**Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development**
**Vol. 20, Issue 2, 2020**
**PRINT ISSN 2284-7995, E-ISSN 2285-3952**

# ENERGY DEMAND FORECAST FOR TURKISH AGRICULTURE SECTOR: GRANGER CAUSALITY AND COINTEGRATION TEST

**Mehmet Arif ŞAHİNLİ, Ahmet ÖZÇELİK**

Ankara University, Faculty of Agriculture, Department of Agricultural Economics, 06110 Dışkapı, Ankara, Turkey, Emails: asahinli@ankara.edu.tr, sahinliarif@gmail.com, aozcelik@agri.ankara.edu.tr

***Corresponding author*:** asahinli@ankara.edu.tr, sahinliarif@gmail.com

***Abstract***

*Due to the fact that, Turkey is a importing energy, we must determine the energy needs in the Turkish agricultural sector. In this study, consumed energy data in agriculture was used between 1972 and 2015 years. According to Turkish Statistical Institute's database, agriculture sector shares in GDP 6.2 percent in 2016 and percentage change compared to same period in previous year -0.1 percent. Agriculture sector shares in GDP 6.1 percent in 2017 and percentage change compared to same period in previous year 17.2 percent. Gross domestic product increased by 5.2% compared with the same quarter of the previous year in the second quarter of 2018. When the activities which constitute gross domestic product were analysed the total value added decreased by 1.5% in the agricultural sector compared with the same quarter of the previous year in the chained linked volume index. Trend model was used to energy trend in the econometric analysis of this study. Granger causality analysis results show that one-way causality relation at 5% level of significance towards GDP denoted EC was detected.*

***Key words:*** *agriculture, energy, granger causality, cointegration test*

## INTRODUCTION

There is a linked with energy consumption and growth has been extensively studied in the literature. And, it is very important a debate about the direction of causality between these two variables. That is, there is no consensus on whether economic growth will lead to energy consumption or whether energy consumption is a locomotive for economic growth. The pace of economic development and the standard of living are two determinants of energy demand. The growth in total energy demand will reflect the changing energy intensity in each end use, which is a reflection of the changing nature of production and consumption in an economy. In particular, the energy elasticity of the energy demand falls while the development of the countries is moving out of the industrialization phase [12]. Turkey's energy supply is based on imports. In the last decade, three quarters of Turkey's primary energy consumption was met through imported sources. Other sectors are not taking place until the effective implementation of energy efficiency with a 6% share in Turkey's overall energy consumption [2]. There are some national and international studies about agricultural gross domestic product, agricultural credits and the energy consumed in agriculture are as follows. [14], [3], [15], [13], [1], [16], [6].

## MATERIALS AND METHODS

### Materials

At the first stage of the analysis, the stationarity test was performed and it was investigated whether there was time effect on the variables I examined. In order to perform the Granger causality analysis, the series belonging to the variables must be stationary. The unit root test is a valid test used to determine the degree of stationary. The most commonly used unit root tests in the analyses are Dickey Fuller test (DF), Augmented Dickey Fuller test (ADF) and Philips-Perrron test (PP). In this study, ADF was used to test the stability of the variables. In the ADF unit root test, the Akaike Information Criteria (AIC) was used to determine the optimal number of delays.

### Methods

The cointegration test investigates the existence of a long-term relationship among the variables studied and this test investigates

whether two stationary time series on the same scale move together in the long run. Namely, if series are stable at the same level, there is a long term relation between the series. The Johansen Cointegration test developed by [9] and [10] was used in this study to test for the existence of a cointegration relationship between agricultural gross domestic product (fixed prices) and consumption energy in the agriculture. If a cointegration state arises between our series, it can be said that at least one of these variables is causality.

The empirical results presented in this paper are calculated within a simple Granger-causality test in order to test whether Agricultural Gross Domestic Product (GDP) (at fixed prices) "Granger cause" Energy consumption in agriculture (EC) and vice versa. Thus, the following two equations can be specified (Mahdavi and Sohrabian, 1991).

$$(GDP)_t = \propto + \sum_{i=1}^{m} \beta_i (GDP)_{t-i} + \sum_{j=1}^{n} \tau_j (EC)_{t-j} + \mu_t$$

$$(EC)_t = \theta + \sum_{i=1}^{P} \phi_i (EC)_{t-i} + \sum_{j=1}^{q} \psi_j (GDP)_{t-j} + \eta_t$$

Model estimation was done using Eviews 7.0 Econometrics package program. Unit root test analysis is estimated using Augmented Dickey Fuller and later VAR coefficients are estimated using Ordinary Least Squares (OLS) regression.

