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CAUSALITY AND VAR ANALYSIS OF TURKISH MILK PRODUCER PRICE

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Abstract

In this study, there are many influential indicators on the milk producer price which are 4 separate functions: milk production, maize price, clover prices and straw price. This study explores the application of the VAR analysis approach to time series data of producer milk prices covering the period from January 1st, 2010 to December 31st, 2019. The data were taken from the database of the Turkish Statistical Institute. One-way causality relation at 5% level of significance towards milk producer price denoted clover price were detected. In this case, it is possible to say that there is a link between milk producer price and clover price. VAR analysis results show milk production, maize price, clover price and straw price effects on milk producer price.

Key words**:** *milk producer price, milk production, maize price, clover price, straw price, granger causality, var analysis*

INTRODUCTION

Raw milk prices in Turkey determined in accordance with the principles of the "Regulation on Purchase and Sale in Raw Contractual Procedure" published in the Official Gazette dated 16 April 2015 and numbered 29328 [16]. Milk price factors such as market conditions, seasonal fluctuations in milk quantity, supply and demand balance, milk quality and geographical location are effective. According to quality and parity, the raw milk reference price is determined by bargaining between industrialists and producer representatives. The National Milk Council brings together the representatives of producers and industrialists and later announces the "the recommended price". Milk price is mostly determined via the supply and demand balance.

Agricultural prices are compiled for the purpose of making calculations about the changes in economic welfare and purchasing power of producers who are engaged in agricultural activities. The raw milk/feed parity shows how much feed a producer will buy with the income from the sale of 1 liter/1 kg of raw milk. And, the generally accepted parity is 1.5. However, in Turkey, the raw milk/feed parity has remained below 1.5 for many years and the average raw milk/feed parity for 2019 has been calculated as 1.22 [15]. The milk production in Turkey was realized 9,506,028 metric tones in 2019. Comparing the years 2018 and 2019, the production of milk decreased by 5.26%. Producer price milk ratio was up to 20.70% [22].

Especially, households' consumption for milk as unpacked milk from buying producers. The demand of milk relies on various factors for example economic factors, socio-economic and cultural factors. Because, buying milk from producers is cheaper than market price. For this reason, consumers prefer buying milk directly from producers. Producer prices are crucial elements of microeconomic indicators because agricultural establishments in an economy follow these indicators. The fluctuations in the milk price have a significant effect not only on producers but also on the food industry and consumers. Government managements can play an important role in trying to maintain stability in milk production and prices by implementing suitable policies. Thus, an exact and accurate forecasting strategy for milk prices and production by a forecasting technique is

necessary to assist the government's decision-making for subsequent months. The relations between the food demand, one of the household expenditure items which occupies an important place in human life, (bread and cereals; meat, fish and poultry; oils, milk, dairy products, and egg; fresh, dry, frozen vegetables and fruits; fast food and various food; alcoholic and non-alcoholic beverages) and the factors affecting these expenditure items will be examined in econometric terms [20].

This study applies time series analysis to assess the trend of the Republic of Turkey's milk prices on a monthly basis over the period from 2010 to 2019. The data was gained from The Turkish Statistical Office's (Turkstat) database. The trend analysis of milk prices over time is crucial due to the profound influence this indicator has on agricultural commodity prices. Granger causality and the VAR analysis were used as the time series method to analyze the trend of the producer milk price variables during the study period. The paper examined the milk producer price and the other variables effecting on milk prices. We used in here VAR model to determine between the relationship milk price and the other variables. This method calculated the impulse response functions. The EViews 10 Econometrics package was used for the estimation of the research analysis.

Time series data analysis has been an increasingly more important subject in various research areas such as economics, agricultural economics, econometrics, statistics, business, psychology, engineering, social sciences and etc.

The direct impact of the exchange rate on agricultural prices and/ or exports is quite significant [3] [4] [1].

They intend to find further empirical evidence to investigate whether the dairy cooperatives' oligopoly power that is implicit in the dynamic pricing games exists and how it influences the beverage milk margins from 1983 to 2012 [2].

