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The impact of fluctuating international fertiliser prices and exchange rates on domestic fertiliser prices in Türkiye

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Abstract: This study aims to examine the relationship between domestic and international prices of di-ammonium phosphate (DAP) and urea fertilisers together with exchange rates in Türkiye using the non-linear autoregressive distributed lag (NARDL) model on monthly data for the period of January 2011 to September 2022. The result of the study provides empirical evidence about the presence of asymmetries in the short and long-run among these fertilisers. The findings of the study confirm that international prices of di-ammonium phosphate and urea fertilisers have a symmetric effect in the long-run and exchange rate of the Turkish lira to US dollars has an asymmetric effect on the domestic prices of fertilisers in the short run. This is the first study in Türkiye to delineate the dynamic simultaneous interaction among these markets and its findings can be extremely useful for academicians, and policymakers to make decisions regarding the market structure of countries that do not have sufficient domestic resources for fertiliser supply and are dependent on imports.

Keywords: di-ammonium phosphate; NARDL; price and exchange rate transmission; urea

Fertilisers are chemicals or mixes of necessary nutrients that are applied to soil or plants in order to promote growth and enhance agricultural yields. They play an important role in modern agriculture, addressing nutritional shortages and increasing overall output. The major types of fertilisers used worldwide include nitrogen, phosphorus and potassium.

The world's fertiliser use has been steadily increasing over the years due to the growing global population and the need to enhance the agricultural productivity. Higher yields can be seen all across the world with the use of higher-yielding varieties and larger amounts of fertiliser. In order to attain the best yield and quality from a crop, fertilisers are crucial plant nutrients. Fertilisers containing the three main nutrients of nitrogen (N), phosphorus (P), and potassium (K) are mostly used by farmers. 201.8 million metric tonnes (Mt) of nutrients were consumed globally in fertilisers in 2020 – 112.3 Mt of N, 48.9 Mt of P, and 40.5 Mt of K. There was a 7.4 % increase in N nutrient use, 14.6% increase in P use, and 39.2 % increase in K use between 2011 and 2020 (IFA 2023). The prices for fertilisers on the global market may change in response to changes in the supply and demand. Fluctuating weather conditions, increases in crop prices, the implementation of protectionist trade policies, the upward demand

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to bio fuel production where crops are used as an input etc. have all led to an increase in the demand for fertilisers. Changes in the fertiliser production costs as a result of fluctuating energy prices have also an impact on the production. Ammonia (NH_3) is a key ingredient in the industrial manufacturing of urea. It consists of nitrogen (N) and hydrogen (H_3). Because hydrogen is manufactured from natural gas, natural gas accounts for the majority of the total cost of ammonia manufacturing. Additionally, since the manufacturing and transportation of di-ammonium phosphate (DAP) depend on crude oil, changes in energy costs have a substantial impact on its cost.

There are many studies on fertilisers in the literature, with the majority focusing on the nexus between the energy, fertiliser and agricultural markets, but the emphasis is often on price and volatility spillovers (Nazlioglu and Soytas 2012; Reboredo 2012; Gardebroek and Hernandez 2013; Nazlioglu et al. 2013; Beckman and Riche 2015; De Nicola et al. 2016; Etienne et al. 2016; Fowove 2016; Kocaarslan and Soytas 2019; Ucak et al. 2022). However, according to our knowledge, the price transmission between international and local fertiliser prices is somehow a neglected subject in which only one study (Alemu et al. 2011) was found in the literature.

International fertiliser prices are particularly important for countries dependent on fertiliser imports. Changes in the international prices of fertilisers, which are of inevitable importance for agricultural production and productivity, and also for global food security (Emam 2023) can lead to volatility in domestic markets, resulting in fluctuations in fertiliser usage and, consequently, fluctuations in agricultural production. If domestic and international prices move in the same direction after accounting for domestic transaction costs, the domestic fertiliser market is said to be successfully integrated. If the gap between domestic and international prices widens, it may indicate that changes in international prices are not being fully reflected. Some possible explanations include the presence of market power, insufficient knowledge, transportation/storage, financing, and other infrastructure in the fertiliser market, which permits economic agents to fail to fully pass on changes in the international pricing to domestic prices. However, the impact of the exchange rate on domestic prices is of inevitable importance. When the local currency depreciates against the US dollar, a rise in the commodity price in the local currency is greater than the increase in the international price in dollars. As a result, prices diverge from one another.

This study will contribute to the subject by answering two major questions for countries that do not have sufficient domestic resources for fertiliser supply and are dependent on imports. Do domestic fertiliser prices respond similarly to both upward and downward movements in the international fertiliser prices? Additionally, how do domestic fertiliser prices respond to changes in international price movements? Due to the effects such differences have on the agricultural production, this subject is crucial. The second concern is whether the exchange rate is one of the main elements that directly affect domestic pricing, implying that fluctuations in the exchange rate alone could contribute to a wider price disparity.

This paper examines the impact of international price movements and changes in the exchange rate on the value of Turkish domestic fertiliser prices. The non-linear autoregressive distributed lag (NARDL) model is employed to capture the anticipated asymmetry in domestic fertiliser price responses to the changing international prices and exchange rate. It is argued, in this paper, that countries that do not have sufficient domestic resources for fertiliser supply and who are dependent on imports are open to fluctuations both in international markets and domestic exchange rates. It is conjectured that if the markets are not under perfect competitive conditions and the exchange rate volatility is also high, the short-term impact of the exchange rate-related shocks will be higher than the impact of the volatility in international markets. Therefore, this leads to an inherently asymmetric price response in the short run. The above questions are being examined using monthly data from January 2011 to September 2022 based on examples of di-ammonium phosphate (DAP) and urea fertilisers, widely used in the Turkish fertiliser market.

