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Modeling Asymmetric Effects of Exchange Rate Fluctuations on Agricultural Trade Balance: Evidence from Iran and Iraq

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Abstract

The exchange rate plays a crucial role in foreign trade and has asymmetric effects. This study examines the asymmetric effects of exchange rate volatility on the trade balance in the agricultural sector between Iran and Iraq, using the non-linear ARDL model from 1998 to 2020. The results show that Iraq's GDP and oil price fluctuations positively affect the trade balance. In contrast, Iran's GDP and the U.S. economic sanctions against Iran have negative and significant effects on the trade balance of Iran with Iraq in the agriculture sector. The results do not confirm the existence of the J-curve effect in the trade relations between Iran and Iraq, because an increase in the bilateral exchange rate, in both the long-run and short-run, improves the trade balance of Iran with Iraq in the agriculture sector. Furthermore, the positive and negative fluctuations of the bilateral exchange rate have different effects on the trade balance. While the devaluation of the national currency does not cause a downward trend in the short run, the exchange rate policy can improve the trade balance from the beginning.

Keywords

Exchange rate, J-Curve, non-linear GARCH model, non-linear ARDL model.

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Introduction

Iran has experienced significant exchange rate volatility and economic instability in recent years, particularly after the United States imposed economic sanctions from 2011 onwards. Due to the long-standing dependence of the Iranian government on oil exports and the strong impact of world oil price fluctuations on Iran's economy, there has been a shift towards developing non-oil exports. As a result, the Iranian government has placed greater emphasis on agricultural exports as a major component of non-oil exports. In 2020, Iran's exports to Iraq weighed 17.6 million tons. During that year, Iraq accounted for 27% of Iran's total exports, surpassing China as Iran's top export market (IRICA, 2021). To enhance trade relations, it is crucial to establish appropriate trade and exchange rate policies and understand the relationship between the exchange rate and trade balance (Bostan et al., 2018). The real exchange rate of the national currency and its fluctuations determine the country's ability to compete globally by affecting its trade balance. Therefore, governments implement proper exchange rate policies to achieve their long-term and short-term goals. Sometimes, increasing the exchange rate is a policy adopted to improve the trade balance and international competitiveness over the long term. In contrast, it leads to the worsening of the trade balance in the short-run, which is known as the J-curve phenomenon (Thom, 2017). Scholars have shown significant interest in understanding the effect of exchange rate fluctuations on trade balance, and have studied different aspects of this issue. Several research has focused on the J-curve effect, such as Halicioglu (2008), which examined the existence of a bilateral J-curve between Turkey and its 13 trading partners using the ARDL model, but the results did not confirm its existence. Similarly, Akbostanci (2004), Narayan (2006), Shahbaz et al. (2012), and Yazgan and Ozturk (2019) found no evidence of the J-curve effect. Bahmani-Oskooee and Harvey (2010) studied the trade balance between Malaysia and its 14 largest trading partners and demonstrated little evidence to support the J-curve phenomenon, except in a few cases. Some scholars achieved opposite results regarding the J-curve phenomenon based on their approach (Harvey 2018). However, some of them have recognized the J-curve effect (Fuard et al., 2021; Nguyen et al., 2021; Gurtler, 2019; Bahmani-Oskooee et al., 2018; Wang et al., 2012). Another critical issue in the literature is the asymmetry of exchange rate fluctuations, which is discussed in the context of nonlinear analysis. While some scholars examine the relationship between exchange rates and the trade balance in a symmetric frame, the majority focus on the asymmetric impact of exchange rate fluctuations on the trade balance (Bahmani-Oskooee and Fariditavana, 2014; Bahmani-Oskooee et al., 2016; Bahmani-Oskooee and Aftab, 2018; Nguyen et al., 2021; Hunegnaw and Kim, 2020).

Although many studies have been conducted on the impact of exchange rate fluctuations on the trade balance, the literature review confirms that there has been little attention given to examining the asymmetric effect of the exchange rate of the Iranian Rial to the U.S. dollar on Iran's agricultural trade balance. It is important to note that the exchange rate's asymmetric behavior has significant effects on Iran's agricultural trade balance. Therefore, this study aims to investigate the existence of the J-curve phenomenon and determine the short- and long-run asymmetric effects of the exchange rate on the agricultural trade balance between Iran and Iraq, which is its major agricultural trading partner. Specifically, two primary questions will be addressed: i) What are the asymmetric effects of exchange rate fluctuations on the agriculture trade balance of Iran and Iraq in both the short- and long-run? and ii) Dose the J-curve effect occur in the agricultural trading between these two nations?

