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Estimation the Relationship Between Crude Oil and Selected Food Products

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Abstract

Purpose: Increasing food prices as a result of food crisis in 2007-2008 increased interest in this relationship in the literature. The objective of this research is to establish a causal link between crude oil and food prices by examining the prices of various food commodities, including wheat, sunflower, soybean, cotton, and corn.
Design/Methodology/Approach: To investigate the relationship between World crude oil and food prices, the Granger causality test, Johansen Cointegration analysis, vector autoregression model, vector error correction model, impact and response analysis, and variance decomposition methods were used using monthly data for the years 1992-2021.
Findings: The findings highlight both short- and long-term connections between the variables, as well as the influence of food prices on crude oil during the second sub-period.
Originality/Value: Studies investigating the relationship between food prices and crude oil were mostly conducted through "energy". The difference of this study is the fact that it draws attention to the impact of crude oil on food prices next to the effect of food product prices accepted as internal variable in the literature on crude oil.
Key words: Energy, Granger Causality, Food Commodities

Ham Petrol ve Seçilmiş Gıda Ürünleri Arasındaki İlişkinin Tahmini
Özet

Amaç: 2007-2008 yıllarında yaşanan gıda krizi sonucu artan gıda fiyatları, literatürde bu ilişkiye olan ilgiyi artırmıştır. Bu araştırmanın amacı, buğday, ayçiçeği, soya fasulyesi, pamuk ve mısır gibi çeşitli gıda emtialarının fiyatlarını inceleyerek ham petrol ile gıda fiyatları arasında nedensellik ilişkisi kurmaktır.
Tasarım/Metodoloji /Yaklaşım: Dünya ham petrol ve gıda fiyatları arasındaki ilişkiyi araştırmak için 1992-2021 yıllarına ilişkin aylık veriler kullanılarak Granger nedensellik testi, Johansen Eşbütünleşme analizi, vektör otoregresyon modeli, vektör hata düzeltme modeli, etki ve tepki analizi ve varyans ayrıştırması yöntemleri kullanılmıştır.
Bulgular: Bulgular, değişkenler arasındaki hem kısa hem de uzun vadeli bağlantıların yanı sıra ikinci alt dönemde gıda fiyatlarının ham petrol üzerindeki etkisini vurgulamaktadır.
Özgünlük/Değer: Gıda fiyatları ile ham petrol arasındaki ilişkiyi araştıran çalışmalar çoğunlukla "enerji" üzerinden yapılmıştır. Bu çalışmanın farkı, literatürde içsel değişken olarak kabul edilen gıda ürünü fiyatlarının ham petrol üzerindeki etkisinin yanında, ham petrolün gıda fiyatları üzerindeki etkisine dikkat çekmesidir.
Anahtar kelimeler: Enerji, Granger Nedensellik, Gıda Ürünleri

1.INTRODUCTION

One of the most important global sources of fuel, crude oil constitutes the basis of global energy consumption. Investigating the impact of crude oil on macro and micro economic levels became one of the most important subjects in the energy economy especially after the first oil price shock in 1973(Pal and Mitra,2020).
The oil crisis of the 1970's was a turning point for oil markets and economies. Following this crisis, global economies started to be characterized with neo-liberal policies and oil markets became more significant compared to the past. After the Yom-Kippur War in 1973, (Arab oil embargo), significant increases took place in oil prices. The price of crude oil per barrel that was 15.66 dollars in 1973 increased to 45.78 in the second quarter of 1974. Following the Iranian revolution in 1978, price per barrel increased from 38.28 to 76.93 dollars. Besides, another peak took place after the global oil crisis in 2008 as 125.21 dollars per barrel (Figure 1).

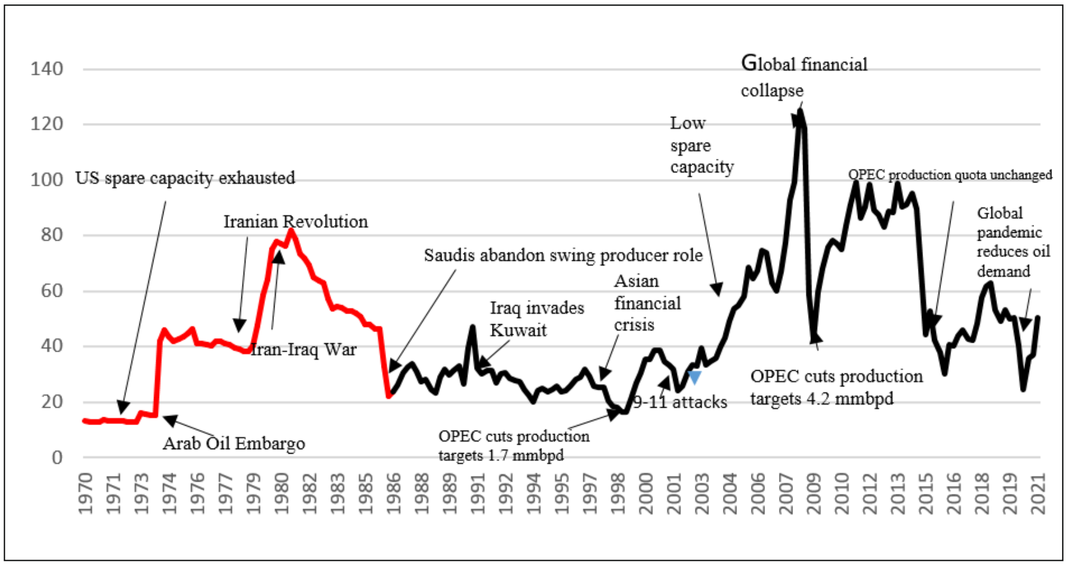


Figure1. Reaction of Crude Oil Prices to Geopolitical and Economic Events

As a crucial component in the production of various goods and services, crude oil plays a significant role in shaping human existence and daily life.It has many application areas on economy sectors such as agriculture, industry, and transportation in addition to household. Thus, unstable increases and decreases in crude oil prices affect quality of human life (Jahangir and Dural, 2018). This causes fluctuations in oil prices to affect prices of other products.