Turkish fertiliser market. The production of fertilisers in Türkiye started in the 1950s. From 1960 onwards, the factory prices were determined by decrees issued by the government upon the recommendation of the State Planning Organization (DPT). Starting from 1973, the distribution and supply of fertilisers were assigned to the public institutions, namely the Turkish Agricultural Equipment Corporation (TZDK) and the Turkish Sugar Factories Inc. (TŞFAŞ). In 1974, the fertiliser subsidy was initiated. In 1986, the fertiliser supply and marketing were liberalised and direct support from the government to producer and distributor public institutions has been removed (Konyalı 2016). Starting from 1998, privatisation efforts aimed at reducing the public presence in the fertiliser sector began

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with state–owned production companies Turkish Fertilizer Industry Inc and Istanbul Fertilizer Industry Inc. (İGŞAŞ). The organisation established in 1954 under the name Azot Sanayi T.A.Ş., with facilities in Kütahya, Samsun, Gemlik, and Elazığ, continued its activities under the state-owned enterprise named Turkish Fertilizer Industry Inc (TÜGSAŞ) in 1984. By 1998, TÜGSAŞ, which was included in the privatisation process, had a share of around 45% of the total production. The facilities of TÜGSAŞ in Gemlik, Kütahya, Samsun, and the sole producer of urea at that time, İGSAŞ, were privatised and transferred to private companies in 2004. Then, by 2005, the privatisation of the industry was completed.

In 2018, all fertiliser producers/importers in Türkiye were private companies and there were 1 284 companies in the sector. However, among these companies, there are 6 producers/importers, 20 importers and 11 factories, which have continuity in the market and a higher volume of transactions. However, six of these companies (namely Toros, İgsaş, Bagfaş, Ege Gübre, Gemlik and Gübretaş) represent about 80% of the market (Tagem 2018). Therefore, we can assume that the fertiliser market in Türkiye can be described by an oligopolistic market structure in which a small number of producers try to restrict the output and/or fix prices in order to achieve above-normal market returns.

In Türkiye, nitrogen, phosphorus and potassium are the most used fertilisers. Due to the possibility of being used in the production of explosive substances, the use of nitrate-based fertilisers has been banned in Türkiye from 2016 and farmers have directed their consumption towards urea. When the chemical fertiliser usage quantities Türkiye were examined after 2011, an increase in the consumption was observed (Table 1). In 2020, the fertiliser consumption reached its historically highest level, but sharp declines have been observed in the subsequent years. According to industry experts, the explanation for this decline is attributed to the high volatility in prices.

Natural gas, phosphate rock, potash, ammonia, nitric acid, sulfuric acid, and phosphoric acid are among the raw materials and intermediate inputs for fertilisers, and since Türkiye lacks domestic raw material resources, the chemical fertiliser sector is more than 90% dependent on imports. Fertilisers are either imported as a final product and presented to the consumer or the raw materials are imported and used in the production of fertilisers. The production costs consist of 65–80% of the raw materials. Exports account for less than 10% of the production. During the period of 2005–2016, a total of 6.7 billion Turkish lira (TL) was paid in fertiliser subsidies (the authors are unable to provide the amount in USD, because of the varying exchange rate during the period 2005–2016), covering an average of 15% of the producer's fertiliser costs (Tagem 2018).

Table 1. Total annual fertilizer consumption and production quantities

Year	Consumption (tonnes)	Production (tonnes)
2011	3 749 921	4 766 356
2012	3 661 156	5 339 893
2013	5 813 612	3 576 598
2014	5 471 518	3 547 796
2015	5 507 779	3 674 261
2016	6 744 922	3 358 323
2017	6 332 872	3 841 644
2018	5 411 881	4 027 004
2019	6 087 714	4 661 491
2020	7 143 144	6 546 895
2021	6 480 101	6 335 104
2022	5 902 539	5 163 508

Source: Ministry of Agriculture and Forestry (2023)

As stated in the above section, a domestic fertiliser market is said to be effectively integrated if the domestic and international prices move in the same direction after adjusting for the domestic transaction costs. If the disparity grows, it may indicate that changes in international prices are not being fully reflected. Figures 1 and 2 depict the monthly international and domestic (bold black line) DAP and urea fertiliser price movements in USD. When we examine the price movements, it can be observed that the domestic prices of DAP and urea fertilisers follow the international prices in the same direction when measured in USD. At the same time, there are significant differences between the domestic and international prices, and this is particularly more significant in the case of DAP fertilisers.

The price gaps between the domestic and international prices have steadily decreased since 2011 as seen from Figure 3. However, in 2021, high volatility could be observed and from February 2021 to May 2021 the price gap remained negative in the DAP fertilisers. Again, in May 2022 and April 2022, a negative price gap can be seen both in the DAP and urea fertilisers. It can be observed that after each period of negative prices, prices suddenly rise.

In 2021, to prevent the increasing prices in the domestic market (Figure 4), the Ministry of Trade in-

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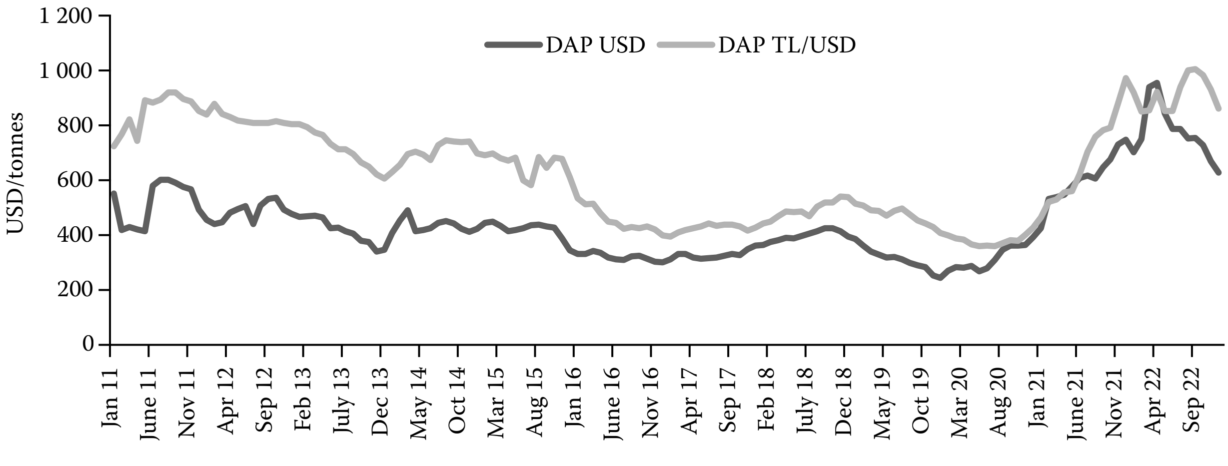

Figure 1. International and domestic price movements – DAP

DAP – di-ammonium phosphate; *DAP* USD – international price of di-ammonium phosphate in USD; *DAP* TL/USD – domestic price of di-ammonium phosphate in Turkish liras converted to USD
Source: Authors' own elaboration

