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The Asymmetric Effects of the Determinants of Real Exchange Rate in Jordan: The Role of Price Index Selection

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Abstract: *This study examines the asymmetric dynamics of real exchange rate (RER) determinants in the short- and long-run, which investigates whether the asymmetry exists in the behavior of real exchange rate (RER) determinants in Jordan. It also investigates the effect of the choice of price index used in RER measurement on the cointegrating relationship between RER and its determinants. Workers' remittances (REM), foreign reserves (RES), government expenditures (EXP) and terms of trade (TOT) were chosen as determinants of the RER, which was measured with four different price indices; ($CPI_{U.S}/CPI_{JOR}$, GDP Def. $r_{U.S}$/GDP Def.$_{JOR}$, $IPI_{U.S}$/GDP Def. $_{JOR}$, $PPI_{U.S}$/GDP Def. $_{JOR}$). Quarterly data were applied from Jordan for the period of (2004-2017) using nonlinear autoregressive distributed lag (NARDL) model. The results indicate that the choice of the price index affect significantly the symmetry/asymmetry patterns of the RER determinants, thus, the choice of the price index should be directly linked to the purpose of the study to gain accurate results. Moreover, expansive fiscal policy may increase TOT by causing a country's currency to depreciate. However, TOT was the only determinant that resulted in symmetrical behavior regardless of the price index chosen as a basis for measuring a currency's RER. Contrary to the study's hypothesis, fluctuations in Jordanian imports and exports do not fluctuate with RER. With respect to the short-run symmetry, foreign reserves (RES), governmental expenditures (EXP) and TOT may influence RER asymmetrically leading to possibility to peg RER in the short-run. The expansionary economic policy may have a greater impact on RER than the contractionary policy, which may in turn increase TOT. Hence, overvaluation of RER may hamper economic growth. This may be particularly true for emerging [or emerging-market] economies, such as Jordan's, which are overseen by weak institutions and plagued by market failure.*

Keywords: nonlinear autoregressive distributed lag (NARDL), workers' remittances, foreign reserves, governmental expenditures, terms of trade (TOT).

JEL Codes: C32, E31, F31

1. Introduction

In an open economy, the real exchange rate (RER) is a vital factor in international trade and plays a crucial role in the adjustment process. Because RER volatility reflects economic cycles internationally, it is necessary to capture the forces behind RER fluctuations. Several studies focusing on short-run movements in the RER treat these movements as temporary fluctuations that ultimately yield to long-run equilibrium for which changes in purchasing power parity (PPP) provide sufficient explanation.

Other studies including (Mpofu, 2021) and (Mustafa, 2019), have aimed to find out what factors affected RER, especially in the developing countries, and also they sought to quantify their effects on RER, in

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order to clarify the factors that affect international trade and competitiveness. The determinants tested in these studies include workers' remittances (*Rem*), foreign reserves, government expenditures, and TOT.

Over the past decade, researchers have investigated the nonlinearity and asymmetry of numerous economic relationships, in an effort to more coherently model governments' decision-making processes. To the authors' knowledge, however, few studies have satisfactorily answered whether or not the cointegrating relationship between the RER and its determinants is nonlinear and asymmetric.

The high volume of literature on the RER reveals that interpretations of the RER are highly variable, in part because a study's choice of measurement has a significant effect on the resultant rate. Types of indices used include the Consumer Price Index (CPI), among the most widely used because of its availability and the global availability of the basket of goods on which it is based; the Producer Price Index (PPI); the Gross Domestic Product (GDP) Deflator, which facilitates comparisons of real economic activity levels over time; and the Import Price Index (IPI), which focuses on imported goods and prices within specific industries, making it particularly useful for studying developing countries.

This paper investigates whether asymmetry exists in the behavior of RER determinants in Jordan, as well as to provide empirical clarity regarding the choice of price index used to measure RERs on the cointegrating relationship between the RER and its determinants. The main purpose of this study is to distinguish whether the potential asymmetric behavior in the main determinants of RER affect the empirical results based on the price index selection and, hence to investigate whether series adjust asymmetrically towards its long-run equilibrium value.

2. Literature Review

Analysis and accurate investigation of RER fluctuations is essential to an open economy. In the literature, excellent efforts were provided in attempt to determine the fundamentals of RER and their ability to shoot in the long run. Among those determinants were Workers' remittances, foreign currency reserves, government expenditures and TOT.

Workers' remittances area is a major source of foreign currencies for developing countries. From 2004 to 2017, the period covered by this study, remittances grew more than 200%, from roughly USD160 billion in 2004 to roughly USD 483 billion [i] in 2018 (World Bank, 2019). Even in 2004, the amount of money sent to developing countries as remittances was nearly triple the total amount of foreign aid distributed worldwide (Ratha, 2004). In Jordan, the ratio of workers' remittances to real GDP ranged from 22-30%, underscoring the importance of remittances to the country's economic development. Workers' remittances tackle some critical issues regarding RER (Amuedo-Dorantes and Pozo, 2004); (Lartey et al., 2012).

Capturing the effect of foreign currency reserves on exchange rates is particularly crucial in the Jordanian case because of those reserves' role in pegging exchange rates. Central banks can protect a country's currency from outside attacks by pegging the local currency to the bank's own foreign currency reserves (McKinnon and Schnabl, 2003), thereby allowing a country to maintain competitive export prices. A devalued currency, in contrast, makes exports less profitable and imports more expensive, decreasing TOT—and therefore the citizenry's standard of living. In addition, foreign currency reserves increase a country's capacity for trade. Therefore, previous studies have directed their attention to institutional arrangements, rather than the method of exchange rate measurement (Terada-Hagiwara, 2004).

