THE RELATIONSHIP BETWEEN AGRICULTURAL RAW MATERIALS AND OIL PRICE: AN EMPIRICAL ANALYSIS

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A B S T R A C T

The motivation of this study is to investigate the relationship between the price of agricultural raw materials and the real exchange rate of the USA and the price of crude oil. For this purpose, annual data from 1990 to 2020 were used. In the study, the cointegration relationship and the elasticity coefficients of the variables were estimated with the help of ARDL bounds test. In addition, the causality relationship was determined with the help of the Granger test. According to the results obtained, it was concluded that there is a cointegration relationship in the models established for agricultural raw materials. In addition, the elasticity coefficient of oil price was found to be positive. According to the Granger causality analysis results, a one-way causality relationship from oil price to agricultural raw materials was determined. We present some policy implications based on our findings in this study.

Introduction

While the rise in oil prices since 2003 rose to 145 dollars in July 2008, it decreased to 40 dollars in December 2008 with the effect of the international crisis. It has been observed that the fluctuations in the dollar affect the agricultural commodity prices in a similar way. The similarities in price volatility between oil prices and agricultural commodity prices have generated interest in the literature to understand the relationship between food prices and energy (Abbott vd., 2009; Fowowe, 2016).

The effects of the economic crisis experienced in the world in 2008 also made its impact on agricultural commodity prices. Agricultural commodity prices, which have a fragile structure, have undulant fluctuations throughout the years. Studies in recent years show that fluctuations in oil prices have a significant effect on agricultural commodity prices (Adam et al ., 2018; Vu et al., 2019, Roman et al., 2020). Fluctuations in oil prices have had various reflections on our lives. One of these results is the changes that cause

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inflation in product prices depending on the prices of agricultural materials. Shocks in the prices of agricultural materials can be caused by various factors. One of these factors is fluctuations in crude oil prices. Increases in crude oil prices increase the prices of agricultural materials. Demand and climate changes also cause the prices of agricultural materials to increase (Chen et al., 2010).

The reasons why the prices of agricultural materials have similar volatility with the prices of crude oil consist of the reflections in terms of supply and demand. When examined in terms of supply, there are supply costs of agricultural materials. Agricultural materials inherently have high logistics costs. In addition, chemical fertilizers used in the production of agricultural materials consist of petro derivatives. As the increase in crude oil prices increases production and logistics costs, it also causes an increase in agricultural materials prices. The increase in economic activities and the increase in the demand for food products, goods and services as well as crude oil prices with the expansionary monetary policy are among the reasons for the increase in agricultural materials prices in terms of demand (Hanson et al., 1991; Hochman et al., 2012; Baumeister and Kilian, 2014; Pal and Mitra, 2018). As the consumption of the world population increases and the level of welfare increases, the prices of agricultural materials also increase. In addition, the increase in speculative investments in commodity markets is another factor that increases the prices of agricultural materials (Gorton ve Rouwenhorst, 2006; Yahya vd., 2019; Bekiros vd., 2017; Bhardwaj vd., 2015).

The aim of this study is to examine the effect of oil price and real exchange rate on agricultural raw materials prices. The Autoregressive Distributed Lag (ARDL) method was used to estimate the empirical relationship between oil price, real exchange rate and agricultural raw materials prices by taking data from annual observations. The ARDL method used in this study estimates the cointegration relationship between the series and the cointegration coefficients of the series. In this way, the elasticity coefficients of the variables in the long run are estimated and their effects on each other are analyzed.

The study provides various contributions to the literature. The first contribution of this study was that the effect of oil price and real exchange rate on agricultural raw materials prices was examined, and the effect of possible petroleum shocks on agricultural raw materials prices was investigated in this study, which was analyzed using the ARDL method. The second contribution of the study to the literature was the analysis of the relationship between agricultural commodity price and oil price in the literature (Nazlioglu and Soytas, 2012; Rezitis, 2015; Fowowe, 2016; Taghizadeh-Hesary et al., 2019; Aye and Odhiambo, 2021). In this study, it is aimed to add a different dimension to the literature by emphasizing the relationship between agricultural raw materials prices and oil price.