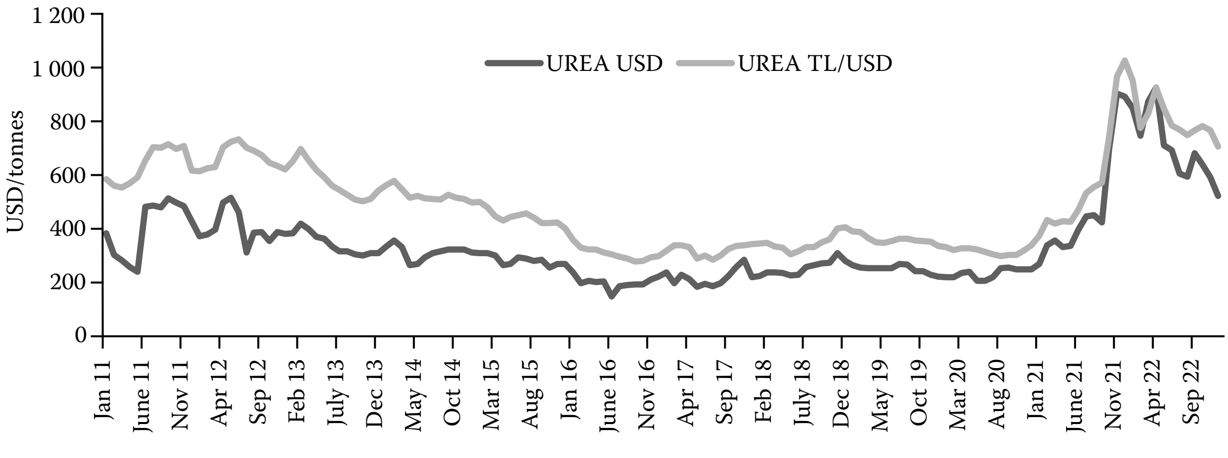

Figure 2. International and domestic price movements – urea

UREA USD – international price of urea in USD; *UREA* TL/USD – domestic price of urea in Turkish liras converted to USD
Source: Authors' own elaboration

cluded fertilisers in the list of goods subject to export registration with the regulation published in the Official Gazette on October 12, 2021. Later organic and water-soluble special fertilisers were taken out of the scope of the export ban. Also, at the end of December 2021, President Erdogan announced that there would be a discount ranging from 5% to 13% in fertiliser prices for Tarım Kredi Kooperatifleri (Agricultural Credit Cooperatives), and the prices would be fixed until April 2022. Although this statement only applied to the Agricultural Credit Cooperatives, farmers postponed their purchases, thinking that this policy would cover the entire sector.

From the end of 2020 onwards, a downward trend in fertiliser consumption began, and this decline has continued (Table 1). A decrease in the demand due to drought in Türkiye and the continuous postponement of purchases due to price fluctuations could be the result of a decrease in the consumption. However, when Figures 1 and 2 are examined together with Figure 4, it becomes evident that the sudden and significant increases in the domestic market in the year 2021 and 2022 can only be explained in conjunction with exchange rate shocks in Türkiye. The price of fertilisers quickly reflects changes with the exchange rates. Consequently, the effect of global price

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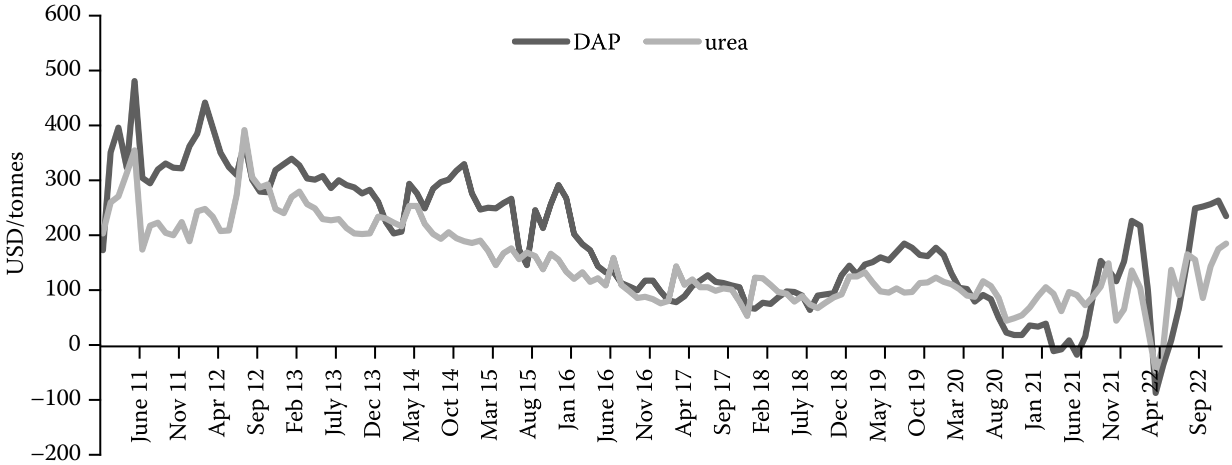

Figure 3. Price gaps (USD per tonnes)

DAP – di-ammonium phosphate
Source: authors' own elaboration

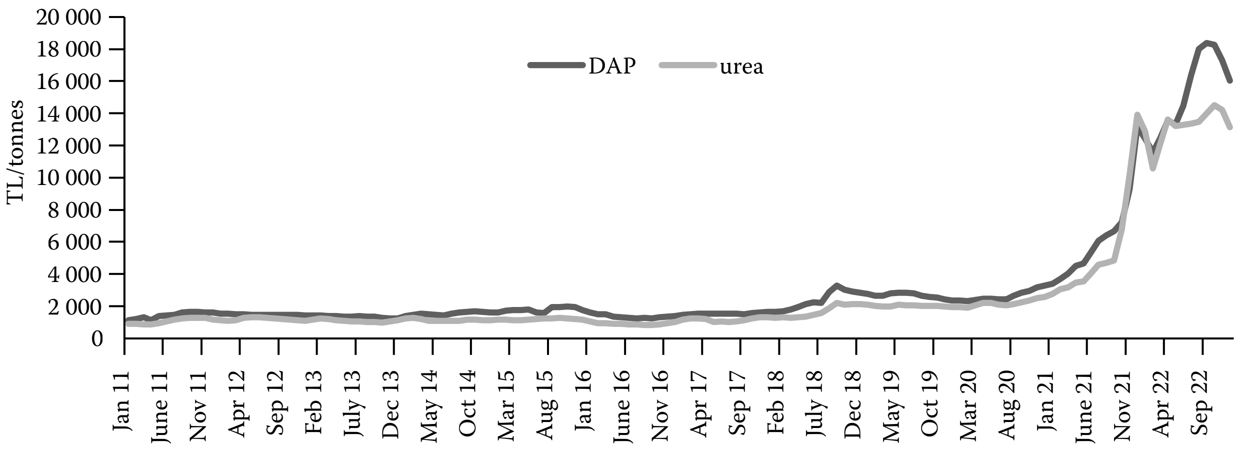

Figure 4. Domestic price movements (Turkish lira per tonne) – *DAP* and urea

DAP – di-ammonium phosphate; the authors are unable to provide the amount in USD, because of the volatile exchange rate in the critical period
Source: Authors' own elaboration

