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# RELATIONSHIP BETWEEN FOOD PRICES AND NON-RAW MATERIALS INPUT: VAR ANALYSIS

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## ABSTRACT

Inflation is defined as the general increase in prices in the most general sense and is an important macroeconomic indicator. The increase in food prices is affected by the general inflation rate and it is an important indicator in determining the monetary policies implemented. In recent years, factors such as global crises, climate changes, foreign dependency in energy have sharpened the rises in national indicators. In this study, in Turkey, the effects of electricity-natural gas, Brent oil, dollar exchange rate and labor cost (minimum wage), which are the most important cost items in forming food prices, in the quarterly periods between 2003Q1-2022Q4 were analyzed. Vector Autoregression (VAR) model was used as the analysis method, the cointegration relationship between the variables can be accepted with a lagged value in the model and the error correction model is assumed to consist of an autoregressive distributed lag model. Literature review showed that external factors will affect food prices more as a hypothesis. According to the variance decomposition analysis results in the VAR model, the most important factors affecting food prices are exchange rate in the short run and Brent oil price in the long run. It has been observed that the minimum wage has the lowest effect. In the research, one limitation is that only factors such as electricity-natural gas, Brent oil, dollar exchange rate and labor cost were taken into account in evaluating impact on food prices, and other economic, social and climatic factors affecting agricultural production were not taken into account. In previous studies, the effects of factors such as electricity-natural gas, Brent oil price, dollar rate and labor cost on food prices were examined separately; this study contributes to determining which factor is more effective over the long and short term.

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## 1. INTRODUCTION

Inflation, which is defined as the general increase in prices, is an indicator affecting all segments economically (Barbaros, Kalaycı and Bakır, 2019). Food prices are an important factor in the formation of ideas about the economic policies and welfare levels of countries. Fluctuations in food prices impact on producers, consumers and market makers and create significant price risk and uncertainty (Chavas, Hummels, and Wright, 2014).

Although the share of labor costs in the total production cost in the food sector is small compared to other sectors, the rate of labor force working with minimum wage is higher than in other sectors because of the high number of jobs that do not require qualifications (Lee, Schluter, and O'Roark, 2000). The increase in consumption of processed and ready-made food and the substitution of the sector with labor, however, can lead to an increase in the need for labor and subsequent increased cost to the consumer (Bhattacharya and Jain, 2020; Norazman, Khalid, and Ghani, 2018).

Energy costs are one of the most important expense items in the food industry. As well as supply shocks and the financial crisis volatility in food prices, it is also explained by the energy market (Von Braun and Tadesse, 2012). It is observed that the increase in oil prices has a greater effect on food prices, especially in developing countries (Dillon and Barrett, 2016). Petroleum is an important input used in stages such as processing and transportation of agricultural and food products from production to consumption. Oil price volatility affects the agricultural food prices and food security negatively due to the increase in costs (Taghizadeh-Hesary, Rasoulinezhad, and Yoshino, 2019).

With globalization, international goods, services and capital mobility have increased and the exchange rate based on the pricing of these products has begun to take an important place in the economies of the countries (Petek and Çelik, 2017). The increase in exchange rate after the Covid-19 crisis caused a break in the exchange rate-inflation relationship and shows that the exchange rate is closely related to

inflation (Bozdağlıoğlu and Yılmaz, 2017). In addition, it is observed that when a country is financially weak, it affects the exchange rate negatively and causes volatility in commodity prices (Boubakri, Guillaumin, and Silanine, 2019).

Many studies on inflation exist in the international literature. In the national literature within a narrow scope studies have been done on the inflation of agricultural and food products, the effect of international macroeconomic variables on agricultural production and food industry prices (Bayramoğlu and Yurtkur, 2015), the asymmetric effect of real income and oil prices on food prices (Altıntaş, 2016), the effects of price increases in agricultural and food products on inflation (Eştürk and Albayrak, 2018), the effect of price increases in food products on general inflation (Ulusoy and Şahingöz, 2020), as well as the effect of oil prices and exchange rates on food prices (Gökçe, 2021).

In the international literature, studies have covered the political unrest caused by increase in food prices and volatility (Bellemare, 2011), the impact of shocks in global food prices on the Turkish economy (Kapusuzoğlu, Liang, and Ceylan, 2018), the effect of financial and energy markets on food prices (Śmiech et al., 2019) the relationship between agricultural commodity prices and oil prices in the global market (Su et al., 2019), and the effect of monetary policies on food prices (Iddrisu and Alagidede, 2020).