Materials and methods

Based on the research background of Bahmani Oskooee and Fariditavana (2016), the trade balance behavior of Iran can be expressed as a reduced form (Equation 1), where the agricultural trade balance equation is a function of the exchange rate, real domestic income and real income of Iran's trading partner countries such as Iraq, and world oil prices as follows:

$$Ln\,TB_t = \beta_0 + \beta_1 Ln\,GDP_{IRN.t} + \beta_2 Ln\,GDP_{IRQ.t} + + \beta_3 Ln\,REX_t + \beta_4 V_t + \beta_5\,Oil_t + \beta_6\,D_{US} + e_t \quad (1)$$

where TB_t is the trade balance of Iran's agriculture sector with Iraq, $GDP_{IRN.t}$ and $GDP_{IRQ.t}$ are the real GDP of Iran and Iraq, respectively, REX_t is the bilateral real exchange rate, V_t is the bilateral real exchange rate fluctuation, Oil_t is the world crude oil price fluctuation, D_{US} is a dummy variable that implies the economic sanctions imposed by the United States that take the value of zero for the period before 2011, the year of imposing the economic sanctions, and one otherwise, e_t is the error term with $iid{\sim}(0.\sigma_e^2)$ and ln is the symbol of the natural logarithm.

The gross domestic product (GDP) directly affects the import and export of products, so Iran's GDP and Iraq's GDP are expected to be negative and positive, respectively. Exchange rate fluctuations positively affect the trade balance of the agriculture sector; as the exchange rate increases, the value of the domestic currency decreases, and imports decrease. A similar explanation is valid for changes in oil prices. The real exchange rate of the two countries in Equation (1), calculated indirectly by the exchange rates of Iran (Rial) and Iraq (Dinar) currencies in terms of the U.S. dollar, using the consumer price index (CPI) for Iraq and Iran. For measuring exchange rate and oil price fluctuations in Equation (1), the GARCH family models can be utilized. The GARCH model is the most commonly used structure for many financial time series, with limitations such as negative coefficients or failure to show asymmetric effects. To demonstrate the asymmetric effects, Engel (1990) introduced the first non-linear model, called the simple asymmetric GARCH or SAGARCH model, which has the limitation of non-negative coefficients. To overcome these limitations, Nelson (1991) proposed the Exponential GARCH (EGARCH) model by defining conditional variance in logarithmic form, in which the variance always remains positive. This model can explain that negative shocks lead to a greater conditional variance than positive shocks. The threshold GARCH model, TGARCH, has been proposed by Zakoin (1994) and Glosten et al. (1993), which explains the real effects that have occurred in the past, but their effects appear in the present and may be asymmetric. Overall, this model is expressed as Equation (2):

$$h_t^{1/2} = \omega + \sum_{i=1}^{p} \alpha_i |\varepsilon_{t-i}| + + \sum_{i=1}^{r} \gamma_k |\varepsilon_{t-k}|\ (\varepsilon_{t-k} > 0) + + \sum_{j=1}^{q} \beta_j h_{t-j}^{1/2} + v_t \quad (2)$$

where ε_t is the conditional normal distribution, $N(0.h_t)$, $\omega > 0$, $\alpha_i > 0$ and $\beta_i > 0$ for all i, and γ_i shows asymmetric effects. If γ is significantly opposite to zero, the effect of the news on fluctuations is asymmetric. In other words, positive (good) and negative (bad) news have asymmetric effects on the exchange rate and/or oil fluctuations. The NGARCH model was proposed by Higgins and Berra (1992), where at conditioned standard deviation, it reaches the power δ and is a function of lags of deviation of conditional standards and shocks with the same power as its mathematical form in Equation (3).

$$h_t = \omega + \sum_{i=1}^{p} \alpha_i(\varepsilon_{t-i} - \gamma_i)^2 + \sum_{j=1}^{p} \beta_j h_{t-1} + v_t \quad (3)$$

Engle's ARCH test was used to detect the presence of the linear ARCH effects in the residual terms of the conditional mean model. In this test, the assumption of conditional variance H_0: $\alpha_1 = \alpha_2 = \cdots = \alpha_q$ is made using the LM statistic with the χ^2 distribution. In addition to the linear ARCH test, the non-linear GARCH test should be carried out. Using the non-linear GARCH test, the null hypothesis of conditional variance can be directly tested against the alternative hypothesis of asymmetric ARCH. Engle and Ng (1993) presented some tests to examine the different effects of positive and negative shocks on conditional variance. Due to the stationary property of the variables, multivariate time-series techniques such as VAR, VECM, and ARDL models could be carried out to estimate Equation 1. This equation is a long-run model, and an error-correction model is used to determine the short-run effects. Since the exchange rate and oil price fluctuation variables will be extracted from GARCH models, they are expected to be stationary at the data level. Therefore, according to the literature, the ARDL model is a proper model to estimate Equation (1). The ARDL method proposed by Pesaran et al. (2001) makes it possible to simultaneously estimate long-run and short-run equilibrium relations. In this approach, the existence of a long-run relation between variables is determined using the bound test as in Equation (4).