hikes on domestic markets will be explored along with changes in the exchange rates in the following sections.

MATERIAL AND METHODS

The non-linear ARDL cointegration test, developed by Shin et al. (2014), is applied in this study to examine the relationship between international and domestic prices of di-ammonium phosphate, urea, and the exchange rate in Türkiye. The study utilises monthly time series data from January 2011 to September 2022. The chosen period is determined by the data availability. Table 2 provides information on the data sources.

In the literature, researchers have utilised linear methods to explore the relationship between various macroeconomic variables. Traditionally, standard time series techniques like cointegration, granger causality, standard ARDL, and vector error correction modelling are used. These methods work based on the assumption that the association between variables are linear. Cointegration-based approaches can examine linear short-run and long-run relationships, but cannot be used to test for the asymmetric effects. As seen from Figures 5 and 6, the data under consideration may

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Table 2. List of variables studied and sources of collected data for each variable

Variable name	Units	Abbreviation	Source
Di-ammonium phosphate retail price	TL/tonnes	*DAP*	MMB (2023)
Di-ammonium phosphate international price	USD/tonnes	*DAPF*	IndexMundi (2023)
Urea retail price	TL/tonnes	*UREA*	MMB (2023)
Urea international price	USD/tonnes	*UREAF*	IndexMundi (2023)
Exchange rate (USD/TL)	USD/TL	*KUR*	CBRT (2023)

Source: Authors' own elaboration

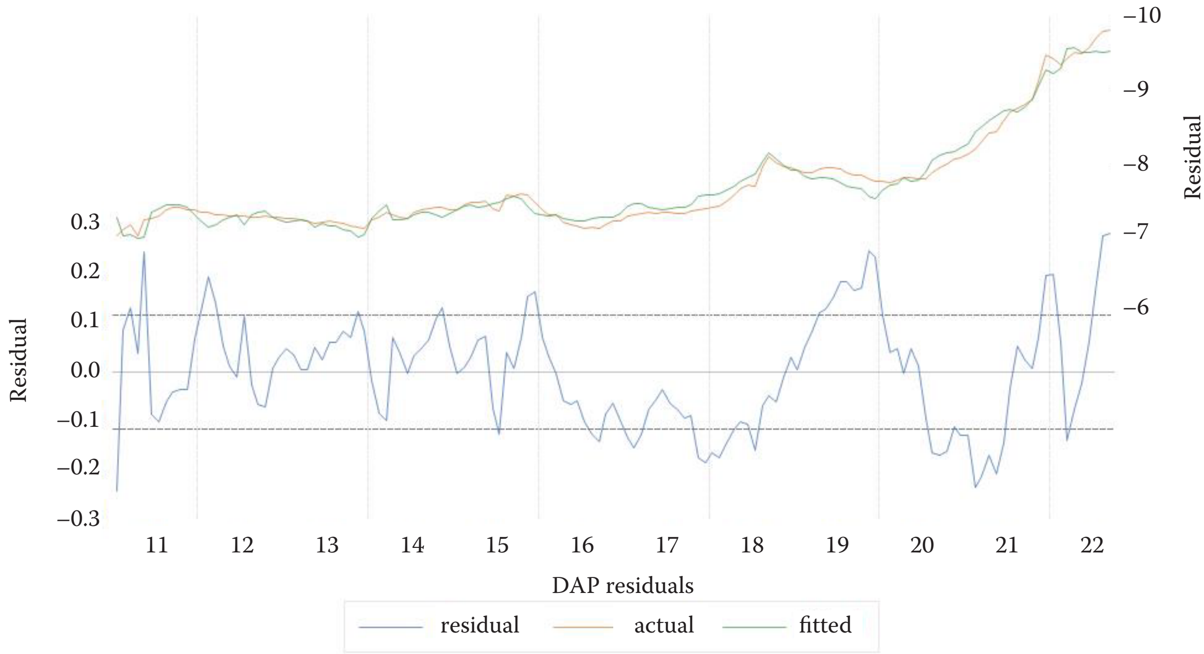

Figure 5. Residual analysis of logarithmic *DAP* equation $LDAP = A_1 + A_2\ LDAPF + A_3\ LKUR$

DAP – di-ammonium phosphate retail price; *LDAP* – logarithm of di-ammonium phosphate retail price; *LDAPF* – logarithm of di-ammonium phosphate international price; *LKUR* – logarithm of exchange rate (USD/TL)
Source: Author's own elaboration

contain non-linearities. Therefore, the NARDL model is better suited to modelling the asymmetric impacts, that is to test for long and short run asymmetries.

The NARDL bound testing cointegration approach decomposes the variables into positive and negative changes to see whether variables have a non-linear impact. It allows us to capture the long run and short run asymmetric relationship between the variables. The NARDL model has several advantages. It is flexible to the cointegration dynamics between the variables, so it can be used regardless of the different integration orders, that is I (0) or I (1), or can be fractionally integrated. However, the variables under study should not be integrated with an order of 2 or higher (Pesaran et al. 2001; Lahiani et al. 2016; Bouri et al. 2017; Kumar et al. 2021). The test is free from the spurious regression problem (Liu et al. 2017). The model allows us to compute asymmetric dynamic multipliers and, in that way, we can quantify the respective responses of the dependent variables to positive and negative changes in each of the explanatory variables.

