The Asymmetric Impact of Exchange Rate on Inflation in Egypt Since 2013

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- **Abstract:**

This paper aims to analyze the impact of exchange rate changes on the price level in Egypt since 2013. The objective of this study is not only to test the existence of such relationship but also to identify to what extent the inflation responds to exchange rate are different by the direction of this change. In order to test this asymmetric impact of exchange rate on inflation, Nonlinear Auto Regressive Distributed Lag model (NARDL) is used. This model could capture not only the cointegration between the two variables, but also the asymmetric exchange rate pass-through inflation.The analysis shows that exchange rate has a significant impact on inflation in Egypt in the short run and long run,and that this impact is asymmetric. Inflation responds only to the positive changes in the exchange rate in both short run and long run, while negative changes were insignificant.

Keywords: Exchange Rate, Inflation, Asymmetric, NARDL

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التأثير غير المتناظر لسعر الصرف على معدل التضخم في مصر من 2013

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- **مُلخص:**

تهدف هذه الورقة إلى تحليل تأثير تغيرات سعر الصرف على معدل التضخم في نصر منذ عام 2013. حيث يتمثل الهدف الرئيسي للورقة ليس فقط في اختبار وجود مثل هذا التأثير وإنما أيضاً تحديد ما إذا كان تأثير تغيرات سعر الصرف على التضخم متناظرة في كلا اتجاهي التغير أم أنها تختلف. ولاختبار فرضية التأثير غير المتناظر لسعر الصرف لى معدل التضخم استخدمت الورقة نموذج الانحدار الذاتي للفجوات الموزعة غير الخطي NARDL وهو النموذج الي يحدد وجود الكامل المشترك بين متغيري الدراسة وأيضاً يختبر تناظر أو تماثل تأثير التغيرات الموجبة والسالبة لسعر الصرف على معدل التضخم. وقد خلصت الورقة إلى أن لتغيرات سعر الصرف تأثيراً معنوياً على معدل التضخم في مصر منذ عام 2013 في كلا الأجلين القصير والطويل. وبفصل اتجاهي التغيير تبين أن تغيرات سعر الصرف الموجبة هي التي تخلف تأثيراً معنوياً على معدلات التضخم في الأجل القصير والطويل.

الكلمات المفتاحية: سعر الصرف، التضخم، NARDL

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1. Introduction:

High inflation rates have become one of the main challenges surrounding world economy nowadays, and one of the main interests to policy makers especially in developing countries is how the changes in the value of local currency is transmitted to the price levels. This impact transition is known as exchange rate pass through which doesnot only affect the inflation in the short run, but also affected the inflation projections in the long run.

In this context, there are a considerable solid literature discussing the interaction between inflation rate and exchange rate especially in the developing countries. Studying this relationship is crucial as most of countries targeting inflation in their economic policies and thus, it is important to understand the size and the duration of the exchange rate pass-through effect on inflation.

In Egypt, high Inflation Rates are considered as one of the main economic challenges especially in the light of the recent global economic political uncertainties. In the past decade Egypt managed to devaluate its currency more than one time, and with each devaluation the inflation tended to increase. This study aims to analyze the way in which the exchange rate affects the price level in Egypt and to test the hypothesis of asymmetry in this relationship using Egyptian Quarterly economic data since the first quarter of 2013 to the second quarter of 2022.

2. Literature Review:

Theoretically, exchange rate affects inflation rate directly through its effect on the price of imported goods and services. Thus, the significance of this direct impact depends on the share of this imported goods in the average consumption in this country. Exchange rates also affected the price of imported intermediate goods and thus the cost of production and then inflation (McCarthy, 2000).

On the other hand, exchange rate indirectly affects price levels through its impact on domestic demand for local substitute goods but this effect depends mainly on the elasticity of substitution between domestic and imported goods (Demirel, 2021).

This asymmetric impact of exchange rate on inflation could be explained by many factors: the first is related to the different impact of the direction of changes in exchange rate, appreciation or depreciation, especially in countries with high exchange rate volatility. According to (Pollard, 2004) the passthrough effect is higher when the importing country's currency appreciated as exporters tends to decrease their prices to increase their domestic market share. While they tend to decrease their profit margin in the case of depreciation instead of increase prices to avoid losing market shares. This different impact needs to be clarified in order to adopt the appropriate policy in targeting inflation by central banks (Demirel, 2021).

