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Determinants of Food Prices in Türkiye: Fourier Engle-Granger Cointegration Test*

Türkiye'de Gıda Fiyatlarının Belirleyicileri: Fourier Engle-Granger Eşbütünleşme Testi

Veysel İNAL[1], Şerif CANBAY[2], Mustafa KIRCA[3]

ABSTRACT

This study aims to reveal the effects of consumer interest rates, real effective exchange rate index, and food production index on the food price index in Türkiye, in the date range 2008M04-2020M08. The relationships between the variables were investigated with the Fourier Engle-Granger (FEG) cointegration test, long-run coefficient estimators, and Fourier Granger causality tests based on the error correction model. This study uses a novel developed time series analysis while investigating the factors that cause the increase in the food price index, which has become a serious problem in Türkiye. It is the first study on this subject for Türkiye in terms of the period and the method. According to the FEG cointegration test results, it was determined that consumer interest rates, real effective exchange rates, and food production index significantly affected food prices in the long run. Over the long term, a 1% increase in the food production index decreased the food price index by 0.39% and 0.33%, and a 1% increase in the real exchange rate index reduced the food price index by 0.26% and 0.25%. Consumer interest rates did not have a significant effect. In addition, according to the Fourier Granger causality test results based on the error correction model, causality relationships from the real effective exchange rate index and food production index to the food price index were determined. The study contains important findings for policymakers.

Keywords: Food price index, Real effective exchange rate, Consumer interest rates, Food production index, Fourier Engle-Granger cointegration test
Jel Code: C32, E31, F31

ÖZ

Bu çalışma, 2008M04-2020M08 döneminde Türkiye'de tüketici faiz oranları, reel efektif döviz kuru endeksi ve gıda üretim endeksinin gıda fiyat endeksi üzerindeki etkilerini ortaya koymayı amaçlamaktadır. Değişkenler arasındaki ilişkiler Fourier Engle-Granger (FEG) eşbütünleşme

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[1] Ph.D., Assist. Prof., Sakarya University, Faculty of Political Sciences, Department of Public Finance, Sakarya, Turkiye
[2] Ph.D., Assoc. Prof., Düzce University, Akçakoca Bey Faculty of Political Sciences, Department of Economics, Düzce, Turkiye
[3] Ph.D., Assoc. Prof., Ordu University, Ünye Faculty of Economics and Administrative Sciences, Department of Economics, Ordu, Turkiye

ORCID: V.İ. 0000-0002-1143-4184;
Ş.C.0000-0001-6141-7510;
M.K.0000-0002-5630-7525

Corresponding author/Sorumlu yazar:
Veysel İNAL,
Sakarya University, Faculty of Political Sciences, Department of Public Finance, Sakarya, Turkiye
E-mail/E-posta:
veyselinal@sakarya.edu.tr

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testi, uzun dönem katsayı tahmin edicileri ve hata düzeltme modeline dayalı Fourier Granger nedensellik testleri ile incelenmiştir. Bu çalışmada, Türkiye'de ciddi bir sorun haline gelen gıda fiyat endeksindeki artışa neden olan faktörler araştırılırken yeni geliştirilen bir zaman serisi analizi kullanılmıştır. Hem dönem hem de yöntem açısından Türkiye için bu konuda yapılan ilk çalışmadır. FEG eşbütünleşme testi sonuçlarına göre, uzun dönemde tüketici faiz oranları, reel efektif döviz kuru ve gıda üretim endeksinin gıda fiyatları üzerinde anlamlı etkisinin olduğu tespit edilmiştir. Uzun vadede, gıda üretim endeksindeki %1'lik bir artış gıda fiyat endeksini %0,39 ve %0,33 oranında, reel döviz kurundaki %1'lik bir artış ise gıda fiyat endeksini %0,26 ve %0,25 oranında düşürmektedir. Tüketici faiz oranlarının önemli bir etkisi yoktur. Ayrıca hata düzeltme modeline dayalı Fourier Granger nedensellik testi sonuçlarına göre reel efektif döviz kuru endeksi ve gıda üretim endeksinden gıda fiyat endeksine doğru nedensellik ilişkisi vardır. Çalışma politika yapıcılar için önemli bulgular içermektedir.

Anahtar Kelimeler: Gıda fiyat endeksi, Reel efektif döviz kuru, Tüketici faiz oranı, Gıda üretim endeksi, Fourier Engle-Granger eşbütünleşme testi
Jel Code: C32, E31, F31

1. Introduction

In the Hierarchy of Needs theory, self-actualization at the top of the pyramid is only possible by completing certain stages. Maslow's theory suggests that to maintain a specific hierarchy, one cannot move up to the next level of the pyramid without meeting the most basic needs that form the basis of the pyramid. The most basic physiological need for the continuation of life, being the first stage of the pyramid, is food (Maslow, 1943). It is the source of life for all living things and serves as both a commercial commodity and a source of welfare (Page, 2013). However, food prices also have significant effects on commodity markets. Excessive fluctuations in the food supply or prices can destabilize regional and global markets (Bekkers, Brockmeier, Francois, & Yang, 2017). For example, food scarcity and the shortage of resources for food production force people to migrate, on the one hand, and can form the basis of many political conflicts. Additionally, the expansion of global trade networks has increased the interdependence of nations' agriculture and food systems since the second half of the 19th century. Problems related to food supply and nutrition were at the top of the agenda of the League of Nations after World War I. The hunger and famine experienced in Europe after the Second World War brought the issue of food, which poses a threat to national and regional security, to the agenda again (Page, 2013).