**Causality**

[11] emphasized that Although it is not exactly the same, causality is closely related term to the idea of cause-and-effect. In other words, if you find Granger causality in your data, there is not a causal link in the true sense of the word. When Econometricians say "cause" what they mean is "Granger-cause," although a more appropriate word might be "precedence". [8] proposed a time series data based approach in order to determine causality.

There are three different types of situation in which a Granger-causality test can be applied:

-If a simple Granger-causality test, there are two variables and their lags;

-If a multivariate Granger-causality test more than two variables are included, because it is supported that more than one variable can influence the results;

-Finally, 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 [7].

## RESULTS AND DISCUSSIONS

In this study, agricultural gross domestic product (GDP) at fixed prices and energy consumption in agriculture (EC) data were used. GDP values are fixed and Turkish Liras. It has been compiled from Turkish Statistical Institute. Energy consumption in agriculture values are taken by Ministry of Energy.

In this study, constant prices of agricultural gross domestic product in Turkey were examined is whether the causality between energy consumed in agriculture. For that reason, Granger causality test is used. This test is the most preferred method because of its ease of implementation. Descriptive statistics of the variables were calculated and given in Table 1.

Table 1. Descriptive Statistics for GDP (Turkish Lira) and EC (000 tons)

| Variables | Number of Observations | Mean | Median | Std. Dev. | Minimum | Maximum |
|---|---|---|---|---|---|---|
| GDP | 18 | 9.81E+09 | 9.57E+09 | 1.26E+09 | 8.15E+09 | 1.25E+10 |
| EC | 18 | 3826.78 | 3728.76 | 984.23 | 2827.06 | 6754.65 |

Source: The Author's calculation.

The lag lengths for all estimated models in this study were selected by Augmented Dickey-Fuller [4] [5]. Critical levels of these models (three models: intercept and trend, intercept and none, none) 1%, 5% and 10% were used to determine whether differences were significant. Based on the results of these tests, a lag length of five years was used for all the estimations in this study. The results of the lag length determination are given below in detail:

**Fixed GDP Series (GDP):** It is developed by Augmented Dickey Fuller (ADF) $\tau_\tau$, $\tau_\mu$ and $\tau$ unit root test and implemented for GDP series. While ADF unit root is implementing, hypothesis are given below for every three model:

$$H_0: \delta = 0$$
$$H_0: \delta < 0$$

First, model is estimated by general situation and if error term has serial correlation, lagged values for dependent variables are added the model later we overcome this serial correlation problem. In line with, we use the specific approximations to show the phase of process.
After estimating the model as general form (intercept and trend model), (we don't add any lagged values) calculated AIC results are given below (Table 3).
Lag value is p = 1. In this situation, we can start to implement the unit root test analysis. By using the lag value p = 1, OEKK estimation results for ADF unit root test are given in Table 2 and Table 3.

Table 2. Correlogram of D (GDP)

| Autocorrelation | Partial Correlation | | AC | PAC | Q-Stat | Prob |
|---|---|---|---|---|---|---|
| ***\| . \| | ***\| . \| | 1 | -0.35 | -0.35 | 2.59 | 0.11 |
| . \|* . \| | . \| . \| | 2 | 0.13 | 0.01 | 2.96 | 0.23 |
| . \| . \| | . \| . \| | 3 | -0.05 | -0.01 | 3.03 | 0.39 |
| . \| . \| | . \| . \| | 4 | 0.06 | 0.04 | 3.12 | 0.54 |
| . \| . \| | . \| . \| | 5 | -0.06 | -0.03 | 3.23 | 0.67 |
| . \|* . \| | . \|* . \| | 6 | 0.13 | 0.11 | 3.77 | 0.71 |
| . \| . \| | . \|* . \| | 7 | 0.06 | 0.17 | 3.88 | 0.79 |
| . \| . \| | . \|* . \| | 8 | 0.04 | 0.11 | 3.92 | 0.86 |
| . *\| . \| | . *\| . \| | 9 | -0.16 | -0.14 | 4.88 | 0.85 |
| . *\| . \| | .**\| . \| | 10 | -0.07 | -0.23 | 5.08 | 0.89 |
| . \|* . \| | . \| . \| | 11 | 0.13 | 0.07 | 5.99 | 0.87 |
| .**\| . \| | . *\| . \| | 12 | -0.21 | -0.17 | 8.74 | 0.73 |