$$\begin{aligned}\Delta LnTB_t &= \alpha_0 + \sum_{i=1}^{m} \delta_i \Delta LnTB_{t-i} + \\ &+ \sum_{i=0}^{m} \phi_i \, \Delta LnGDP_{IRN.t-i} + \sum_{i=0}^{m} \varphi_i \, \Delta LnGDP_{IRQ.t-i} + \\ &+ \sum_{i=0}^{m} \eta_i \, \Delta LnREX_{t-i} + \sum_{i=0}^{m} \kappa_i \, \Delta LnOil_{t-i} + \\ &+ \sum_{i=0}^{m} \lambda_i \, \Delta V_{t-i} + \theta_1 LnTB_{t-i} + \\ &+ \theta_2 LnGDP_{IRN.t-1} + \theta_3 LnGDP_{IRQ.t-1} + \\ &+ \theta_4 LnREX_{t-1} + \theta_5 LnOil_{t-1} + \\ &+ \theta_6 V_{t-1} + \theta_7 D_{US} + e_t \quad (4)\end{aligned}$$

Equation (4) is an error-correction model in which the lagged error term of Equation (1) is replaced by the linear combination of lagged level variables as its equivalent. The estimate of coefficients attached to first-differenced variables determines the short-run effects. The estimates of θ_1 - θ_7, which were normalized on θ_1, analyze the long-run effects, because for validation of long-run effects, it is necessary to establish the cointegration. Pesaran et al. (2001) suggested using the *F* test to determine the joint significance of lagged-level variables that indicate cointegration. They tabulate new critical values for the F test, which accounts for integrating properties of all variables; thus, there is no need to test for unit root and being integrated of order (0) or order (1).

In this paper, it is claimed that depreciations and appreciations of the exchange rate may have asymmetric effects on the agricultural trade balance. The fluctuations of the bilateral exchange rate are divided into two negative (NEG) and positive (POS) parts. These are simply defined as a partial sum of negative and positive changes as Equation 5 (Bahmani-Oskooee and Fariditavana, 2015).

$$\begin{aligned}POS_t &= LnREX_t^+ = \sum_{j=1}^{t} \Delta LnREX_j^+ = \\ &= \sum_{j=1}^{t} \max(\Delta LnREX_j, 0) \\ NEG_t &= LnREX_t^- = \sum_{j=1}^{t} \Delta LnREX_j^- = \\ &= \sum_{j=1}^{t} \min(\Delta LnREX_j, 0) \quad (5)\end{aligned}$$

where REX_t^+ and REX_t^- is the positive (POS_t) and negative (NEG_t) parts of the bilateral real exchange rate fluctuations, respectively, Δ, first-order difference, and *ln* is the symbol of the natural logarithm.

Following Shin et al. (2014) and Bahmani-Oskooee and Fariditavana (2015), involving both POS and NEG variables in the error-correction model, a non-linear ARDL model is obtained as Equation (6).

$$\begin{aligned}\Delta LnTB_t &= \alpha_0 + \sum_{i=1}^{m} \delta_i \Delta LnTB_{t-i} + \\ &+ \sum_{i=0}^{m} \phi_i \, \Delta LnGDP_{IRN.t-i} + \sum_{i=0}^{m} \varphi_i \, \Delta LnGDP_{IRQ.t-i} + \\ &+ \sum_{i=0}^{m} \eta_i \, \Delta LnREX_{t-i} + \sum_{i=0}^{m} \kappa_i \, \Delta LnOil_{t-i} + \\ &+ \sum_{i=0}^{m} \lambda_i \, \Delta V_{t-i} + \sum_{i=0}^{m} \mu_i \, \Delta POS_{t-i} + \\ &+ \sum_{i=0}^{m} \upsilon_i \, \Delta NEG_{t-i} + \theta_1 LnTB_{t-i} + \\ &+ \theta_2 LnGDP_{IRN.t-1} + \theta_3 LnGDP_{IRQ.t-1} + \\ &+ \theta_4 LnREX_{t-1} + \theta_5 LnOil_{t-1} + \theta_6 V_{t-1} + \\ &+ \theta_7 POS_{t-1} + \theta_8 NEG_{t-1} + \theta_9 D_{US} + e_t \quad (6)\end{aligned}$$