Using the NARDL model, it is possible to observe both positive and negative asymmetric cointegration between the variables in both the short-term and long-term. The equation used to represent the asymmetric long-run regression (Shin et al. 2014) is as follows:

$$Y_t = \delta^+ X^+_t + \delta^- X^-_t + e_t \quad (1)$$

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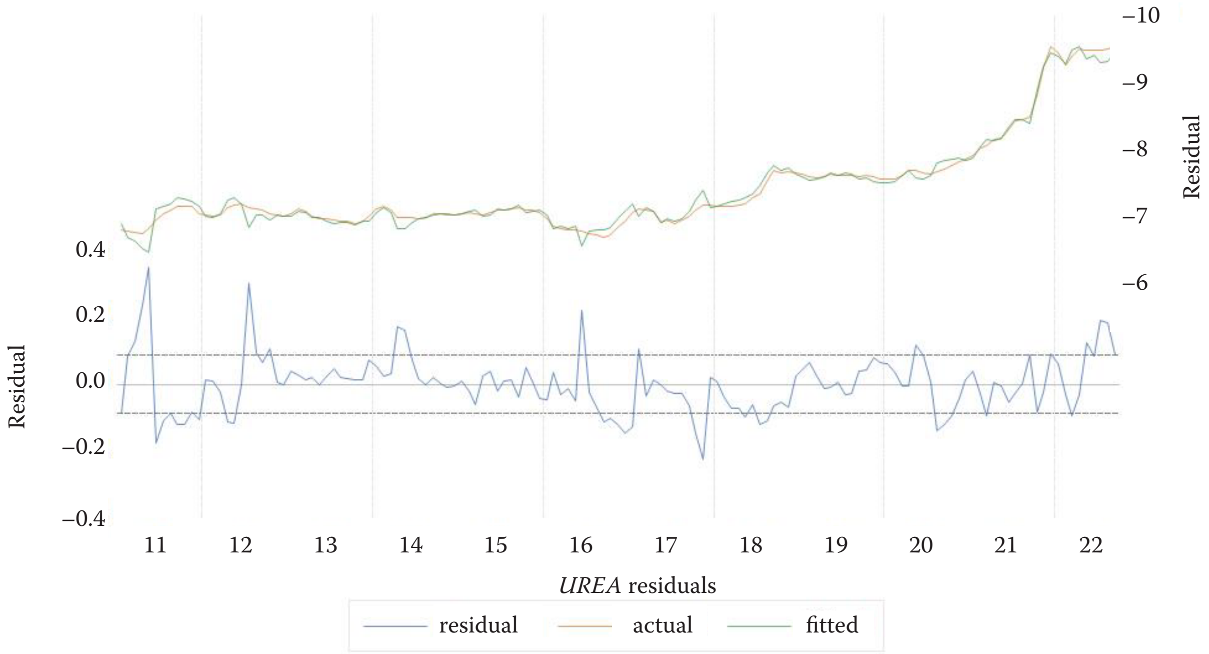

Figure 6. Residual analysis of logarithmic Urea equation $LUREA = B_0 + B_1\, LUREAF + B_2\, LKUR$

LUREA – logarithm of urea retail price; *LUREAF* – logarithm of urea international price; *LKUR* – logarithm of exchange rate (USD/TL)
Source: Author's own elaboration

where: Y_t – dependent variable; δ^+, δ^- – associated long-run parameters.

Specifically, X^+_t and X^-_t represent the sum of positive and negative changes in the exogenous variable, respectively, such as:

$$X_t^+ = \sum_{i=1}^{t} \Delta x_1^+ = \sum_{i=1}^{t} \max(\Delta x_i, 0) \tag{2}$$

$$X_t^- = \sum_{i=1}^{t} \Delta x_1^- = \sum_{i=1}^{t} \min(\Delta x_i, 0) \tag{3}$$

Based on Equations (1–3), the general form of the non-linear (asymmetric) ARDL model can be represented as follows:

$$\begin{aligned} \Delta y_t = {} & \theta + \vartheta_y y_{t-1} + \vartheta_x^+ x_{t-1}^+ + \vartheta_x^- x_{t-1}^- + \\ & + \sum_{i=1}^{m} \partial_i \Delta y_{t-i} + \\ & + \sum_{i=0}^{n} (\lambda_i^+ \Delta x_{t-i}^+ + \lambda_i^- \Delta x_{t-i}^-) \end{aligned} \tag{4}$$

where: Δ – changes in the dependent variables.

The purpose of the long-term analysis is to measure the time and speed in the adjustment of the exogenous variables on the dependent variable, so ϑ^+ and ϑ^- are the long-run asymmetry coefficients. The Wald test is employed to test the long-run symmetry of the null hypothesis, i.e. $\vartheta^+ = \vartheta^-$. On the other hand, to assess the immediate impact of the fluctuations in the independent variables on the dependent variable, a short-term analysis is required and the short-run asymmetric coefficients are expressed by λ^+ and λ^-. The Wald test is applied to test the short-run symmetry of the null hypothesis, i.e. $\lambda^+ = \lambda^-$.

RESULTS AND DISCUSSION

The descriptive statistics of the variables are presented in Table 3. According to Jarque-Bera (JB) statistics, it is evident that the entire price series exhibits a non-normal distribution. Logarithm of DAP retail price (*LDAP*) and logarithm of urea retail price (*LUREA*) exhibit the highest mean value and standard deviations, indicating that the domestic price of the fertiliser series has the highest level of volatility, as anticipated.

The Pearson correlation coefficients among the variables are given in Table 3. The domestic prices of fertilis-

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Table 3. Descriptive statistics

Statistics	*LDAP*	*LDAPF*	*LKUR*	*LUREA*	*LUREAF*
Mean	7.698	6.031	1.311	7.427	5.720
Median	7.398	6.016	1.184	7.121	5.632
Maximum	9.819	6.860	2.907	9.546	6.829
Minimum	7.024	5.472	0.418	6.698	4.960
SD	0.656	0.287	0.658	0.713	0.382
Skewness	1.769	0.674	0.606	1.808	1.018
Kurtosis	5.420	3.161	2.438	5.530	3.771
Jarque-Bera	108.045	10.848	10.486	114.474	27.895
Probability	0.000	0.004	0.005	0.000	0.000
Observations	141	141	141	141	141

LDAP – logarithm of di-ammonium phosphate retail price; *LDAPF* – logarithm of di-ammonium phosphate international price; *LKUR* – logarithm of exchange rate (USD/TL); *LUREA* – logarithm of urea retail price; *LUREAF* – logarithm of urea international price
Source: Authors' own elaboration

ers (*LDAP* and *LUREA*) are positively associated with all the variables. The correlation matrix in Tables 4 and 5 shows that, in general, the correlation between the domestic fertiliser prices and the international prices as well as the exchange rate are positive and statistically significant. Therefore, the increase in the domestic prices of fertilisers are associated with simultaneous increases in international prices and exchange rate.