Review of the national and international literature showed no study has been found on the effect of energy prices, exchange rates and labor costs on food prices. Hence, this study investigates to what extent the effects of energy (electricity-natural gas, Brent oil), dollar exchange rate and minimum wage in Turkey, which constitute the biggest cost items other than raw material prices, are on food prices.

With the analysis made, it is aimed to present solutions by revealing the factors having the greatest impact on food prices. In this way, measures can be taken to prevent an increase in food prices.

## 2. MATERIAL AND METHODOLOGY

In the 2003-2021 period, Turkey's food inflation data regarding the food price index, electricity-natural gas price index and international Brent oil price ($) as energy variables, minimum wage and dollar exchange rates as monetary values constitute quarterly data. Secondary data used in the research were obtained from Turkish Statistical Institute (Türkiye İstatistik Kurumu) (TURKSAT), Central

Bank of the Republic of Turkey (Türkiye Cumhuriyet Merkez Bankası) (CBRT) Electronic Data Distribution System (EVDS).

Descriptive statistics regarding the variables used in the study are given in Table 1. The mean value of the food CPI index in the examined period was 259.03, and it was the variable with the highest variability with 154.25 standard deviations, while there were 7.32 multiple differences in the periods with the maximum and minimum values.

TABLE 1
Descriptive Statistics of the Belong to Variables Used in the Research

| Variables | Symbol | n | Min. | Max. | Mean | Std. Deviation |
|---|---|---|---|---|---|---|
| Food CPI (index) | FI | 76 | 96.99 | 709.78 | 259.03 | 154.25 |
| Electricity-Natural Gas (index) | EN | 76 | 99.89 | 627.49 | 257.39 | 134.70 |
| Brent oil ($) | BO | 76 | 28.15 | 112.16 | 68.80 | 25.05 |
| Minimum wage (TL) | MW | 76 | 226.00 | 2825.90 | 987.95 | 0.85 |
| Dollar exchange rate (TL) | DE | 76 | 1.19 | 11.16 | 2.87 | 2.18 |

Source: CBRT, 2022; TURKSAT, 2022

The relationship between food inflation and the dollar exchange rate, which affects the price of energy, labor costs and raw material inputs, apart from raw material inputs, has been examined by Vector Autoregressive Model (VAR) analysis. The Vector Autoregression (VAR) model was developed by Sims (1980) and revealed that all variables (dependent-independent) used in the model should be considered as internal (values determined in the model). In this model, if there is a cointegration relationship between the variables, the lagged value of the variables can be accepted and the error correction model can create a VAR model from the

autoregressive distributed lag model (Erarslan, Pehlivanoğlu, and Narman, 2021).

Variables must be stationary in the VAR model, which is one of the time series analysis models. In this study, Augmented Dickey-Fuller (ADF) and Phillips Perron (PP) unit root tests, which are the most used methods to determine the stationarity of the series, were applied. With these stationarization tests, the possibility of spurious regression in time series is eliminated and the accuracy of analysis is ensured (Akıncı, Akıncı, and Yilmaz, 2014). The equation related to the unit root test is as follows:

$$(1) \qquad \Delta Y_t = \alpha_0 + \alpha_1 t + \gamma Y_{t-1} + \sum_{i=1}^{k} B_i \, \Delta Y_{t-1} + \mathcal{E}_t$$

In the equation, $\Delta Y_t$ stationarity is the coefficient that determines the analyzed time series, $\alpha_0$ and $\alpha_1 t$ are the coefficients that determine whether there is a systematic trend in the analyzed time series, and $u_t$ represents the random error term. While the ADF test, one of the stagnation tests, considers whether there is a unit root and the appropriate lag length, the PP unit root test does not take into account the structural break (Gültekin and Hayat, 2016).

The Vector Autoregression (VAR) model establishes a simultaneous equation system in case the effects of variables on each other are difficult to understand their influence and multifaceted (Gültekin and Hayat, 2016). The presence of a lagged model in the model is preferred because it allows strong predictions for the future and can reveal dynamic relationships in time series without any restrictions (Petek and Çelik, 2017). The equation related to the time series with one dependent variable in the model is as follows:

$$(2) \qquad Y_t = A_1 Y_{t-1} + \ldots + A_p Y_{t-p} + B x_t + \mathcal{E}_t$$

While $Y_t$, which is the dependent variable in the equation, represents the variable vector, $x_t$ refers to the determinist variable, t time, p the delay number, A and B stationarity coefficients, and $\mathcal{E}_t$ the error term vector (Gültekin and Hayat, 2016).