The main content of this article is as follows: In the second part, information will be given about the various data range examining the relationship between agricultural raw materials, the oil market and the real exchange rate, and the recent literature investigating different countries and country groups with different methods. In the third section, the data and the methodologies used in this study will be explained. In the fourth chapter, the cointegration relationship between the prices of agricultural raw materials, the real exchange rate and the price of crude oil and the cointegration coefficient estimates will be obtained and interpreted economically. In the fifth chapter, the results will be evaluated and policy recommendations will be made.

Review of the literature

In a market where the prices of the agricultural commodity fluctuate, economists closely monitor the factors due to which the prices fluctuate. In this part of the study, studies examining the relationship between commodity price (CP) and oil price (OP) are included. Baffes (2007) analyzed the relationship between OP and CP by examining the period from 1960 to 2005. According to the empirical results, an increase in OP increases CP. Zhang and Qu (2015) investigated the relationship between six types of agricultural commodities and OP by adding daily data from 2004 to 2014. The findings are that shocks on the five agricultural commodities of the shocks are asymmetrical.

Among the studies examining the relationship between agricultural CP and OP, Paris (2018) examined the long term relationship between agricultural CP and OP by examining the period from 2001 to 2014. In the empirical results, it has been determined that OP causes an increase on agricultural CP. Zafeiriou et al. (2018) aimed to predict the relationship between crude OPs and agricultural products in their study. Empirical findings show that crude OP directly affect the prices of agricultural products used in biodiesel and ethanol production. Olasunkanmi and Oladele (2018) analyzed the relationship of OP shock with agricultural CP covering the period of 1997 and 2016. Using Linear ARDL and Non-linear ARDL techniques, they found that OP had a positive effect on CP.

Jiang et al (2018) investigated the relationship between OP, agricultural raw, metal markets, material markets in their study, discussed the period between 1986 and 2017. The findings showed that the oil market lags behind the agricultural raw material market. Using monthly data from 1997 to 2016, Fasanya et al (2019) analyzed the empirical relationship between OP and CP. In the findings, it was determined that the increase in OP increased the agricultural CP.

In another study, Roman et al. (2020) analyzed the relationship between crude oil and food prices in their study using monthly data from 1990 to 2020. In their findings, there is a long-term relationship between crude oil and meat prices. In addition, the relationship between crude oil and food and cereal in the short term was determined. Vu et al (2020) examined the relationship between ten agricultural commodities and OP by using monthly data for the period 2000 to 2019. According to the empirical results, it has been determined that OP can change biofuel and exchange rates and agricultural prices. Aye and Odhiambo (2021) investigated the effect of OP on agricultural growth in South Africa in their empirical study using quarterly data from 1980 to 2020. According to the empirical results, it was concluded that OP negatively affect agricultural growth.

In this part of the literature review, studies examining the causal relationship between agricultural commodity and OP will be discussed. The results of studies examining the causal relationship between agricultural commodity and OP are remarkable. We can divide such studies into four groups:

i) Unidirectional hypothesis: Nazilioglu (2011) investigated the causality relationship between OP and agricultural CP by examining the period from 1994 to 2010. According to the findings, nonlinear causality relationships were determined between OP and agricultural commodity. Ma et al (2015) analyzed the relationship between OP, agricultural CP and exchange rate using monthly data from 2002 to 2013. In their findings, they concluded that OP causal of soybean price, and exchange rate is not the dominant factor over CP. Kuhe and Uba (2018) analyzed the period between 2006 and 2017 and investigated the relationship between OP, exchange rate and CP. In their findings, it was determined that crude OP and exchange rate increased the agricultural CP. According to the causality analysis, a one-way causality relationship was determined from crude OP and exchange rate to agricultural CP. Mokni and Ben-Salha (2020) investigated the relationship between oil and food. According to the causality relationship findings, they found one-way causality from food prices to OP.

ii) Feedback hypothesis: Nazlioglu and Soytas (2012) analyzed the relationship between 24 CP and OP. The results of cointegration and causality analysis between the variables showed that OP has an effect on agricultural CP. In addition, they found a bidirectional causality relationship between OP and CP. Yang et al. (2021) found similar results using monthly data from 1992 to 2019. In another study, Resitis (2015) found similar results for the period between 1983 and 2013. Coronado et al. (2018) examined the causal relationship between OP and agricultural CP for the period 1990 to 2006. In the obtained findings, they found bidirectional causality between OP and CP. Su et al. (2019) examined the relationship between OP and CP using data from 1990 to 2017. They determined that there is a positive bidirectional causality relationship between OP and agricultural CP that changes over time. Cheng and Cao (2019) found a bidirectional causality relationship between food price and crude OP in their study, in which they examined the relationship between crude OP and global food price using the data from 1990 to 2017.