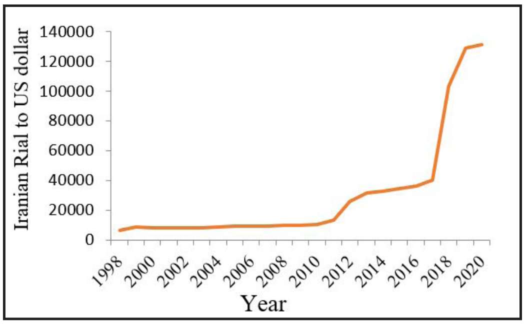
Short-run asymmetry is established if $\mu_i \neq v_i$ for each individual m. Stronger evidence of short-run asymmetry is established if $\sum\mu_i \neq \sum v_i$ and long-run asymmetry is established if $\theta_7 \neq \theta_8$. Adjustment asymmetry is acquired by the pattern of dynamic multipliers. While the first three asymmetries are tested by the Wald test, the last one is evaluated only by observing the adjustment pattern. On the other hand, in the non-linear ARDL model, the hypothesis of the J-curve can be proved if the coefficient of the negative exchange rate changes, θ_8, is positive and significant (Bahmani-Oskooee and Fariditavana, 2015 and 2016).

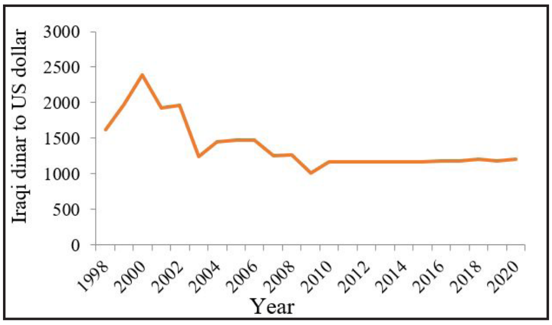
Data

The study uses annual data covering the period from 1998 to 2020. The required data were extracted from the Customs Administration of Iran (IRICA) based on 20,000 tariff codes. These data cover the annual values of imports and exports of agricultural products in four parts and 24 chapters, separately for all agricultural subsectors: (1) live animals and animal products, (2) vegetable products, (3) animal fats, oils, and fats, and (4) products of the food industry, beverages, etc. Iran's CPI, GDP, and Rial to Dollar exchange rate were gathered from the Iranian Central Bank. Iraq's CPI, GDP, and Dinar to Dollar exchange rate were obtained from the IMF, and the world oil prices were collected from OPEC. The variations in the exchange rate of the Iranian Rial to the U.S. dollar from 1998 to 2020 are shown in the left chart of Figure (1). As seen, the Iranian Rial to the U.S. dollar exchange rate has undergone an utterly steady trend from 1998 to 2010 and then has had an increasing trend since 2011. Most exchange rate fluctuations in Iran have been observed in 2017 until meeting its highest level in 2020, with an average of 25557.7 Rial for 1$ and minimum and maximum values of 6468 and 133850 Rial, respectively.

Based on the right chart of Figure 1, the exchange rate of the Iraqi dinar to the U.S. dollar widely fluctuated until 2010 when it met its highest level in 1999 and then declined until 2009. After 2010, the exchange rate was relatively steady. The average exchange rate in Iraq during 1998-2020 was 1400.1 dinars for $1, with minimum and maximum values of 1009.3 and 2453.9 dinars, respectively, during 1998-2020. In this study, the real bilateral trade balance at the base price of 2010 in dollars is defined as the difference between the logarithm of exports and imports of agricultural products between Iran and Iraq.

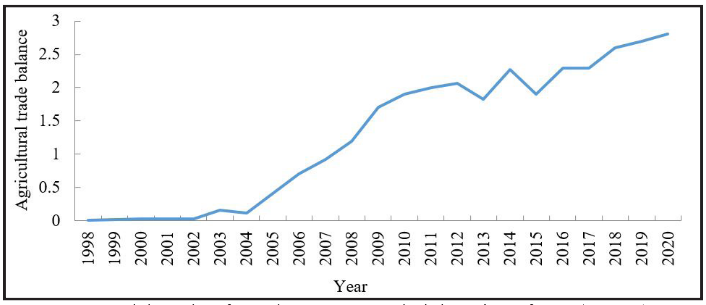
Figure 2 displays that the trade balance of the agriculture sector between Iran and Iraq was almost constant until 2004 and then had a nearly upward trend. The average real bilateral trade balance of the agriculture sector between Iran and Iraq from 1998 to 2020 was 1.23 billion dollars. The minimum and maximum values were equal to 0.005 and 2.69, which occurred in 1999 and 2020, respectively.





Source: Iranian Central Bank and IMF

Figure 1: The Iranian Rial and the Iraqi dinar to the U.S. dollar exchange rate during 1998-2020.



Source: Own elaboration from the Customs Administration of Iran (IRICA)

Figure 2: The trade balance of the agriculture sector between Iran and Iraq from 1998 to 2020.