Since the mid-2000's, similar to the standing fluctuation in oil prices, significant increases took place in food prices. Unprecedented hikes in the prices of essential food staples, such as wheat, rice, and corn, are placing significant strain on many countries that heavily rely on food imports. These escalating prices are particularly affecting vulnerable developing nations (Udoh and Egwaikhide, 2012). For instance, Egypt, which is the world's leading wheat importer, brings in an average of 11 million tons of wheat every year (Faostat, 2016). Yemen closely follows, importing approximately 2 million tons of wheat annually (World Bank, 2013). In contrast, Nigeria, which spends a staggering 700 million dollars annually on importing Thai rice, has earned the dubious distinction of being the largest importer of rice globally (Usda, 2015).

However, the evolution of the sunflower crop on a global scale is also quite remarkable. In terms of sunflower crops, which was 9.6 million hectares in 1975, it increased to 52 MnT for 27 Mha in 2018 (Pilorge, 2020). With the increase in oil prices from 60 dollars per barrel in 2005 to 128 dollars per barrel in 2008, there was a significant increase in the demand for ethanol. This increased the demand for cellulosic materials such as corn which resulted in an increase in their prices. The surge in corn prices acted as a catalyst for farmers to shift their focus from cultivating competing crops, such as cotton. Consequently, the land area dedicated to cotton cultivation decreased from 5.586 million hectares to 3.063 million hectares in 2008/09, with farmers opting to grow corn instead (Zeballos,2020).

The correlation between crude oil price volatility, the global economic crisis, food security concerns, and climate change has stimulated interest among economic agents, biofuel industries, and decision-makers to increase biofuel production and usage (Janda et al., 2021). However, the obstacle of low crude oil prices since 2014 has hindered this progress. The production of biofuels utilizing corn and soybeans has created a link between the energy and agricultural markets. This alternative use of agricultural products has led to an indirect change in land use, exacerbating the problem of climate change. Therefore, the development of market dependency is noteworthy, especially concerning the utilization of corn and soybeans for both food and biofuel production. The rise in corn prices can also be linked to prevailing conditions in the food market, underscoring the interdependence of corn price fluctuations and biofuels. (Pal and Mitra, 2017).

The recent fluctuations in oil prices and the increase in food prices have garnered significant global attention. Various sources in the literature have highlighted the adverse impact of sudden price hikes and drops in these two sectors on the global economy (Heady and Fan, 2008; Auer et.al 2017; Dalheimer et.al,2021). Consequently, several researchers have established a link between the recent rise in food prices and the corresponding increase in oil prices, which serves as a crucial input for food production. Additionally, the surge in crude oil prices has resulted in a rising demand for biofuels as a substitute for traditional energy sources. The association between the expansion of biofuels during the 2007-2008 period and the food price crisis has raised significant concerns about the causal relationship between the two (Lucotte 2016; Ma et al., 2016; Ahmadi et al., 2016). The increase especially in biofuel production caused increase in demand for corn in the USA as the raw material of bio-ethanol. This increase in demand for corn caused increase in price of corn and other agricultural products since they compete for cultivation area and other agricultural sources (Wang et al., 2014;Ogede and Ajayi 2022).

It is important to keep in mind that a correlation between crude oil and food product prices does not necessarily indicate that one causes the other. Previous research has largely focused on the causality from crude oil prices to food product prices, but it has often overlooked the possibility of reverse causality. Baumeister and Kilian (2014) have proposed that the adoption of mechanization in agricultural production can increase energy consumption in the sector, which may subsequently drive up demand for energy and crude oil prices. This implies that an increase in agricultural production could actually contribute to higher crude oil prices, rather than the other way around.
Furthermore, it is important to note that a correlation between crude oil prices and food product prices does not always indicate a causal relationship from crude oil prices to food product prices. The possibility of reverse causality has often been ignored in previous studies. According to Baumeister and Kilian (2014), the use of mechanization in agriculture can increase energy consumption in the sector, which may lead to an increase in demand for energy and crude oil prices. This means that reverse causality may be more likely to occur as the agriculture and biofuel industries expand. While empirical evidence is limited, some studies have acknowledged the existence of causality from food prices to energy prices. (Su et al., 2019; Vacha et al., 2013; Maadid et al., 2017; Natanelov et al., 2011; Zhang et al., 2010;Darwez et.al 2023).
The current study focuses on analyzing the relationship between food prices and crude oil prices, while also distinguishing the impact of food prices on the basic cost of living. By examining the simultaneous increase in food and oil prices, the study aims to provide insights into the potential mutual relationship between these two prices.
The results of this study will aid in gaining a deeper understanding of the intricate interplay between food prices and crude oil prices. To achieve this, the study examines the relationship between not only wheat and corn but also oil and other commodities, such as sunflower, cotton, and beans, that have a bi-directional connection with oil.