## 3. FINDINGS

### 3.1 CHANGES IN FOOD PRICES AND INFLATION IN TURKEY

As a macroeconomic concept, inflation has been one of the most

important economic problems in Turkey for years. The fact that Turkey is an open economy causes an increase in sales costs and prices in domestic markets in parallel with increasing international food prices (Altıntaş, 2016). In developing countries such as Turkey, high food inflation causes high general inflation and this situation can lead to monetary policies implemented (Bhattacharya and Jain, 2020).

Because the rate of increase in food prices causes general inflation to a large extent it reduces the general consumption demand and leads to socio-economic consequences (Eştürk and Albayrak, 2018). Especially in the last five years, 30% of the increase in inflation is attributed to food prices, and factors such as global crises, climate changes and foreign dependency in energy have paved the way for the increase (Ulusoy and Şahingöz, 2020).

### 3.2 EFFECTS OF NON-AGRICULTURAL RAW MATERIAL INPUTS ON FOOD PRICES

In order to perform VAR analysis, it is first necessary to determine whether the series related to the variables used in the research are stationary to the same degree. The stationarity of the variables means that the means and variance are not variable (Kalkavan, Eti, and Yüksel, 2020). The results of Augmented Dickey Fuller (ADF) and Phillips Perron (PP) unit root tests applied to the natural logarithms of the data of the variables are shown in Table 2. It was observed that the variables became stationary at the 5% significance level by taking their primary differences, and the stationarity of all variables at the same level indicates that it is appropriate to apply the VAR analysis.

At the stage of creating the VAR model, the appropriate lag length should be determined so that the results of impulse-response analyses and variance decomposition are consistent. In determining the lag length, LR (LR test statistics), FPE (Final estimation error), AIC (Akaike information criterion), SC (Schwarz information criterion) and HQ (Hannan-Quinn information criterion) tests are applied (Kalkavan, Eti, and Yüksel, 2020). As seen in Table 3, the lag length of the VAR model was calculated as 3 according to the LR, FPE and AIC criteria. According to this result, the appropriate VAR model was determined as VAR(3).

In Table 4, the coefficient values of the estimation results of the variables in the VAR(3) model created according to the lag length are given. In the model, the differences of the series are taken according to the lag length and the trend variable (c) is shown in the

model depending on the previous data. Based on the dependent variable food consumer index, the overall explanatory level of the model was observed to be 99%, and it was observed that there was a positive correlation between the electricity and natural gas index of the three lag periods and the food inflation in the 2 lag periods in the dollar exchange rate.

TABLE 2
Unit Root Test Results of Variables

| | ADF | | | | PP | | | |
|---|---|---|---|---|---|---|---|---|
| Level | | | | | | | | |
| Variable | Intercept | | Trend & Intercept | | Intercept | | Intercept ve Trend | |
| | ADF Test | P Value | ADF Test | P Value | t Test | p Value | t Test | p Value |
| lnFI | 3.73 | 1.000 | 4.20 | 1.000 | 4.27 | 1.000 | 3.02 | 1.000 |
| lnEN | 0.79 | 0.993 | -1.55 | 0.801 | 1.09 | 0.997 | -1.69 | 0.746 |
| lnBO | -2.83 | 0.059 | -2.76 | 0.216 | -2.35 | 0.158 | -2.20 | 0.484 |
| lnMW | 1.12 | 0.998 | -1.59 | 0.789 | 0.25 | 0.974 | -3.18 | 0.097 |
| lnDE | 2.86 | 1.000 | -1.03 | 0.934 | 4.44 | 1.000 | -0.47 | 0.983 |
| 1st Difference | | | | | | | | |
| lnFI | -1.79 | 0.380 | -10.79 | 0.000* | -7.86 | 0.000* | -11.95 | 0.001* |
| lnEN | -3.77 | 0.005* | -3.89 | 0.017* | -2.97 | 0.043* | -3.11 | 0.013* |
| lnBO | -3.35 | 0.016* | -3.50 | 0.047* | -4.32 | 0.001* | -4.34 | 0.005* |
| lnMW | -3.79 | 0.005* | -3.91 | 0.017* | -17.07 | 0.000* | -19.14 | 0.000* |
| lnDE | -7.27 | 0.000* | -8.47 | 0.000* | -7.27 | 0.000* | -10.75 | 0.000* |