Results and discussion

The stationarity of the variables (in logarithmic transformation) was tested using the Augmented Dickey-Fuller (ADF) and Elliott et al. (DF-GLS) unit root tests. The results are presented in Tables 1 and 2, respectively. According to these tables, the bilateral exchange rate, Iran's real GDP, Iraq's real GDP, and the trade balance are integrated of order one, I(1). The variables of positive and negative exchange rate fluctuations and oil price fluctuations are stationary at level I(0). The results of the DF-GLS and ADF tests confirm each other.

The results from Engle and Ng (1993) tests reported in Table 3 include the significant bias test (SB), negative size bias test (NSB), positive size bias test (PSB), and joint test. According to this table, the bilateral exchange rate series exhibit asymmetric behavior due to the significance of coefficient SB. Moreover, the significance of the PSB coefficients shows that the effect of positive shocks on the conditional variance also depends on its size. Considering the results, the null hypothesis in which the coefficients are simultaneously zero is rejected, indicating the existence of the non-linear ARCH effects. This result is in line with Ghahremanzadeh et al. (2022) which revealed that Iran's exchange rate exhibits an asymmetric behavior.

Variables[a]	Data level				First-order difference			
	τ-Statistic	Critical value (5%)	p-value	Results	τ-Statistic	Critical value (5%)	p -value	Results
($LnREX_t$)	1.58	-3.54	0.76	Non-stationary	-5.03	-3.65	0.035	Stationary
(NEG_t)	4.345	-3.54	0.007	Stationary	--	--	--	--
(POS_t)	5.731	-3.54	0	Stationary	--	--	--	--
($LnGDP_{IRN,t}$)	-1.61	-3.54	0.75	Non-stationary	-4.44	-3.65	0.011	Stationary
($LnGD_{PIRQ,t}$)	-2.557	-3.54	0.3	Non-stationary	-3.78	-3.69	0.04	Stationary
(LnTBt)	-2.03	-3.54	0.55	Non-stationary	-6.18	-3.65	0.004	Stationary
(V_t)	-3.58	-3.54	0.04	Stationary	--	--	--	--

Note: [a] Variables are defined based on equation 1.
Source: Own elaboration

Table 1: The results of the Augmented Dicky-Fuller unit root test at the level and first-order difference of the data.

Variables[a]	τ-Statistic (Data level)	Critical value (5%)	Critical value (10%)	Results	τ-Statistic (First-order difference)	Results
($LnREX_t$)	-1.84	-3.19	-2.89	Non-stationary	-2.95	Stationary
(NEG_t)	-3.78	-3.19	-2.89	Stationary	-	-
(POS_t)	-3.25	-3.19	-2.89	Stationary	-	-
($LnGDP_{IRN,t)}$	-1.17	-3.19	-2.89	Non-stationary	-3.77	Stationary
($LnGDP_{IRQ,t}$)	-1.3	-3.19	-2.89	Non-stationary	-2.91	Stationary
($LnTB_t$)	-1.403	-3.19	-2.89	Non-stationary	-3.8	Stationary
(V_t)	-3.11	-3.19	-2.98	Stationary	-	-

Note: [a] Variables are defined based on equation 1.
Source: Own elaboration

Table 2: The results of the DF-GLS unit root test.

	ARCH Test (linear)	Sign Bias Test (SB)	Negative size Bias Test (NSB)	Positive size Bias Test (PSB)	Joint test
Bilateral Exchange rates	2.11* (0.06)	2.47** (0.05)	1.43 (0.2)	4.71** (0.01)	3.35** (0.02)
Oil prices	3.86** (0.04)	1.59 (0.29)	0.08 (0.49)	2.1* (0.073)	2.08 (0.1)

Note: The numbers in parentheses show the levels of significance, and ***, ** and * show the significance at the levels of 1, 5, and 10%, respectively.
Source: Own elaboration

Table 3: The results of the linear and non-linear ARCH effects tests.

In the case of the world oil price series, the effects of the linear ARCH are confirmed. In other words, the error terms of the mean equation have conditional heteroscedasticity variance. Furthermore, except for PSB, none of the statistics SB, NSB, and joint test in the oil price series are statistically significant. Therefore, the non-linear GARCH model was also estimated for oil prices. Different types of linear and non-linear GARCH models, including GARCH, EGARCH, TGARCH, GJRGARCH, and NAGARCH, were estimated to determine the proper model to obtain the fluctuations of bilateral exchange rates and the world oil price. The proper model was selected by satisfying the theoretical conditions and characteristics of GARCH models (e.g., the coefficients of ARCH and GARCH and the sum of the coefficients are positive and smaller than one). In addition, we used the maximum likelihood, AIC, and Bayesian information criterion (BIC). The results of the estimated models are shown in Table 4. The findings suggest that TAGARCH and EGARCH models were appropriate for modeling exchange rate and oil price fluctuations, respectively. Jimo et al. (2024) also showed that the EGARCH model is a proper model for modeling the non-linear effect of the exchange rate in Indonesia, and they indicated that shocks to the volatility of the exchange rate have a symmetrical effect.