Researchers investigate the implications of hedonic pricing for price dynamics of different commodities [5]. They studied the U.S. fluid milk market has been experiencing two trends in the recent decade: the fast growth of private label milk and organic milk. They find that socio-demographic factors still play important roles in household choice of milk types, and fluid milk, as a whole, is an inferior good [6]. They studied an evolution of the margin risks was performed using the relationship between excess price yield, prices of margin and conditional volatility of milk [9]. Dynamic relationships among weekly retail prices for milk from three regions of Kyrgyzstan are studied in an error correction framework. These results are related to the levels of state-run milk marketing facilities versus private-run milk marketing facilities and surplus versus deficit milk production in each region [12]. Although it isn't exactly the same, causality is closely related term to the idea of cause-and-effect [13]. They stressed that Gross Domestic Product and Energy Consumption [14]. Researchers investigate the nonlinear adjustment between consumer and producer prices in the Greek milk sector using a threshold error correction autoregressive model [17]. He mentioned that the Holt-Winters methods can be used for forecasting time series data that have both trend and seasonal patterns [19]. They used the VAR models to examine the relationships in agricultural prices [21]. He emphasized the granger-causality can also be tested in a VAR framework, in this case the multivariate model is extended in order to test for the simultaneity of all included variables [10].

The first part of this paper provides an overview of the literature about milk price trends and their importance for Turkish agricultural sector. The second and third parts give the research methodology used in the paper. The author emphasizes the Granger causality and VAR analysis. Finally, the last part contains the empirical results of the research.

MATERIALS AND METHODS

Data

In this study, the data set contains 120 monthly time series observations for the period 2010 through 2019. The data could be

viewed as being in five different variables: Milk producer prices, milk production, maize price, clover price, straw price. All of these data were obtained from Turkish Statistical Institute [22].

Econometric model

In order to implementation of the Granger causality analysis, all of the series should be stationary. The unit root test is using the determine the degree of stationary. Unit root tests in the analyzes are Dickey Fuller test (DF), Augmented Dickey Fuller test (ADF) and Philips-Perron test (PP). ADF was used to test the stability of the variables in this research. The Akaike Information Criteria (AIC) was used to determine the optimal number of delays.

The mutual relationships between variables in VAR modelling are revealed by Granger Causality tests. In addition, Granger Causality tests, which show the causality relationships between variables, are tests in VAR form and are very sensitive to the length of the lag. The Granger Causality test is applied to stationary series at the appropriate delay level. For the VAR model in which the variables included in the study are included in the system as binary at the level where they are stationary, the length of the lag was decided according to the AIC information criterion. The results obtained for each variable pair are listed. After deciding on the appropriate lag length, the causality test was applied and the results were presented. He proposed a time series data-based approach in order to determine causality [11].

Vector Auto Regressive (VAR) model is defined as a dynamic simultaneous equations system in literature. All variables such as dependent, independent and endogenous variables are determined at first and determined variables effect each other in the system [18].

Software program

During the model estimation and analysis were made by Eviews 10 Econometrics package program.

RESULTS AND DISCUSSIONS

The lag lengths for all estimated models in this study were selected by Augmented Dickey-Fuller [7] [8]. The results of the lag length determination are given below in the following results.

Unit Root Tests Results

Maize prices series

The graph of the corn price variable over time is obtained as follows. According to the figure, the series contains a stochastic trend. In order to provide variance stability and linearity, the logarithm of the series is taken first. Although the general trend of the logarithmic maize price variable over time has not changed, it can be said that the variance decreases due to the smaller numbers as a result of logarithmic transformation.

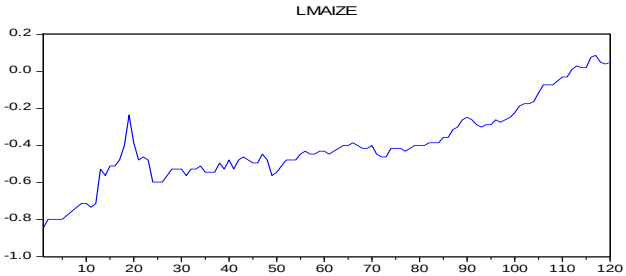

Fig. 1. The monthly maize prices (kg/TL) from January 2010 to December 2019

Source: Author's own calculation.