Source: The Author's calculation.

Developing by Dickey-Fuller (DF) tables, %1, %5 and %10 significant levels and for T=18 values and statistics values and value are compared. According to this, values and statistics values are compared, we can reject H0 hypothesis for (Intercept and none) and none level of significance. Series is stationary or not include unit root (Table 3).

Table 3. Unit root test results for first difference of GDP series

| **Level of significance** | **Intercept and trend** $t_{\hat{\delta}}$ **=-2.61** | **Intercept and none** $t_{\hat{\delta}} = -3.53$ | **None** $t_{\hat{\delta}} = -4.43$ |
|---|---|---|---|
| 1% | -3.92 | -4.67 | -2.71 |
| 5% | -3.07 | -3.73 | -1.96 |
| 10% | -2.67 | -3.31 | -1.61 |
| DF Statistics | $t_{\hat{\delta}} > \tau_{\tau}$ | $t_{\hat{\delta}} < \tau_{\mu}$ | $t_{\hat{\delta}} < \tau$ |
| Decision | $H_0$ Accept | $H_0$ Reject | $H_0$ Reject |

Source: The Author's calculation.

As a conclusion, GDP series are not stationary for level but after taking first difference of series, this series are stationary. For that reason, we can say that GDP series are first difference integrated I (1) (Table 3).
**Energy Consumption Series (EC):** It is developed by Augmented Dickey Fuller (ADF) $\tau_{\tau}$, $\tau_{\mu}$ and $\tau$ unit root test and implemented for EC series. While ADF unit root is implementing, hypothesis are given below for every three model:

$$H_0: \delta = 0$$
$$H_0: \delta < 0$$

First, model is estimated by general situation and if error term has serial correlation, lagged values for dependent variables are added the model later we overcome this serial correlation problem. In line with, we use the spesific approximations to show the phase of process.

Table 4. Correlogram of D (EC)

| Autocorrelation | Partial Correlation | | AC | PAC | Q-Stat | Prob |
|---|---|---|---|---|---|---|
| ***\| . \| | ***\| . \| | 1 | -0.35 | -0.35 | 2.55 | 0.11 |
| . *\| . \| | .**\| . \| | 2 | -0.11 | -0.26 | 2.80 | 0.25 |
| . \| . \| | . *\| . \| | 3 | -0.01 | -0.18 | 2.81 | 0.42 |
| . \| . \| | . *\| . \| | 4 | -0.02 | -0.16 | 2.82 | 0.59 |
| .**\| . \| | ***\| . \| | 5 | -0.25 | -0.46 | 4.59 | 0.47 |
| . \|* . \| | .**\| . \| | 6 | 0.16 | -0.34 | 5.33 | 0.50 |
| . \|* . \| | . *\| . \| | 7 | 0.19 | -0.11 | 6.55 | 0.48 |
| . *\| . \| | . *\| . \| | 8 | -0.09 | -0.19 | 6.86 | 0.55 |
| . \| . \| | . *\| . \| | 9 | 0.01 | -0.19 | 6.87 | 0.65 |
| . \| . \| | .**\| . \| | 10 | -0.03 | -0.32 | 6.92 | 0.73 |
| . \| . \| | . *\| . \| | 11 | 0.03 | -0.20 | 6.97 | 0.80 |
| . \| . \| | . \| . \| | 12 | -0.02 | -0.06 | 7.00 | 0.86 |

Source: The Author's calculation.

After estimating the model as general form (intercept and trend model), (we don't add any lagged values) calculated AIC results are given below (Table 5).