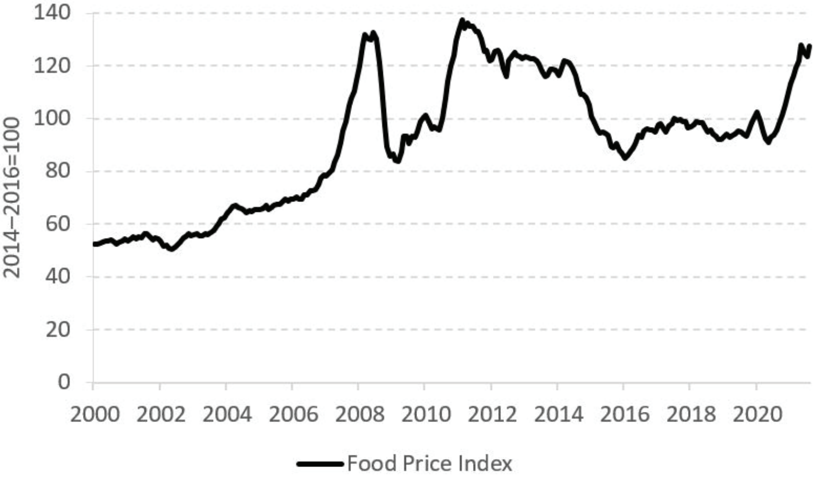
Considering today's conditions, with the effect of globalization, increasing income and welfare, especially in developing countries, has led to an increase in population and life expectancy. All these developments have increased the demand for food, which is one of the most basic needs, and this has increased the food consumption rate more than the rate of production. This can be observed more clearly at the turn of the century (Abbot, Hurt, & Tyner, 2008). The sharp increase in food prices from 2007 to the middle of 2008 has been called the global food crisis (Baltzer, 2013). However, globalization, and technological and logistics infrastructure developments have caused the food supply to accelerate today and the food variety to increase. Despite all these developments, food costs continue to increase. Especially after the 2000s, the rise in the price of agricultural products due to supply and demand has also resulted in an increase in food prices throughout the world. Rising food prices peaked in 2007-2008, and this process was also referred to as the food crisis period. Although there was a decrease in food prices in 2009, food prices started to rise again after 2010 (Bayramoğlu & Koç Yurtkur, 2015).

While COVID-19 increased unemployment rates on a global scale, this situation, on the other hand, led to a decrease in household income. Besides, in the period when all these restrictions became widespread, household expenditures concentrated on the food sector. Along with the increase in the share of household income allocated to food, the cuts in the food supply caused an increase in food prices (Petetin, 2020). Food price increases have attracted attention again, negatively impacting household welfare (Wodon, Tsimpo, & Coulombe, 2008). These developments make the food supply and food safety issues an important part of economic development. Therefore, concerns about increases in food demand, food prices, and food supply continue to increase day by day in developed and developing countries (Esmaeili & Shokoohi, 2011). Again, supply disruptions due to COVID-19 have significantly increased demand for food, as with many basic consumer goods. Besides, food as a component of the consumer price index (CPI) has grown faster than the overall CPI in all regions of the world. On average, food product prices in August 2020 were 5.5% higher than in August 2019 (Valentina, 2020). These price increases continue to seriously affect low-income consumers (Jomo & Chowdhury, 2020).

The annual report of the Global Network Against Food Crises, published by the Food and Agriculture Organization of the United Nations (FAO) and World Food Program (WFP), suggests that 135 million people experienced acute food insecurity as of the end of 2019, in 55 countries and regions examined around the world. On a regional basis, Africa ranks first in this area with 73 million, followed by the Middle East and Asia region with 43 million, Latin America and the Caribbean region with 18.5 million, and Europe with half a million. The report also indicates that 17 million children below 5 are malnourished, and 75 million children are of below-average height in 55 countries and regions experiencing a food crisis. Additionally, the food price index reached 116.0 in February 2021, increasing by 16.7% compared to February of the previous year. In February 2021, it increased by 2.4% compared to the previous month, attaining the highest price level in the last seven years. In February 2021, compared to the same month of the previous year, global vegetable oil prices increased by 51%, cereals by 26.6%, dairy products by 9.8%, and sugar by 9.6% (FAO & WFP., 2020).

The 2000-2021 food price index (FPI) reported by the Food and Agriculture Organization of the United Nations (FAO, 2021) is as follows.

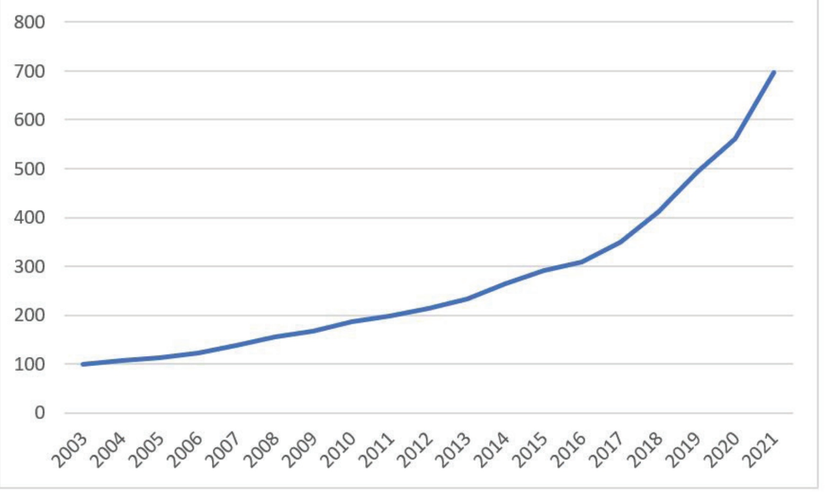
Figure 1. 2000-2021 FPI reported by the FAO of the United Nations



Source: FAO, 2021. https://doi.org/10.4060/cb4477en-fig42

From January 2000 to August 2021, the FPI increased by 74.8 to 127.4 points. The index increased for 12 consecutive months between May 2020 and May 2021, reaching its highest value since 2011 (FAO, 2021) as COVID-19 restrictions impacted supply chains and raised prices. While Türkiye's FPI was 93.6 in January 2003, it was 708.25 in August 2021. This shows that food prices increased 7.57 times in the relevant period. When the graph in Figure 2 is examined, it is in a constantly increasing trend regardless of the food price index in Türkiye. This table suggests that food prices have increased continuously in the last 20 years due to Türkiye's unique factors.

