Asymmetric exchange rate pass-through to consumer prices in Egypt

تأثير سعر الصرف غير المتماثل على أسعار المستهلك في مصر

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Abstract

This paper investigates the exchange rate pass-through to consumer prices in Egypt during the period (1960- 2020). A Nonlinear Autoregressive Distributed Lags (NARDL) model is employed to isolate domestic currency depreciations from its appreciations and to account for the potential asymmetry in the impact of the exchange rate on consumer prices. The results of the study show evidence of asymmetric pass-through to consumer prices in the long run. The exchange rate pass-through effect is found to be positive but incomplete in the periods of domestic currency depreciation and statistically insignificant in the periods of currency appreciation. These results are consistent with the stickiness of prices downwards. Accordingly, we recommend that the Egyptian monetary authority should carefully and consistently monitor the behavior of the exchange rate and adopt efficient exchange rate management policies so as to reduce exchange rate fluctuations, resist the inflationary pressures arising from the external sector and ensure the stability of consumer prices.

Keywords: Asymmetric exchange rate pass-through – Consumer prices – Inflation – Non linear ARDL - Egypt.

المستخلص:

يتناول هذا البحث معدل انتقال سعر الصرف إلى أسعار المستهلك في مصر خلال الفترة (١٩٦٠– ٢٠٢٠).

يتم استخدام نموذج الانحدار الذاتي الموزع غير الخطي (NARDL) لعزل انخفاضات قيمة العملة المحلية عن

ارتفاعاتها وتفسير عدم التماثل المحتمل في تأثير سعر الصرف على أسعار المستهلك. تظهر نتائج الدراسة دليلاً على عدم تناسق أسعار المستهلك على المدى الطويل. وتبين أن تأثير سعر الصرف إيجابي ولكنه غير مكتمل في فترات انخفاض قيمة العملة المحلية وغير مهم إحصائيا في فترات ارتفاع قيمة العملة. وتتوافق هذه النتائج مع ثبات الأسعار في الانخفاض. وعليه نوصي السلطة النقدية المصرية بمراقبة سلوك سعر الصرف بعناية وباستمرار وتبني سياسات فعالة لإدارة سعر الصرف بما يؤدي إلى الحد من تقلبات سعر الصرف ومقاومة الضغوط التضخمية الناشئة عن القطاع الخارجي وضمان استقرار أسعار المستهلك.

الكلمات المفتاحية: سعر الصرف غير المتماثل – أسعار المستهلك – التضخم – ARDL غير الخطي – مصر.

Introduction

The challenge of maintaining price stability and low inflation rates continue to persist in most of the developing economies, especially, small open ones. Low inflation rate is a necessary condition for achieving macroeconomic stability. In general, high inflation rates adversely affect macroeconomic stability through different channels; lower domestic savings enhanced by deeply negative real interest rates, lower capital accumulation because of increased uncertainty, and real exchange rate depreciation due to decreasing the purchasing power of domestic currency. In an economy facing strong inflationary pressures, it is important for the central bank to be aware of the determinates of inflation and the monetary conditions required for achieving the targeted rates. The degree to which domestic prices adjust to changes in foreign exchange rates is a key factor in understanding inflation dynamics and thus designing monetary policy.

In Egypt, the effect of exchange rate changes on domestic prices has attracted an increasing attention among researchers and policymakers since the 1990s when the Egyptian government launched the Economic Reform and Structural Adjustment Program (ERSAP), after which Egypt had witnessed different macroeconomic policies and multiple changes in its exchange rate regime.

In November 2016 and based on the recommendation of the International Monetary Fund (IMF), the Egyptian monetary authority announced the liberalization of the exchange rate and hence the devaluation of the Egyptian pound. As a result, the Egyptian pound devalued by around 50%. In March 2022, a second substantial devaluation took place and Egyptian pound lost about 18% of its external value. This

was followed by a third devaluation in October 2022 by 23.5%. Although these successive devaluations were mainly intended to stabilize the economy and mitigate the adverse repercussions caused by the covid-19 pandemic and the global inflationary pressures of the Russian-Ukrainian war, they resulted in an unprecedented increase in prices of all goods and services, and hence lower standards of living and harder living conditions especially for the vulnerable low-income groups.