Several studies indicate that an increase in government expenditures may spur domestic consumption, which may in turn devalue local currency by creating a trade imbalance (Aaron et al., 1997; Ajao and Igbekoyi, 2013; Rasong and Sombatthira, 2021). Abimanyu (1998) analyzed the relationship between the actual RER, the equilibrium RER, and other macroeconomic variables. That paper's estimate showed that an RER is significantly affected by government consumption and the fiscal deficit. Increases in both government consumption and the fiscal deficit appreciate RER. In short, fiscal variables matter when it comes to stabilizing exchange rates (Kuncoro, 2015).

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Additional literature analyzes TOT and its effect on exchange rate (Jongbo, 2022; Mustafa, 2019). An increase in TOT indicates either an increase in the price of exports, a decrease in the price of imports, or both. Regardless, TOT may affect the RER significantly, particularly in developing countries (Hinkle and Monteil, 1999) such as Jordan. An RER is sensitive to fluctuations in TOT after crossing specific threshold of commodity currencies (Coudert et al., 2013).

Moreover, which foreign and domestic price indices are chosen directly affects the measurement of RER (Hinkle and Monteil, 1999). A rich prior literature documents this phenomenon and compares the effects of index choice on RER measurement, with the CPI, PPI, GDP Deflator, and IPI among the most-discussed indices. If those indexes moved in parallel, then the resultant RERs would be nearly the same or differ insignificantly on an empirical level (Hinkle and Monteil, 1999).

The first price index used in measuring an RER to start with is CPI; the most common used index in empirical literature (Hinkle and Monteil, 1999); (Chinn, 2000[ii]); (Patel, 2016). The Purchasing Power Parity (PPP) approach concerns itself with consumption price levels more than production cost indices do (Hinkle and Monteil, 1999). As an expenditure price index, CPI captures import prices rather than export prices, and is therefore more sensitive to changes in TOT over time. However, CPI has pitfalls of its own, chiefly it is sensitive to changes in indirect taxes, price controls (Hinkle and Monteil, 1999). The basket of goods and services measured by CPIs differs between countries, as each basket reflects country-specific consumer spending patterns; as a result, RERs derived through measurement of CPI ratios may be less useful for comparing standards of living internationally. (Hinkle and Monteil,1999). RER calculations based on CPI ratios must also take seasonal fluctuations into account (Zanello and Desruelle, 1997); several sources provide seasonally-adjusted CPIs.

GDP Deflator is another frequently-used index (Dornbusch, 1988); (Hinkle and Monteil, 1999); (Ahn et al., 2017; Mahradikka, 2020). GDP Deflator, also called the implicit price deflator because it measures the changes in values of all goods and services produced by an economy, is an alternative rather than a substitute for CPIs: a GDP deflator is a production deflator that includes exports, while a CPI is an expenditure price index that includes imports. These two price indices may behave differently due to changes in TOT (Hinkle and Montiel, 1999). Hinkle and Montiel (1999, p. 144) suggest "using a domestic private consumption deflator instead of the GDP deflator when CPI data is not available."

Since RER is usually measured in order to assess a country's economic competitiveness, it might be more beneficial to use production or cost indices, rather than consumption indices. One of the most common is Wholesale Price Index (WPI) or Producer Price Index (PPI)[iii]which heavily weight traded goods, is usually used in industrial studies of imports and exports (Fleissig and Grennes, 1994). WPI supports the PPP hypothesis, and is considered the best measure of tradable goods because the goods in the basket of goods measured by the index are relatively similar across countries (Chinn, 2000).

RER measurements are less reliable when a WPI is used to measure a foreign country's RER and a GDP deflator used for a study's "home" country: WPIs are based on tradable goods while GDP deflators take all goods into account; as a result, the final price ratio is highly sensitive to changes in productivity on both sides and the RER is distorted (Hinkle and Monteil, 1999). Moreover, WPI is unsuitable for measuring RERs in developing countries owing to its heavy reliance on primary commodities (Hinkle and Monteil, 1999). More consistent results may be obtained through the use of homogeneous price indices (e.g., foreign and domestic CPIs). Nonetheless, some scholars stated that WPI of trading partners and domestic GDP deflator ratio is more favorable in presenting the theoretical notion of RER than using CPIs (Athukorala and Rajapatirana, 2003; Mahraddika, 2020), especially that CPI is subject to manipulation since it is politically observable (Mahraddika, 2020).

Economic theory usually concerns itself with defining the determinants of RER, rather than specifying the functional form of the relationship between RER and its determinants. As a result, most of the literature assumes a linear relationship between RER and its determinants which may not be born out by empirical evidence (Katrakilidis and Trachanas, 2012). This study, guided by the model of Shin, Yu and Greenwood-Nimmo (2014; henceforth, "Shin et al."), revisits the cointegration between RER and its determinants using a NARDL model to investigate the symmetry/asymmetry of those determinants in the long- and short-run. This

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study further adds to the literature by investigating the possibility of inefficiency using a linear cointegration test of ARDL and switching to NARDL to quantify the degree of symmetry between the chosen determinants, and through measuring the effect of price index choice on the aforementioned cointegrating relationship between RER and its determinants.

The remainder of this paper presents the following sections: Section 3 presents the study's principal methodology and econometric model. Section 4 shows and discusses the empirical results of the study, and Section 5 presents concluding remarks and suggestions for further research.

3. Research Elaboration

This study uses quarterly data from 2004 to 2017; the data were collected from the Central Bank of Jordan and Federal Reserve Economic Data (FRED) database. Firstly, to calculate (RER), Purchasing Power Parity (PPP) is used as follows.

$$RER = NER * (\frac{US\_P}{J\_P}) \quad \ldots\ldots\ldots\ldots (1)$$

Where, NER is the nominal exchange rate and P is the price index. This paper uses the following four price indices:

1) $CPI_{U.S}/CPI_{JOR}$,
2) $GDP\ Deflator_{U.S}/GDP\ Deflator_{JOR}$,
3) $IPI_{U.S}/GDP\ Deflator_{JOR}$,
4) $PPI_{U.S}/GDP\ Deflator_{JOR}$.