The number of delays suitable for the ADF Unit Root test to be applied to the logarithmic maize price series was found to be k = 12 according to the AIC information criteria. At this lag level, according to the ADF unit root test, the lmaize variable is not stationary. When looked at the 1st rank difference level, k = 12 was found and when the 1st order difference is taken, it is accepted that the series became stationary.

Table 1. Unit root test for maize price series

Level of significance	Intercept and trend $t_{\hat{\delta}}$ =-1.00323	Intercept and none $t_{\hat{\delta}} = -11.04886$	None $t_{\hat{\delta}}$ =10.72654
%1	-4.037668	-3.486551	-2.584707
%5	-3.448348	-2.886074	-1.943563
%10	-3.149326	-2.579931	-1.614927
DF Statistics	$t_{\hat{\delta}} < \tau_{\tau}$	$t_{\hat{\delta}} < \tau_{\mu}$	$t_{\hat{\delta}} < \tau$
Decision	H_0 Reject	H_0 Reject	H_0 Reject

Source: Author's own calculation.

Milk production series

The graphic of the milk production variable is obtained as follows. According to the figure, the series includes the stochastic trend as well as the seasonal change. Before proceeding to the ADF unit root test, the series should be seasonally adjusted. Seasonal change in the series exhibits an additive structure. Therefore, the milk production variable has been seasonally adjusted using the Additive Moving Averages method. The logarithm of the seasonally adjusted milk production variable is used. The seasonally adjusted logarithmic milk production (lmilkpro) variable with respect to time is as follows.

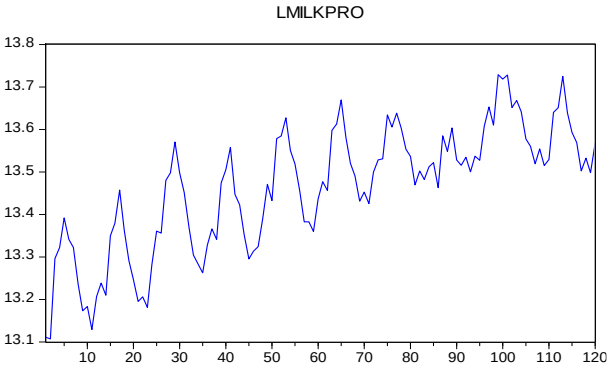

Fig. 2. The monthly milk production (tonnes) from January 2010 to December 2019
Source: Author's own calculation.

The appropriate delay number for the ADF Unit Root test to be applied to the logarithmic milk production series was found to be k = 12 according to the AIC information criteria. According to ADF unit root test at this latency level, the variable lmilkpro is not static. When looked at the 1st rank difference level, k = 12 was found and when the 1st order difference is taken, it is accepted that the series became stationary.

Table 2. Unit root test for milk production series

Level of significance	Intercept and trend $t_{\hat{\delta}}$ =2.708390	Intercept and none $t_{\hat{\delta}} = -2.640462$	None $t_{\hat{\delta}}$ = 2.419105
%1	-4.046072	-3.492523	-2.586753
%5	-3.452358	-2.888669	-1.943853
%10	-3.151673	-2.581313	-1.614749
DF Statistics	$t_{\hat{\delta}} < \tau_{\tau}$	$t_{\hat{\delta}} < \tau_{\mu}$	$t_{\hat{\delta}} < \tau$
Decision	H₀ Reject	H₀ Reject	H₀ Reject

Source: Author's own calculation.

Straw price series

The graph of the straw price variable over time is obtained as follows. According to the figure, the series contains a stochastic trend. In order to provide variance stability and linearity, the logarithm of the series is taken first. Although the general trend of the logarithmic straw price variable with respect to time has not changed, it can be said that the variance decreases due to the smaller numbers as a result of logarithmic transformation.