The second factor explaining this asymmetric impact is the size of this change. Small and large variations in exchange rate do not reflect in the same way in price level.

A lot of studies tried to analyze the exchange rate pass through inflation and its dynamics,and while some indicate that this relationship is linear or symmetric (Marazzi, 2005), (Athukorala, 1991) and (Herzberg, 2003). There are significant body of literature that argued the existence of asymmetry in the exchange rate pass-through as: (Gil-Pareja, 2000)(Goldberg, 1995), (Bussiere, 2006), and (Mahdavi, 2002).

In these studies, various sources of asymmetry are identified, but the most obvious asymmetry is that associated with the direction of exchange rate variation: appreciation or depreciation, and the size of that change. (Nogueira, 2002) addetwo more factors explained the asymmetric impact which are the output gap and the macroeconomic stability.

Some studies linked the size of the impact of exchange rate on inflation with the level of this inflation as (Choudri, 2001) and

(Taylor, 2000). (Choudri, 2001) studied the impact of exchange rate on inflation in 71 countries from 1997 to 2000, he found that the exchange passthrough to inflation was higher for countries that already have a high inflation rate. While from inflation targeting perspective, (Kum, 2012) and (Edwards, 2006) found that countries with this policy target had a diminishing pass-through effects of exchange rate on inflation.

On the other hand, (Ahmad, 1999) found that the impact period effects of temporary shock on inflation and exchange rate are divergent, while the long run effects are convergent, and that the continuous on shock can produce a persistence but non accelerating divergence between inflation rate and the rate of devaluation. The study also concluded that although the relationship between price level and exchange rate is not unidirectional, the short run effect of devaluation on prices is smaller than the effect of inflation on exchange rate.

(Obeng, 2022) study focused on the asymmetric nature of the impact of exchange rate on inflation using NARDL. Using Ghana monthly economic data from January 1990 to January 2020, the study found that the cointegration between inflation rate and exchange rate in Ghana is asymmetric in both short and long run. The impact differ according to the direction of change as the impact is larger in the case of depreciation than appreciation.

In the same context, (Nogueira, 2002) argued that there are many sources of nonlinearity in the relationship between inflation and exchange rate. Countries responds asymmetry to the magnitude of changes in exchange rate. These asymmetric responds are due to different macroeconomic stability conditions of those countries.

3. Methodology:

The study of the impact of Exchange rate on inflation could not be done using standard linear model as the changes in exchange rate do not affect inflation equally. According to empirical

literatures, the pass-through effect of exchange rate on inflation is asymmetric especially in countries with high exchange rate volatility.

To test asymmetric impact of exchange rate on inflation this paper adopted nonlinear autoregressive distributed lag model NARDL. This model could be used to detect the long-run and short-run asymmetric simultaneously. In this model the independent variable is decomposed into its positive and negative partial sums reflecting the asymmetric long run effect of the positive and negative changes of this variable, as follow:

$$y_t = \beta^+ x_t^+ + \beta^- x_t^- + u_t \quad (1)$$

Where the coefficient Parameters β^+ and β^- reflect the long run positive and negative changes in the explanatory variable x_t on the explained variable y_t, respectively. And:

$$x_t^+ = \sum_{i-1}^{t-1} I\,(\Delta x_{t-i} > 0)\Delta x_{t-i}, \quad \text{and}$$

$$x_t^- = \sum_{i-1}^{t-1} I\,(\Delta x_{t-i} < 0)\Delta x_{t-i} \quad (2)$$

In the previous equation, (I) refer to the indicator function where it is equal to one if the event between brackets occurs and zero if it does not (Demirel, 2021). And the NARDL (p, q) equation is as follow (Shin, 2014):

$$y_t = \sum_{j=1}^{p} \emptyset_j\, y_{t-j} + \sum_{j=0}^{q} \left(\theta_j^+ x_{t-j}^+ + \theta_j^- x_{t-j}^-\right) + \epsilon_t \quad (3)$$