The results in Table 4 show that the estimated γ coefficient for these models is positive, indicating that the news of increasing bilateral exchange rates is more volatile than that of exchange rate declines. It can also be noted that the sum of the coefficients α and β, $(\alpha + \beta)$, in the bilateral exchange rate equation is 0.88. Since this value is close to one, the bilateral exchange rate fluctuations are somewhat steady. In other words, the shocks will gradually disappear, and any fluctuation will have a relatively long-run effect on the bilateral exchange rate. Additionally, the sum of coefficients $(\alpha + \beta)$ for the oil price equation is 0.64. Again, the value is less than one, indicating that the oil price fluctuations are steady and that the shocks will disappear over time.

Based on the AIC and SBC criteria, the optimal

	GARCH	EGARCH	TGARCH	GJRGARCH	NAGARCH
Exchange rate					
ω	0.054*** (0.001)	-2.13 (0.13)	0.0021 (0.43)	0.00031*** (0.001)	-0.0003* (0.09)
α_1	0.42** (0.01)	0.63** (0.01)	0.00015** (0.003)	0.238 (0.12)	0.137*** (0.000)
β_1	-0.95*** (0.000)	-0.18** (0.04)	0.88** (0.01)	0.721** (0.02)	0.824*** (0.000)
γ	-	-0.347*** (0.000)	0.31* (0.06)	-0.028** (0.04)	-0.020 (0.4)
AIC	-818.03	-943.7	-919.3	-843.4	-878.2
BIC	-814.66	-928.1	-935.3	-825.7	-852.3
Log likelihood	313.3	386.8	343.2	318.6	343.2
Oil prices					
ω	0.013*** (0.000)	2.03 (0.17)	0.0023*** (0.000)	0.0034 (0.21)	0.0025** (0.02)
α_1	0.28 (0.120)	0.21** (0.023)	0.38*** (0.001)	0.42** (0.012)	0.18 (0.11)
β_1	0.32*** (0.000)	0.43*** (0.005)	0.82* (0.08)	0.61 (0.12)	0.74** (0.012)
γ	-	0.28* (0.09)	-0.5** (0.02)	-0.173** (0.03)	0.176*** (0.000)
AIC	-351.5	-364.6	-321.1	-381.5	-312.4
BIC	-339.9	-351.1	-310.3	-356.4	-303.2
Log likelihood	234.4	243.7	189.5	272.7	194.3

Note: The numbers in parentheses show the levels of significance, and ***, ** and * show the significance at the levels of 1, 5, and 10%, respectively.
Source: Own elaboration

Table 4: The results of the linear and non-linear GARCH models estimation for the exchange rate and oil prices.

number of lags was determined to be two. Therefore, the asymmetric ARDL (1, 0, 1, 1, 2, 0, 1, 0) model (level presentation) was estimated, and the results are given in Table 5. The results showed that the positive and negative real exchange rate fluctuations significantly affected the agriculture trade balance; however, there are different magnitude effects, and the sign of these fluctuations on the agriculture trade balance is consistent with the theoretical basis. Iraq's GDP has a positive and significant effect on the agricultural trade balance of Iran and Iraq.

Table 5 shows the bound test result. Based on this, the null hypothesis of a long-run relation is rejected. This means the variables follow and affect each other in the long run. In other words, Iran's agricultural trade balance is affected by the exchange rate, exchange rate fluctuations, Iran's GDP, Iraq's GDP, and oil price fluctuations in the long run.

The results of the long-run estimation by the asymmetric ARDL method are presented in the upper part of Table (7). Based on this, in the long run, a one percent increase in Iraq's GDP leads to an improvement in the trade balance of the agricultural sector of Iran and Iraq by 22.19%. Bahmani-Oskooee and Fariditavana (2014) achieved similar results. With the increase in Iraq's income, its import demand from Iran will increase. As expected, Iran's GDP sign is negative. In other words, as Iran's GDP declines, Iran's trade balance with Iraq will improve in the long run. If Iran's GDP increases (decreases) by one percent in the long run, then the trade balance between Iran and Iraq will decrease (increase) by 35.03%. It is expected that with an increase in the bilateral real exchange rate, the value of imports to Iran will reduce and exports will increase, which is valid for Iraq, as shown in Table (7). In other words, if the exchange rate increases by 1%, the trade balance between Iran and Iraq improves by 20.85%. This means that a depreciation of the domestic currency and a decrease in the price of domestic agricultural products have increased the purchases of agricultural products by trading partners, thereby improving the trade balance between these countries. These results are similar to those of Nguyen et al. (2021), who concluded that the exchange rate has a negative effect on import demand.