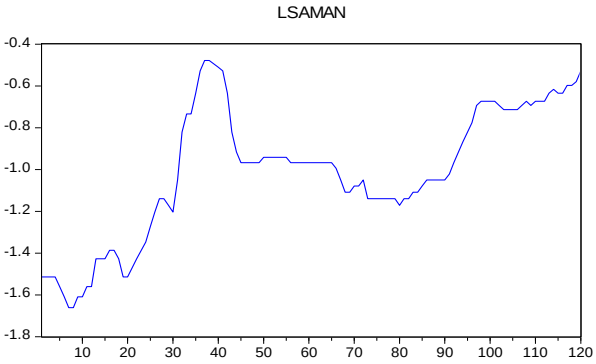

Fig. 3. The monthly straw price (kg/TL) from January 2010 to December 2019
Source: Author's own calculation.

The appropriate delay number for the ADF Unit Root test to be applied to the logarithmic straw price series was found to be k = 12 according to the AIC information criteria. At this delay level, the lstraw variable is not stationary according to the ADF unit root test. When looked at the 1st rank difference level, k = 12 was found and when the 1st order difference is taken, it is accepted that the series became stationary.

Table 3. Unit root test for straw price series

Level of significance	Intercept and trend $t_{\hat{\delta}} = -5.60000$	Intercept and none $t_{\hat{\delta}} = -5.626511$	None $t_{\hat{\delta}} = -5.672818$
%1	-4.038365	-3.487046	-2.584707
%5	-3.448681	-2.886290	-1.943563
%10	-3.149521	-2.580046	-1.614927
DF Statistics	$t_{\hat{\delta}} < \tau_{\tau}$	$t_{\hat{\delta}} < \tau_{\mu}$	$t_{\hat{\delta}} < \tau$
Decision	H₀ Reject	H₀ Reject	H₀ Reject

Source: Author's own calculation.

Clover price series

The graph of clover price variable over time is obtained as follows. According to the chart, the series contains a stochastic trend. In order to provide variance stability and linearity, the logarithm of the series is taken first. Although the general trend of the logarithmic clover price variable with respect to time has not changed, it can be said that the variance

decreases due to the smaller numbers as a result of the logarithmic transformation.
The appropriate delay number for the ADF Unit Root test to be applied to the logarithmic clover price series was found to be k = 12 according to the AIC information criteria. At this delay level, according to the ADF unit root test, the Lclover variable is not stationary.

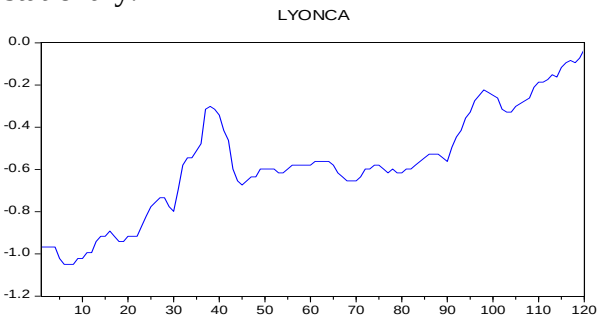

Fig. 4. The monthly clover price (kg/TL) from January 2010 to December 2019
Source: Author's own calculation.

When looked at the 1st rank difference level, k = 12 was found and when the 1st order difference is taken, it is accepted that the series became stationary.

Table 4. Unit root test for clover price series

Level of significance	Intercept and trend $t_{\hat{\delta}} = -6.44$	Intercept and none $t_{\hat{\delta}} = -6.44697$	None $t_{\hat{\delta}} = -6.232822$
%1	-4.037668	-3.486551	-2.584707
%5	-3.448348	-2.886074	-1.943563
%10	-3.149326	-2.579931	-1.614927
DF Statistics	$t_{\hat{\delta}} < \tau_{\tau}$	$t_{\hat{\delta}} < \tau_{\mu}$	$t_{\hat{\delta}} < \tau$
Decision	H_0 Reject	H_0 Reject	H_0 Reject

Source: Author's own calculation

Milk producer price series

The graph of the milk producer price variable over time is obtained as follows. According to the chart, the series contains a stochastic trend. In order to provide variance stability and linearity, the logarithm of the series is taken first. Although the general trend of the logarithmic milk producer price variable with respect to time has not changed, it can be said that the variance decreases due to the smaller numbers as a result of logarithmic transformation.