The main objective of this study is to examine the extent of exchange rate pass-through to consumer prices in Egypt during the period (1960- 2020) using annual data and the Nonlinear Autoregressive Distributed Lag (NARDL) approach following Shin et al. (2014) to isolate domestic currency depreciations from appreciations and account for their potential asymmetric impact on consumer prices.

Our study contributes to the extant literature by assessing the effect of changes in the exchange rate on consumer prices over a long-time span ranging from 1960 to 2020. This long period was selected to include the different exchange rate regimes and several currency devaluations that the Egyptian economy had witnessed especially the substantial devaluation of 2016. Our study also includes the period when the intention of adopting an inflation-targeting regime was officially announced in 2005 and the monetary authority started working on its prerequisites. Furthermore, most of the previous studies assumed that both domestic currency depreciations and appreciations have a symmetric effect on inflation. However, recent theoretical and empirical research suggests that the adjustment behavior of some of the economic variables involves significant asymmetries, so in this study, we hypothesize that the exchange rate changes have an asymmetric impact on consumer prices.

Following this introductory section, we present a brief overview of the theoretical and empirical literature in section 2. An analytical overview of the development of the exchange rate regime, exchange rate and consumer prices is presented in section 3. Sections 4 and 5 present model specification and data, and econometric methodology, respectively. Empirical results are summarized in section 6. Section 7 concludes and provides some policy recommendations.

1. Theoretical background and empirical literature review

Goldberg and Knetter (1997) defined the exchange rate pass-through (ERPT) as the percentage change in domestic currency prices of imports in a country resulting from one percent change in the nominal exchange rate between the country and its trading partners. According to Menon (1995), ERPT is defined as the degree to which exchange rate changes are reflected in the domestic currency prices of traded goods.

However, changes in import prices are to some extent also passed on to producer and consumer prices. In our paper, the exchange rate pass-through is studied more broadly as the change in the consumer prices that results from a change in the nominal exchange rate.

The exchange rate pass-through to domestic inflation is demonstrated through two main transmission channels: a direct and an indirect channel. The direct channel of transmission operates via consumption and cost sub-channels. Through the consumption channel, an exchange rate shock is directly transmitted from the prices of imported goods and services to the overall price level. Concludingly, the final influence on overall price level will depend on the import substitutability, price rigidities and the degree of competition in the market. Through the cost channel, the shock is initially transmitted to the prices of imported inputs then to the producers' prices and eventually, to the final prices of domestic products. On the other hand, the indirect channel links between the exchange rate and inflation through external demand on exports. Through this channel, depreciation of the domestic currency increases the competitiveness of domestic products in international markets resulting in higher exports, which increases the aggregate demand and hence, boosts the aggregate output and increases the overall price level. In addition, depreciation causes an increase in the relative price of imports causing an increase in the demand for domestic products. As a result, the supply of domestic products becomes insufficient to meet this excess demand creating an upward pressure on the price of domestic products. In the long run, the increase in internal as well as external demand for domestic products causes an increase in real wages and subsequently, the cost of production and hence, the overall price level (Kahn, 1986; Lafleche, 1997; Rincon and Rodriguez, 2016).

In the literature, there is no consensus on the key determinates of ERPT to domestic prices. The exchange rate pass-through to domestic prices is determined by various microeconomic as well as macroeconomic factors. Krugman (1989) and Dornbusch (1987) emphasized the role of microeconomic determinants. They attributed the incomplete ERPT to competition among firms and their tendency to

adjust their mark up prices to maintain their market share instead of fully passing the exchange rate changes to prices. Accordingly, the exchange rate shocks are partially absorbed by lowering firms' profits and adjusting their mark-ups (Campa and Goldberg, 2005). These mark ups adjustments are mainly determined by the degree of product differentiation (the substitutability between imported and domestic goods), the degree of market integration and the degree of price discrimination. Hence, lower product differentiation and market integrations as well as higher degree of price discrimination lead to higher ERPT. In addition, rigidities of nominal prices delay the impacts of exchange rate fluctuations in the short run (Obstfeld and Rogoff, 2000). Finally, the different stages of production process may take place in different countries, the final price of a commodity embodies different currencies that may not all move together resulting in lower pass-through (Mishkin, 2008). Concludingly, the ERPT may appear to be weak.