As noted previously, the NARDL test is unaffected by the issue of spurious regression. All the variables incorporated in the model should be integrated in a similar order. In contrast, it is compulsory to examine the unit root characteristics of the sample data series included in the model as the NARDL technique is not applicable in the presence of I (2) series. As a prerequisite, the variables being analysed must not be integrated of an order of 2 or higher. Therefore, to check the series whether or not a variable is integrated of an order of two, both the augmented Dickey Fuller test (ADF) (Dickey and Fuller 1979) and the Phillips Perron (PP) unit root test (Phillips and Perron 1988) are applied. Table 6 presents the results.

According to the ADF and PP test results, all the variables in question contain a unit root in the level, but the first differences are statistically significant, therefore, they are all integrated in an order of 1. Table 7 reports the results of the bounds test for the nonlinear cointegration approach. The bounds test's *F*-test value exceeds the critical value of the upper bound at a 1% level of significance. This confirms the asymmetric cointegration. Therefore, applying the NARDL specifications is valid.

The main objective of the study is to check whether or not the effect of changes in the international prices and exchange rates on the domestic prices are asymmetric or symmetric. The short and long-run estimated [based on Equation (4)] coefficients of the nonlinear ARDL are presented in Tables 8 and 9. Table 10 presents the Wald test for the long and short-run symmetry.

Table 4. Correlation matrix DAP

Variables	*LDAP*	*LDAPF*	*LKUR*
LDAP	1	–	–
LDAPF	0.601***	1	–
LKUR	0.897***	0.229***	1

***significant at 1% level; DAP – di-ammonium phosphate; *LDAP* – logarithm of di-ammonium phosphate retail price; *LDAPF* – logarithm of di-ammonium phosphate international price; *LKUR* – logarithm of exchange rate (USD/TL)
Source: Authors' own elaboration

Table 5. Correlation matrix urea

Variables	*LUREA*	*LUREAF*	*LKUR*
LUREA	1	–	–
LUREAF	0.658***	1	–
LKUR	0.879***	0.241***	1

***significant at 1% level; *LUREA* – logarithm of urea retail price; *LUREAF* – logarithm of urea international price; *LKUR* – logarithm of exchange rate (USD/TL)
Source: Authors' own elaboration

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Table 6. Unit root tests

Variable	ADF level	ADF first difference	Order of integration	PP level	PP first difference	Order of integration
LDAP	2.769	–4.968***	I(1)	3.553	–8.776***	I(1)
LDAPF	–1.121	–9.959***	I(1)	–1.129	–9.943***	I(1)
LUREA	1.724	–7.546***	I(1)	1.810	–6.366***	I(1)
LUREAF	–1.470	–11.692***	I(1)	–1.343	–11.80***	I(1)
LKUR	2.019	–8.250***	I(1)	2.442	–7.628***	I(1)

***significant at 1% level; ADF – augmented Dickey Fuller test; PP – Phillips Perron test; *LDAP* – logarithm of di-ammonium phosphate retail price; *LDAPF* – logarithm of di-ammonium phosphate international price; *LKUR* – logarithm of exchange rate (USD/TL); *LUREA* – logarithm of urea retail price; *LUREAF* – logarithm of urea international price
Source: Authors' own elaboration

Table 7. The bounds test results

Variable	*F*-statistic	Lag structure	Decision
DAP	11.209***	4, 1, 0, 4, 3	cointegration
UREA	12.262***	3, 0, 0, 1, 3	cointegration

***significant at 1% level; *DAP* – di-ammonium phosphate retail price; *UREA* – urea retail price
Source: Authors' own elaboration

The long-run coefficients of the selected variables according to the NARDL model are presented in Table 8. According to the results, the international price of *DAP* and urea have a statistically significant symmetric influence on the domestic prices. Considering the similar statistical significance and direction of the estimated elasticities, the variation in the logarithm of DAP international price (*LDAPF)* seems to have a symmetric effect on the *LDAP* in the long-run. Also, the variation in the logarithm of urea international price (*LUREAF)* again seems to have a symmetric effect on the *LUREA* in the long-run. In addition to this, the Wald test accepts the hypothesis of long-term symmetry. There is a dissimilar statistical significance and direction of the estimated elasticities in the logarithm of exchange rate (USD/TL) (*LKUR)* for both the DAP and urea equation. A statistically significant asymmetric influence on the domestic prices is observed when there is a positive exchange rate shock, while a negative exchange rate shock does not have any influence. Therefore, the variation in the *LKUR* seems to have an asymmetric effect both on the *LUREA* and *LDAP*. The results of the Wald test (Table 10) confirm the asymmetric effects.

The results of the error correction model are shown in Table 9. Both the DAP equation (–0.180) and the UREA equation (–0.258) indicate that the error correction terms (*ECT*s) are negative and statistically significant in all the cases. This suggests that following a shock, the prices of DAP and urea have a tendency to stabilise. Specifically, it takes approximately 5.5 months (1/–0.18) for DAP and 4 months (1/–0.258) for urea to adjust. Therefore, the speed of adjustment is relatively high.

Table 8. Estimated long-run coefficients of DAP and urea equations using the NARDL approach

Variable	Coefficient	*t*-statistic	Probability	Variable	Coefficient	*t*-statistic	Probability
$DAPF^+$	1.124	0.131	0.000	$UREAF^+$	1.057	13.635	0.000
$DAPF^–$	1.311	0.101	0.000	$UREAF^–$	0.988	23.639	0.000
KUR^+	0.748	4.190	0.000	KUR^+	0.504	3.045	0.002
$KUR^–$	0.015	0.032	0.974	$KUR^–$	–0.002	–0.006	0.994
C	7.373	0.079	0.000	*C*	6.756	96.430	0.000

DAP – di-ammonium phosphate; NARDL – non-linear autoregressive distributed lag model; *DAPF* – di-ammonium phosphate international price, *KUR* – exchange rate (USD/TL); *UREA* – urea retail price; *UREAF* – urea international price
Source: Authors' own elaboration