Figure 2. Food Price Index (Türkiye)



Source: (TURKSTAT, 2022)

As in the rest of the world, food prices continuously increase in Türkiye. Increases in food prices reduce social welfare and cause instability in the economy. Therefore, all these developments have managed to draw the attention of both policymakers and researchers to this field. Food inflation has increased significantly, especially with the depreciation of the Turkish Lira, the ongoing increases in international agricultural commodities and food prices, and the agricultural drought. With the developments in exchange rates, high price increases in agricultural inputs such as fertilizers and feed, which are highly sensitive to exchange rates, were experienced in various food groups (CBRT, 2022). The food and non-alcoholic beverages group inflation increased significantly in the early stages of the COVID-19 epidemic due to disruptions in supply chains (CBRT, 2020). According to the calculation made by the Turkish Statistical Institute (TSI, 2022), in January 2022, CPI increased by 11.10% compared to the previous month, by 48.69% compared to the same month of the previous year, and by 22.58% according to the twelve-month averages. The food and non-alcoholic beverages inflation ranked second with 55.61%, right after transportation inflation, being among the main groups where the increase is higher compared to the same month of the previous year.

In light of all these developments, the reasons for the rise in food prices is a key research topic. There are a limited number of studies in the literature on the determinants of food prices. There are many studies about this topic, especially in recent years. The fundamental variables in interaction with food prices in this limited study are exchange rate, interest rate, and food supply amount. To this end, this study aims to reveal the effects of consumer interest rates, real effective exchange rate index, and food production index on the food price index in Türkiye. For this purpose, monthly data for the period 2008M04-2020M08 was used. In 2008, a very sharp increase in food prices occurred in the world, and with it, the world faced a serious global economic crisis. This period was chosen especially in order to investigate the developments in food prices after these developments. The Fourier Engle-Granger (FEG) cointegration test was also used to determine the significant effects of consumer interest rates, real effective exchange rate index, and food production index on the food price index in the long run. After determining the long-term cointegration relationship, cointegration coefficients were estimated with Fully-Modified Ordinary Least Square (FMOLS) and Dynamic Ordinary Least Square (DOLS) estimators. After estimating the long-run coefficients, the short- and long-run Granger causality relationships were determined with the error correction model using the residual terms obtained from the FMOLS estimation.

2. Literature review

Irrespective of developed or developing countries, inflation has been on the rise throughout the world in recent years. Especially, the unstoppable rise of food prices is the biggest trigger for this. In particular, the reduction in supply (Dev, 2020) along with the COVID-19 pandemic and the restrictions on transit between countries has deepened this problem with disruptions in the supply chain. In addition, the increase in energy and transportation costs in this process has led to a much higher increase in food prices. Although these developments are global problems, the economic policies that policymakers can use to prevent these problems and how these policies are used can also be determinative on food prices. These policies tend to realize their effects on real macroeconomic variables through the interest rate channel, mostly through expansionary monetary policy. However, when these policies were implemented, they increased inflation even more. On the other hand, the changes in interest rates with the increase in inflation affected the exchange rate, especially in developing countries.

Food prices are affected by many macroeconomic variables as well as food demand and supply situations. The most vital among these are exchange rate, interest rate, and food production (Engle & Rangel, 2008; Karali & Power, 2013; Bayramoğlu & Koç Yurtkur, 2015). Rises in the exchange rate, one of the variables that directly affect food prices (Abbott et al., 2008), cause inflationary pressure on the domestic output price by increasing imported input prices. Therefore, exchange rate increases will be the cause of inflation (Woo, 1984). On the other hand, the overvaluation of the domestic currency will make the imported food products cheaper. This situation may lead to a downward shift in the demand curve of consumers and an increase in the amount of imported food (Lamb, 2000). This effect, which is caused by the overvalued domestic currency, reduces the production enthusiasm of domestic producers, and after a certain period, since the amount of related food products is caused only by imports, a contraction may be seen in the domestic markets. Based on this background, in such economies where external debt is high, the value of the national currency has significant effects on production and output. The depreciation of the national currency, the increase in net exports and output, and the increase in exchange rates, together with the rising debt payment costs, also reduce domestic demand. The volatilities experienced in exchange rates cause great pressures on costs, especially in developing countries that have not deepened financially. Such a situation not only changes the export and import volume of agricultural products but also significantly affects food prices. Therefore, there is a significant interaction between exchange rates and food prices. Exchange rate volatility leads to uncertainty in the prices of all kinds of goods used in the food or agriculture sector, which is the subject of imports, and this uncertainty causes inflation increases after a certain time.

In an environment of high and volatile food inflation, which deeply affects both developed and developing economies, limited but distinctive literature has emerged focusing on the determinants of food inflation. The existing studies in the literature: Lamb (2000), Çıplak and Yücel (2004), Başkaya, Gürgür and Öğünç (2008), Trostle (2008), Gilbert (2010), Baek and Koo (2010), Kara and Öğünç (2012), Davidson, Halunda, Lloyd, Mccorriston and Morga (2012), Reboredo and Ugando (2014), Bayramoğlu and Koç Yurtkur (2015), Baffes and Dennis (2014), Korkmaz and Bayır (2015), Wong and Shamsudin (2017), Karacan (2017), Gündüz, Kalaycı and Afşar (2017), Katusiime (2018), Nadiah and Mansur (2018), Karadaş and Koşaroğlu (2020), Kutlu (2021), Dua and Goel (2021), Agyei et al. (2021), and Makun (2021), when examined, conducted studies to determine the relationship between exchange rate and food prices. They consequently concluded that the exchange rate is crucial for food prices.