TABLE 3
Lag Length Table of VAR Model According to Relevant Criteria

| Lag | LogL | LR | FPE | AIC | SC | HQ |
|---|---|---|---|---|---|---|
| 0 | 159.439 | NA | 1.00e-08 | -4.231 | -4.074 | -4.1687 |
| 1 | 663.469 | 925.206 | 2.00e-14 | -17.355 | -16.414 | -16.980 |
| 2 | 723.648 | 102.223 | 7.70e-15 | -18.319 | -16.593* | -17.631* |
| 3 | 755.938 | 50.426* | 6.47e-15* | -18.519* | 16.009 | -17.519 |

* Appropriate lag length

TABLE 4
The Coefficient Values of The Estimation Results of The VAR(3) Model

| | lnMW | lnBO | lnDE | lnEN | lnFI |
|---|---|---|---|---|---|
| lnMW(-1) | 0.338 | -0.103 | 0.188 | -0.001 | -0.095 |
| lnMW(-2) | 0.341 | 0.215 | -0.268 | 0.005 | -0.081 |
| lnMW(-3) | -0.103 | 0.069 | 0.076 | -0.026 | 0.130 |
| lnBO(-1) | -0.017 | 1.363 | 0.088 | -0.059 | 0.107 |
| lnBO(-2) | -0.118 | -0.293 | -0.085 | -0.032 | -0.080 |
| lnBO(-3) | 0.076 | -0.163 | -0.052 | -0.012 | -0.010 |
| lnDE(-1) | -0.167 | -0.330 | 0.911 | 0.030 | 0.078 |
| lnDE(-2) | 0.166 | 0.086 | -0.084 | -0.039 | 0.022 |
| lnDE(-3) | -0.090 | 0.218 | 0.048 | 0.007 | -0.029 |
| lnEN(-1) | 0.202 | -0.931 | 1.396 | 1.633 | 0.039 |
| lnEN(-2) | -0.391 | 1.375 | -2.048 | -0.734 | 0.009 |
| lnEN(-3) | 0.007 | -0.324 | 0.680 | 0.012 | -0.025 |
| lnFI(-1) | 1.025 | 0.119 | -0.227 | 0.019 | 0.871 |
| lnFI(-2) | -1.155 | 0.338 | 0.419 | 0.022 | -0.383 |
| lnFI(-3) | 0.918 | -0.071 | -0.031 | 0.078 | 0.505 |
| C | -0.122 | 0.166 | -0.681 | -0.064 | 0.152 |
| $R^2$ | 0.996 | 0.961 | 0.990 | 1.000 | 0.998 |

Lagrange Multipliers (LM) test statistics are used to determine whether the error terms of the VAR model used in the research are related to each other (autocorrelation) (Petek and Çelik, 2017). According to the LM test results of the model in Table 5, autocorrelation was tested up to 6 lags, it was determined that the probability values were greater than 0.05 in all lag lengths and there was no variance problem with autocorrelation.

TABLE 5
Autocorrelation Test Results

| Autocorrelation-LM Tests Results | | |
|---|---|---|
| Lag | LM Statistics | Probability Value |
| 1 | 25.60553 | 0.4334 |
| 2 | 19.78210 | 0.7611 |
| 3 | 28.76230 | 0.2782 |
| 4 | 27.72777 | 0.3250 |
| 5 | 28.51291 | 0.2891 |
| 6 | 30.64525 | 0.2049 |

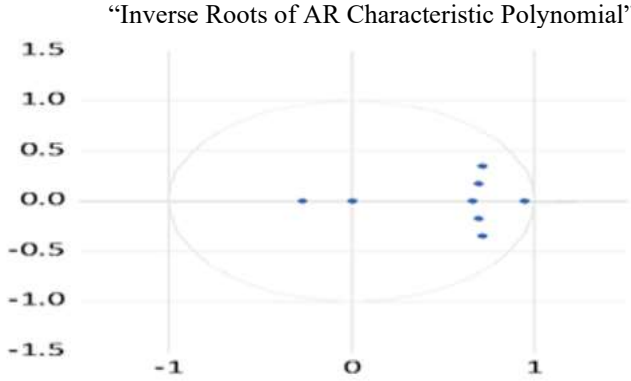
In the VAR model, whether the variance of error terms is different in the whole sample is analyzed with the White Variance Test (Petek and Çelik, 2017). Since the probability value of the model used in the research in Table 6 is higher than the 0.05 significance level as a result of the White Variance Test, it is accepted that the variance of the error term is constant and there is no problem of varying variance.