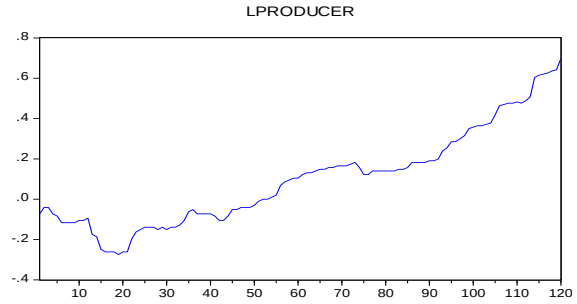

Fig. 5. The monthly milk producer price (kg/TL) from January 2010 to December 2019
Source: Author's own calculation.

The appropriate delay number for the ADF Unit Root test to be applied to the logarithmic milk producer price series was found to be k = 12 according to the AIC information criteria. At this lag level, the lproducer variable is not static according to the ADF unit root test. When looked at the 1st rank difference level, k = 12 was found and when the 1st order difference is taken, it is accepted that the series became stationary.

Table 5. Unit root test for milk producer price series

Level of significance	Intercept and trend $t_{\hat{\delta}} = -8.55010$	Intercept and none $t_{\hat{\delta}} = -7.763973$	None $t_{\hat{\delta}} = -7.263529$
%1	-4.037668	-3.486551	-2.584707
%5	-3.448348	-2.886074	-1.943563
%10	-3.149326	-2.579931	-1.614927
DF Statistics	$t_{\hat{\delta}} < \tau_{\tau}$	$t_{\hat{\delta}} < \tau_{\mu}$	$t_{\hat{\delta}} < \tau$
Decision	H_0 Reject	H_0 Reject	H_0 Reject

Source: Author's own calculation.

Granger Causality Test Results

Reciprocal causality relationship between dmaize and dproducer variables:

When testing the mutual causality relationship between dmaize and dproducer variables, the solution is as follows.

$$maize_t = \sum_{i=1}^{7} \alpha_i maize_{t-i} + \sum_{j=1}^{7} \beta_j producer_{t-j} + u_t producer_t$$

$$= \sum_{i=1}^{7} \lambda_i maize_{t-i} + \sum_{j=1}^{7} \delta_j producer_{t-j} + w_t$$

$$H_0: \beta_j = 0$$

$$H_1: \beta_j \neq 0$$

Table 6. Granger causality tests for dmaize and dproducer

Lags: 7			
Null Hypothesis:	Obs	F-Statistic	Prob.
DMAIZE does not Granger Cause DPRODUCER	112	1.34424	0.2380
DPRODUCER does not Granger Cause DMAIZE		1.17424	0.3247

Source: Author's own calculation.

Decision: According to Granger causality analysis results, at 5% level of significance DMAIZE does not Granger Cause DPRODUCER and DPRODUCER does not Granger Cause DMAIZE.

Reciprocal causality relationship between dmilkpro and dproducer variables:

When testing the mutual causality relationship between dmilkpro and dproducer variables, the solution is as follows.

$$milkpro_t = \sum_{i=1}^{12} \alpha_i milkpro_{t-i} + \sum_{j=1}^{12} \beta_j\, producer_{t-j} + u_t producer_t$$
$$= \sum_{i=1}^{12} \lambda_i milkpro_{t-i} + \sum_{j=1}^{12} \delta_j\, producer_{t-j} + w_t$$
$$H_0: \beta_j = 0$$
$$H_1: \beta_j \neq 0$$

Table 7. Granger causality tests for dmilkpro and dproducer

Lags: 12			
Null Hypothesis:	Obs	F-Statistic	Prob.
DMILKPRO does not Granger Cause DPRODUCER	107	0.88451	0.5656
DPRODUCER does not Granger Cause DMILKPRO		1.64938	0.0941

Source: Author's own calculation.

Decision: According to Granger causality analysis results, at 5% level of significance DMILKPRO does not Granger Cause DPRODUCER and DPRODUCER does not Granger Cause DMILKPRO.