Interest rates are another considerable determinant on the level of prices. Especially, high inflation forces policymakers to increase interest rates (Hannsgen, 2004). This case can be explained by the existence of a positive relationship between interest rates and inflation (Gibson, 1923; Fisher, 1930; Friedman & Schwartz, 1982; Hannsgen, 2004). Hence, another way to control rising food prices is the interest rate policy practices of central banks. A decrease in interest rates increases the amount of consumption and investment and, therefore, the total demand. If the increase in aggregate demand is not supported by production, that is, by supply, it leads to an increase in prices. In the opposite case, that is, a decrease in the amount of demand results in decreases in food prices after a certain period of time (Baffoe-Bonnie, 1998). Friedman and Schwartz (1982), Barsky and Summers (1988), Mohanty and

Klau (2001), Mills (2008), Imran, Anwar and Hye (2009), Abdullah and Kalim (2012), Chadha and Perlman (2014), Özdemir and Yıldırım (2017), and Dua and Goel (2021) conducted studies to observe the effects of interest rates on food prices. As a result, they reported that there is a causality relationship between the variables and that these relationships are directly related.

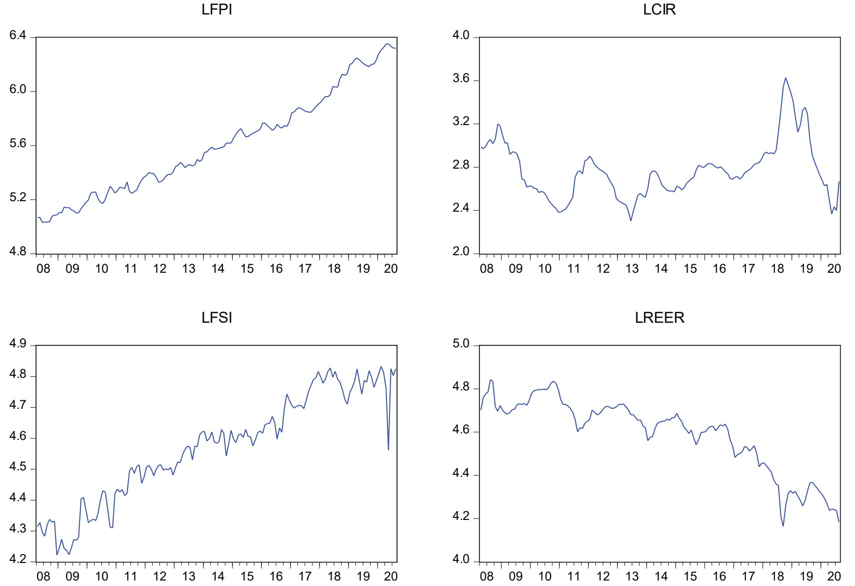
The price mechanism runs based on supply and demand conditions. The price and quantity balance of the food or agricultural products in question vary based on the supply-demand conditions. According to the Law of Supply, an increase in food supply will lead to a decrease in food prices, and a decrease in food supply leads to an increase in food prices. Equilibrium in food markets could be possible when the amount of food supply and demand is equal, as in other commodity and factor markets. In a situation where there is no significant change in demand, decreases that may occur in supply cause prices to rise. On the other hand, when there is not much change in supply, increases in demand may cause prices to rise. During the COVID-19 pandemic, the increasing demands of households for food and the cuts in the food supply have led to an increase in food prices (Petetin, 2020). Increasing supply in the agricultural sector reduces food prices (De Janvry & Sadoulet, 2002; Christiaensen & Subbarao, 2005). Some studies focusing on the correlation between food prices and food supply are those of Muth (1961), Lamb (2000), Çıplak and Yücel (2004), Dikmen (2006), Erdal (2006), Abbott et. al. (2008), Erdal and Erdal (2008), Doğan and Gürler (2013), Woertz, Soler, and Farrés (2014), Xie and Wang (2014), Özbay and Çelik (2016), Eren, Kal and Özmen (2017), Ağazade (2021), Gümüşsoy (2021) and Makun (2021).

It is seen that important studies have been carried out in Türkiye regarding food prices in recent years. Güngör and Erer (2022) examined the relationship between food prices and exchange rates. The study revealed the effect of fluctuations in the exchange rate on food prices, especially during the Covid-19 period. In addition, they found that both the increase in oil prices and the increase in demand for the post-Covid 19 period effected food prices. Similarly, Uysal, Yılmaz, and Kasa (2022) concluded that the impact of exchange rate shocks on food prices became more pronounced, especially in the post-2016 period. Demir (2022), on the other hand, investigated the relationships between global energy prices, food prices, and inflation using the time-varying causality analysis method. Especially in the last quarter of 2008, they revealed that there are bidirectional causality relationships between these variables. Yurttancikmaz, Ahmid, Öndeş, and Karcioğlu (2020), on the other hand, examined the relationships between oil prices, exchange rates, and food prices. In the study, they found that there are causal relationships from oil prices and exchange rates to food prices. Unlike the previous studies in the literature, this is the first research to examine the effects of consumer interest rates, real effective exchange rate index, and food production index together on the food prices index for Türkiye. With the inclusion of these three variables in the model together, the effect of the variables on food prices can be accurately determined. In addition, the most important criterion for the selection of these three variables is that factors such as exchange rate, interest rate, and production volume are the leading indicators as determinants of inflation in the literature. This research differs in terms of the method used and the period studied. It also differs from past research in revealing the long- and short-run dynamics of food prices. In studies conducted on Türkiye, it has been revealed that causality relationships are generally examined. For this reason, both long-term and short-term coefficients are revealed with the method we used in the study. Considering the structural changes in both the variables and the model mentioned below while performing the analysis also makes the findings more powerful.

3. Data and model

This study investigates the impact of consumer interest rates (LCIR), reel effective exchange rate index (LREER), and food production index (LFSI) on the food prices index (LFPI) in Türkiye for the period 2008M04-2020M03. Data were accessed on the Electronic Data Delivery System (EDDS, 2021). The logarithmic transformations of the variables were taken and included in the analysis. The time-series graphs of the variables are shown in Figure 3, indicating that there are fluctuations and structural breaks in the variables. Hence, analyses are made in the next stages by taking this situation into account to obtain more reliable and consistent findings.