iii) Neutrality hypothesis: In their study, Nazlioglu and Soytas (2011) found results that support neutrality hypothesis. Fowowe (2016) analyzed the relationship between OP and CP for the period 2003 to 2014. According to the empirical findings, no causal relationship was found between OP and agricultural CP.

iv) Mixed results: Saghaian (2010) investigated the relationship between CP and OP by taking the period 1996 to 2008. In the findings, a correlation was determined between OP and CP. In addition, while the causal relationship from oil to some CP was determined, a bidirectional causality relationship was determined towards some others. Vo et al. (2019) investigated the causality relationship between oil markets and agricultural products by using monthly data from 2000 to 2018. According to the findings, it has been determined that not every oil shock makes the same contribution to the effects of agricultural price fluctuations on the agricultural market. Thus, it proves that the crude oil market causes fluctuations in agricultural CP.

Materials and methods

In this study, annual data of the real effective exchange rate and crude oil price of the USA are used for the price of agricultural raw materials for the period 1990 to 2020. All data were obtained from the IMF database and detailed explanations are given in Table 1.

Table 1. Data description

Agricultural Raw Materials	Description	Unit
Cotton	Cotton Outlook 'A Index', Middling 1-3/32 inch staple, CIF Liverpool	US cents per pound
Hard Logs	Best quality Malaysian meranti, import price Japan	US$ per cubic meter
Hard Sawnwood	Dark Red Meranti, select and better quality, C&F U.K port	US$ per cubic meter
Hides	Heavy native steers, over 53 pounds, wholesale dealer's price, US, Chicago, fob Shipping Point	US cents per pound
Rubber	Singapore Commodity Exchange, No. 3 Rubber Smoked Sheets, 1st contract	US cents per pound
Soft Logs	Average Export price from the U.S. for Douglas Fir	US$ per cubic meter
Soft Sawnwood	Average Export price of Douglas Fir	US$ per cubic meter
Wool, Coarse	23 micron, Australian Wool Exchange spot quote	US cents per kilogram
Wool, Fine	19 micron, Australian Wool Exchange spot quote	US cents per kilogram
OIL	Brent Crude	US$ per barrel
REER	US (reel effective)	Index 2010=100
ARM	Agricultural Raw Materials Index	

The econometric method used in the study is given below:

$$ARM_t = f(REER_t, OIL_t) \tag{1}$$

here, ARM stands for agricultural raw materials; REER refers to the real effective exchange rate of the USA; OIL represents the price of crude oil and t represents the time dimension.

$$lnARM_t = \beta_0 + \beta_1 lnREER_t + \beta_2 lnOIL_t + \varepsilon_t \tag{2}$$

lnARM refers to the natural logarithm of agricultural raw materials; lnREER represents the natural logarithm of the real effective exchange rate of the USA; lnOIL refers to the natural logarithm of the price of crude oil; ε stands for the white noise error term; t represents the time dimension.

In this study, Peseran et al (2001) technique was used to test the cointegration relationship between the variables. The prerequisite for this test is that the variables must be stationary at the level or at the primary difference. Therefore, before the ARDL bounds test, the stationarities of the variables were determined with the help of (ADF) and Phillips and Perron (PP) unit root tests.

When the ARDL bound test is compared with the cointegration test of Johansen and Juselius (1990), it is seen that it is used more frequently in the literature. We can collect the advantages of ARDL bound test in four groups: i) It gives better results in small samples (Ghatak and Sidekick, 2001). ii) The ARDL bound test can be used for both I(0) and I(1) order series. However, in Johansen and Juselius (1990) cointegration test, the variables must be stationary in I(1). iii) The ARDL bound test addresses the endogenity of some variables in the regression by giving long term estimates (Odhiambo, 2009). iv) The ARDL bound test can predict the long and short term effects of the variable (Bentzen & Engster, 2001).