TABLE 6
White Variance Test Result

| Chi-square Test | df | Prob |
|---|---|---|
| 934.2101 | 900 | 0.2084 |

AR-Root test is applied to test the stationarity of the VAR model. The fact that the inverse roots of the AR characteristic polynomial are not outside the unit circle shows that the established model is stationary and dynamically stable (Sarıtaş, 2018). In Figure 1, it has been shown that the inverse roots of the AR characteristic polynomial are distributed inside the circle with radius 1 and the stationarity of the model is not a problem.

FIGURE 1
Stationary Plot of The AR Characteristic Polynomial




Variance decomposition analysis determines the prediction error variance of a variable for future periods and shows how much of the change is due to itself and how much is due to other variables (Petek and Çelik, 2017). The variance decomposition results of the food and beverage CPI, which is the dependent variable in the

research, are given in the following Table 7, and the biggest independent variable affecting food price inflation was exchange rates with 11.29% in the 1st period, while in the 10th period, Brent oil price with a rate of 37.64%. has been the most significant. The fact that the Brent oil price is dependent on the dollar exchange rate and the dollar exchange rate is the second independent variable affecting food price inflation at the end of the 10th period led to an increase of more than 30 times during the period.

TABLE 7
Variance Decomposition Results for Food and Beverage CPI Index

| Food CPI Variance Decomposition | | | | | | |
|---|---|---|---|---|---|---|
| Period | St. Error | FI | MW | BO | DE | EN |
| 1 | 0.026 | 85.967 | 0.568 | 0.845 | 11.288 | 1.332 |
| 2 | 0.037 | 73.196 | 1.009 | 7.334 | 17.190 | 1.272 |
| 3 | 0.042 | 58.078 | 5.720 | 14.326 | 20.760 | 1.115 |
| 4 | 0.046 | 51.557 | 5.078 | 20.346 | 21.868 | 1.156 |
| 5 | 0.052 | 49.548 | 4.036 | 24.644 | 20.446 | 1.327 |
| 6 | 0.057 | 45.701 | 3.396 | 28.666 | 20.847 | 1.390 |
| Food CPI Variance Decomposition | | | | | | |
| Period | St. Error | FI | MW | BO | DE | EN |
| 7 | 0.060 | 42.065 | 3.154 | 31.222 | 22.034 | 1.525 |
| 8 | 0.062 | 40.020 | 2.977 | 31.932 | 23.181 | 1.890 |
| 9 | 0.066 | 39.103 | 2.825 | 31.332 | 24.329 | 2.412 |
| 10 | 0.069 | 37.650 | 2.585 | 30.668 | 26.194 | 2.902 |

In previous national studies on the subject, Bayramoğlu and Yurtkur (2015) revealed that the most important variable affecting food product price in Turkey in the short and long term is the dollar exchange rate, while Altıntaş (2016) determined that the increase in food prices is more affected by real income increases than oil prices, Gökçe (2021) argued that food prices are fragile against shocks in Brent oil prices and exchange rate. In the international literature; Lee et al. (2000) determined that the effect of a 10% increase in the minimum wage on food prices in the USA remained at the 1% level.

## 4. CONCLUSION

As a result of the research, in Turkey, the most influential factors on food and beverage inflation periodically were Brent oil price and

exchange rate. The main reason for this is that the inputs used in agriculture and food production depend on imports and that economic indicators are affected by international developments. While the effect of exchange rate among these two variables occurred in the short term, it was observed that the effect of Brent oil price was greater in the long term.

In the international literature, it has been observed that energy prices, especially of Brent oil, lead to an increase in food prices, especially in developing countries. In Turkey, although the same result is obtained in the long run, it has been observed that the periodic fluctuations in the exchange rate, which is one of the macroeconomic indicators, cause the increase in food inflation at the same level. On the other hand, increase in the minimum wage has a very limited effect on food inflation compared to other variables, and it is observed that the consumer purchasing power is limited due to the increase in inflation. In a narrow scope, macroeconomic policies should be determined to minimize the effect of exchange rate on food prices and measures should be taken to reduce vulnerability to shocks that may occur due to its impact on other variables. On the whole, in order to ensure food security, production planning should be developed by taking into account world food prices and policies, productivity should be increased by using agricultural technology, projects that will ensure preservation of products should be encouraged, and energy sources should be diversified to reduce dependence on foreign energy sources.

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