Where θj^+ and θj^- are the asymmetrically distributed lag parameters. While the conditional nonlinear error correction is:

$$\Delta y_t = \alpha_0 + \rho y_{t-1} + \theta^{+\prime} x_{t-1}^{+\prime} + \theta^{-\prime} x_{t-1}^{-\prime} + \sum_{j=1}^{p-1} \gamma_j \Delta y_{t-j} + \sum_{j=0}^{q-1} \left(\pi_j^{+\prime} \Delta x_{t-j}^+ + \pi_j^- \Delta x_{t-j}^-\right) + e_t \quad (4)$$

$$\Delta y_t = \rho\varepsilon_{t-1} + \sum_{j=1}^{p-1}\gamma_j \Delta y_{t-j} + \sum_{j=0}^{q-1}\left(\pi_j^{+\prime}\Delta x_{t-j}^{+} + \pi_j^{-}\Delta x_{t-j}^{-}\right) + e_t \quad (5)$$

Where ξ_t represents the nonlinear error correction term.

To test cointegration among the variables, two procedures are followed. The first is an F test developed by following the F Bounds-Testing procedure developed by (Pearan, 1998). While the second is the t-statistic testing procedure developed by following (Banerjee, 1998). After testing cointegration, Wald test is used to test both short- term and long-term symmetries whose conditions are:

$\sum_{i=0}^{q-1}\pi_i^{+} = \sum_{i=0}^{q-1}\pi_i^{-}$ for short term symmetry

$\beta^{+} = \beta^{-}$ for long term symmetry

Results and Discussion:

This paper used quarterly data obtained from the Egyptian central bank reports for the period 2013: Q1 to 2022: Q2, to estimate the relationship between exchange rate and inflation. Following the studies of (Campa, 2006) and (Nogueira, 2002) the following model was adopted:

$$inf_t = \mu + \sum_{i=1}^{p}\emptyset_i inf_{t-1} + \sum_{i=0}^{q1}\theta_i^{+} ex_{t-1}^{+} + \sum_{i=0}^{q2}\theta_i^{-} ex_{t-1}^{-} \sum_{i=0}^{q3}\alpha_i imp_{t-1} + \sum_{i=0}^{q3}\delta_i\, growth_{t-1} \quad (6)$$

Where (*inf*) is inflation rate and (*ex*) is the nominal exchange rate. This exchange rate is decomposed into two factors reflecting the direction of the change (ex^{+}, ex^{-}). (*imp*) is the Egyptian imports growth Rate. While (*growth*) is the annual real GDP growth rate. The following table shows the used data, that were collected mainly from the Egyptian Central Bank reports.

Table (1): variables of the model

	exchange rate*	Inflation*	Growth**	Imports**
2022q2	18.802	1.397%	8.300	-7.1833
2022q1	16.281	1.546%	9.800	0.5143
2021q4	15.902	0.522%	7.700	8.6947
2021q3	15.904	0.695%	2.900	5.3953
2021q2	16.164	0.586%	2.000	14.7983
2021q1	15.887	0.118%	0.700	-4.4367
2020q4	15.871	0.738%	-1.700	-9.492
2020q3	16.098	-0.091%	5.000	-12.8977
2020q2	16.126	0.442%	5.600	-14.8143
2020q1	15.951	0.421%	5.600	-7.5227
2019q4	16.337	0.181%	5.697	-4.4343
2019q3	16.731	0.795%	5.621	-9.632
2019q2	17.258	0.272%	5.549	0.609
2019q1	17.830	1.057%	5.348	6.4917
2018q4	18.137	-0.521%	5.385	15.046
2018q3	18.140	2.247%	5.400	27.597

2018q2	18.037	1.719%	5.282	27.4073
2018q1	17.896	0.406%	5.181	15.693
2017q4	17.924	0.620%	5.002	11.2657
2017q3	18.022	1.783%	4.417	2.5067
2017q2	18.340	1.394%	3.916	-11.5933
2017q1	17.683	2.882%	3.420	-7.3617
2016q4	14.483	3.225%	4.451	-3.721
2016q3	8.770	1.305%	3.715	8.761
2016q2	8.770	1.697%	4.053	4.1823
2016q1	7.930	0.938%	5.117	26.701
2015q4	7.781	0.595%	3.333	-0.0253
2015q3	7.720	1.273%	3.271	-2.1477
2015q2	7.520	0.497%	5.222	18.665
2015q1	7.520	1.464%	5.629	-13.4223
2014q4	7.130	0.035%	5.139	7.0253
2014q3	7.130	1.781%	3.458	29.6087
2014q2	7.054	0.234%	1.528	-19.4073
2014q1	6.941	1.044%	1.611	-6.208