Therefore, RER is measured in this paper as follows:

$$RER = ln\left(\frac{rer_t}{rer_{t-1}}\right) \quad \ldots\ldots\ldots\ldots\ldots (2)$$

Two types of price index, CPIs and GDP Deflators, are used as the basis for RER measurement for both home and foreign countries. Some empirical studies used GDP Deflator instead of CPI as a result of certain n data being more available than others. However, CPI and GDP Deflator index may behave differently in response to changes in TOT (Hinkle and Montiel, 1999).

Due to the limitation of the data in Jordan, the analysis has been limited to the following four determinants which represent among the most important variables that play a crucial role in determining RER. Those determinants are; workers' remittances (*Rem*), foreign reserves (*Res*), governmental expenditures (*Gexp*) and terms of Trade (*TOT*). Each of the chosen determinants (*X*) was converted to natural logarithm:

$$X = ln\left(\frac{x_t}{x_{t-1}}\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

The NARDL model suggested by Shin et al. (2014: p.8) is applied in order to investigate the effect of positive and negative shocks on the determinants:

$$X_t = X_0 + X_t^- + X_t^+ \quad \ldots\ldots\ldots\ldots\ldots (4)$$

Where;

$$X_t^- = \sum_{j=1}^{t} \Delta X_j^- = \sum_{j=1}^{t} Min(\Delta X_j, 0) \quad \ldots\ldots\ldots\ldots\ldots\ldots (5)$$

$$X_t^+ = \sum_{j=1}^{t} \Delta X_j^+ = \sum_{j=1}^{t} Max(\Delta X_j, 0) \quad \ldots\ldots\ldots\ldots\ldots\ldots (6)$$

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The equations (5) and (6) are the partial sums of negative and positive changes in the determinants respectively. Decomposing each determinant according equation (4), as applied by Fedoseeva (2016), we subsequently obtain the long-run equation of RER.

$RER_t = c + \beta_1 REM_t^- + \beta_2 REM_t^+ + \beta_3 RES_t^- + \beta_4 RES_t^+ + \beta_5 EXP_t^- + \beta_6 EXP_t^+ + \beta_7 TOT_t^- + \beta_7 TOT_t^+$ .... (7)
With $c = \alpha + RER_0$.

In order to examine the dynamic model, the NARDL model of Shin et al. (2014) is applied as follows:

$\Delta RER_t = a_0 + a_1(RER_{t-1} - a_2 REM_{t-1}^- - a_3 REM_{t-1}^+ - a_4 RES_{t-1}^- - a_5 RES_{t-1}^+ - a_6 EXP_{t-1}^- - a_7 EXP_{t-1}^+ - a_8 TOT_{t-1}^- - a_9 TOT_{t-1}^+) + \sum_{\tau=0} \mu_\tau \Delta REM_{t-\tau}^- + \sum_{\tau=0} \pi_\tau \Delta REM_{t-\tau}^+ + \sum_{\tau=0} \rho_\tau \Delta RES_{t-\tau}^- + \sum_{\tau=0} \sigma_\tau \Delta RES_{t-\tau}^+ + \sum_{\tau=0} \theta_\tau \Delta EXP_{t-\tau}^- + \sum_{\tau=0} \gamma_\tau \Delta EXP_{t-\tau}^+ + \sum_{\tau=0} \delta_\tau \Delta TOT_{t-\tau}^- + \sum_{\tau=0} \varphi_\tau \Delta TOT_{t-\tau}^+ + \sum_{\omega=0} \vartheta_\omega \Delta RER_{t-\omega} + u_t$ .... (8)

The equation is estimated by means of a stepwise regression after selecting the number of lags according to the Akaike Information Criterion (AIC) using EViews 10. Thus, equation (8) is assessed as follows:

$\Delta RER_t = a_0 + a_1 RER_{t-1} - b_2 REM_{t-1}^- - b_3 REM_{t-1}^+ - b_4 RES_{t-1}^- - b_5 RES_{t-1}^+ - b_6 EXP_{t-1}^- - b_7 EXP_{t-1}^+ - b_8 TOT_{t-1}^- - b_9 TOT_{t-1}^+ + \sum_{\tau=0} \mu_\tau \Delta REM_{t-\tau}^- + \sum_{\tau=0} \pi_\tau \Delta REM_{t-\tau}^+ + \sum_{\tau=0} \rho_\tau \Delta RES_{t-\tau}^- + \sum_{\tau=0} \sigma_\tau \Delta RES_{t-\tau}^+ + \sum_{\tau=0} \theta_\tau \Delta EXP_{t-\tau}^- + \sum_{\tau=0} \gamma_\tau \Delta EXP_{t-\tau}^+ + \sum_{\tau=0} \delta_\tau \Delta TOT_{t-\tau}^- + \sum_{\tau=0} \varphi_\tau \Delta TOT_{t-\tau}^+ + \sum_{\omega=0} \vartheta_\omega \Delta RER_{t-\omega} + u_t$ .... (9)

Note that $b_2$andb_3 consist of elasticity and speed of adjustment. Thus, the following formula should be used to test elasticity:

For *Rem*: $a_2 = -\frac{b_2}{a_1}$and $a_3 = -\frac{b_3}{a_1}$
For *Res*: $a_4 = -\frac{b_4}{a_1}$and $a_5 = -\frac{b_5}{a_1}$
For *Gexp*: $a_6 = -\frac{b_6}{a_1}$and $a_7 = -\frac{b_7}{a_1}$
For *TOT* : $a_8 = -\frac{b_8}{a_1}$and $a_9 = -\frac{b_9}{a_1}$

Three types of asymmetries were tested which are; elasticities of the determinants, reaction (long-run) asymmetry and the impact (short-run) asymmetry. The key hypothesis of the current research is based on the fact that the choice of price selection index plays a significant role in the symmetry/asymmetry patterns of the determinants of RER for Jordan.