Reciprocal causality relationship between dstraw and dproducer variables:

When testing the mutual causality relationship between dstraw and dproducer variables, the solution is as follows.

$$straw_t = \sum_{i=1}^{1} \alpha_i straw_{t-i} + \sum_{j=1}^{1} \beta_j\, producer_{t-j} + u_t producer_t$$
$$= \sum_{i=1}^{1} \lambda_i straw_{t-i} + \sum_{j=1}^{1} \delta_j\, producer_{t-j} + w_t$$
$$H_0: \beta_j = 0$$
$$H_1: \beta_j \neq 0$$

Table 8. Granger causality tests for dstraw and dproducer

Lags: 1			
Null Hypothesis:	Obs	F-Statistic	Prob.
DSTRAW does not Granger Cause DPRODUCER	118	0.71587	0.3993
DPRODUCER does not Granger Cause DSTRAW		3.57260	0.0613

Source: Author's own calculation.

Decision: According to Granger causality analysis results, at 5% level of significance DSTRAW does not Granger Cause DPRODUCER and DPRODUCER does not Granger Cause DSTRAW.

Reciprocal causality relationship between dclover and dproducer variables

When testing the mutual causality relationship between dclover and dproducer variables, the solution is as follows.

$$clower_t = \sum_{i=1}^{1} \alpha_i clower_{t-i} + \sum_{j=1}^{1} \beta_j\, producer_{t-j} + u_t producer_t$$
$$= \sum_{i=1}^{1} \lambda_i clower_{t-i} + \sum_{j=1}^{1} \delta_j\, producer_{t-j} + w_t$$
$$H_0: \beta_j = 0$$
$$H_1: \beta_j \neq 0$$

Table 9. Granger causality tests for dclover and dproducer

Lags: 1			
Null Hypothesis:	Obs	F-Statistic	Prob.
DCLOVER does not Granger Cause DPRODUCER	118	1.08889	0.2989
DPRODUCER does not Granger Cause DCLOVER		8.26577	0.0048

Source: Author's own calculation.

Decision: According to Granger causality analysis results, at 5% level of significance DCLOVER does not Granger Cause DPRODUCER but DPRODUCER is Granger Cause DCLOVER. That is, One-way causality relation at 5% level of significance towards producer denoted clover was detected. In this case, it is possible to say that there is a link between milk producer price and clover price.

VAR Analysis Results

In order to decide the system delay length, the AIC values obtained from the VAR models whose parameters are estimated are listed below, with the maximum delay length being 12 months.

The system reached the lowest AIC value with a lag length of k = 12. In VAR analysis, it is important to order variables in obtaining impulse-response functions and variance decomposition results. Especially if the cross correlations between the error terms of the variables are not zero, there may be large variations in the results obtained from different ordering of variables. Therefore, in the light of the results obtained from the Granger Causality test and a priori information obtained from the economic theory, the variables in the analysis were ordered from the most exogenous to the most internal. This ranking; maize price, milk production, straw price, clover price, producer milk price.

Table 10. VAR Lag Order Selection Criteria

Table 10. VAR Lag Order Selection Criteria

Endogenous variables: DMAIZE DMILKPRO DPRODUCER DSAMAN DYONCA

Lag	LogL	LR	FPE	AIC	SC	HQ
0	1051.878	NA	2.18e-15	-19.56780	-19.44291*	-19.51717
1	1093.686	78.92854	1.60e-15	-19.88199	-19.13259	-19.57819*
2	1124.604	55.47919	1.43e-15	-19.99260	-18.61872	-19.43565
3	1137.978	22.74839	1.80e-15	-19.77530	-17.77692	-18.96518
4	1171.600	54.04554	1.55e-15	-19.93644	-17.31357	-18.87317
5	1197.007	38.46706	1.58e-15	-19.94406	-16.69669	-18.62762
6	1242.090	64.04380	1.12e-15	-20.31945	-16.44759	-18.74985
7	1274.970	43.63418	1.02e-15	-20.46672	-15.97038	-18.64396
8	1293.308	22.62293	1.24e-15	-20.34221	-15.22137	-18.26629
9	1326.563	37.91677	1.16e-15	-20.49650	-14.75117	-18.16742
10	1352.241	26.87843	1.30e-15	-20.50918	-14.13936	-17.92694
11	1395.133	40.88691	1.09e-15	-20.84360	-13.84928	-18.00820
12	1465.102	60.16071*	5.72e-16*	**-21.68415***	-14.06534	-18.59559