Figure 3. Time Series Graphs of The Variables Used in the Analysis



The relationships among the variables can be simply represented as follows:

$$LFPI_t = \beta_0 + \beta_1 LCIR_t + \beta_2 LFSI_t + \beta_3 LREER_t + e_t \tag{1}$$

t in Equation 1 shows that the variables are a time series. β_0 is the coefficient of the constant term, and $\beta_{1,2,3}$ are the coefficients that show the degree and direction in which the independent variables affect the dependent variable. Here, β_1 is expected to be significant and positive, and β_2 and β_3 are expected to be significant and negative. represents the error term.

4. Method

In the first stage of the study, the stationarity levels of the variables were examined thanks to the Fourier ADF (FADF) and Augmented Dickey–Fuller (ADF) unit root tests. In the second stage, the long-run relationships between the variables were determined using the Fourier Engle-Granger cointegration test. In the third stage, the coefficients of the obtained cointegration relationship were estimated by means of the Fully Modified Least Squares (FMOLS) and Dynamic Least Square (DOLS) estimators. Finally, the error correction model was estimated, and it was investigated whether the error correction mechanism worked. Again, using this model, whether or not there was a causality relationship from the independent variables to LFPI was investigated by the Granger causality test based on the error correction model. In the following part, information about the relevant methods is given.

4.1. Fourier ADF unit root test

In this study, the FADF unit root test, which was introduced to the literature by Enders and Lee (2012), was employed. By adding trigonometric terms to the classical ADF unit root test equation, Enders and Lee (2012) avoided problems such as pre-detection of structural breaks and prior determination of the shape of the series. Besides, these trigonometric terms take into account the structural breaks that occur in the variables. The model of the FADF unit root test is as follows:

$$\Delta y_t = \alpha_1 + \delta t + \alpha_k \sin\left(\frac{2\pi kt}{T}\right) + \beta_k \cos\left(\frac{2\pi kt}{T}\right) + \sum_{i=1}^{p} \sigma_i \Delta y_{t-i} + \theta y_{t-1} + \varepsilon_t \tag{2}$$

Using the model (2), nonlinear FADF unit root test results are obtained. The *sin* and *cos* in the equation represent the trigonometric terms. In the FADF test procedure, the model is first estimated with its appropriate k value. The appropriate k value is the frequency number that gives the least residual squares sum. In the stationarity decision of the series, the significance of the coefficient θ is checked. The result obtained is compared with the table critical values obtained by Enders and Lee (2012) with bootstrap simulation. The hypotheses of the test are as follows:

$h_0 : \theta = 0$ (unit root)

$h_1 : \theta < 0$ (no unit root)

If the test statistic for which the decision rule is calculated for the hypotheses is greater than the table critical values in absolute value, is rejected. In other words, the series is stationary. In such a case, trigonometric terms should be tested for significance. In this test, in which Wald F test statistic is used, if the F test statistic value is greater than the table critical value, is rejected, and it is concluded that the trigonometric terms are significant. In the opposite case, the result is that the trigonometric terms are meaningless, suggesting the use of traditional tests (Enders & Lee, 2012; Gurdal, Kırca, Inal, & Degirmenci, 2018). In this study, the ADF unit root test developed by Said and Dickey (1984), which is one of the traditional unit root tests, is used in case the trigonometric terms are insignificant. In the ADF unit root test, the hypotheses are the same as in the FADF unit root test. If the statistical test value obtained in the decision rule is greater than the critical values or the probability value is less than the 1%, 5%, and 10% significance levels, the basic hypothesis is rejected.

4.2. Fourier Engle-Granger cointegration

The concept of cointegration is defined as a long-run equilibrium relationship between variables. Granger (1981) and Engle and Granger (1987) developed the first cointegration tests. However, these traditional cointegration tests do not consider structural breaks that occur for different reasons. There may be errors in the findings obtained from these tests, which do not cover structural breaks. In other words, the power of the tests lowers. In order to prevent this situation, cointegration testers that allow structural breaks have been developed by Gregory and Hansen (1996), Hatemi-J (2008), and Maki (2012). However, these tests also have shortcomings. Yılancı (2019) and Engle and Granger (1987) added the Fourier functions to the cointegration equation and developed a new cointegration test named the Fourier Engle-Granger test (FEG). With the inclusion of these Fourier functions in the cointegration equation, there is no need to predetermine the number and forms of structural breaks. FEG cointegration regression is as in equation 3 (Yılancı, 2019):

$$y_{1t} = a_0 + \gamma_1 \sin\left(\frac{2\pi kt}{T}\right) + \gamma_2 \cos\left(\frac{2\pi kt}{T}\right) + \beta' y_{2t} + u_t \qquad (3)$$

The y_{1t} in the model represents LFPI, and the y_{2t} in the explanatory variable represents LCIR, LFSI, and LREER. The and values are Fourier functions. At this point, it is important to determine the *k* value in $\frac{2\pi kt}{T}$, that is, the frequency number. Equation (3) is estimated by giving values from 1 to 5, and the *k* value that gives the smallest sum of residual squares is determined as the appropriate *k* value. The equation is re-estimated with this value. After estimating the equation, the error term is derived as follows:

$$\hat{u}_t = y_{1t} - \hat{\alpha}_0 - \hat{\gamma}_1 sin\left(\frac{2\pi kt}{T}\right) - \hat{\gamma}_2 cos\left(\frac{2\pi kt}{T}\right) - \hat{\beta}' y_{2t} \quad (4)$$

After the error term is derived, the Augmented Dickey-Fuller unit root test is applied to the error term, as in the Engle and Granger (1987) cointegration test. The ADF unit root test equation is estimated as:

$$\Delta\hat{u} = \rho\hat{u}_{t-1} + \sum_{i=1}^{p} \gamma_i \hat{u}_{t-i} + \varepsilon_t \quad (5)$$

As the *ρ* coefficient in the ADF equation number 5 is statistically significant, it is decided that there is cointegration (Yılancı, 2019). Here, the test statistic value calculated to test whether the *ρ* value is significant is compared with the values in the critical value table in Yılancı (2019). If the calculated test statistical value is greater than the table critical values, the variables have a cointegration relationship. Similarly, by adding the trend term to equation (3), the cointegration test for the fixed-trend model can be designed similarly. In this equation, the existence of a cointegration relationship shows that the independent variables are influential on the dependent variable in the long run.