Variable	Coefficient	t-statistic	Probability
LnTB(-1)	-3.85**	-4.406	0.000
LnREX	27.6	1.94	0.112
$LnREX_{POS}$	18.96**	4.388	0.000
$LnREX_{POS}(-1)$	13.08**	2.468	0.023
$LnREX_{NEG}$	-14.45***	-3.227	0.004
$LnREX_{NEG}(-1)$	-11.41	-1.640	0.117
$LnGDP_{IRN}$	-39.9***	-5.188	0.000
$LnGDP_{IRN}(-1)$	-22.1	1.24	0.896
$LnGDP_{IRN}(-2)$	18	1.16	0.53
$LnGDP_{IRQ}$	13.47***	6.619	0.000
LnOil	15.5***	5.916	0.000
LnOil(-1)	7.5*	1.92	0.075
D_{US}	-3.4	1.72	0.15
Constant	15.791***	5.731	0.000

Note: ***, **, and * show significance at the levels of 1, 5, and 10%, respectively.
Variables are defined based on equation 1
Source: Own elaboration

Table 5: The results of the dynamic pattern estimation, ARDL (1,0, 1,1,2,0,1,0).

F(k = 6) = 5.560		
Upper-bound	Lower-bound	Bounds / Sig.
3.757	2.522	10%
4.457	3.046	5%

Source: Own elaboration

Table 6: The critical values of the Pesaran et al. (2001) test.

Variables	coefficient	t-statistic	p-value
Long-run equation			
REX	20.85	1.45	0.137
REX_{POS}	14.79**	-2.01	0.034
REX_{NEG}	-5.76**	-2.87	0.023
$LnGDP_{IRN}$	-35.03**	-2.05	0.07
$LnGDP_{IRQ}$	22.19**	2.67	0.031
LnOil	7.75**	1.99	0.08
D	-6.44	-1.65	0.14
Short-run equation			
dREX	27.6	1.94	0.112
$dREX_{POS}$	18.96***	4.388	0.000
$dREX_{NEG}$	-14.45***	-3.227	0.004
$dLnGDP_{IRN}$	-39.9***	-5.188	0.000
$dLnGDP_{IRN}1$	18	1.16	0.53
$dLnRGDP_{IRQ}$	13.47***	6.619	0.000
dLnOil	15.5***	5.916	0.000
D	-3.4	1.72	0.15
ECM(-1)	-0.614***	-7.024	0.000

Note: ***, **, and * show significance at the levels of 1, 5, and 10%, respectively. Variables are defined based on equation 1
Source: Own elaboration

Table 7: The results of estimating the long-run relation of agricultural trade balance by the non-linear ARDL model.

As the estimation results show, the long-run coefficients of positive and negative exchange rate fluctuations are equal to 14.79 and 5.76, respectively, indicating that in the long-run, the appreciation in the real bilateral exchange rate (decrease in the Rial against the dinar) has had a greater effect on the Iran-Iraq trade balance compared to the decrease in the real bilateral exchange rate, leading to more exports to Iraq than imports from it. This means that a one percent increase in the real bilateral exchange rate has led to a 14.79% increase in the trade balance between Iran and Iraq. Therefore, the appreciation in the real bilateral exchange rate has had a greater effect on the Iran-Iraq trade balance than the depreciation in the exchange rate. Based on Table 7, the trade balance improves with an increase in oil price fluctuations, so the Iran-Iraq trade balance will rise by 7.75% with a one percent increase in oil price fluctuations. The increase in oil price fluctuations has increased the uncertainty about income from the sale of crude oil, leading to the implementation of policies that help increase the exports of other products and reduce imports to the country, which will improve the trade balance.