Krugman (1989); Darvas (2001); Steel and King (2004); Beirne and Bijsterbosch (2009); and Razafimahefa (2012) claimed that the speed of the ERPT is influenced by the exchange rate regime. Under flexible regimes, producers consider changes in the exchange rate as just temporary. Therefore, they do not adjust their selling prices rapidly. On contrast, producers consider any change in the exchange rate as permanent and will have a permanent effect on their production costs under fixed exchange rate regimes. As a result, they adjust selling prices instantaneously.

At the macroeconomic level, Taylor (2000) argued that the ERPT and persistence of inflation are directly related. Exchange rate shocks are expected to exert inflationary pressures due to volatility of consumer prices. However, less persistent level of inflation and more stable monetary policy was found to have limited the ERPT to domestic prices in many industrial countries (Mishkin, 2008). Consequently, under inflation targeting regimes, anchored inflation expectations help to reduce inflationary pressures of exchange rate shocks. Among the other macroeconomic determinates of ERPT, output growth, degree of trade openness, composition of imports, and credibility of the monetary authority are found to key factors that affect the degree of ERPT (McCarthy, 2000; Campa & Goldberg, 2005).

Empirical evidence on the impact of exchange rate changes on domestic prices is inconclusive. Several studies examined the ERPT to domestic prices using not only different econometric methodologies but also different indicators of the price level such as Consumer price index (CPI), Producer price index (PPI), Import prices (IP). While the findings of Goldfajn and Werlang (2000), McCarthy (2000) showed that the ERPT estimates across different countries were significantly different. Other empirical studies found that the exchange rate influences domestic prices, and that

ERPT declines along different stages of the distribution process (McCarthy, 2000; Bhundia, 2002). The findings of Rowland (2004), Hyder and Shah (2004) and Leigh and Rossi (2002) concluded that exchange rate changes had limited impact on consumer prices, compared to the producer prices in Colombia, Pakistan, and Turkey respectively. Belaisch (2003) found similar results where the prices of tradable goods were found to be more sensitive to exchange rate shocks than consumer prices in Brazil. On contrast, Uddin et al. (2014) indicated that the ERPT to consumer prices is highest Bangladesh.

McCarthy (2000) investigated the ERPT on a sample of industrialized economies using the Vector Autoregression (VAR) model. The study found that the exchange rate has a modest effect on consumer prices and that the ERPT is correlated with the degree of trade openness of the economy. The Study concluded that countries with a higher share of imported goods were associated with higher magnitude of ERPT. The results of this study shifted empirical studies' focus towards developing countries because of their high share of imported goods.

Following McCarthy (2000), Savastano et al. (2005) investigated the ERPT in eight emerging economies including Egypt during the period (1990-2004) using a VAR model. The study was based on the price chain approach and used both CPI and WPI as indicators of inflation. For Egypt, the empirical evidence showed that ERPT to CPI was low and statistically insignificant. However, ERPT to WPI was statistically significant and much higher ranging from 30% to 60%.

In Egypt, Massoud (2014) and Helmy et al. (2018) followed the same price chain model by McCarthy (1999) to analyze the effect of exchange rate changes on domestic inflation using a Structural vector autoregression model (SVAR). The study conducted by Massoud (2014) investigated ERPT during the period (2003-2013). The results found evidence of an incomplete pass-through for both CPI and PPI. The magnitude of the ERPT was modest for both indicators; however, it was much larger for the CPI as the PPI excluded imported goods.