4. The Empirical Results and Discussions

Descriptive statistics, correlation matrix and unit root tests are implemented and presented in tables (1-3), respectively; table (1) provides descriptive analyses of the studied variables. Mean and median for most of the variables are within a narrow range, as is further supported by the standard deviation values. As a measure of symmetry in observations distribution, the degree of skewedness indicates that RER $IPI_{U.S}/GDP\ Def._{JOR}$, RER $PPI_{U.S}/GDP\ Def._{JOR}$, Res and TOT are moderately skewed in their observations. Meanwhile, RER $GDP\ Def._{U.S}/GDP\ Def._{JOR}$,RER $IPI_{U.S}/GDP\ Def._{JOR}$, Rem, and Gexp are approximately symmetric. While kurtosis showed that the dataset of Res, Gexp and TOT apparently have heavier tails than a normal distribution bell curve.

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Table 1. Descriptive diagnostics

Descriptive	**RER**				**RER Determinants**			
	$CPI_{U.S}/CPI_{JOR}$	GDP Def. $r_{U.S}$/GDP $Def._{JOR}$	$IPI_{U.S}$/GDP $Def._{JOR}$	$PPI_{U.S}$/GDP $Def._{JOR}$	**Rem**	**Res**	**Gexp**	**TOT**
Mean	0.725	0.017	2.632	3.873	0.010	0.018	0.023	-0.003
Median	0.702	0.028	2.776	4.082	0.005	0.017	0.060	-0.017
Maximum	0.847	0.106	3.463	5.161	0.156	0.241	0.628	0.259
Minimum	0.653	-0.089	1.428	2.061	-0.200	-0.329	-0.646	-0.203
Std. Dev.	0.065	0.067	0.565	0.890	0.085	0.098	0.265	0.093
Skewness	0.707	-0.170	-0.608	-0.501	-0.240	-0.755	-0.393	0.609
Kurtosis	1.993	1.389	2.172	2.050	2.618	5.049	3.107	3.954
Observations	55	55	55	55	55	55	55	55

Source of Data: The Central Bank of Jordan and Federal Reserve Economic Data (FRED) database

The Analysis: authors' computation via EViews.

Table (2) presents the correlation between the variables of the study. The high positive correlation between RER$CPI_{U.S}/CPI_{JOR}$ and RER$PPI_{U.S}/GDP\ Deflator_{JOR}$ is justified. PPI provides a primary indicator for CPI; increases in production costs are passed on to retailers and, in turn, to consumers, resulting in an elevated CPI. RER$PPI_{U.S}/GDP\ Deflator_{JOR}$ and RER $IPI_{U.S}/GDP\ Def._{JOR}$ are almost perfectly correlated, while RER $PPI_{U.S}/GDP\ Deflator_{JOR}$ and RER $CPI_{U.S}/CPI_{JOR}$ are almost negatively perfectly correlated. It might be misleading to attempt interpreting those findings since the composition of each of the price index is different. Furthermore, those price indexes are comparing two different countries: a highly developed country (USA) with developing emerging country (Jordan). Notably, the correlation between determinants of the RER and all measured RERs is weak—with a value of around zero.

Table 2. Correlation Matrix

		RER				**RER Determinants**			
		GDP $Deflator_{U.S}$/GDP $Deflator_{JOR}$	$CPI_{U.S}/CPI_{JOR}$	$IPI_{U.S}$/GDP $Deflator_{JOR}$	$PPI_{U.S}$/GDP $Deflator_{JOR}$	**Rem**	**Res**	**Gexp**	**TOT**
RER	$CPI_{U.S}/CPI_{JOR}$	**0.149**							
	$IPI_{U.S}$/GDP $Deflator_{JOR}$	**0.034**	**-0.936**						

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	$PPI_{US}/GDP\ Deflator_{JOR}$	**0.024**	**-0.952**	**0.988**					
ER Determinants	**Rem**	**0.714**	**0.156**	**-0.048**	**-0.056**				
	Res	**0.101**	**0.023**	**0.01**	**-0.002**	**0.193**			
	Gexp	**0.483**	**0.054**	**0.091**	**0.075**	**0.052**	**0.045**		
	TOT	**-0.016**	**0.006**	**0.036**	**0.019**	**-0.131**	**-0.071**	**0.095**	**1**

Source of Data: The Central Bank of Jordan and Federal Reserve Economic Data (FRED) database

The Analysis: authors' computation via EViews.

Before conducting a NARDL test, unit root tests have been applied (as shown in table (3)) to ensure that none of the series of data are integrated at I(2). Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests were conducted to test the unit root of the variables. As shown in table (3), all the variables are stationary at level or first difference, indicating that the necessary conditions for the application of a NARDL model have been fulfilled.

In table (4), the bound test provided stark evidence, irrespective of the choice of price index, of a cointegrating relationship between the RER and its determinants; this result supports that of previous studies that focus on developing countries (Mustafa, 2019).

The results of the long-run dynamics are presented in table (4), *Rem* dynamics were sensitive to a statistically significant degree when RER was based on CPI and GDP Deflator price ratios, with higher sensitivity to an increase in *Rem*. Estimated long-run coefficients of *Rem* were -0.145, 0.496 on RER based on CPI and GDP Deflator price ratios respectively. There are multiple possible reasons for the different sign and magnitude of the coefficients. Because CPIs are expenditures price indices, CPI-based comparisons between Jordan and the US may be misleading due to differences in the composition of the commodities basket used to calculate CPI in each country. Also, CPIs namely focus on non-tradable commodities. Moreover, the differences may be the result of divergences in RER measurement derived from a change in TOT (Hinkle and Montiel, 1999).