The ARDL bounds test adapted to our study:

$$\Delta lnARM = \alpha_0 + \sum_{i=1}^{m} \alpha_{1i} \Delta lnARM_{t-1} + \sum_{i=1}^{m} \alpha_{2i} \Delta lnREER_{t-1} + \sum_{i=1}^{m} \alpha_{3i} \Delta lnOIL_{t-1} + \delta_1 lnARM_{t-1} + \delta_2 lnREER_{t-1} + \delta_3 lnOIL_{t-1} + \varepsilon_t \quad (3)$$

Δ; denotes the first difference, α; denotes the parameters to be estimated, ε_t denotes the white noise error term. In Equation 3: $H_0: \delta_1 = \delta_2 = \delta_3 = 0$, and $H_1: \delta_1 \neq \delta_2 \neq \delta_3 \neq 0$ (Gövdeli, 2019).

$$(1-L)\begin{bmatrix} ARM \\ OIL \\ REER \end{bmatrix} = \begin{bmatrix} a_1 \\ a_2 \\ a_3 \end{bmatrix} + \sum_{i=1}^{p}(1-L)\begin{bmatrix} b_{11i} & b_{12i} & b_{13i} \\ b_{21i} & b_{22i} & b_{23i} \\ b_{31i} & b_{32i} & b_{33i} \end{bmatrix} X \begin{bmatrix} ARM_{t-1} \\ OIL_{t-1} \\ REER_{t-1} \end{bmatrix} + \begin{bmatrix} \beta_1 \\ \beta_2 \\ \beta_3 \end{bmatrix} + ECT_{t-1} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \end{bmatrix} \quad (4)$$

where 1-L is the delay operator; ECT_{t-1} ECT_{t-1}, delayed error correction term; β_j (j=1,2,3) are correction coefficients and ε_{jt} (j=1,2,3) are error correction terms (Shahbaz et al., 2015).

When determining long-term causality, it is checked that the ECT_{t-1} coefficient is between (-1, 0) and is statistically significant. Thus, the effect of a shock that may occur in the variables will continue to decrease and it will approach the equilibrium again in the long run.

Results

After explaining the techniques used, empirical results and evaluations will be made in this part of the study. Before proceeding to the ARDL bound test, it should be investigated whether the prerequisite variables are stationary at level or first difference order. The unit root test results of the variables are presented below:

Table 2. Unit root test results

Variables	LEVEL		1ST DIFFERENCES		Result
	ADF	PP	ADF	PP	
	t statistics	t statistics	t statistics	t statistics	
Cotton	-2.5531	-2.6520	-5.3534*	-5.4451*	I(1)
Hard Logs	-2.4109	-2.5105	-5.4186*	-5.4186*	I(1)
Hard Sawn Wood	-2.0493	-2.1944	-4.7665*	-4.7649*	I(1)
Hides	-0.1157	-0.0407	-5.2674*	-5.2657*	I(1)
Rubber	-1.4046	-1.5357	-4.1034*	-4.0835*	I(1)
Soft Logs	-2.8376	-2.9281	-4.3257*	-4.2713**	I(1)
Soft Sawnwood	-3.2604	-3.2316**	-4.1360**	-3.9891*	I(1)
Wool, Coarse	-1.0401	-1.0772	-4.3866*	-3.7690*	I(1)
Wool, Fine	-1.8689	-1.8706	-5.1266*	-8.2909*	I(1)
OIL	-1.1739	-1.1692	-4.3226*	-4.2242*	I(1)
REER	-2.6301	-1.6306	-3.8485*	-3.8784*	I(1)
ARM	-1.6570	-1.7620	-4.4762*	-4.4762*	I(1)

Note: 1% and 5% are represented by * and **, respectively.

In the results obtained, it has been determined that the Soft Sawnwood variable has a unit root at the level according to the ADF test and becomes stationary by taking the difference. According to the PP test, the Soft Sawnwood variable was found to be stationary at the level. For this reason, it is accepted that the variable is stationary by taking the difference, that is, it becomes stationary in the first order. Other variables are unit rooted at the level and stationary at first difference. In summary, all variables are stationary at order 1. Thus, it has been proven in Table 2 that the precondition of ARDL bound test is met.

