusiastic about growing potato. However, price uncertainties result in fluctuations in the production in this crop in Turkey. For sustainable potato farming in Turkey, establishment of an efficient marketing organization is a necessity. Potato product in Turkey does not go beyond a registration process in trade stock markets. In this context, lack of crop-specific stock markets is a major drawback for Turkey. At this point, farmer unions have significant roles in protecting the farmer against the risks and uncertainties appeared under market conditions.

For the potato crop, which is a major raw material for food industry as well as a direct food for human consumption, it is necessary to conduct a contract-based production system. Policies are needed to be developed for efficient, profitable and sustainable potato farming. Thus, price uncertainties that the producers face can be overcome, and contribution of this major crop to national economy can be increased.

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