Table 5. Unit root test results for first difference of EC series

| **Level of significance** | **Intercept and trend** $t_{\hat{\delta}}$ **=-4.28** | **Intercept and none** $t_{\hat{\delta}} = -4.44$ | **None** $t_{\hat{\delta}}$ **=-5.28** |
|---|---|---|---|
| 1% | -4.89 | -4.06 | -2.71 |
| 5% | -3.83 | -3.12 | -1.96 |
| 10% | -3.36 | -2.70 | -1.61 |
| 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: The Author's calculation.

Lag value is p = 4. In this situation, we can start to implement the unit root test analysis. By using the lag value p = 1, OEKK estimation results for ADF unit root test are calculated and shown in Table 4 and Table 5.

Developing by Dickey-Fuller (DF) tables, %1, %5 and %10 significant levels and for T=18 values and $\tau_\tau, \tau_\mu$ $and$ $\tau$ statistics values and $t_{\hat{\delta}}$ value are compared. According to this, $t_{\hat{\delta}}$ values and $\tau_\tau, \tau_\mu$ $and$ $\tau$ statistics values are compared, we can reject $H_0$ hypothesis for (Intercept and none) and none level of significance. Series is stationary or not include unit root (Table 5).

As a conclusion, EC series are not stationary for level but after taking first difference of series, this series is stationary. For that reason, we can say that EC series is first difference integrated I(1) (Table 5).

Since the variables are at the same level of stability, the long-term relationship is to be examined. In this context, the Johansen cointegration test was used to investigate the existence of a long-running relationship between the two series. The results of this test are given in the following Table 6.

Table 6. VAR Lag Order Selection Criteria

| Lag | LogL | LR | FPE | AIC | SC | HQ |
|---|---|---|---|---|---|---|
| 0 | -425.36 | Na | 1.12e+24 | 61.05 | 61.14 | 61.04 |
| **1** | **-408.87** | **25.90*** | **1.91e+23** | **59.26** | **59.54*** | **59.24** |
| 2 | -403.71 | 6.64 | 1.70e+23* | 59.10 | 59.55 | 59.05 |
| 3 | -400.04 | 3.67 | 2.04e+23 | 59.14 | 59.78 | 59.08 |
| 4 | -396.43 | 2.57 | 2.86e+23 | 59.20 | 60.02 | 59.12 |
| 5 | -388.67 | 3.32 | 3.10e+23 | 58.66* | 59.67 | 58.57 |

Source: The Author's calculation.

At the 0.05 critical value, trace statistic and maximum eigenvalue statistic show that there is no cointegration rank (Table 7 and Table 8). Granger causality analysis results were given in Table 8. These results stressed that one-way causality relation at 5% level of significance towards GDP denoted EC was detected. In this manner, we can say that Turkey is dependent on the energy sector in the agricultural sector to grow.

Table 7. Johansen Integration Test Summary

| Null Hypothesis ($H_0$) | Eigenvalue | Trace Statistic | 0,05 Critical Value |
|---|---|---|---|
| r = 0 | 0.47 | 12.54 | 18.40 |
| r ≤ 1 | 0.09 | 1.76 | 3.84 |
| Null Hypothesis ($H_0$) | Eigenvalue | Maximum Eigenvalue Statistic | 0.05 Critical Value |
| r = 0 | 0.47 | 10.78 | 17.15 |
| r ≤ 1 | 0.09 | 1.16 | 3.84 |

Source: The Author's calculation.

After taking first difference of GDP series, this series are found in stationary. We can say that GDP series are first difference integrated I(1). EC series are not stationary for level but after taking first difference of series, these series are stationary and first difference integrated I(1). In this context, the Johansen cointegration test was used to investigate the existence of a long-run relationship between the two series. According to Granger causality analysis results, one-way causality relation at 5% level of significance towards GDP denoted EC was detected. In this case, it is possible to say that Turkey is dependent on the energy sector in the agricultural sector to grow.

Table 8. Pairwise Granger Causality Tests

| Null Hypothesis | Obs | F-Statistic | Prob. | Decision |
|---|---|---|---|---|
| D (EC) does not Granger Cause D (GDP) | 16 | 0.45 | 0.65 | Accept |
| D (GDP) does not Granger Cause D (EC) | | 5.72 | 0.01 | Reject |

Source: The Author's calculation.