A country's currency tends to increase (and therefore its competitiveness tends to decrease) with an increase in remittance inflow from emigrant workers. Increased consumption deriving from an increase in household income may be apparent in local CPIs. As a result, the sign of *Rem* coefficients (for both increased and decreased remittances) was negative. Conversely, an increase in remittances may lead to a decrease in exports in favor of an increase in imports. Hence, the remittances impose a penalty on export producers; this increased economic cost matches the Dutch disease, which clarified the effect of currency appreciation on shifting from tradable goods to nontradable ones (Hinkle and Montiel, 1999); (Amuedo-Dorantes and Pozo, 2004); (Hassan and Holmes, 2013). *GDPJor* may tend to decline with a loss of export production, which leads to RER appreciation (i.e., a decrease in the value of the Jordanian dinar). This appreciation explains the positive sign of the *Rem* coefficients[iv]. Therefore, the government must enact rigorous regulations to ensure that workers' remittances are received through formal channels. In doing so, it can control the effect of remittances on the local economy.

The long-run coefficients of *Gexp* (positive and negative) are statistically significant (at 5 percent) when an RER is measured based on GDP Deflator or CPI. *Gexp* coefficients had higher values when RER was measured according to the GDP Deflator ratio. This result is a matter of controversy in the literature. Some studies have argued that an increase in government expenditures eventually causes the local currency to appreciate,[v] while other studies argue that increased expenditures, by lowering savings rates, ultimately have the opposite effect and increase the RER[vi].Much therefore depends on whether Ricardian equivalence is

ISSN: 2247 - 6172
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URL: http://www.reaser.eu
e-mail: editors@reaser.eu

observed.[vii]The empirical results of Gexp with RER measured by CPI are consistent with (Kuncoro, 2015), while those of Gexp with RER measured by GDP Deflator is consistent with (Chowdhury, 2012).

Two out of four RER measures showed statistical significance for both positive and negative long-run TOT coefficients. An increase in exports—and therefore in TOT—may raise wages in export-oriented industries, thereby increasing consumption and raising the RER. In such a case, the opposite (i.e., decreased exports ultimately lowering an RER) would also be true (Mustafa, 2019).

Table (5) represents the cornerstone of this study. It reports the long-run elasticities of both types of partial sum of each determinant. The results show the workers' remittances is positively correlated with RER regardless of the choice of price index; if workers' remittance drop by 1% then the RER decreases by7 - 22 %;a 1% increase in remittances raises the RER by 7 - 39%. Overvaluation of RERs may have a deleterious impact on economic growth, especially for emerging economies such as Jordan, due to those economies' weak institutions and propensity for market failure; these foibles underscore workers' remittances as a factor in an RER (Daway-Ducanes, 2019).

Similarly government expenditures have positive effect on RER appreciation and depreciation regardless of the price index chosen as a basis for measurement. However, RERs measured based on $PPI_{U.S}/GDP\ Deflator_{JOR}$ demonstrate comparatively higher sensitivity. One positive shock in government expenditures increases an RER 8 to 25%, while a 1% decrease in government expenditures lowers an RER by 7 to 25%. The researches declared the effect of increasing governmental expenditures differ between developing countries and developed ones (Kuncoro, 2015).Several studies indicate that cyclical changes in government expenditures may encourage private consumption (Linnemann, 2006),which may push demand upward and depreciate local currencies through the creation of a trade imbalance (Aaron et al., 1997; Ajao and Igbekoyi, 2013). Government expenditures therefore merit careful attention, given that they may be considered a proxy for fiscal policy.

ISSN: 2247 - 6172
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(Volume 24, Issue 2 / 2022), pp. 121 -139
URL: http://www.reaser.eu
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Table 3. Unit Root Results for the Studied Variables

UNIT ROOT TEST TABLE (PP)

	RER				**RER determinants**			
At Level	***GDP Deflator$_{U.S}$/GDP Deflator$_{JOR}$***	***CPI$_{U.S}$/CPI$_{JOR}$***	***IPI$_{U.S}$/GDP Deflator $_{JOR}$***	***PPI$_{U.S}$/GDP Deflator $_{JOR}$***	**Rem**	**Res**	**Gexp**	**TOT**
With Constant	-12.067***	-1.618	-2.298	-1.971	-8.979***	-6.267***	-33.719***	-6.425***
With Constant & Trend	-18.321***	-0.726	-2.513	-3.758**	-11.28***	-6.289***	-42.839***	-6.404***
Without Constant & Trend	-7.415***	-2.704***	1.357	1.794	-8.381***	-6.114***	-20.256***	-6.487***
At First Difference	**d(*GDP Deflator$_{U.S}$/GDP Deflator$_{JOR}$*)**	**d(*CPI$_{U.S}$/CPI$_{JOR}$*)**	**d(*IPI$_{U.S}$/GDP Deflator $_{JOR}$*)**	**d(*PPI$_{U.S}$/GDP Deflator $_{JOR}$*)**	**d(Rem)**	**d(Res)**	**d(Gexp)**	**d(TOT)**
With Constant & Trend	-26.32***	-5.54***	-9.29***	-11.09***	-26.35***	-33.16***	-70.44***	-36.62***
Without Constant & Trend	-26.40***	-5.14***	-7.15***	-7.19***	-26.90***	-35.45***	-71.54***	-36.24***

UNIT ROOT TEST TABLE (ADF)