Table 3. Cointegration test results

Dependent Variables		Critical Values		
		1%	5%	10%
	I(0) Bound	4.13	3.10	2.63
	I(1) Bound	5.00	3.87	3.35
	Stats	Cointegration Results		
Cotton	4.49	□		
Hard Logs	6.27	□		
Hard Sawn Wood	8.23	□		
Hides	4.88	□		
Rubber	4.40	□		
Soft Logs	4.74	□		
Soft Sawnwood	4.87	□		
Wool, Coarse	4.46	□		
Wool, Fine	4.08	□		
ARM	5.69	□		

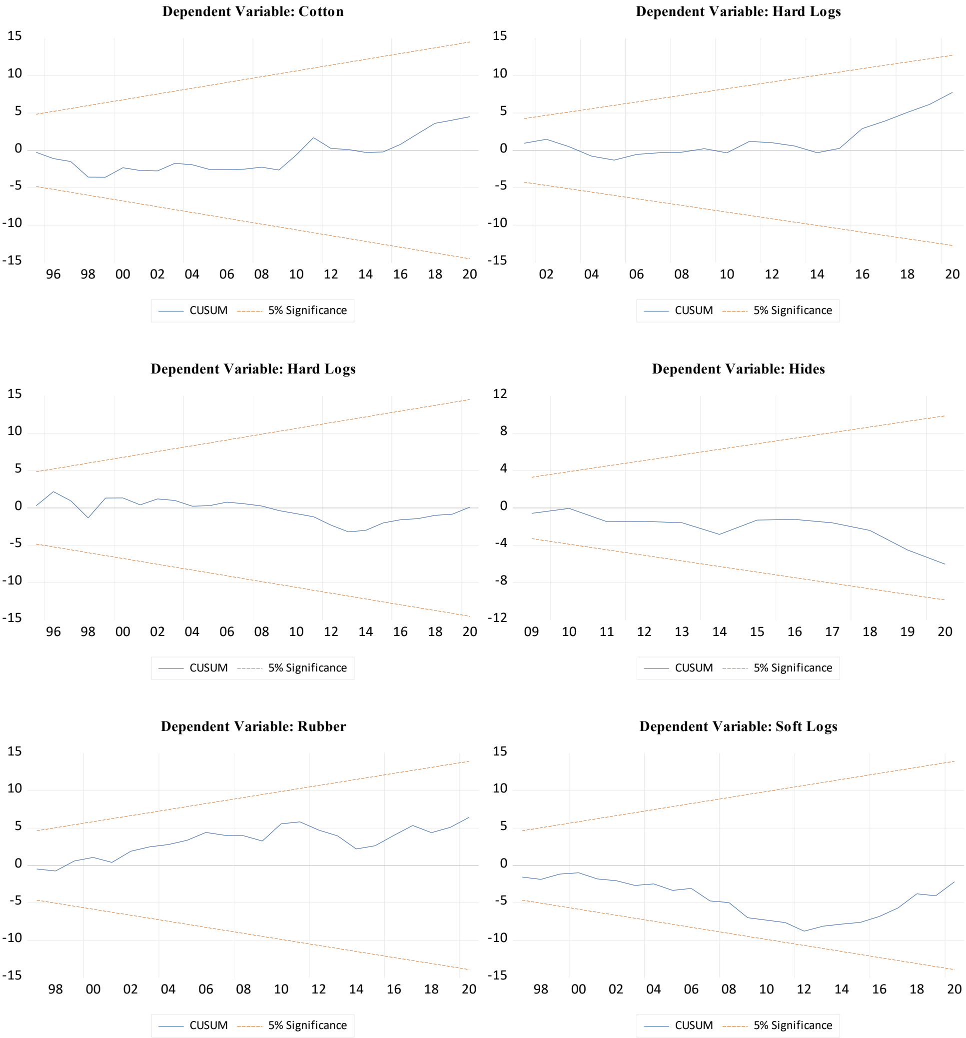
The results of the cointegration relationship between the variables are presented in Table 3. According to the findings, since the null hypothesis of Hard Logs and Hard Sawn Wood variables was rejected at the 1% level, the finding that “there is a cointegration relationship between the alternative hypothesis variables” was accepted. The null hypothesis of “variables at the 5% level” was rejected because the other variables remained in the unstable region at the 1% significance level.