2013q4	6.874	0.330%	1.638	-17.7177
2013q3	7.084	0.960%	1.961	-12.331
2013q2	6.929	0.731%	2.201	-5.231
2013q1	6.783	1.608%	2.920	2.2443

Source: * Central Bank of Egypt statistics, on:

https://www.cbe.org.eg/en/EconomicResearch/Statistics/Pages/OfficialRatesListing.aspx

** Egyptian Ministry of Planning & Economic Development, on:

https://mped.gov.eg/Analytics?id=61

Using E-views 12, the descriptive statistics of these variables are generated as follow:

	Exchange Rate	Growth	Imports	Inflation
Mean	13.20369	4.246411	1.674403	0.009718
Median	15.90292	4.725328	0.244500	0.007665
Maximum	18.80187	9.800000	29.60870	0.032253
Minimum	6.783083	-1.700000	-19.40730	-0.005213
Std. Dev.	4.795357	2.147208	13.23094	0.007937

Source: Calculated using Eviews 12.

The statistical analysis of the data shows that most of the variables showed a considerable volatility or variation during the study time, especially imports which coefficient of variation is relatively high comparing to other variables.

Before adopting the NARDL model, ADF test of stationarity is performed to identify the integration level of the variables as the NARDL is only used when variables are I(0) or I(1). Using Augmented Dickey Fuller test (ADF): Exchange rate is stationary at the first difference I(1). While growth rate, imports and inflation are stationary at level.

To apply NARDL, two series for exchange rate are generated one for the positive changes (exc_pos), while the other capture the negative changes of exchange rate (exc_neg). After that, the optimal lag length for the model is identified for all regressor using Schwarz Info Criterion (SIC), and the NARDL model suitable for the data is NARDL (3,2,4,4,4). The estimation results are shown in the following table:

Table 2: Estimation Results

Selected Model: NARDL(3, 2, 4, 4, 4)				
Variable	Coefficient	Std. Error	t-Statistic	Prob.*
INFLATION(-1)	-0.9566	0.2326	-4.1121	0.0017
INFLATION(-2)	-0.8948	0.2857	-3.1320	0.0095
INFLATION(-3)	-0.4722	0.2077	-2.2732	0.0441
EX_NEG	0.0257	0.2325	0.1106	0.9139

EX_NEG(-1)	0.3122	0.2102	1.4851	0.1656
EX_NEG(-2)	-0.2248	0.1325	-1.6962	0.1179
EX_POS	0.0571	0.0089	6.4535	0.0000
EX_POS(-1)	0.0585	0.0140	4.1876	0.0015
EX_POS(-2)	0.0682	0.0175	3.8957	0.0025
EX_POS(-3)	0.0578	0.0184	3.1506	0.0092
EX_POS(-4)	0.0277	0.0137	2.0179	0.0687
GROWTH	-0.0004	0.0009	-0.4960	0.6297
GROWTH(-1)	0.0002	0.0009	0.2337	0.8195
GROWTH(-2)	0.0012	0.0009	1.3765	0.1960
GROWTH(-3)	-0.0005	0.0012	-0.4739	0.6449
GROWTH(-4)	-0.0009	0.0009	-0.9530	0.3611
IMPORT	0.0004	0.0001	3.9842	0.0021
IMPORT(-1)	0.0002	0.0001	1.5581	0.1475

IMPORT(-2)	0.0002	0.0001	1.9444	0.0779
IMPORT(-3)	-0.0001	0.0001	-0.4300	0.6755
IMPORT(-4)	0.0002	0.0001	1.9083	0.0828
C	0.0212	0.0066	3.2384	0.0079
R-squared	0.9007	Mean dependent var		0.0098
Adjusted R-squared	0.7112	S.D. dependent var		0.0084
S.E. of regression	0.0045	Akaike info criterion		-7.7354
Sum squared resid	0.0002	Schwarz criterion		-6.7377
Log likelihood	149.6344	Hannan-Quinn criter.		-7.3997
F-statistic	4.7531	Durbin-Watson stat		2.3051
Prob(F-statistic)	0.0053			

Source: from the output of E-views12

The estimation results suggested that in the short run only the positive changes in the exchange rate are significant while negative changes in all its lags are significant. It also suggested that imports value has a significant effect on inflation rate, while the coefficient of growth rate is insignificant.