	RER				**RER determinants**			
At level	***GDP Deflator$_{U.S}$/GDP Deflator$_{JOR}$***	***CPI$_{U.S}$/CPI$_{JOR}$***	***IPI$_{U.S}$/GDP Deflator $_{JOR}$***	***PPI$_{U.S}$/GDP Deflator $_{JOR}$***	**Rem**	**Res**	**Gexp**	**TOT**
With Constant	-1.394	-2.094	-2.288	-2.399	-2.231	-6.267***	-13.344***	-6.431***
With Constant & Trend	-1.365	-0.094	-1.024	-0.647	-2.705	-6.287***	-13.627***	-6.412***
Without Constant & Trend	-1.767*	-1.444	1.438	1.827	-2.034**	-6.117***	-2.060**	-6.492***

ISSN: 2247 - 6172
Review of Applied Socio- Economic Research
(Volume 24, Issue 2 / 2022), pp. 121 -139
URL: http://www.reaser.eu
e-mail: editors@reaser.eu

At First Difference	d(*GDP Deflator$_{U.S}$/GDP Deflator$_{JOR}$*)	d(*CPI$_{U.S}$/CPI$_{JOR}$*)	d(*IPI$_{U.S}$/GDP Deflator $_{JOR}$*)	d(*PPI$_{U.S}$/GDP Deflator $_{JOR}$*)	d(Rem)	d(Res)	d(Gexp)	d(TOT)
With Constant	-5.391***	-1.898	-3.89***	-3.632***	-6.246***	-6.507***	-9.423***	-5.270***
With Constant & Trend	-5.437***	-5.550***	-3.208*	-3.624**	-6.175***	-6.431***	-9.315***	-5.201***
Without Constant & Trend	-5.206***	-1.451	-3.30***	-2.608**	-9.217***	-6.579***	-9.528***	-5.331***

Notes: the values presented above is t-statistics, (*)Significant at the 10%; (**)Significant at the 5%; (***) Significant at the 1%. and (no) Not Significant

Source of Data: The Central Bank of Jordan and Federal Reserve Economic Data (FRED) database

The Analysis: authors' computation via EViews.

ISSN: 2247 - 6172
Review of Applied Socio- Economic Research
(Volume 24, Issue 2 / 2022), pp. 121 -139
URL: http://www.reaser.eu
e-mail: editors@reaser.eu

TOT is among the variables that effect RERs; the theoretical literature indicated that an improvement in TOT may deteriorate an RER (i.e., appreciate local currency). An improvement in TOT indicates a shift in a country's labor force from nontraded goods toward traded goods sectors, and this shift explains the signs of the TOT coefficients under different RER measurements. RERs based on IPI/GDP Deflator were negative because IPI is the denominator of TOT.

Table 4. NARDL Outcomes

The Price level index used	$CPI_{U.S}/CPI_{JOR}$	$GDP\ Deflator_{U.S}/GDP\ Deflator_{JOR}$	$IPI_{U.S}/GDP\ Deflator_{JOR}$	$PPI_{U.S}/GDP\ Deflator_{JOR}$
Const	-0.046***	0.149***	0.134	0.161*
RER_{t-1}	-2.188***	-3.570***	-0.969	-1.544*
Rem^{+}_{t-1}	-0.145***	0.496***	0.380	0.134
Rem^{-}_{t-1}	-0.183***	0.361***	0.213	0.102**
Res^{+}_{t-1}	0.035**	0.081*	-0.075	-0.157
Res^{-}_{t-1}	0.023	0.003	-0.063	0.055
$Gexp^{+}_{t-1}$	-0.183***	0.292***	0.238	0.377
$Gexp^{-}_{t-1}$	-0.163***	0.340***	0.244	0.345
TOT^{+}_{t-1}	0.099***	0.088**	-0.548	-0.346
TOT^{-}_{t-1}	0.057***	0.143***	-0.371	-0.371
$\Delta Rem+$		0.148***	0.237**	0.161
$\Delta Rem-$			0.312**	
$\Delta\ Res+$	-0.063**	0.050		
$\Delta\ Res-$	0.039*			0.196***
$\Delta Gexp+$	-0.031***	0.037**	0.203**	0.055*
$\Delta Gexp-$	-0.026**	0.088**		0.117**
$\Delta\ TOT+$			0.079**	
$\Delta\ TOT-$		0.102***		
$\Delta\ RER_{t-1}$	1.171***	1.619***		0.254**
$\Delta\ RER_{t-2}$	1.058***	0.683***	-0.396***	
$\Delta\ RER_{t-3}$	1.099***		-0.407***	-0.340***
$\Delta\ RER_{t-4}$	0.581***			0.167*
$\Delta\ RER_{t-5}$	0.487***			
ΔRem^{+}_{t-1}	0.047	-0.130**		

ISSN: 2247 - 6172
Review of Applied Socio- Economic Research
(Volume 24, Issue 2 / 2022), pp. 121 -139
URL: http://www.reaser.eu
e-mail: editors@reaser.eu

Δ Rem^{-}_{t-1}		-0.150**		
$\Delta Res +_{t-1}$		-0.091**		0.201***
$\Delta Res -_{t-1}$	0.047**			
$\Delta Res +_{t-2}$				0.091
$\Delta Res -_{t-2}$		-0.123**		
$\Delta Gexp +_{t-1}$		-0.131**	-0.067	-0.072*
$\Delta Gexp -_{t-1}$		-0.200***		-0.259***
$\Delta Gexp +_{t-2}$	0.081***	-0.058**		-0.151***
$\Delta Gexp -_{t-2}$	0.062***	-0.066***		
$\Delta TOT +_{t-1}$	-0.085**		0.532***	0.303***
$\Delta TOT -_{t-1}$		-0.062**	0.240***	0.207***
$\Delta TOT +_{t-2}$	-0.063**		0.240**	0.166**
$\Delta TOT -_{t-2}$	0.054***	-0.045	0.150**	0.112*
R^2	0.933	0.994	0.972	0.986
Adj. R^2	0.846	0.988	0.953	0.972
LM-Corr	0.1426	0.5747	0.240	0.890
Hetero.	0.4446	0.2656	0.498	0.487
Normality	0.592	0.684	0.871	0.560
Stability (CUSUM, CUSUM SQ)	Stable in both tests	Stable in both tests	Stable in both tests	Stable in both tests
Cointegration(Bound Test	6.975***	28.586***	5.788***	7.849***

Note: *,**,* represent the significance level at 1%, 5% and 10% respectively.**

Upper and lower bounds (critical values) are reported in (Pesaran et al., 2001) for the case: unrestricted and no trend for k=4

(at 10% sig level: I(0)= 2.45, I(1)= 3.52; at 5% sig. level: I(0)= 2.86, I(1)=4.01).