4.3. Long-run coefficient estimation

After determining the significant cointegration relationship, the FMOLS developed by Phillips and Hansen (1990) and the DOLS estimators developed by Stock and Watson (1993) were used for cointegration coefficient estimations. Phillips and Hansen (1990) argue that using the Least Squares (OLS) estimator to estimate the long-run coefficients among the variables with a cointegration relationship ends up with biased results. It was emphasized by Stock and Watson (1993) that the DOLS estimator is preferable to other estimators. The long-run coefficients between the variables are obtained by adding the trigonometric terms in our equation (3), which is stated as the FEG equation in our study, to the FMOLS and DOLS equations as exogenous variables. Thus, the effect of trigonometric terms, which are important in the long-run relationship, is also considered in the coefficient estimation.

4.4. Error Correction model and Fourier Granger causality test based on error correction model

After estimating the long-run coefficients using FMOLS and DOLS estimators, the error terms ($\hat{u}_t$)ut of the model were derived by using the FMOLS estimator as shown in equation (4). After the error term was obtained, the error correction model was estimated as follows:

$$\Delta y_{1t} = \theta_0 + \theta_1 \Delta y_{2t} + b_1 \Delta sin\left(\frac{2\pi kt}{T}\right) + b_2 \Delta cos\left(\frac{2\pi kt}{T}\right) + \partial \hat{u}_{t-1} + \varepsilon_t \quad (6)$$

The coefficient ∂ in the model (6) belongs to the error term lag. If this coefficient is between 0 and -1 and is significant, it means that the error correction mechanism perfectly works in the model. Besides, the fact that the θ_1 coefficients in this model are significant indicates that the variables affect the related dependent variable in the short run.

Howard (2002) claims that if there is cointegration between the variables, the causality test should be done over the error correction model, as noted by Granger (1969). In this context, the Wald F test statistical value calculated by applying the constraint test to each coefficient of the independent variables in the model (6) is to test the short-run causality from the independent variables to the dependent variables, while the Wald F test statistical value calculated with a constraint test applied to the coefficient ∂ of the error correction term can be used to test for long-run causality. The test statistic value can be used to test for long-run causality. If the Wald F test statistical value calculated as a result of these test constraints is statistically significant, this means that significant causality relationships are detected. The inclusion of information on trigonometric terms in an error correction model created in this way also strengthens the findings.

5. Empirical analysis and discussion

In this part of the study, the findings obtained using the methods given above are included. First, the findings of the FADF and ADF unit root tests are given in Table 1. The purpose of these tests is to determine the stationarity levels of the series before proceeding to the cointegration and causality tests. The ADF unit root test and the Fourier ADF test, which takes into account structural breaks and changes and allows soft breaks, were also applied to the series in order to increase the reliability of the test results and to provide a comparison opportunity. The unit root test results of the variables are reported in Table 1.

Table 1: FADF-ADF Unit Root Test Results

Constant Model						
	FADF				ADF	
Variables	**FADF**	**F-stat**	**k**	**p**	**I(0)**	**I(1)**
LFPI	3.2616	6.2868	3	10	1.6732	-9.6446*
LCIR	-1.5366	2.8135	4	12	-2.5065	-6.4650*
LFSI	-1.2158	0.4454	1	4	-0.9887	-14.551*
LREER	1.3473	1.7923	5	12	0.0775	-9.9717*
Constant and Trend Model						
	FADF				ADF	
Variables	**FADF**	**F-stat**	**k**	**p**	**I(0)**	**I(1)**
LFPI	-2.7704	3.3278	1	12	-0.7738	-9.6717*
LCIR	-2.8125	2.6967	4	13	-2.7952	-6.4320*
LFSI	-5.5578	3.0205	2	1	-2.3470	-14.5010*
LREER	-4.7676	8.2519	1	9	-2.0268	-10.0710*

Notes: *, **, and *** notations express significance at 1%, 5%, and 10%, respectively. For F-stat calculated using the constant model, the statistical table value at the 5% significance level is 7.58, while it is 9.14 in the constant-trend model. (Enders and Lee 2012:197).

In the FADF unit root test, it is first tested whether there are significant trigonometric terms in the variables. For this, the calculated F statistical values are compared with the critical values. As stated in the information below in Table 1, the critical values are taken from the study of Enders and Lee (2012). The calculated F statistical values are smaller than the critical table values for all variables and models. In this case, the trigonometric terms are insignificant. Therefore, it is appropriate to use the results of the traditional ADF test. The findings revealed that the stationarity levels of the variables are I(1). This situation paved the way to investigate the possible long-run cointegration relationship between the variables. In Table 2, the Fourier Engle-Granger cointegration results are reported.

Although trigonometric terms are insignificant in variables, trigonometric terms may have significance in the cointegration relationship between variables. Thus, structural changes are taken into account in the cointegration test. Additionally, the FEG cointegration test was performed by taking into account the "trend" effect, which is clearly seen when the graph of the dependent variable LFPI in Figure 2 is examined.

Table 2 shows the results of the FEG cointegration test developed by Yılancı (2019). According to the FEG cointegration test results in Table 2, there is a significant causality relationship. LCIR, LFSI, and LREER together affect LFPI in the long run because the calculated statistical value of the test is greater than the 10% critical value in Yılancı's (2019) study. Thus, the basic hypothesis stating that there is no cointegration was rejected. More clearly, in the long run, LCIR, LREER, and LFSI affect the LFPI together.