After that error correction model is estimated as follow:

Table (3): Error correction model estimation

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(INFLATION(-1))	1.3669	0.3668	3.7272	0.0033
D(INFLATION(-2))	0.4722	0.1706	2.7669	0.0183
D(EX_NEG)	0.0257	0.1302	0.1975	0.8471
D(EX_NEG(-1))	0.2248	0.0853	2.6364	0.0231
D(EX_POS)	0.0571	0.0061	9.3166	0.0000
D(EX_POS(-1))	-0.1537	0.0325	-4.7247	0.0006
D(EX_POS(-2))	-0.0855	0.0216	-3.9617	0.0022
D(EX_POS(-3))	-0.0277	0.0109	-2.5353	0.0277
D(GROWTH)	-0.0004	0.0005	-0.8704	0.4027
D(GROWTH(-1))	0.0002	0.0004	0.5399	0.6000
D(GROWTH(-2))	0.0015	0.0005	3.1096	0.0099
D(GROWTH(-3))	0.0009	0.0006	1.3962	0.1902
D(IMPORT)	0.0004	0.0001	6.0066	0.0001
D(IMPORT(-1))	-0.0004	0.0001	-3.4317	0.0056
D(IMPORT(-2))	-0.0002	0.0001	-2.2062	0.0495

D(IMPORT(-3))	-0.0002	0.0001	-3.0314	0.0114
CointEq(-1)*	-3.3235	0.4984	-6.6677	0.0000
R-squared	0.9359	Mean dependent var		0.0001
Adjusted R-squared	0.8717	S.D. dependent var		0.0104
Sum squared resid	0.0002	Schwarz criterion		-7.2675
Durbin-Watson stat	2.3051			

Source: from the output of E-views12

To test the existence of cointegration among the variables, the Bounds test is used, the test shows that there is a cointegration between variables as F-statistics is larger than the higher bound critical value at 5% significance Level, as shown from following table:

Table (4): Bounds test for Cointegration

F-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	Value	Signif.	I(0)	I(1)
F-statistic	5.0942	10%	2.2	3.09
k	4	5%	2.56	3.49
		2.50%	2.88	3.87
		1%	3.29	4.37

Source: from the output of E-views12

The bounds test suggested that there is a cointegration between variables as F-statistic is larger than the test upper bounds.

After that the long-run coefficients are estimated as follow:

Table (5): long run Estimates

Variable	Coefficient	Std. Error	t-Statistic	Prob.
EX_NEG	0.0375	0.1100	0.3410	0.7367
EX_POS	0.0804	0.0101	7.9463	0.0000
GROWTH	0.0014	0.0002	5.7335	0.0000
IMPORT	0.0001	0.0001	1.3079	0.2057

Source: from the output of E-views12

Again, the long run results showed that only the positive movement in exchange rate is significant. These results could be confirmed by conducting Wald test for asymmetry. The result is as follow:

Table (6): Wald-test results

Test Statistic	Value	Df	Probability
t-statistic	4.1975	8.0000	0.0030
F-statistic	17.6191	(1, 8)	0.0030
Chi-square	17.6191	1.0000	0.0000

Source: from the output of E-views12

The result of the test is to reject H_0 which stated that the coefficients of positive and negative changes are equal. And thus, the test confirms the asymmetric impact of exchange rate on inflation.

- **Conclusion:**

From the estimation of the NARDL model we can conclude that there is a cointegration between inflation rate and exchange rate in Egypt since 2013. The exchange rate affects the price level of the country in both short-run and long-run. But the inflation responds asymmetrically to the changes in exchange rate. Only the positive changes of exchange rate affect the price levels in both short and long run. This is actually making sense as the producers used to transfer the increase in the costs resulting from the changes in the exchange rate directly to consumer especially in the case of local and imported goods which demand is less elastic than its supply, while on the other hand there are more caution in decreasing the process as the exchange rate decrease again. The other factor that may explain theses results is the gap between official exchange rate and real effective exchange rate, which makes the projection of future exchange rate always with the expectation of increasing and that any decrease in exchange rate is thought to be temporary and thus has no impact on prices.

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