Source of Data: The Central Bank of Jordan and Federal Reserve Economic Data (FRED) database

The Analysis: authors' computation via EViews.

However, RER based on *GDP Deflator*$_{U.S}$*/GDP Deflator*$_{JOR}$ was odd in its signs compared to the other measured RERs. When TOT changes significantly, movement in CPI (reflecting changes in the prices of imported goods) and GDP Deflator (changes in the prices of exported goods) may differ. Therefore, a fluctuation in TOT may cause RERs to diverge as well as a result of the opposing methodologies (Hinkle and Monteil, 1999).

ISSN: 2247 - 6172
Review of Applied Socio- Economic Research
(Volume 24, Issue 2 / 2022), pp. 121 -139
URL: http://www.reaser.eu
e-mail: editors@reaser.eu

Table 5. Long-run Elasticities and Symmetry outcomes

RER

	$CPI_{U.S}/CPI_{JOR}$	$GDP\ Deflator_{U.S}/GDP\ Deflator_{JOR}$	$IPI_{U.S}/GDP\ Deflator_{JOR}$	$PPI_{U.S}/GDP\ Deflator_{JOR}$
Long-run elasticities				
Rem +	0.066	0.139	0.392	0.087
Rem -	0.083	0.101	0.220	0.066
Res +	-0.016	0.023	-0.077	-0.102
Res -	-0.011	0.001	-0.065	0.035
Gexp+	0.083	0.082	0.246	0.244
Gexp-	0.074	0.095	0.252	0.223
TOT+	-0.045	0.025	-0.565	-0.224
TOT-	-0.026	0.040	-0.383	-0.240
Symmetry Testing				
Long-run Symmetry				
Rem	0.097	0.000	0.043	0.639
Res	0.657	0.094	0.886	0.024
Gexp	0.005	0.000	0.748	0.135
TOT	0.126	0.174	0.076	0.765
Short-run Symmetry				
Rem	0.164	0.084	0.638	-
Res	0.003	0.182	-	0.322
Gexp	0.007	0.384	0.174	0.564
TOT	0.001	0.932	0.020	0.280

The values in the tables are the P-value

Source of Data: The Central Bank of Jordan and Federal Reserve Economic Data (FRED) database

The Analysis: authors' computation via EViews.

When TOT improves, GDP Deflator tends to increment more evidently than CPI. Ultimately, the net effect of changes in TOT depends on the change in export and import prices and also on the relative percentage

ISSN: 2247 - 6172
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(Volume 24, Issue 2 / 2022), pp. 121 -139
URL: http://www.reaser.eu
e-mail: editors@reaser.eu

of imports and exports within an economy; thus, the net effect of changes in TOT cannot be determined on a general basis. Moreover, the prices in Jordan rise faster than prices in U.S. (Al-Qalawi and Al-Waked, 2017).

Table (5) also presents, through LR-symmetry and SR-symmetry results, respectively, the reaction and impact symmetry/asymmetry; the Wald test was applied separately on each determinant and RER measurement. We begin with RER measured based on CPI ratios. In this instance, only the null hypothesis of government expenditures was rejected in LR-Symmetry; for the other three determinants were aligned with the null hypotheses. While the SR-Symmetry hypothesis regarding *Rem* was accepted, however the other three determinants showed asymmetrical behavior for *Res*, *Gexp* and TOT. However, in testing impact symmetry/asymmetry—also by means of a Wald test—to find out whether there is inequality of the coefficient of first differenced variables, the results disclosed the significance of all determinants except workers' remittances. Workers' remittances constitute a main source of foreign currencies, especially in developing countries. They may be larger than a government's foreign reserves, as the reserves are more. The government must take advantage of this effect by encouraging workers to send remittances solely through formal channels. World Bank (2006) declared that 50% of workers' remittances are received through informal channels. The magnitude of this informal channel may have a deleterious impact on local exchange rates—this is, of course, in addition to the threat informal remittance channels present from a money laundering and terrorist financing perspective (Jongwanich, 2007).

The study's empirical results suggest that upstream and downstream RERs are cointegrated with their main determinants. This cointegration indicates asymmetric adjustment between the RER and overall price levels and verifies the existence of a long-run cointegration relationship between the RER and its determinants, along with the overall price level index with underlying adjustment process being highly asymmetric. Clearly, there is a difference between the values of the asymmetric adjustments, with *Rem* and TOT coefficients for both positive and negative fluctuations. In such a case, it can therefore be concluded that real exchange rate responds asymmetrically to the changes in its macroeconomic determinants and the overall price level index, where the adjustment speed to the new equilibrium at period t is faster when the residual is positive than when is negative.

5. Conclusions

One the crucial topics in international economics is RER and its determinants, however many of the previous studies assumed a linear relationship between RER and its determinants. In 2014 Shin et al. suggested "modelling asymmetric cointegration and dynamic multipliers in a nonlinear ARDL", and, in doing so, opened the door to extensive empirical review. Building on that work, this paper attempts to investigate the asymmetric dynamics of RER determinants in short- and long-run.