Table 2: FEG Cointegration Test Results

Model	Test Statistic	K	Min SSR	5% Critical Value	10% Critical Value
LFPI=f(LCIR, LFSI, LREER)	-5.2852*	1	0.1897	-5.294	-4.497

Notes: * indicates the cointegration relationship at the 10% statistical significance level.
Critical values were derived from Yılancı (2019).

After determining significant long-run relationships with the FEG cointegration test, cointegration parameter estimations were made with FMOLS and DOLS estimators to see which variable affects LFPI and how. The findings of both estimators are given in Table 3.

Table 3: FMOLS –DOLS Estimator Results[a]

FMOLS			DOLS		
Variables	**Coefficient**	**Probability**	**Variables**	**Coefficient**	**Probability**
LCIR	0.0090	0.7661	LCIR	0.0057	0.8679
LFSI	-0.3844*	0.0008	LFSI	-0.3360**	0.0148
LREER	-0.2593**	0.0251	LREER	-0.2532***	0.0670
C	7.8044*	0.0000	*C*	7.5790*	0.0000
TREND	0.0096*	0.0001	TREND	0.0094*	0.0000
SIN	0.0346**	0.0214	*SIN*	0.0323**	0.0472
COS	0.0270	0.0117	*COS*	0.0296**	0.0121

Notes: * and ** show the significance of 5% and 10% statistical significance levels, respectively.
[a] Both the trend term and the trigonometric terms have a significant effect in the long run.

Based on the FMOLS and DOLS estimators, the coefficient values calculated by both estimators are found to be close to one another. Thus, this indicates that the coefficients obtained are consistent. According to the findings obtained from both estimators, only LCIR (consumer interest rates) does not significantly affect the LFPI variable in the long run. This rate generally affects consumer, housing, and vehicle loans. Consumer loans are used for white goods, durable consumer goods, home equipment and renovation, vacation, clothing, wedding, engagement, and school expenses rather than food production and consumption (Bakkal & Aysan 2011). This finding shows that the consumer interest rate does not directly affect food prices in the long run.

A 1% increase in LFSI (food production index) reduces LFPI (food prices index) by an average of 0.38%-0.33% in the long run. LFSI represents food production and constitutes the supply aspect of the food market. If the demand is constant or the increase in demand is smaller than the increase in supply, the increase in supply decreases food prices. This finding is in line with the economic theory. The LFSI (food production index) value in Figure 2 reflects a positive trend. However, the increasing trend in population both in Türkiye and globally increases the domestic and foreign demand for food. Considering the 2013-2022 foreign trade statistics published by TSI, the share of food product exports in total exports corresponds to an average of 7.73% (TSI 2022a). From 2016 to 2020, food exports have increased in value continuously. One of the most important indicators determining the domestic demand for food consumption is the population. While Türkiye's population was 71.5 million in 2008, it increased to 83.6 million in 2020 and 84.7 million in 2021. Besides, the analysis of the consumption expenditures of households marks that the highest share is in food expenditures with approximately 20.7% (TSI, 2022b). If we increase the food supply more than this demand, the increases in the food price index can be prevented to some extent. From the beginning to the end of the examined period, while the food production index increased 1.84 times in Türkiye, the food price index increased 3.59 times. This specifies that the supply in food demand is more than the increase in the food supply. Another key issue affecting food production is the development of agricultural production. Moreover, the share of employment in the agricultural sector in total employment decreased from 23.14% in 2008 to 18.11% in 2020. The decrease in food production can be shown as evidence of the increase in imports of agricultural raw materials used in food production.

A 1% increase in LREER (real effective exchange rate index) reduces LFPI (food prices index) by 0.25% in the long run. The increase in the real effective exchange rate index shows that the Turkish Lira is appreciated against developed and developing currencies. The LREER graph in Figure 2 exhibits that the Turkish Lira tends to depreciate throughout the analyzed period. The depreciation of the Turkish Lira impacts the food price index through various channels. First, the depreciation of TL, or in other words, the increase in exchange rates, increases production costs. Türkiye is a country that imports many inputs such as fertilizers, diesel, agricultural tools and equipment, pesticides, and seeds used in agricultural production (Agriculture and Forestry Council, 2022). The increase in the exchange rate increases the prices of these imported inputs, increasing the cost of agricultural production in the first place and the cost of food production in the second step. With these increasing costs, the food price index is rising. In addition to these import costs, which constitute the production factor, the upward movement in imported raw material products also increases the food price index through the exchange rate channel. This rise in costs increases the consumer food price and thus the general consumer inflation. The effects of the exchange rate on prices have been the subject of many academic studies, and fundamental findings have been collected about these impacts (e.g., Mirdala, 2014; Campa & Goldberg, 2005; Puch & Duc, 2021; Anh, Quan, Phuc, Chi, & Duc, 2021). Secondly, the increase in the exchange rate due to the import of many final food products from abroad increases the price of these products, leading to an increase in the food price index. As can be perceived from these correlations, changes in the exchange rate affect food prices in Türkiye in various ways.

After estimating the long-run coefficients, the error correction model was conducted. The model aims to test the functionality of the error correction mechanism, as stated in the method part. Table 4 shows the estimation results of the error correction model. To this end, the error correction model is estimated by using the error term obtained from the FMOLS estimator.

Table 4: Error Correction Model

Variables	Coefficient	Probability
DLCIR	-0.0001	0.8944
DLFSI	-0.1643*	0.0003
DLREER	-0.1147**	0.0891
C	0.0087*	0.0001
DSIN	0.0057	0.9240
DCOS	0.0473	0.4246
ECT(-1)	-0.2087*	0.0001

* and ** show the significance at 5% and 10% statistical significance levels, respectively.