2. LITERATURE

The correlation between the price of oil and food prices became a topic of discussion, particularly in the aftermath of the 2007-2008 food price crisis (Timmer, 2010). This was primarily due to the belief that the rising cost of crude oil was the primary cause of the major shock that agricultural markets experienced during this period. The sharp hikes in agricultural product prices, crude oil prices, and biofuels were primarily held responsible for the crisis. As a result, the interplay between agricultural products and biofuels was thoroughly examined.
Yu, Bessler, and Fuller (2006) conducted an analysis of cointegration and causality to examine the impact of high crude oil prices on global food prices and demand for vegetable oil. The study revealed that the influence of crude oil price shocks on food prices was relatively small and insignificant.
In a study conducted by Campiche et al. (2007), the co-movements between crude oil prices and the prices of various agricultural commodities in the USA, including corn, sorghum, sugar, soybean, soy oil, and palm oil, were analyzed using weekly data from 2003 to 2007. The research revealed that soybean prices were more strongly correlated with crude oil prices, primarily due to the biofuel market, as opposed to corn prices.
Elobeid et al. (2007) argued that the continued expansion of corn-based ethanol production, following the rise in oil prices, would have a significant impact on both the US and global agriculture sectors.
Balcombe and Rapsomanikis (2008) employed Bayesian methodologies to explore long-term linkages and identified a stable equilibrium between ethanol, sugar, and crude oil prices.
Xiaodong and Hayes (2009) found that the wheat, corn, and crude oil markets exhibited spillover effects in volatility, indicating a high level of interdependence. This can be largely attributed to ethanol production, which has created a close link between these markets.
Vansteenkiste (2009) employed a dynamic factor model to demonstrate that changes in commodity prices are largely driven by various common macroeconomic factors.
Chen et al. (2010) examined the correlation between soybean, wheat, and corn prices and crude oil prices, concluding that fluctuations in grain prices are driven by fluctuations in crude oil prices.
Baffes (2010) conducted OLS regressions to examine the transmission of oil price fluctuations to other commodity prices, and found that food commodities are still impacted by oil prices even when accounting for macroeconomic factors. According to Gilbert's (2010) analysis, the correlation between crude oil and food commodity prices can be attributed to factors such as monetary and financial developments as well as rising demand. Meanwhile, Chang and Su (2010) utilized a bivariate EGARCH model to demonstrate the relationship between crude oil and corn prices. Natanelov et al. (2011) claimed that biofuel regulations decrease the correlated changes between oil and corn prices until a certain level, beyond which the relationship is reversed.
In contrast, Gohin and Chantret (2010) conducted a general equilibrium analysis to investigate the relationship between energy prices and global food prices, and found that there exists an indirect positive effect caused by the impact of costs. Their study highlighted a different perspective on the connection between these two key economic factors.

Esmaeili and Shokoohi (2011) employed principal component analysis to examine the interdependence of food prices and various macroeconomic indicators, with a particular focus on crude oil prices. By doing so, they aimed to gain insights into the factors that influence fluctuations in food prices. Their study sheds light on the complex relationship between crude oil prices and food prices, and how other macroeconomic indicators also play a role in driving these fluctuations.

The authors analyzed the price movements of various commodities, including eggs, meat, milk, oilseeds, rice, sugar, and wheat from 1961 to 2005, and found that the food production index had the greatest impact on the macroeconomic index, while the oil price index had an indirect effect on food prices by influencing the food production index.

Through the application of panel cointegration and Granger causality analysis, Nazlıoğlu and Soytaş (2012) examined the relationship between world oil prices and twenty-four agricultural products using monthly data over a period of 30 years. Their results showed that fluctuations in oil prices have a notable impact on the prices of agricultural commodities.

In his study, Obadi (2014) utilized the VECM analysis to investigate the short-term and long-term connections between crude oil prices and agricultural commodities such as palm oil, wheat, corn, sugar, rice, and barley. The results indicated a significant long-term association between crude oil prices and food prices, with crude oil prices playing a causal role in driving fluctuations in food prices. This suggests that changes in crude oil prices can have far-reaching consequences on the global food market, and highlights the need for a better understanding of the interconnections between these two key economic factors.

Hamulczuk's (2016) research pointed out the increasing correlation between Brent crude oil prices and food index prices, where policies related to biofuels are one of the contributing factors. Nwoko et al. (2016) investigated the short-term impact of oil prices on food prices in the United States from 2000 to 2013 and discovered a significant relationship between the two variables. Koirala (2015) identified a robust connection between agricultural commodities and future energy prices. Resitis (2015) concluded that international agricultural commodity prices are significantly impacted by crude oil prices and US dollar exchange rates. Taghizadeh-Hesary et al. (2019) highlighted the link between energy and food security, underscoring the negative effect of high oil prices on food security and the importance of a balanced energy mix that incorporates renewable sources. This would not only improve energy security but also contribute to food security.

Karakotsios et al. (2021) investigated the association between global food prices and crude oil prices over both a short and long-term period, using monthly data spanning from January 2000 to December 2015. The results of their study indicate that there is a causal link between crude oil prices and food prices.

Conversely, certain studies offer a contrasting perspective, indicating that there is no direct link between crude oil prices and food prices. These studies propose that other factors, such as climate variability, supply chain disruptions, and geopolitical tensions, may have a more significant impact on food prices. Thus, the relationship between crude oil prices and food prices remains a subject of ongoing debate and further research is needed to fully understand this complex issue. As an illustration, Zhang and co-authors (2010) contend that the escalation of crude oil prices does not have a direct influence on food prices.Furthermore, Ciaian's (2011) theoretical framework proposes that agricultural shocks may affect crude oil prices through multiple channels. As per the findings of this study, a rise in agricultural supply resulting from positive efficiency shocks could potentially cause a decline in the profitability of farmers, leading to reduced production and fuel demand. However, in cases where food demand is flexible, an increase in agricultural efficiency could lead to an upsurge in fuel demand due to a rise in food consumption.

Furthermore, the model proposes that the expansion of biofuel production could potentially lower crude oil prices by increasing the overall energy supply. However, there is a possibility that the increase in demand for ethanol feedstocks could lead to a boost in agricultural production, which in turn could result in an increased demand for fuel and subsequently, higher crude oil prices. As a result, the actual impact of the biofuel market on crude oil prices remains uncertain.