This study also takes the choice of price level index used to measure RER into consideration: because a study's choice of price index may radically be a measurement/observation of an RER, it is not always clear which price index is the most appropriate choice. We recommend that future studies choose their price index based on the purpose of the work undertaken.

The current study specifies four determinants of RER: workers' remittances, foreign reserves, government expenditures, and TOT. RER is measured using four different price level indices: $CPI_{U.S}/CPI_{JOR}$, *GDP Deflator* $_{U.S}$*/GDP Deflator* $_{JOR}$, $IPI_{U.S}$*/GDP Deflator* $_{JOR}$ and *PPI* $_{U.S}$*/GDP Deflator* $_{JOR}$.

The results revealed significant long-run asymmetry of workers' remittances when RER is measured based on GDP (i.e., when *GDP Deflator* $_{U.S}$*/GDP Deflator* $_{JOR}$ is chosen as the price level index). Increased household consumption affects the prices of goods and services, which leads to changes in the Jordanian GDP Deflator. This effect may be enhanced as remittance inflows increase because households that receive

ISSN: 2247 - 6172
Review of Applied Socio- Economic Research
(Volume 24, Issue 2 / 2022), pp. 121 -139
URL: http://www.reaser.eu
e-mail: editors@reaser.eu

remittances may also spend more on imports. Hence an asymmetric short-run effect is present when RER is measured based on $IPI_{U.S}/GDP\ Deflator_{JOR}$.

Thus, the asymmetric effect of remittances on RER can be captured when the GDP deflator price index is used. The governments of developing countries should take advantage of this result by encouraging the immigrants to increase the amount of money transfers in foreign currencies to enhance the external development finance. Remittances help to initiate counter-cyclical policies in developing countries, keeping in mind they are altruistic transfers that do not have to be paid back.

Foreign reserves show a long-run asymmetric effect when the RER measured by $PPI_{U.S}/GDP\ Deflator_{JOR}$, and a further short-run asymmetric effect when the RER is measured by $CPI_{U.S}/CPI_{JOR}$. Foreign reserves are directly related to changes in gold prices and political events. When foreign reserves are at acceptable levels domestically, the economy is more likely to stabilize through the reserves' positive effect on base money, which in turn has a positive effect on CPI. It is worth noting that CPI may affect PPI, not the other way around. We therefore recommend that policy makers base monetary policy decisions on RERs measured according to $CPI_{U.S}/CPI_{JOR}$.As increased foreign reserves represent increased wealth, however, the Central Bank should concentrate on maintaining specific levels of foreign reserves, with an eye toward stabilizing the RER.

Government expenditures show long-run asymmetry when an RER is measured based on both $CPI_{U.S}/CPI_{JOR}$ and $GDP\ Deflator_{U.S}/GDP\ Deflator_{JOR}$; asymmetry in the short-run is exhibited with an RER based on $CPI_{U.S}/CPI_{JOR}$.Increases in government expenditures will increase the demand for nontraded commodities. This increase in the demand for nontradeables will raise their prices, leading to an increase in the value of local currency. This phenomenon was among those that Mundell-Fleming illustrated as an effect of fiscal policy on RER (Chowdhury, 2012). However, a country's currency will depreciate if government expenditures tend to be directed toward tradable commodities. As we clarified, the GDP Deflator tends to cover nontradable goods and services more than traded ones, while CPI covers both. Thus, the nature of government expenditures (in particular, the ratio of spending on tradable versus nontradable goods) should be determined in advance of fiscal policy decisions.

Government expenditures showed asymmetric effect in both long- and short-run, suggesting that an expansive fiscal policy may depreciate the local currency, which may in turn increase the ratio of imports to exports—ultimately negatively affecting short-run RERs and appreciating the local currency.

Last but not least, TOT was the only determinant to show along-run symmetrical effect on RERs regardless of the price index used. However, in the short-run, asymmetry was present in RERs measured based on $CPI_{U.S}/CPI_{JOR.}$

Therefore, several corrective reforms can be undertaken to reach an equilibrium state for a country's RER:

1) Supporting trade liberalization, which may increase the ratio of exports to imports.

2) A more fine-grained analysis of government expenditures (both discretionary and nondiscretionary), such that the role of each broad budget category in strengthening or weakening the economy may be determined with greater certainty

3) Facilitating remittance flows through formal, as opposed to informal channels (e.g., by reducing transaction costs), which would confer the additional benefit of combatting money laundering and terrorism financing.

Further research could investigate other determinants of RER, expand the range of countries studied, or lengthen the period covered by the study. A longer time span or more frequently-collected data might better

ISSN: 2247 - 6172
Review of Applied Socio- Economic Research
(Volume 24, Issue 2 / 2022), pp. 121 -139
URL: http://www.reaser.eu
e-mail: editors@reaser.eu

confirm this study's findings. Testing the equilibrium of the RER may add further value and be of particular interest for emerging economies.

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(Volume 24, Issue 2 / 2022), pp. 121 -139
URL: http://www.reaser.eu
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Review of Applied Socio- Economic Research
(Volume 24, Issue 2 / 2022), pp. 121 -139
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End Notes

[i] https://www.worldbank.org/en/news/press-release/2019/04/08/record-high-remittances-sent-globally-in-2018

[ii] Chinn expressed RER in terms of GDP deflators, however he mentioned CPI is the typical price level to be used.

[4] In 1978, United States decided to drop using WPI and it replaced it with PPI which is a similar measure but it's accurately named and calculated (U.S. Bureau Labor Statistics, 2016).

[iv] Refer to (Bussolo et al., 2007) for further detailabout the impact of remittances on RERs.

[v] Blanchard, 2003 as mentioned in Kuncoro, 2015.

[vi] Mankiw, 2000 as mentioned in Kuncoro, 2015.

[vii] https://www.investopedia.com/terms/r/ricardianequivalence.asp

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