According to the error correction model in Table 4, the coefficient of ECT(-1) is between 0 and -1 and is statistically significant. This means that the error correction mechanism works fine. In other words, it shows that the deviations from the short-run equilibrium are corrected in the long-run. However, only LFSI and LREER variables are effective on LFPI in the short run. A 1% increase in LFSI reduces LFPI by 0.16%, and an increase in LREER by 0.11%. Although the changes in the short run are smaller than the changes in the long run, their indicators are the same as in the long run.

Table 5: Fourier Granger Causality Test Results Based on Error Correction Model

Causality Periods		Short-Run			Long-Run
Dependent Variable	**DLFPI**	**DLCIR**	**DLREER**	**DLFSI**	**ECT(-1)**
DLFPI	-	0.01760 (0.8944)	2.9313** (0.0891)	13.7920* (0.0003)	16.7193 (0.0001)

Notes: * and ** show the significance at 1% and 5% statistical significance levels, respectively. The frequency value determined in the cointegration test in FEG was used in the form of k=1.

Table 5 shows the Fourier granger causality test results based on the error correction model. Considering the probability values of the F statistical values calculated by applying the constraint test to the coefficients in Table 5, there are short-run causality relationships from LREER and LFSI to LFPI. Additionally, the statistical value of F, which is calculated from the result of the constraint test applied to the ECT(-1) coefficient, is also significant, indicating that there is a causality relationship from the independent variables to LFPI in the long run. The causality relationships obtained also support the cointegration findings. In addition, these causality findings have been previously reported by Güngör and Erer (2022), Uysal et al. (2022), and Yurttancikmaz et al. (2020) and coincide with the causality findings in their studies. Here, in particular, exchange rates and food production have proven to be important determinants.

6. Conclusion

According to the results of the Fourier Engle-Granger cointegration test conducted to reveal the effects of consumer interest rates, the real effective exchange rate index, and food production index on the food price index in Türkiye, it was determined that the three independent variables have a significant effect on the food price index in the long run. After determining the long-run cointegration relationship, long-run cointegration coefficients were estimated with the Fully Modified Ordinary Least Square (FMOLS) and Dynamic Ordinary Least Square (DOLS) estimators. As a result of the results obtained, a 1% increase in the food production index reduces the food price index by 0.39% to 0.33%. Besides, a 1% increase in the real exchange rate index (the appreciation of the TL) decreases the food price index by 0.26% to 0.25%. Consumer interest rates alone do not have a significant effect on the food price index in the long run. Considering the short-run coefficients of the independent variables, it is inferred that a 1% increase in the food production index reduces the food price index by 0.16%, and a 1% increase in the real effective exchange rate decreases the food price index by 0.11%. According to the findings of the Fourier Granger causality test based on the error correction model, it is seen that it is seen that there are Granger causality from independent variables to the food price index in the long run. According to the results of the constraint test applied to the short-run coefficients, there is a significant causality relationship from the real effective exchange rate index and food production index to the food price index in the short run.

As a result of the findings obtained in the empirical part of the study, it is revealed that especially the food production index and the real effective exchange rate are critical variables in determining food prices. The findings obtained for the effect of food production index and real effective exchange rate on food prices are in parallel with the studies in both theory and the literature. It is possible to reduce food prices with increases in the food production index, which expresses the food supply. At this point, the way to prevent food price increases is to make agricultural production at a level that can meet domestic demand. Therefore, economic policymakers need to take reasonable steps rather than populist approaches to food production. First, the problems related to the sector should be determined, and national agricultural policies should be established. Then, efforts should be made to reduce foreign dependency on imported foods. In this context, small and medium-sized enterprises should be supported to increase their income level, especially in rural areas, and ensure agricultural production and agro-industry integration. In this context, it is necessary to develop the agricultural marketing infrastructure at the beginning and strengthen the food safety and rural economic infrastructure. Then, programs to support rural development investments should be implemented in order to expand the use of new technologies developed for agricultural activities by producers, increase the effectiveness of rural development studies, and contribute to the creation of a particular local development capacity in rural societies (Republic of Türkiye Ministry of Agriculture and Forestry 2020). Such practices may influence reducing food prices and even contribute to the national income of the country in the medium term. In this process, foreign trade should be continued with alternative countries to supply food products or intermediate goods that need to be imported, considering cyclical developments. In a period of tension between Russia and Ukraine, the inability to acquire some products from these countries, like for wheat and sunflower oil suppliers for Türkiye, causes an increase in food prices.

Consequently, as discussed in this paper, increases in the real effective exchange rate represent the increase in the Turkish Lira. Especially with the increase in food imports and the increase in externally-sourced inputs used for food production, the depreciation of the Turkish Lira increases food prices. To this end, especially in the agricultural sector, the increase in producer input costs, mostly indexed to foreign currency, is reflected in food prices. First, ways to meet foreign producer inputs with domestic resources should be discovered in this context. To this end, policymakers should use economic policy instruments to ensure price stability in a coordinated manner. Hence, it is essential to increase domestic production first and then maintain the stability of the exchange rate. These findings suggest the significance of both fiscal and monetary policies in food price inflation.

In order to reduce the effect of exchange rate fluctuations on food prices, open market operations, rediscount loans, required reserve ratios, interest policies, and communication policies should be used to determine the exchange rate in a more stable and predictable way. Here, these policies should be determined by considering both domestic and foreign market conditions. In addition, one of the most important variables that determine exchange rates is capital movements. This should be taken into account in policy decisions. However, it should not be forgotten that excessive dependence on capital movements has a negative effect on the macroeconomic indicators of the country (Juhro, Siregar & Trisnanto, 2022). For this reason, structural reforms are needed to resolve Türkiye’s over-dependence on foreign capital. When looking at the fiscal policy instruments, reducing taxes on food production, encouraging food production, selective financing opportunities, and grants to support food production are important. These policies will be effective in ensuring stability in food prices in countries like Türkiye.

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