A similar study was conducted by Helmy et al. (2018) covering the period (2003-2015) to examine ERPT in Egypt. The empirical results of the study were in line with Massoud (2014); thus, the impact of exchange rate shocks to both PPI and CPI were substantial but slow and incomplete. The study also compared the effect of the increase in import prices on domestic prices to the impact of exchange rate changes. The results were much higher in the case of exchange rate changes reflecting that the indirect transmission channel is stronger than the direct channel.

Awad (2019) studied the reasons behind the weak statistical association between exchange rate shocks and inflation in Egypt. This study utilized SVAR and the Markov switching regression models. The results showed that the ERPT to inflation is insignificant across the whole period (2006-2016). However, the results were significant for the sub-periods (2006-2014) and (2011-2016). The study attributed the variation of ERPT between the sub-periods to monetary policy intervention and structural breaks in the time series data resulting due to changes in monetary policy regimes.

Previous studies conducted on Egypt assumed that inflation rate respond symmetrically to domestic currency depreciations as well as appreciations. However, several recent studies have found evidence of potential asymmetric impact of exchange rate movements on domestic prices. This asymmetric impact is mostly attributed to price rigidities meaning that prices are less sticky upwards than they are downwards. The new strand of empirical literature relaxes the assumption of a symmetric ERPT so as not to distort the impacts of monetary policies. The findings of Razafimahefa (2012) for countries in Sub- Saharan Africa.; Frankel et al. (2012); Delatte and Lopez-Villavicencio (2012) for four major developed countries; Maka (2013) for Ghana; Baharumshah et al. (2017) in Sudan generally supported the asymmetric hypothesis, which indicates that currency depreciation has a different impact on domestic prices than currency appreciation.

2. Analytical overview on exchange rates and inflation rates in Egypt

Before estimating the exchange rate pass-through to domestic consumer prices in Egypt, it is important to analyze and understand the evolution of the adopted exchange rate regimes and relate the exchange rate changes to the inflationary trends witnessed by the Egyptian economy. Figure (1) depicts the evolution of Exchange rate and inflation rate in Egypt during the period (1960-2020).

Figure (1): Exchange rate and inflation rate in Egypt during the period (1960-2020).
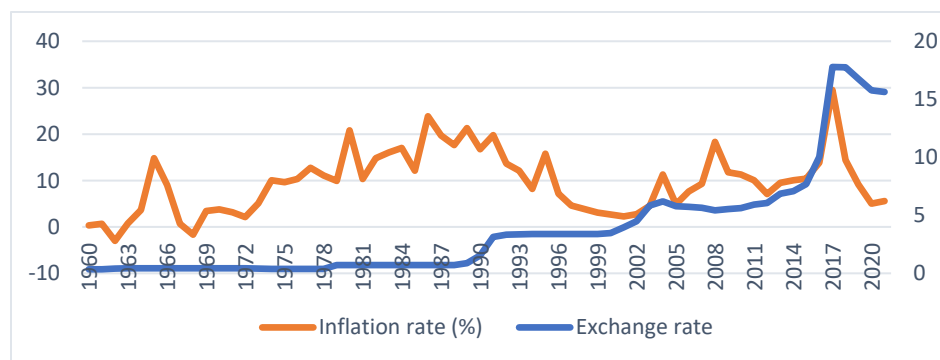
Source: Authors' calculations based on world bank database.

Starting from the 1960s till the early 1990s, Egypt had adopted a fixed exchange rate regime. The Egyptian monetary authority had kept the exchange rate of the Egyptian Pound fixed to the USD. The central bank of Egypt (CBE) had adjusted the exchange rate of the Egyptian pound from 0.70 (LE/$) to 1.55 (LE/$) in 1990. In 1991 as a part of the Economic Reform and Structural Adjustment Program (ERSAP), the CBE altered its exchange rate regime to a managed floating regime. As a result of adopting the new regime, the exchange rate of the Egyptian Pound devalued from 1.55 (LE/ $) to 3.4 (LE/$), on average between 1990 and 2000. Following the first stage of the ERSAP, the inflation rate had experienced a declining path. The inflation rate had significantly declined from 19.75% in 1991 to 2.7% in 2000.