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Table 9. Estimated error correction model (ECM) equations

DAP equation			Urea equation		
Variable	coefficient	probability	variable	coefficient	probability
C	–0.001	0.836	*C*	–0.012	0.044
ΔDAP_{-1}	0.038	0.525	$\Delta UREA_{-1}$	0.250	0.005
ΔDAP_{-2}	–0.113	0.062	$\Delta UREA_{-2}$	–0.148	0.026
ΔKUR^{+}	1.135	0.000	$\Delta UREA_{-3}$	–0.127	0.047
ΔKUR^{-}	0.158	0.596	$\Delta UREAF^{+}$	0.474	0.000
ΔKUR_{-1}^{-}	–0.185	0.541	ΔKUR^{+}	0.769	0.000
ΔKUR_{-2}^{-}	0.540	0.055	ΔKUR^{+}_{-1}	0.191	0.147
ECT	–0.180	0.000	ΔKUR^{+}_{-2}	–0.350	0.009
–	–	–	ΔKUR^{+}_{-3}	0.345	0.008
–	–	–	ΔKUR^{-}	–0.098	0.718
–	–	–	ΔKUR_{-1}^{-}	–0.240	0.413
–	–	–	ΔKUR_{-2}^{-}	0.745	0.004
–	–	–	*ECT*	–0.258	0.000

Δ – the first difference operator; *DAP* – di-ammonium phosphate retail price; *DAPF* – di-ammonium phosphate international price, *KUR* – exchange rate (USD/TL); *UREA* – urea retail price; *UREAF* – urea international price.

Source: Authors' own elaboration

Table 10. Wald test results for long- and short-term symmetry

Equation	Variable	Long-term	Short-term	Specification
DAP	*LDAPF*	–1.724	–	symmetry
	LKUR	1.927**	–	asymmetry
	ΔKUR^{+}	–	9.712***	asymmetry
	ΔKUR^{-}	–	2.439*	asymmetry
Urea	*LUREAF*	1.069	–	symmetry
	LKUR	1.888*	–	asymmetry
	$\Delta UREAF^{+}$	–	9.712***	asymmetry
	ΔKUR^{+}	–	3.565***	asymmetry
	ΔKUR^{-}	–	2.811***	asymmetry

*, **, *** significant at 10%, 5%, 1% level, respectively; DAP – di-ammonium phosphate; Δ – the first difference operator; *LDAPF* – logarithm of di-ammonium phosphate international price; *LKUR* – logarithm of exchange rate (USD/TL); *LUREAF* – logarithm of urea international price.

Source: Authors' own elaboration

The computed short and long-term estimates are important, provided a co-integration association holds among the variables. The results of the analysis in Table 9 indicates that positive exchange rate shocks cause a contemporaneous positive price adjustment in DAP (1.135), whereas, negative exchange rate has no influence. For the urea equation, its own price causes a positive adjustment in the first lag (0.250), but negative adjustments in the second (–0.148) and third lags (–0.127) approximately mitigate the effects in the short run. The positive shocks in international price of the urea are significant and cause a positive adjustment in the short run. The positive exchange rate shocks cause a contemporaneous positive price adjustment in urea and again the positive adjustments in the second (–0.350) and third lags (–0.345) approximately mitigate their effects. The negative exchange rate shock is only significant in the second lag (0.745).

Alemu et al. (2011) examine the impact of international fertiliser prices and exchange rates on domestic fertiliser prices. Although their objective and methodology are different, they find long- and short-run symmet-

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ric effects and, in line with us, show that exchange rate changes play a significant role in local prices. As we have not found any other similar studies in the literature, and this is the first study on the subject in Türkiye, we do not have the opportunity to compare our results.

CONCLUSION

This study examines the impact of international fertiliser prices and exchange rates on domestic fertiliser prices in the case of Türkiye. The NARDL model is applied to identify both long-term and short-term asymmetric relationships between the domestic prices of urea and DAP and their international prices and exchange rates. The findings provide evidence for the existence of both long-run and short-run asymmetries. More specifically, the results imply that the international prices of di-ammonium phosphate and urea fertilisers have a symmetric effect in the long run. However, the exchange rate of the Turkish lira against the USD has an asymmetric effect on the domestic fertiliser prices in the short run.

When a country is reliant on foreign sources for fertiliser raw materials and production, it is not possible to avoid the issues caused by fluctuations in the international markets, and eventually these international price fluctuations will have an impact on the domestic prices. The dependency of fertilisers on the energy prices make them vulnerable to changes and a potential crisis point in energy markets. For example, the recent sanctions of Belarus and Russia, export restrictions of China and the Ukrainian war have caused an increase in fertiliser prices (Alexander et al. 2023; Arndt et al. 2023). It has made fertilisers more expensive, imposing a burden on farmers.

In countries with weak financial markets, supply crises, along with currency crises stemming from financial markets, these lead to an increase in the costs in nominal terms. The necessity of using fertilisers during the production stage to obtain the final product, leads to an increase in production costs before the product enters the market. Since the farmer is also uncertain about the price of their product, they will be making the decision to use fertilisers under uncertainty. The significantly increasing fertilizer prices, along with the effects of supply and exchange rate shocks, will lead to devastating costs for farmers if preventive measures are not taken. Although, farmers could choose to use less fertiliser, like in the case of Türkiye.

The fluctuations in fertiliser prices, which have an undeniable impact on agricultural production and productivity, have effects on the sustainability of agricultural production. In import-dependent countries, inevitable exchange rate shocks can also create negative effects. As many countries are net importers of fertilisers, policymakers will seek to take various measures to minimise the impact of changes in the energy prices and possible exchange rate shocks on fertiliser prices, therefore, on the farmers and, consequently, on the agricultural production and productivity. In the short and medium term, stability can be achieved through the use of income, input, and price supports, despite being costly for both public finances and/or final consumers. However, this approach is not sustainable. For long-term stability, structural transformations that reduce the dependency on imports are necessary. Taking into account the negative environmental impacts of chemical fertiliser usage, reducing its use can be achieved primarily through raising awareness among farmers. Increasing the production and utilisation of more natural compost-like organic fertilisers, which can be sourced from domestic resources, can be the next steps, aiming for long-term sustainability.

Based on the empirical analysis results, it is recommended to create a market information and monitoring system in Türkiye. This system will monitor the fluctuations in input and product prices in connection with international fertiliser prices and exchange rates. By doing so, policymakers would implement various measures to minimise the impact of fluctuations in energy prices and potential exchange rate shocks on the cost of fertilisers, which, in turn, would affect farmers and eventually, the agricultural production and productivity.