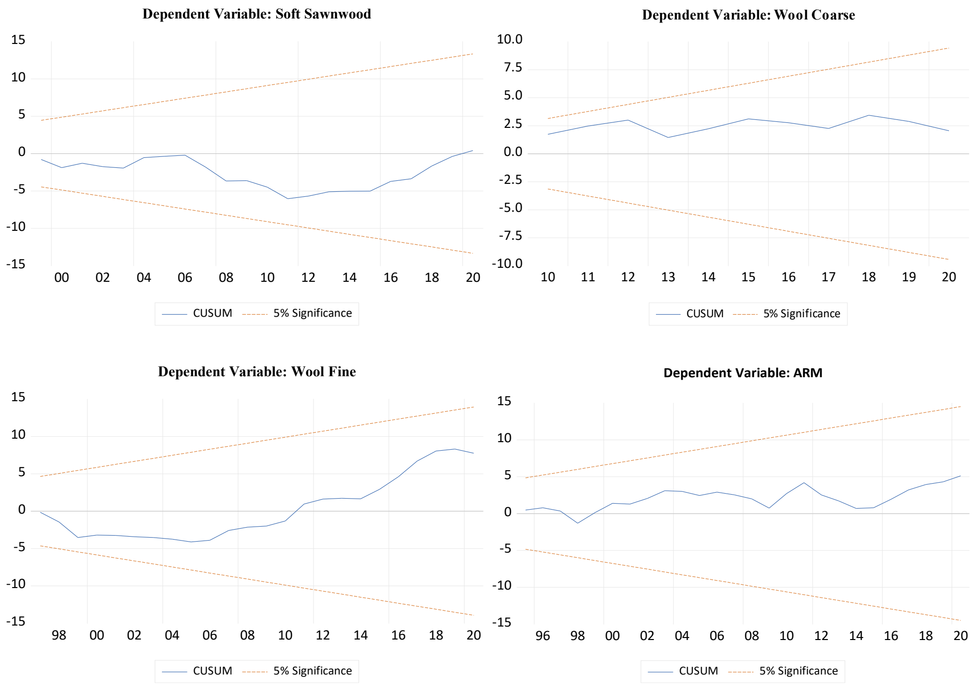
Table 4. Long-term estimates

	ARDL Estimate				**FMOLS Estimate**				**DOLS Estimate**			
	OIL		**REER**		**OIL**		**REER**		**OIL**		**REER**	
Dependent Variables	Coef	p value	Coef	p value	Coef	p value	Coef	p value	Coef	p value	Coef	p value
Cotton	0.08	0.31	-2.10	0.01	0.10	0.15	-1.84	0.00	0.09	0.32	-2.34	0.03
Hard Logs	0.22	0.03	-1.42	0.08	0.13	0.03	-1.78	0.00	0.06	0.31	-2.62	0.00
Hard Sawn Wood	0.13	0.01	-1.69	0.00	0.14	0.00	-1.43	0.00	0.10	0.00	-1.82	0.00
Hides	0.01	0.96	-0.42	0.14	-0.09	0.33	-1.84	0.03	-0.06	0.52	-1.45	0.19
Rubber	0.52	0.00	-2.58	0.01	0.59	0.00	-2.60	0.00	0.52	0.00	-3.79	0.00
Soft Logs	-0.09	0.11	-0.71	0.17	-0.05	0.33	-0.23	0.62	-0.06	0.30	-0.53	0.32
Soft Sawnwood	0.08	0.01	0.17	0.47	0.13	0.00	0.48	0.11	0.10	0.01	0.12	0.73
Wool, Coarse	0.69	0.00	0.41	0.79	0.76	0.00	0.44	0.78	0.68	0.00	1.18	0.49
Wool, Fine	0.42	0.01	-0.02	0.99	0.41	0.00	0.23	0.75	0.26	0.01	-1.65	0.09
ARM	0.19	0.00	-1.37	0.00	0.21	0.00	-1.19	0.00	0.17	0.00	-1.78	0.00

Table 4 presents the long-term estimation results of the variables. The reason why FMOLS and DOLS estimator results are given in addition to the ARDL bound test estimator is to support the empirical findings. According to the empirical results where the dependent variable is agricultural raw materials and the independent variable is OIL and REER variables, we see that the ARDL, FMOLS and DOLS estimator results give approximately similar results. In empirical findings, the OIL variable increases the prices of agricultural raw materials. It has been determined that the elasticity coefficients of the REER variable are generally negative. In the model where the ARM series is the dependent variable, the probability values of the OIL and REER variables were found to be significant at 1%. As expected, the elasticity coefficient of the OIL variable was positive and the elasticity coefficient of the REER variable was negative.