Egypt started the adoption of a floating exchange rate regime in 2003. This was mainly due to the unavailability of dollars at official prices which increased parallel market transactions, as accompanied by the losses in the Egyptian tourism revenues caused by September 2001 terrorist attack against the USA (Massoud, & Willett, 2014). However, the lack of credibility in the newly adopted exchange rate regime and public expectations of further devaluation caused a severe shortage of foreign exchange (Khodeir, 2012). During the period from 2000 to 2004, the Egyptian pound had witnessed a depreciation of 80% against the USD. The disturbance in the foreign exchange market, during this phase, was reflected in highly volatile domestic prices. The inflation rates accelerated to double digit levels to reach 11.3% in 2004. The persistently higher prices, prevailed during 2004, can be attributed to the lagged passthrough effect of the exchange rate changes (Helmy et al., 2018).

In December 2004, the CBE established the interbank foreign exchange market, and the Egyptian pound was strengthened. Furthermore, in 2005, the monetary policy committee announced its intention to adopt an inflation targeting regime upon the fulfillment of its prerequisites (Central bank of Egypt, 2004/ 2005). As a result, the Egyptian Pound appreciated by 7% against the USD and the inflation rate decreased and reached a single digit rate. However, this trend was shortly reversed. Inflation rate sharply increased from 4.9% in 2005 to 7.8% in 2006 reaching 18.3% in 2008. This increase in domestic prices was largely driven by the impact of external factors such as Avian Flu outbreak and the rise in the international food and oil prices.

After the eruption of 2011 revolution, Egypt suffered political and social instability. The huge decline in foreign reserve during this period caused the re-emergence of the black market. In order to stop the significant losses of foreign reserves, the CBE announced the adoption of a new system of putting the USD on auction in 2012 to run alongside the dollar interbank system (Central bank of Egypt,

2011/ 2012). Following the introduction of the Foreign Exchange Auctions, the Egyptian Pound depreciated by 27% against the USD from 6.06 in 2012 to 7.69 in 2015. In addition, the inflation rate increased by 46% from 7.11% to 10.4% during the corresponding period. The upward trend in inflation during this period could be mainly attributed to the depreciation the Egyptian pound and the political and security unrest which negatively affected commodity supply in domestic markets and hence, forced the government to revise the prices of many regulated items within the consumer price index (CPI) basket (Helmy, et al., 2018).

In 2016, with the intention of eliminating the parallel foreign exchange market, the CBE announced the free float of the Egyptian pound causing its value to depreciate to around 17.8 (LE/$) in 2017. The Inflation rate also climbed to an unprecedented rate of 29.5% at the same year. The CBE responded by adopting a tightening monetary policy to reduce the inflationary pressures resulting from the liberalization of the exchange rate. Consequently, inflation rate noticeably declined to 14.4% in 2018 and to 5% in 2020. Considering the recent global conditions, the outbreak of COVID-19, the Egyptian pound appreciated against USD by 6% between 2019 and 2020.

From the previous analysis, we can conclude that inflation has been more volatile than the exchange rate since the latter was relatively stable during the whole period, except for sub-periods of devaluation. Moreover, the relationship between the exchange rate change and inflation involves asymmetries; for instance, the depreciation of the Egyptian pound in 2003 had led to high inflation, while the appreciation of the exchange rate since 2005 was still associated with high inflation.

3. Model specification and Data

Based on the theoretical and empirical evidence, in addition to the exchange rate, the specified model includes other control variables which are expected to affect domestic consumer prices such as output gap, money supply, food price index. The specified model can be represented by the following functional form:

$$CPI_t = f(EX_t, GAP_t, M_t, FPI_t)$$

Where,

CPI_t : the consumer price index (2010=100).

EX_t : the official exchange rate (LE/$).

GAP_t: the output gap calculated using the Hodrick-Prescott (HP) filter.