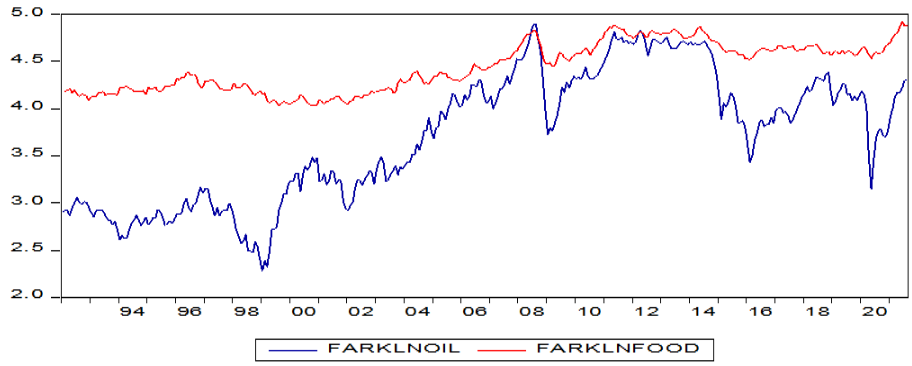
Through the application of non-linear Granger causality tests, Fowowe (2016) sought to investigate the potential relationship between crude oil and food prices in South Africa. The study ultimately determined that there was no statistically significant causal link between these variables, neither in the short run nor the long run. In contrast, Ding and Zhang's (2020) research indicated that crude oil only appears to have a direct impact on metal markets, as their analysis of data from oil, corn, copper, and cattle failed to reveal any significant correlation between crude oil and food prices.

In contrast, Su et al.(2019) found that although there may be bidirectional associations between crude oil and agricultural commodity prices in specific subperiods, it is mainly non-biofuel-related agricultural products that are linked with fuel prices in bi-directional relationships. This research emphasizes the possible influence of agricultural shocks on crude oil prices and the intricate interrelationships between apparently distinct markets.

3. EMPIRICAL ANALYSIS

3.1. Data and methodology

In this study that was conducted to determine connections between world crude oil and food prices (ABD dolar), 5 different food products such as wheat, soybean, sunflower, corn, and cotton were selected. Following previous studies, the period from 1992 m1 to 2021 m8 was discussed. In order to select the optimal delay count, Akaike information criteria (AIC) were considered. Information criteria suggests 2 delays for every two periods. Data on crude oil and food products were accepted in the study after taking their logarithms.



Graph 1. Monthly Food Price Indexes

Table 1 displays a reverse relationship between crude oil prices and food prices in the beginning period, except for sunflower, where there seems to be no correlation.However, during the second period, a substantial positive correlation was detected between crude oil prices and food prices. To further explore these associations, a Granger causality test was employed. In Table 2, the Dickey-Fuller test results are presented, with stability being a critical factor for causality tests (Stock and Watson, 1988).

Table 1. Correlation Matrix

1992-2005							
	OIL	**SUNFLOWER**	**WHEAT**	**FOOD**	**COTTON**	**CORN**	**BEANS**
OIL	1	0.2679653	-0.1263820	0.299473	-0.3237134	-0.1752658	-0.0071679
SUNFLOWER	0.267965	1	0.3194973	0.674047	0.1120978	0.2228127	0.41171685
WHEAT	-0.1263820	0.3194973	1	0.618765	0.6274128	0.8312140	0.65033818
FOOD	0.2994730	0.6740471	0.6187652	1	0.4464763	0.6778002	0.78746347
COTTON	-0.3237134	0.1120978	0.6274128	0.446476	1	0.6155238	0.60141451
CORN	-0.1752658	0.2228127	0.8312140	0.6778002	0.6155238	1	0.75716206
SOYBEAN	-0.0071679	0.41171685	0.6503381	0.7874634	0.6014145	0.7571620	1

2006-2021							
	OIL	**SUNFLOWER**	**WHEAT**	**FOOD**	**COTTON**	**CORN**	**BEANS**
OIL	1	0.7446718	0.6917813	0.8737987	0.4334854	0.7636199	0.77072052
SUNFLOWER	0.7446718	1	0.702276070	0.8609686	0.5405641	0.8111205	0.83261580
WHEAT	0.6917813	0.7022760	1	0.810098	0.6268936	0.8837016	0.83649010
FOOD	0.8737987	0.8609686	0.810098306	1	0.6492637	0.9249905	0.94385033
COTTON	0.4334854	0.5405641	0.626893688	0.649263	1	0.6984251	0.68280598
CORN	0.7636199	0.8111205	0.883701652	0.924990	0.6984251	1	0.93951547
SOYBEAN	0.7707205	0.8326158	0.83649010	0.943850	0.6828059	0.9395154	1

During the study, Augmented Dickey-Fuller test (ADF) was used initially to test stability of variables. Analysis methods were selected based on test results (Table 2). Variables are not stable at the level in both periods. Thus, 1. differences of the relevant variables are taken before proceeding.

Table 2. Results of ADF Unit Root Test

1990-2005					2006-2021			
Level			1.Difference		Level		1.Difference	
	t-statistic	Prob	t-statistic	Prob	t-statistic	Prob	t-statistic	Prob
LNSUNFLO	0.5725	0.8391	-5.8625	0.000	0.44	0.80	-8.19	0.000
LNWHEAT	-0.214	0.6078	-10.20	0.000	0.32	0.77	-11.36	0.000
LNCOTTON	-0.63	0.44	-5.65	0.000	0.27	0.76	-5.48	0.000
LNCORN	-0.205	0.61	-7.33	0.000	0.58	0.84	-10.34	0.000
LNBEANS	-0.03	0.66	-10.02	0.000	0.65	0.85	-9.89	0.000
LNOIL	0.68	0.86	-11.26	0.000	-0.23	0.86	-8.02	0.000
LNFOOD	0.59	0.84	-3.43	0.000				

To construct a relational model between economic variables in a non-structural way, econometricians suggest utilizing vector autoregressive (VAR) and vector error correction (VEC) models. The VAR model is built on the basis of the statistical features of the data, and it considers each internal variable in the system as a lagged value of all other internal variables.