* indicates lag order selected by the criterion, LR: sequential modified LR test statistic (each test at 5% level), FPE: Final prediction error, AIC: Akaike information criterion, SC: Schwarz information criterion, HQ: Hannan-Quinn information criterion

Source: Author's own calculation.

Impulse-Response Functions

Firstly, if we look at the response of the milk producer price against a standard deviation shock that may occur at maize price, the milk producer price gives an increase in the first two months, but after the second month it experiences a rapid decrease until the third month. Milk producer price, which increased again from the third month, after experiencing minor fluctuations, returns to the pre-shock balance level from the sixth month and the shock becomes ineffective.

Secondly, if we look at the response of the milk producer price against a standard deviation shock that may occur in milk production, the milk producer price reacts in a decreasing direction in the first two months, but after the second month it experiences a rapid increase until the sixth month. After a decline in the sixth and seventh month, and after the seventh month, the milk producer price returns to the pre-shock balance level after this month, and the shock becomes ineffective.

As the third, if we look at the response of the milk producer price against a standard deviation shock that may occur in the hay price, the milk producer price reacts in a decreasing direction in the first month, but after this month it experiences a rapid increase until the fifth month. After experiencing a decline between the fifth and eighth months, after the eighth month, the milk producer price returns to the pre-shock equilibrium level from this month onwards and the shock becomes ineffective.

Fourthly, if we look at the response of the milk producer price against a standard deviation shock that will occur in the clover price, the milk producer price reacts in a decreasing direction in the first two months, but after this month it experiences a rapid increase until the sixth month. It is a sharp decline in the sixth month and continues until the eighth month. After the eighth month, the milk producer price returns to the pre-shock balance level after this month, after experiencing minor fluctuations, and the shock becomes ineffective.

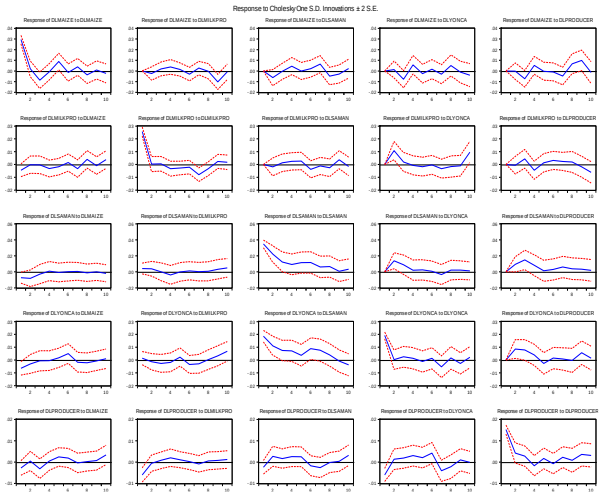

Fig. 6. Impulse-Response functions
Source: Author's own calculation.

CONCLUSIONS

After taking first difference of milk producer price, milk production, maize price, clover price and straw price series, these series are found in stationary. We can say that these series are first difference integrated I(1).

Two types of conclusions arise from this study. First, one-way causality relation at 5% level of significance towards milk producer price denoted clover price were detected. In this case, it is possible to say that there is a link between milk producer price and clover price.

Second, it is an empirical result from VAR analysis that milk production, maize price, clover price and straw price effects on milk producer prices.

If milk producer price, milk production, maize price, clover prices and straw price are enough supported by Turkish government, milk producer prices will be more competitive in the world and enough earnings for milk producers. The VAR analysis to determine the relationship between the agricultural gross domestic product and agricultural supports. Agricultural GDP is significantly affected by agricultural supports [18].

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