M_t : the broad money supply.

FPI_t : the international food price index.

The output gap is calculated using the Hodrick-Prescott (HP) filter to separate the long-run trend in a data series from the short-run fluctuations. The HP filter for GDP decomposes the real GDP growth into trend and cyclical components (De Jong and Sakarya, 2016). The output gap is represented by the cyclical component which is the difference between the actual series of real GDP and its long-run trend.

The annual data of the consumer price index, official exchange rate, Gross domestic product, money supply was drawn from the World Development Indicators (WDI) by the World Bank, while the annual data for food price index is extracted from the world bank commodity price data (the pink sheet). The time path of each of the included variables is presented in figure (2). All the variables are represented in their natural logarithms.

Figure (2): The time path of the variables in Egypt over the period 1960–2020.
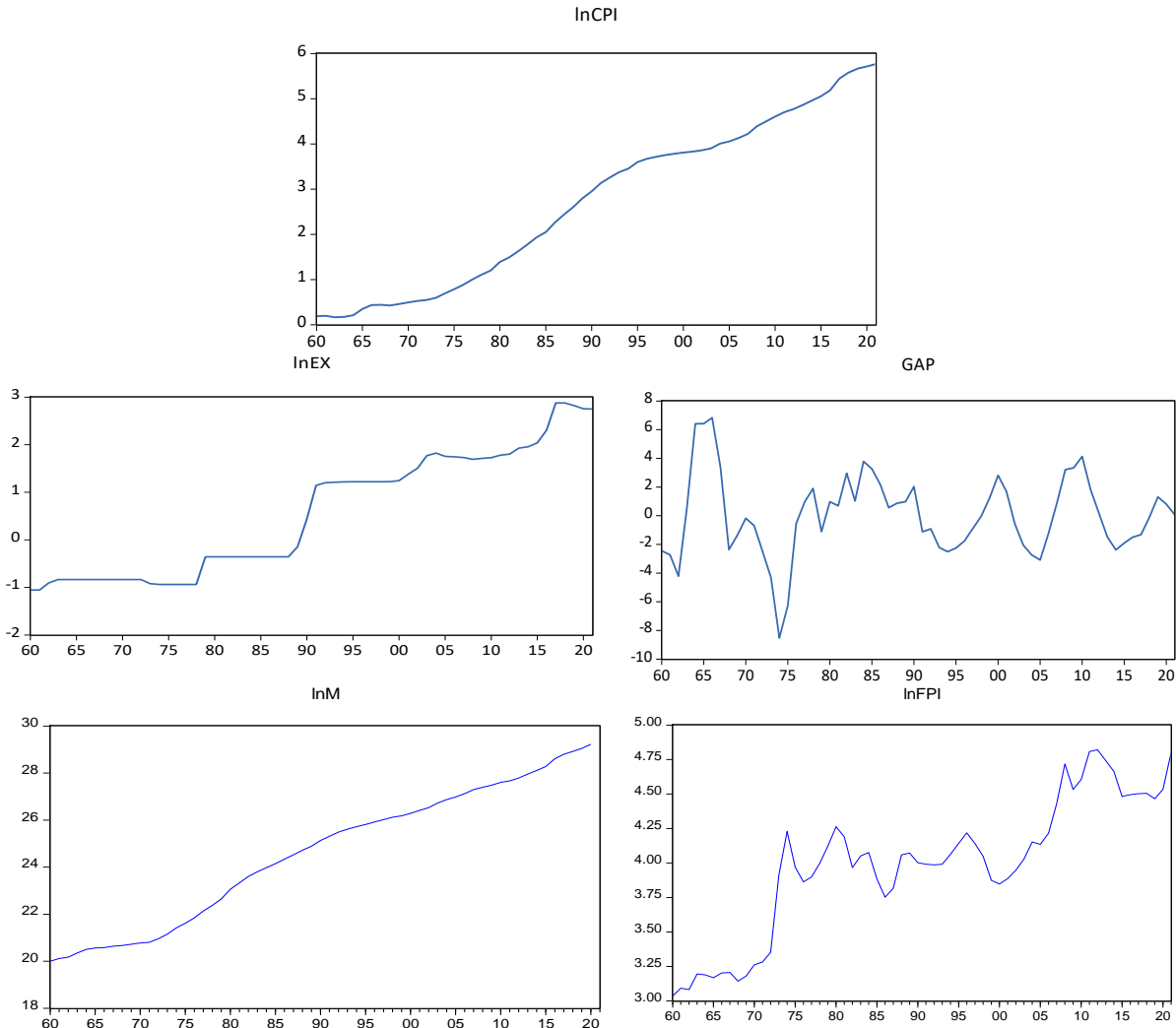
4. Econometric methodology