The univariate autoregressive model has limitations in explaining complex economic systems, which led to the development of the multivariate vector autoregressive (VAR) model. In 1980, Sims introduced the VAR model in economics and advocated for its extensive use in dynamic analysis. The combination of cointegration and error correction models, known as the trace error correction model, was proposed by Engle and Granger. The Error Correction Model is a model created under the condition of the presence of cointegration relationship between variables, and it is derived from the autoregressive distributed lag model. On the other hand, the VAR model is created by combining autoregressive distributed lag models for each equation. The difference between the two models is that the error correction model satisfies the cointegration condition and can model long-term relationships between variables. Additionally, like the VAR model, the error correction model can be used in the analysis of multivariate time series. The VEC model can be seen as a VAR model with cointegration constraints. The VEC model imposes long-run restrictions on endogenous variables, which converge to their cointegration relationships when there is a wide range of short-run fluctuations. This approach helps to capture the complex interdependencies between variables and their long-run dynamics (Brooks, 2008: 350).

In case yt = (y1t, y2t,..., ykt)' is assumed, as stochastic time series with k dimension, t = 1, 2, . . . , T and yt ~ I(1), every yit ~ I(1), i = 1, 2, . . . , k, d-dimension xt = (x1t, x2t,..., xdt) is affected from exogenous time series. VAR model can be formed as follows:

$$Y_t = \beta_1 y_{t-1} + \beta_2 y_{t-2} + \ldots\ldots\ldots\ldots \beta_k y_{t-k} + q_x + u_t \quad (1)$$

In case yt is not affected from exogenous time series of xt = (x1t, x2t,..., xdt)' dimension the VAR model of formula (1) can be stated as follows:

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

Cointegration transformation of Formula (2) would give the follows:

$$\Delta y_t = c + \Pi y_{t-1} + \sum_{i=1}^{p-1} \Gamma i\, \Delta(y_{t-1}) + u_t \quad (3)$$

Here,

$$\Pi = \sum_{i=1}^{p} \beta i - I$$

$$\Gamma i = -\sum_{j=n+1}^{p-1} \beta i; \quad (4)$$

In case yt has cointegration relationship, then n ∏ yt−1 ~ I(0) and formula (3) can be stated as follows:

$$\Delta y_t = qa' y_{t-1} + \sum_{i=1}^{p-1} \Gamma i\, \Delta(y_{t-1}) + u_t \quad (5)$$

Here, $qa'y_{t-1}$ ecmt−1 is the error correction term reflecting the long-term stability relationships between variables and the formula above can be states as follows:

$$mt-1+\sum_{i=1}^{p-1} ri\ \Lambda(y_{t-1}) + u_t \quad (6)$$

Formula (6) is the vector error correction model (VECM) where every equation is an error correction model.

4. FINDINGS

4.1.Johansen cointegration analysis

Unit root test results of crude oil and food prices index values show that all variables are I(1) stationary. Thus, the Johansen Cointegration test was used to determine the long-term relationship between the variables. Two sub-period test results used to determine the long-term relationship between crude oil and food prices are shown in Table 3. In the first period, the test statistical value was found to be less than the required critical values. This demonstrates that there is no long-run relationship between the variables in the first period. In the second period, which reflects the period after the food war, P statistical values show that there is a long-term relationship between the variables according to Trace and Max-Eigen statistics.

Table 3. Johansen Cointegration Results

		1990-2005				2006-2021			
Level		Trace		Max		Trace		Max	
		Eigenvalue	**Prob**	**Eigenvalue**	**Prob**	**Eigenvalue**	**Prob**	**Eigenvalue**	**Prob**
LNSUNFLO	0	0.05	0.08	0.05	0.09	0.04	0.04	0.04	0.33
	1	0.00	0.28	0.00	0.28	0.03	0.00	0.03	0.00
LNWHEAT	0	0.01	0.83	0.01	0.91	0.08	0.00	0.08	0.03
	1	0.00	0.35	0.00	0.35	0.02	0.01	0.02	0.01
LNCOTTON	0	0.00	0.96	0.00	0.98	0.05	0.02	0.05	0.22
	1	0.00	0.46	0.00	0.46	0.04	0.00	0.04	0.00
LNCORN	0	0.04	0.52	0.04	0.44	0.05	0.02	0.05	0.14
	1	0.00	0.85	0.00	0.85	0.03	0.01	0.03	0.01
LNBEANS	0	0.03	0.61	0.03	0.53	0.05	0.02	0.05	0.23
	1	0.00	0.81	0.00	0.81	0.04	0.04	0.04	0.04
LNFOOD	0	0.03	0.75	0.03	0.75	0.07	0.01	0.07	0.11
	1	1.99	0.95	1.99	0.95	0.04	0.00	0.04	0.00

4.2.Short-term analysis

The long-term relationship between the analyzed variables in the second period demonstrates that the deviation from equilibrium in the short-term should be handled with the vector error correction model.

Table 4. VECM Prediction Results

Independent Variable	Coefficient	T-statistic	Probability Values
SUNFLOWER	0.06	0.91	0.36
WHEAT	-0.27	-2.60	0.00
FOOD	1.65	5.62	0.00
COTTON	0.29	2.65	0.008
CORN	-0.07	-0.50	0.61
SOYBEAN	0.08	4.96	0.62
Error Coef	-0.11	-3.24	0.0014
c	-0.004	-0.69	0.48
R^2: 0.37 $F_{(p)}$:15.33 (0.000)			
Dependent Variable: Crude Oil			

In the model the error term coefficient must be negative and meaningful. When Table 4 is studied the error term coefficient is found to be negative and meaningful. This demonstrates that the error term functions, it would balance in the long run, and that there is a causal relationship between variables. Error term coefficient demonstrates that error correction mechanism decreases deviation from balance by 11%. Short-term analysis results demonstrate that in the second sub-period crude oil prices are related with food prices, wheat and cotton.