To the best of our knowledge, this is the first study to examine the relationship between domestic and international prices of di-ammonium phosphate (DAP) and urea fertilisers together with exchange rates in Türkiye. In addition, other developing countries can also benefit by considering the empirical results and suggested policy implications in their policy development processes.

Although this study contributes to the existing literature, it also has some limitations. This study focuses only on Türkiye. Accordingly, other developing countries facing rising international and domestic fertiliser prices can be included in future studies.

REFERENCES

Alemu Z., Jooste A., Louw C. (2011): Price transmission between international and local fertilizer prices: The case of South Africa. In: 21st Annual Food and Agribusiness

https://doi.org/10.17221/308/2023-AGRICECON

Management (IFAMA) Symposium, Frankfurt, June 20–23, 2011: 1–38.

Alexander P., Arneth A., Henry R., Juilette M., Rabin S., Rounsevel M.D.A. (2023): High energy and fertilizer prices are more damaging than food export curtailment from Ukraine and Russia for food prices, health and the environment. Nature Food, 4: 84–95.

Arndt C., Diao X., Dorosh P., Pauw K., Thurlow J. (2023): The Ukraine war and rising commodity prices: Implications for developing countries. Global Food Security, 36: 100680.

Beckman J., Riche S. (2015): Changes to the natural gas, corn, and fertilizer price relationships from the biofuels era. Journal of Agricultural and Applied Economics, 4: 494–509.

Bouri E., Jain A., Biswal P.C., Roubaud D. (2017): Cointegration and nonlinear causality amongst gold, oil, and the Indian stock market: Evidence from implied volatility indices. Resources Policy, 32: 201–206.

CBRT (2023): Exchange rates. Available at https://www.tcmb.gov.tr/wps/wcm/connect/EN/TCMB+EN/Main+Menu/Statistics/Exchange+Rates (accessed July 15, 2023)

De Nicola F., De Pace P., Hernandez M.A. (2016): Co-movement of major energy, agricultural, and food commodity price returns: A time-series assessment. Energy Economics, 57: 28–41.

Dickey D.A., Fuller W.A. (1979): Distribution of the estimators for autoregressive time series with a unit root. Journal of the American Statistical Association, 74: 427–431.

Emam A. (2023): Saudi fertilizers and their impact on global food security: Present and future. Sustainability, 15: 7614.

Etienne X.L., Trujillo-Barrera A., Wiggins S. (2016): Price and volatility transmissions between natural gas, fertilizer, and corn markets. Agricultural Finance Review, 76: 151–171.

Fowowe B. (2016): Do oil prices drive agricultural commodity prices? Evidence from South Africa. Energy, 104: 149–157.

Gardebroek C., Hernandez M.A. (2013): Do energy prices stimulate food price volatility? Examining volatility transmission between US oil, ethanol and corn markets. Energy Economics, 40: 119–129.

IndexMundi (2023): Commodity prices. Available at www.indexmundi.com/commodities/ (accessed June 28, 2023)

International Fertilizer Association (IFA) (2023): Databases. Available at https://www.ifastat.org/databases (accessed June 20, 2023)

Kocaarslan B., Soytas U. (2019): Dynamic correlations between oil prices and the stock prices of clean energy and technology firms: The role of reserve currency (US dollar). Energy Economics, 84: 104502.

Konyalı S. (2016): Fertilizer production and policies in Turkey (Türkiye'de gübre üretimi ve uygulanan politikalar). 12. Tarım Ekonomisi Kongresi, 3: 2041–2048. (in Turkish).

Kumar S., Choudhary S., Singh G., Singhal S. (2021): Crude oil, gold, natural gas, exchange rate and Indian stock market: Evidence from the asymmetric nonlinear ARDL model. Resources Policy, 73: 102194.

Lahiani A., Hammoudeh S., Gupta R. (2016): Linkages between financial sector CDS spreads and macroeconomic influence in a nonlinear setting. International Review of Economics and Finance, 43: 443–456.

Liu Z., Ding Z., Li R., Jiang X., Wu J., Lv T. (2017): Research on differences of spillover effects between international crude oil price and stock markets in China and America. Nature Hazards, 88: 575–590.

Ministry of Agriculture and Forestry (2023): Fertilizer statistics. Available at https://www.tarimorman.gov.tr/Konular/Bitkisel-Uretim/Bitki-Besleme-ve-Tarimsal-Teknolojiler/Bitki-Besleme-Istatistikleri (accessed July 14, 2023; in Turkish).

MMB (2023): Monthly meat and input prices (Yıllara göre aylık et ve girdi fiyatlari). [Unpublished dataset]. (in Turkish)

Nazlioglu S., Soytas U. (2012): Oil price, agricultural commodity prices, and the dollar: A panel cointegration and causality analysis. Energy Economics, 34: 1098–1104.

Nazlioglu S., Erdem C., Soytas U. (2013): Volatility spillover between oil and agricultural commodity markets. Energy Economics, 36: 658–665.

Pesaran M.H., Shin Y., Smith R.J. (2001): Bounds testing approaches to the analysis of level relationships. Journal of Applied Econometrics, 16: 289–326.

Phillips P.C., Perron P. (1988): Testing for a unit root in time series regression. Biometrika, 75: 335–346.

Reboredo J.C. (2012): Do food and oil prices co-move? Energy Policy, 49: 456-467.

Shin Y., Yu B., Greenwood-Nimmo M. (2014): Modelling asymmetric cointegration and dynamic multipliers in a nonlinear ARDL framework. In: Sickles R.C., Horrace W.C. (eds): Festschrift in Honor of Peter Schmidt: Econometric Methods and Applications. New York, Springer: 281–314.

Tagem (2018): Fertilizer Sector Policy Document (Gübre Sektör Politika Belgesi). 2018–2022. Ankara, TOB: 100. Available at https://www.tarimorman.gov.tr/TAGEM/Belgeler/yayin/Gübre%20Sektör%20Politika%20Belgesi%202018-2022.pdf (accessed June 15, 2023; in Turkish)

Uçak H., Ari Y., Yelgen E. (2022): The volatility connectedness among fertilizers and agricultural crop prices: Evidence from selected main agricultural products. Agricultural Economics – Czech, 68: 348–360.

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