## CONCLUSIONS

There are many objectives to implementation of national energy efficiency in Turkish agriculture sector that determined in under Action Plan 2017-2023. Some of them are using of energy-efficient tractors and harvesters, determining to effective method of irrigation methods by lands, energy efficient projects by supported, knowledgeable use of renewable energy resources in agricultural production by farmers, determining of waste potential to produce biomass and promoting its use in agriculture sector. If we implement to these measurements in agriculture sector, we can gather to success in Turkish agriculture sector.

## REFERENCES

[1]Avara, A., Karami, m., 2010, Energy and Exergy Efficiencies in Agricultural and Utility Sectors of Iran Compared with Other Countries. ICMET 2010 - 2010 International Conference on Mechanical and Electrical Technology, Proceedings, art. no. 5598479, pp: 6-10.
[2]Avcıoğlu, O., Herheh, N.S., Lighvan, Y., 2013, Tarımsal Üretimde Enerji Kullanımı ve Enerji Verimliliği. In: Procedings of the 28. Ulusal Tarımsal Mekanizasyon Kongresi, Konya, Türkiye, 96-102.
[3]Deppermann, A., Blesl, M., Boysen, O., Grethe, H., Bruchof, D., 2016, Linkages Between the Energy and Agricultural Sectors: Insights From European Union Greenhouse Gas Mitigation Scenarios. Mitigation and Adaptation Strategies for Global Change 21(5): 743-759.
[4]Dickey, D.A., Fuller, W.A., 1979, Distribution of the Estimators for Autoregressive Time Series With A Unit Root. Journal of the American Statistical Association 74: 427–431.
[5]Dickey, D.A., Fuller, W.A., 1981, Distribution of the Estimators for Autoregressive Time Series With A Unit Root. Econometrica 49: 1057-72.
[6]Dincer, I., Hussain, M.M., Al-Zaharnah, I., 2005, Energy and Exergy Utilization in Agricultural Sector of Saudi Arabia. Energy Policy, 33(11): 1461-1467.
[7]Foresti, P., 2006, Testing For Granger Causality Between Stok Prices And Economic Growth. MPRA.
[8]Granger, C.J., 1969, Investigating Causal Relationships by Econometrics Models and Cross Spectral Methods. Econometrica 37: 425-435.
[9]Johansen, S., 1998, Statistical Analysis of Cointegration Vectors. Journal of Economic Dynamics and Control 12: 231-254.
[10]Johansen, S., Juselius, K., 1990, Maximum Likelihood Estimation and Inferences on Cointegration With Applications to the Demand for Money. Oxford Bulletin of Economic and Statistics 52: 169-210.
[11]Leamer, E., 1985, Vector Autoregressions for Causal İnference? in Karl Brunner and Allan H. Meltzer. In: Carnegie-Rochester Conference Series On Public Policy: Understanding Monetary Regimes. 22: 255-304.
[12]Medlock, K., Kenneth, B., Ronald, S., 2001, Economic Development and End-Use Energy Demand. The Energy Journal 22(2): 77-105.
[13]Kumar, M.D., 2013, Raising Agricultural Productivity, Reducing Groundwater Use and Mitigating Carbon Emissions: Role Of Energy Pricing in Farm Sector. Indian Journal of Agricultural Economics 68(3): 275-291.
[14]Kusek, G., Turker, M., Akdemir, S., Hayran, S., 2017, Structural Characteristics of the Agricultural Sector in Terms of Access to Agricultural Credits in Turkey. New Medit 16(4): 66-72.
[15]Tan, S., Atak, Ş., Şengül, Ü., Tan, S.S., 2015, The Evaluation of The Changes in the Agricultural Sector With Common Economic Indicators in Turkey During the Last Decade. Mediterranean Journal of Social Sciences 6(2S1): 588-595.
[16]Utlu, Z., Hepbasli, A., 2006, Assessment of the Energy and Exergy Utilization Efficiencies in the Turkish Agricultural Sector. International Journal of Energy Research, 30(9): 659-670.