4.3.Granger causality analysis

Based on the findings of Engle and Granger (1987), a stationary linear combination may be formed from two or more non-stationary series that share the same degree of integration. If such a stationary linear combination exists, the series is considered to be cointegrated, indicating the presence of a long-term equilibrium relationship between them.
Linear combination can be written as follows:

$zt = xt - a0 - a_1 y_t$,

Here it is a0 and a1. Here a0 and a1 are constant terms with z being stable. This relationship is a constant balance relationship and zt measures deviation based on balance value. When combining these cointegrated features, a vector error correction model (VECM) is constructed to test for causality (Granger) in at least one direction of the series (Engle and Granger,1987).

Table 5. Granger Causality

	1990-2005			**2006-2021**	
	Chi-sq	**Prob**		**Chi-sq**	**Prob**
SUN-OIL	0.09	0.95	SUN-OIL	2.71	0.25
OIL-SUN	2.63	0.26	**OIL-SUN**	0.32	0.85
WH-OIL	3.05	0.22	WH-OIL	1.09	0.56
OIL-WH	3.01	0.21	OIL-WH	1.15	0.57
COTTON-OIL	1.45	0.48	COTTON-OIL	3.27	0.19
OIL-COTTON	2.11	0.34	**OIL-COTTON**	0.06	0.96
CORN-OIL	1.66	0.43	CORN-OIL	1.69	0.42
OIL-CORN	2.11	0.34	OIL-CORN	2.03	0.36
BEANS-OIL	1.12	0.56	BEANS-OIL	1.95	0.37
OIL-BEANS	0.53	0.56	OIL-BEANS	3.79	0.14
LOIL-LFOOD	10.71	0.00	FOOD-OIL	12.08	0.00
LFOOD-LOIL	0.48	0.78	OIL-LFOOD	0.16	0.91

As described above, results of first sub-period demonstrate that there is no cointegration between variables while the second sub-period demonstrated that all food products used were associated with crude oil in the long run. Therefore, a causality based on VAR for the first sub-period and VECM for the second sub-period was established.
Table 5 results show that there is a one-way causality relationship between food prices and crude oil in both sub-periods. However, while crude oil was the cause of food prices in the first period, food prices were found to be the cause of crude oil in the second period. Looking at food products, it is seen that there is no causal relationship with crude oil. The second sub-period correlation results reveal a strong correlation between food products and crude oil. The conclusion drawn from this is that the relationship between them is indirect.

4.4.Cause effect analysis and variance decomposition

Figure 2 shows the cumulative response of food product prices to oil-specific demand shocks and the response of oil price to food product price shocks. According to the Akaike Information Criterion (AIC) the optimal delay for the tests was determined as two. When the first-period shocks are considered, it is noted that commodity product prices accompany the shock in crude oil in oil-specific shocks. Against the shock in food products, it is seen that the reaction of oil was weak in the first period. In the second period, it is observed that the reaction of commodity products to oil-specific shocks has decreased over time. In the face of the shock in food products, it is observed that the reaction of oil has changed visibly compared to the first period.

Table 6. Variance Decomposition

1992-2005								
Period	**S.E.**	**LO**	**LF**	**LC**	**LCORN**	**LB**	**LS**	**LW**
1	0.083925	100.0000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2	0.119044	98.85816	0.074500	0.723129	0.045561	0.231331	0.039503	0.027814
3	0.145093	97.63605	0.067048	1.452525	0.215757	0.460330	0.027758	0.140527
4	0.166006	96.48790	0.051920	1.987842	0.517473	0.528448	0.086834	0.339585
5	0.183625	95.39088	0.059260	2.331546	0.894111	0.478486	0.245904	0.599812
6	0.199058	94.30020	0.084538	2.532686	1.288775	0.407286	0.491777	0.894738
7	0.213013	93.18321	0.117683	2.642610	1.665737	0.381330	0.804500	1.204930
8	0.225936	92.03046	0.152535	2.700981	2.009162	0.421554	1.166728	1.518582
9	0.238102	90.85101	0.186737	2.734177	2.315586	0.519196	1.563916	1.829382
10	0.249680	89.66282	0.219840	2.758002	2.587401	0.654642	1.983170	2.134129

2006-2021								
Period	**S.E.**	**LO**	**LS**	**LW**	**LF**	**LC**	**LCORN**	**LB**
1	0.087229	100.0000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2	0.141944	98.34192	0.008985	0.517639	1.090408	0.032603	0.007355	0.001089
3	0.180874	95.76832	0.008857	2.044180	1.565452	0.356320	0.115292	0.141582
4	0.209928	91.28653	0.090816	4.616925	1.631130	1.070109	0.525002	0.779492
5	0.233593	85.25342	0.313418	7.758557	1.513421	2.046873	1.171417	1.942895
6	0.253937	78.80892	0.629736	10.87180	1.343567	3.091887	1.902241	3.351857
7	0.271509	72.93201	0.947613	13.58339	1.186453	4.071675	2.588860	4.689996
8	0.286382	68.07224	1.201180	15.78352	1.066429	4.936701	3.165504	5.774420
9	0.298681	64.26834	1.369044	17.51197	0.987700	5.687331	3.616154	6.559462
10	0.308694	61.36679	1.460033	18.85691	0.946354	6.341186	3.950692	7.078043

Results of variance decomposition are observed to be supportive of the results above. When Table 6 is examined, a change in crude oil was self-induced by 89% in the 10th Period of the first sub-period, while this rate decreased to 61% in the second sub-period. This demonstrates that about 39% of the change in crude oil in the post-crisis period was sourced from food prices.