Figure: 1. CUSUM Charts





Cumulative sum (CUSUM) graphs are presented in Figure 1. With the help of CUSUM graphics, the stability of the parameters can be determined. When the CUSUM graphs of the models in which agricultural raw materials are dependent variables are examined, it has been determined that they remain within the line limits at the 5% level, thus the estimated parameters are stable.

Table 5. VECM causality results

	Short-run causality			Long-run causality
Dependent Variable	Δ(ARM)	Δ(OIL)	Δ(REER)	Ect(t-1)
Δ(ARM)	-	9.527 (0.008)	0.040 (0.980)	-0.817 (0.005)
Δ(OIL)	1.748 (0.417)	-	2.264 (0.322)	-0.661 (0.370)
Δ(REER)	4.031 (0.133)	5.255 (0.072)	-	0.138 (0.164)

Note: p values are in parentheses.

Table 5 presents the short- and long-term causality results between agricultural raw materials and oil price, real effective exchange rate. According to the results of the short-term causality analysis, one-way causality relationship from OIL to agricultural raw materials and REER has been determined. In the results of the long-term causality relationship, a causality relationship has emerged from OIL and REER to agricultural raw materials. The findings are in line with the results of Kuhe and Uba (2018), Nazlioglu ve Soytas (2012)'s study.

Conclusions

In the study, the relationship between the prices of agricultural raw materials and the real effective exchange rate of the USA and the price of crude oil was analyzed. Thus, whether the real effective exchange rate and crude oil price have explanatory power on agricultural raw materials has been investigated. For this purpose, annual data from 1990 to 2020 were used. The main results and policy recommendations obtained in this study, in which cointegration causality analysis was conducted, are given below:

First, crude oil prices have a positive effect on agricultural raw materials prices. In the last 30 years, when crude oil prices have fluctuated, it has been observed that agricultural raw materials prices have similar fluctuations. In particular, the increase in the prices of agricultural raw materials due to the jumps in oil prices can cause some problems in the sectors. Secondly, the prices of agricultural raw materials, which directly affect the input prices, are very important for the country's economy. In particular, countries that import agricultural raw materials will feel the impact of oil price shocks in the short term, as well as their reflections on agricultural raw materials prices. Here, policy makers need to develop and implement policies that will minimize external dependence on agricultural raw materials. Third, the cointegration relationship was determined in the models established for nine agricultural raw materials. Thus, it has been determined that agricultural raw materials will act together with crude real effective exchange rate and oil prices in the long run. Our recommendation to policy makers in this regard is to take precautionary measures against negative volatility in prices of agricultural raw materials. In this way, it will be possible to prevent investors and sectors from being affected too much. Fourth, one-way causality relationship from oil price to agricultural raw materials has been determined. Thus, it has been concluded that the changes that may occur in the oil price in terms of supply and demand directly affect the agricultural raw materials. It would be beneficial for policy makers to develop a policy for oil price that directly affects agricultural raw materials. It would be appropriate to provide logistics activities with alternative sources other than oil, such as solar energy, energy from renewable energy sources. It is recommended to make the necessary technological investments in this regard. In this way, the logistics costs of agricultural raw materials will decrease and more stable agricultural raw materials prices will be formed.

Our results are a guide to policy makers and it is necessary to take precautions against oil price fluctuations for agricultural raw materials that countries need. In particular, investments in agricultural raw materials should be evaluated well in this regard and it should be aimed that policy makers and economists produce policies together. It is recommended to increase the competitiveness of countries by minimizing the reflections of oil shocks on agricultural raw materials.

Conflict of interests

The authors declare no conflict of interest.

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