As previously discussed in the literature review section, the exchange rate pass-through starts from the transmission of exchange rate movements to import prices, however, it does not stop at this stage and get transmitted to both the producer and consumer prices because the imported goods are consumed either directly by the final consumers or indirectly used as intermediate inputs in the production process. Thus, it is important to analyze the second stage or the final pass-through of exchange rate changes to consumer prices.

This study employs a modified specification of Delatte and Lòpez-Villavicencio (2012) and Brun-Aguerre et al. (2017). Following Bahmani-Oskooee and Mohammadian (2017) and Kassi, et al (2019), our study uses the model presented in equation (1) to estimate the exchange rate pass-through to domestic consumer prices within a multivariate framework that also captures the effect of the main determinates of inflation, such as money supply (as a proxy for monetary policy actions), output gap (as a proxy for demand pressures) and international food prices (as a proxy for external supply shocks).

$$CPI_t = \gamma_0 + \gamma_1 EX_t + \gamma_2 GAP_t + \gamma_3 M_t + \gamma_4 FPI_t + u_t \qquad (1)$$

Where, CPI_t is the consumer price index, EX_t is the official exchange rate, GAP_t is the output gap, M_t is the broad money supply, FPI_t is the international food price index and u_t is the standard random error term.

The empirical analysis begins with assessing the stationarity properties of the variables of the study by applying the augmented Dickey-Fuller unit root test to ensure a non-spurious estimation and make sure that none of the included series is integrated of order (2). In this regard, the study applies the Augmented Dickey-Fuller (ADF) test on the level and first difference of each series.

After determining the order of integration of each time series, cointegration between the variables is established via the bounds testing approach within a NARDL unrestricted error correction model. If cointegration is established between the variables, our analysis proceeds by estimating the long-run and short-run asymmetric exchange rate pass-through to consumer prices through the decomposition of the exchange rate changes into positive changes, EX_t^+ and negative changes, EX_t^- as presented in equations (2) and (3). Where the EX_t^+ and EX_t^- are the partial sums of the positive and negative changes in the exchange rate respectively:

$$EX_t^+ = \sum_{i=1}^{t} \Delta EX_t^+ = \sum_{i=1}^{t} \max(EX_i, 0) \tag{2}$$

$$EX_t^- = \sum_{i=1}^{t} \Delta EX_t^- = \sum_{i=1}^{t} \min(EX_i, 0) \tag{3}$$

The study utilizes the NARDL approach proposed by Shin et al. (2014) to test the existence of an asymmetric long-run equilibrium relationship between the exchange rate and consumer prices. Although the linear ARDL model offers some advantages when examining co-integration between variables, it doesn't discriminate the effects of increasing and decreasing any of the independent variables. The NARDL model, in contrast, permits the estimation of these asymmetric impacts in both the short-run and the long run. The NARDL used to estimate the asymmetric impacts of exchange rate on consumer prices can be formulated according to equation (4).