5.RESULTS and SUGGESTIONS

The study at hand delves into an empirical analysis of the interplay between crude oil prices and a selected set of food product prices. The research spans over the period from January 1992 to August 2021, utilizing monthly data on global food prices, as well as prices for wheat, corn, soybean, cotton, and sunflower. The results of Johansen Cointegration analysis reveal a lack of a long-term relationship between the variables in the first sub-period, while a long-term relationship is established between crude oil prices and all food products in the second sub-period. Granger causality analysis, on the other hand, suggests that crude oil prices cause food prices in the first sub-period, while in the second sub-period, it is food prices that have an effect on crude oil prices.

Furthermore, the impulse-response analysis highlights that any shock in crude oil prices leads to a positive effect on food prices during the first sub-period. This can be attributed to the heavy reliance of agricultural commodity and food production on oil and its derivatives. These products are widely used as fuel in tractors, fertilizers, and other production processes, as well as for drying, cooling, storage, transportation, and distribution. Hence, an increase in oil prices leads to higher production costs, which ultimately impact food prices.

In summary, this study presents compelling evidence of the intricate relationship between crude oil prices and food product prices, demonstrating how changes in one can cause fluctuations in the other. These findings have significant implications for policymakers and stakeholders in the food industry, highlighting the need for sustainable and strategic measures to address the impact of oil price volatility on global food prices.

In the second sub-period, the impulse-response analysis results indicate that the reaction of crude oil prices to shocks in agricultural commodity prices is positive and fluctuating, in contrast to the stable and negative reaction observed in the first period. This can be attributed to the global food crisis that started in 2006, which caused international food prices to reach unprecedented levels. The prices of corn, wheat, and soybeans increased significantly during this period, leading to an increase in the price of cooking oil, which is a staple food in many poor countries and is produced from soybean and other vegetable sources.

Additionally, the period under investigation saw a notable upswing in crude oil prices, leading to an upsurge in demand for biofuels as a viable alternative energy source. This rise in demand was concurrent with the expansion of biofuel production in 2007-2008, creating a causal relationship between the two sub-periods. The shocks to agriculture affected crude oil prices through two main channels: the indirect cost-push effect and the direct biofuel channel. The results obtained from this study align with the theoretical framework that proposes a potential impact of agricultural shocks on crude oil prices, further emphasizing the need for sustainable and holistic strategies to address the interconnectedness between energy and food systems.

The Renewable Fuel Standard that entered into effect in 2005 demonstrated a strong connection between prices of crude oil and instability in food prices that is closely related with biofuel production. These relationships are confirmed with other studies in the literature (i.e., Coronao et al. 2018, Nazlioglu, 2013). Also, some authors such as Zhang et al., 2010 and Pasrun et al., 2018, Mawejje, 2016, and Cabrea et al., 2016 confirm the long-term relationship between prices of crude oil and food product prices. However, the price index in March 2020 was lower than that in February. The decrease was not a result of the decrease in demand due to the Corona Virus. This was the result of the decrease in oil prices. when price of crude oil drastically decreased in global markets, biofuel producers had to arrange their prices. Our results confirm the short and long-term relationship between prices of crude oil and food products.

In the second sub-period, decreasing impact of a shock based on oil price level on agricultural products demonstrate that instability in food prices must be based on different areas. In addition, the ongoing developments in biofuel market increase production of agricultural products. This demonstrates that biofuel that became important enough to impact oil prices that is the main driving force for all sectors of the economy must be involved in studies and results must continue to be analyzed. To make an evaluation for Turkey based on world prices, it is thought that the government can prevent these excessive price increases by monitoring the prices of basic food products and applying price controls when necessary. In this regard, incentives and support can be provided to support the agricultural sector. Increasing local production can reduce dependence on imports.

Contribution Rate of Researchers Declaration Summary

The authors declare that they have contributed equally to the article and have not plagiarized.

Conflict of Interest Declaration

The authors of the article declare that there is no conflict of interest between them.