In recent years (from 2011 to the present), the imposition of economic sanctions by the United States on Iran has caused some trading partners to limit or completely cut off trade relations with Iran, resulting in a decrease in the volume of imports and exports from or to these countries. The coefficient of the dummy variable of economic sanctions is negative, confirming that the imposition of economic sanctions worsens the trade balance. A Wald test was employed to evaluate if there exists a significant difference between positive and negative fluctuations in the exchange rate. The result showed a value of 5.561, suggesting that exchange rate changes have an asymmetric long-term impact on the agriculture trade balance. This result is consistent with the findings of Bahmani-Oskooee et al. (2016), Bahmani-Oskooee and Aftab (2018), Nguyen et al. (2021), and Hunegnaw and Kim (2020). This matter was one of the questions explored in the current research. The results from the estimation of the error correction model are given in the lower part of Table (7). Based on the results, the coefficient of error correction is negative, significant, and equal to -0.614, showing that in the case of shock and deviation of the exchange rate from the equilibrium, 0.614% of the short-run imbalance of the exchange rate is adjusted to reach long-run equilibrium in each period. After analyzing the relationship between the exchange rate and the trade balance, short-term and long-term effects were evaluated to examine the existence of the J-curve. This is one of as an increase in the exchange rate improves the trade balance both in the long- and short-run, the existence of the J-curve is not confirmed in the trade relationship between Iran and Iraq, which was the second question examined. This result is in line with previous research on the J-curve in agricultural products' trade such as the study by Yazici (2006) on Turkish agricultural trade balance, the analyses by Baek et al. (2009) and Gong and Kinnucan (2015) of the J-curve effect in the US agricultural trade, Yazgan and Ozturk (2019) in Turkey, and Trofimov (2020) of testing the J-curve hypothesis in Agricultural trade of four South East Asian economies (Indonesia, Malaysia, Philippines, and Thailand).

Conclusion

Sharing approximately 1600 kilometers of land and water border with Iran, Iraq is an excellent marketplace for Iranian products in terms of cultural, religious, and ethnic affinity, especially because the aftermath of several major wars in Iraq in recent years has brought about the destruction of this country's productive and economic infrastructure and accelerated call for imported items. The study on the effect of the exchange rate and its fluctuations in the trade balance of Iran's agriculture sector with Iraq revealed that the exchange rate has an asymmetric effect on the trade balance, and each of the positive and negative exchange rate fluctuations in the trade balance is different and significant. The effect of positive changes in the bilateral exchange rate is greater than its negative effect; thus, the non-linear relationship between the exchange rate and the trade balance is confirmed. The Wald test was used to examine the accuracy of the asymmetric effects in more detail, which indicated that the effect of the exchange rate on the trade balance is asymmetric.

The estimates from the non-linear ARDL model showed that Iran's GDP, Iraq's GDP, oil prices, and economic sanctions could justify some parts of the fluctuations in the trade balance of Iran's agriculture sector. The GDPs of Iran and Iraq have significant effects on the trade balance. The increase in GDP in Iraq has increased the tendency of this country to import from Iran, leading to the improvement of the trade balance between Iran and Iraq. The results indicated that the trade balance will decrease by more than 35% when the economic growth rate of Iran increases by one percent. This negative effect is aligned with economic theories so that the increase in income increases imports and reduces the trade balance. In recent years, Iran, as an oil-exporting country, has experienced fluctuations in oil prices and consequent shocks. As a result, Iran is more vulnerable, as a large part of its revenues depends on oil benefits. Hence, the present study examined the effect of oil price fluctuations. According to the results, oil price fluctuations have a positive and significant effect on the trade balance. The trade balance of Iran's agriculture sector with Iraq will improve as the price fluctuations increase.

The unconfirmed J-curve between Iran and its trading partner, Iraq, in this period, shows that in this situation, with the devaluation of the national currency, the trade balance does not undergo a downward trend in the short run, and the exchange rate policy can improve the trade balance from the very beginning. Iran can improve its trade balance by utilizing Iraq as a key trading partner, applying proper exchange rate policies, and enhancing foreign trade relations. The findings indicated that the effect of the exchange rate and its fluctuations on the trade balance using the asymmetric ARDL method provides more comprehensive results than the symmetric ARDL. Given the effects of positive and negative exchange rate fluctuations on the trade balance, the symmetric ARDL cannot provide comprehensive information, so the asymmetric ARDL is more appropriate for imposing appropriate policy to enhance the trade balance. Given the asymmetric effects of the exchange rate on the trade balance in Iran, it is suggested that the government take measures to control exchange rate fluctuations in Iran by implementing an appropriate exchange rate policy in cooperation with the Central Bank of the Islamic Republic of Iran. These methods include monitoring and tracking currency transactions to identify offenders. It is also important to know the tricks of currency appreciation and make a plan to manage their disruptive actions in the country's currency market. In addition, the import of unnecessary foreign goods that are similar to those produced in the country should be prohibited to protect foreign exchange reserves and increase domestic production. Iran and Iraq have been increasing their trade relations. By implementing the right policies, the Iranian government can facilitate regional trade agreements and improve the agricultural trade balance by removing trade barriers. This will lay the foundation for future trade partnerships and tariff agreements. The results confirm that the economic sanctions imposed by the U.S. have a negative effect on the trade balance. Therefore, it is recommended to adopt a policy that, despite the sanctions, could improve Iran's trade relations with Iraq in other ways or to make the necessary efforts to remove the economic sanctions and improve the agricultural trade.

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