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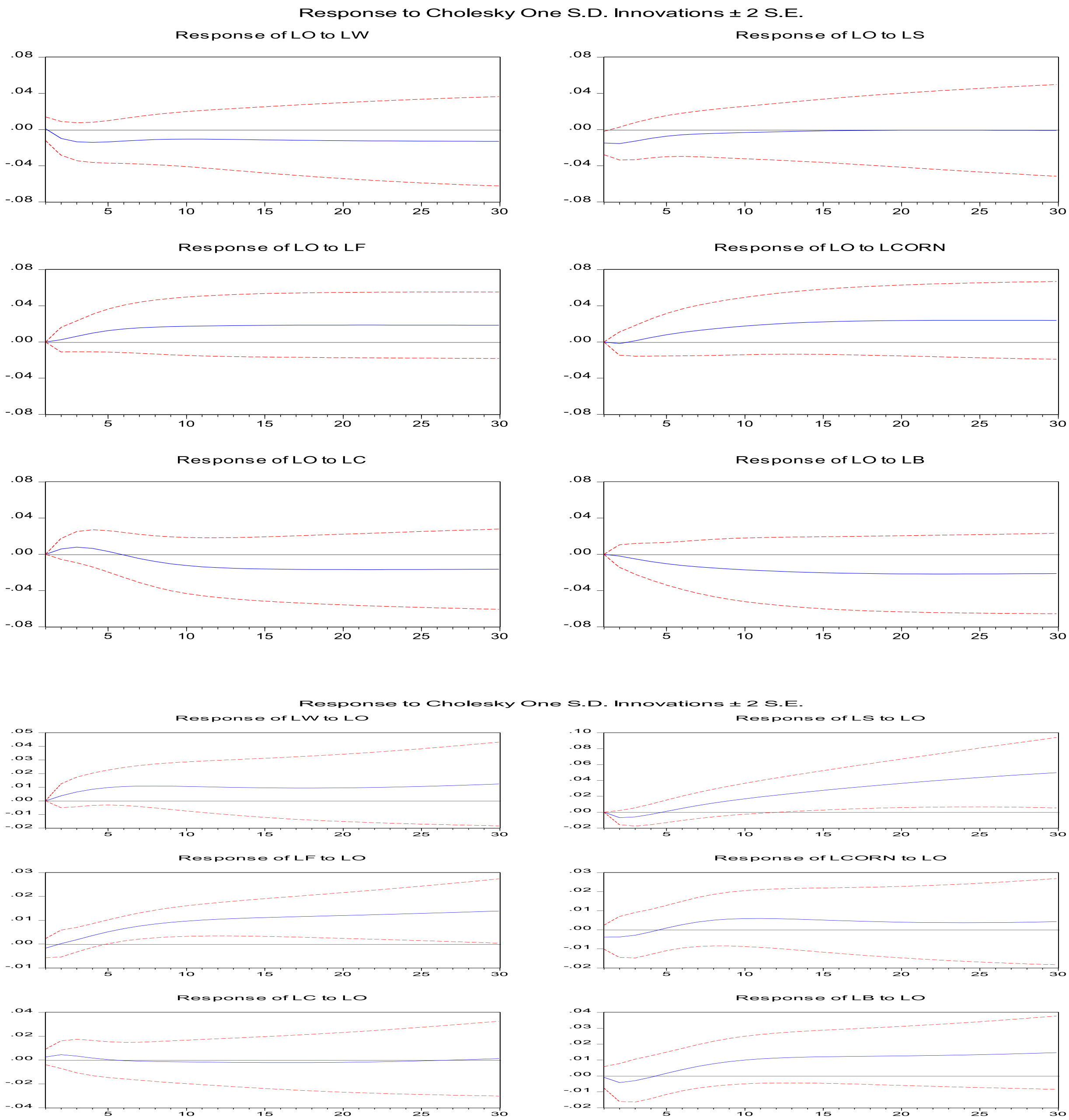
Additional:

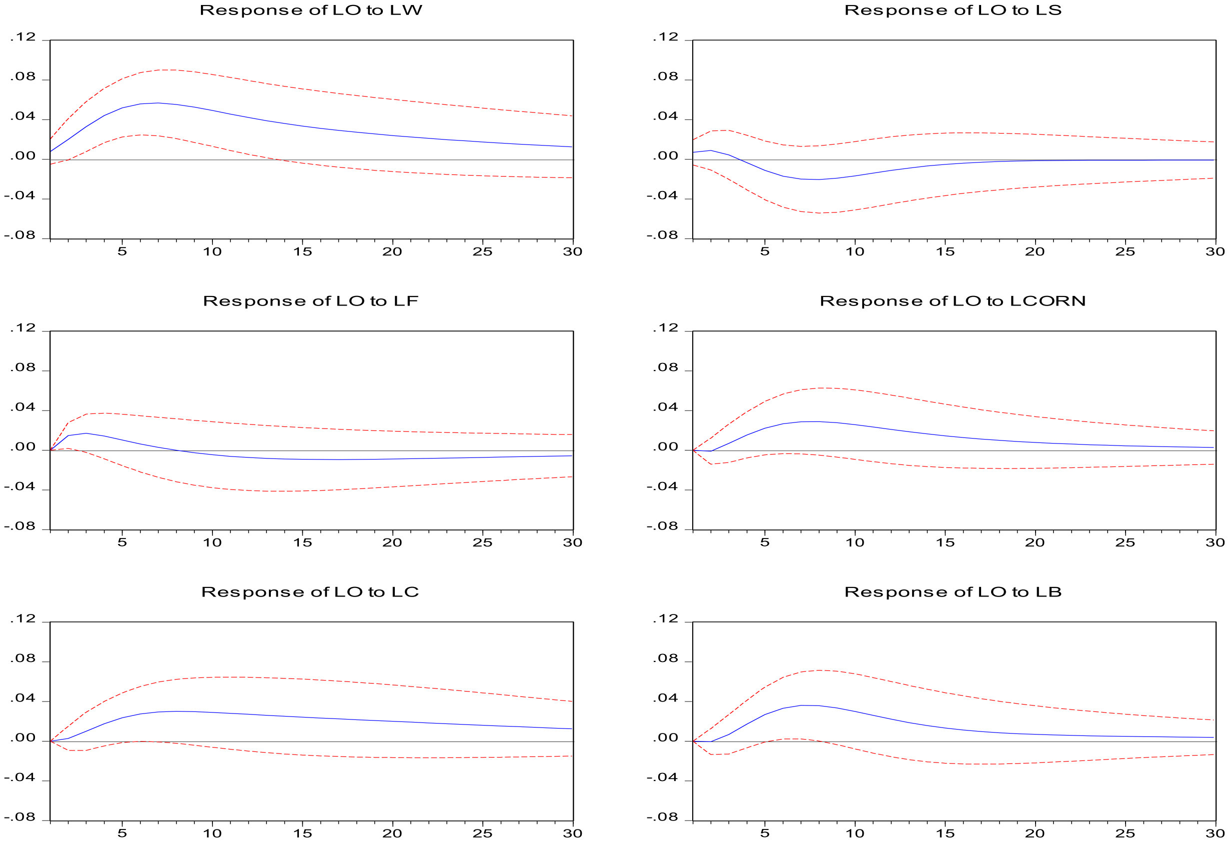
Figure 2. Impulse-Response Analysis Results

2006-2021



2006-2021

Response to Cholesky One S.D. Innovations ± 2 S.E.



Response to Cholesky One S.D. Innovations ± 2 S.E.