$$\Delta Ln\, CPI_t = \alpha_0 + \sum_{i=1}^{\rho} \alpha_{1i} \Delta \ln CPI_{t-i} + \sum_{i=1}^{q1} \alpha_{2i}^+ \Delta \ln EX_{t-i}^+ +$$
$$\sum_{i=1}^{q2} \alpha_{2i}^- \Delta \ln EX_{t-i}^- + \sum_{i=1}^{q3} \alpha_{3i} \Delta \ln GAP_{t-i} + \sum_{i=1}^{q4} \alpha_{4i} \Delta \ln M_{t-i} +$$
$$\sum_{i=1}^{q5} \alpha_{5i} \Delta \ln FPI_{t-i} + \beta_1 \ln CPI_{t-1} + \beta_2^+ \ln EX_{t-1}^+ + \beta_2^- \ln EX_{t-1}^- +$$
$$\beta_3 \ln GAP_{t-1} + \beta_4 \ln M_{t-1} + \beta_5 \ln FPI_{t-1} + \epsilon_t \tag{4}$$

where Δ is the first difference operator, $\alpha_{1i}, \alpha_{2i}^+, \alpha_{2i}^-\, \alpha_{3i}, \alpha_{4i}$, and α_{5i} are the short run dynamic coefficients of the underlying NARDL model. p, $q1$, $q2$, $q3$, $q4$ and $q5$ are the optimal order of lags determined based on the Akaike information criterion (AIC). $\beta 1, \beta_2^+, \beta_2^-, \beta 3, \beta 4$ and $\beta 5$ are the long-run multipliers, and ϵ_t is a white-noise error term.

The bounds test approach for cointegration uses the Wald test (F-test) to establish if there is a long-run relationship among the series. The null hypothesis of no cointegration, $H_0 = \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = 0$, is tested against the alternative that at least one of β_i, $i = \{1, 2, 3, 4, 5, 6\}$ is not equal to zero. The computed F statistic is compared with the critical values provided by Pesaran et al. (2001) and Narayan (2005) for the hypothesis tests. If the computed F-statistic is less than the lower bound value, the null hypothesis of no cointegration cannot be rejected. On the other hand, if the computed F-statistic exceeds the upper bound value, we will reject the null hypothesis and conclude that there is a long-run relationship among the variables. Finally, if the computed F-statistic lies between the lower bound and upper bound, the bound test is inconclusive.

On finding evidence of a long-run relationship between variables, we can proceed to estimate the long-run asymmetric impact of exchange rate on domestic consumer prices using the following equation:

$$Ln\ CPI_t = \beta_0 + \sum_{i=1}^{\rho} \beta_{1i} \ln CPI_{t-1} + \sum_{i=1}^{q1} \beta_{2i}^+ \ln EX_{t-1}^+ + \sum_{i=1}^{q2} \beta_{2i}^- \ln EX_{t-1}^- +$$
$$\sum_{i=1}^{q3} \beta_{3i} \ln GAP_{t-1} + \sum_{i=1}^{q4} \beta_{4i} \ln M_{t-1} + \sum_{i=1}^{q5} \beta_{5i} \ln FPI_{t-1} + \mu_t \qquad (5)$$

Where μ_t is an error term.

The short-run dynamic parameters may be obtained by estimating the restricted error correction model (ECM):

$$\Delta \ln CPI_t = \alpha_0 + \sum_{i=1}^{\rho} \alpha_{1i} \Delta \ln CPI_{t-i} + \sum_{i=1}^{q1} \alpha_{2i}^+ \Delta \ln EX_{t-i}^+ +$$
$$\sum_{i=1}^{q2} \alpha_{2i}^- \Delta \ln EX_{t-i}^- + \sum_{i=1}^{q3} \alpha_{3i} \Delta \ln GAP_{t-i} + \sum_{i=1}^{q4} \alpha_{4i} \Delta \ln M_{t-i} +$$
$$\sum_{i=1}^{q5} \alpha_{5i} \Delta \ln FPI_{t-i} + \varphi EC_{t-1} + \mu_t \qquad (6)$$

where α reflects the short-run dynamic coefficients and φ captures the speed of adjustment needed to restore equilibrium over the long run following a shock to the system.

Finally, the study uses diagnostic checks to examine the adequacy of the estimated NARDL model. These checks include the Lagrange multiplier (LM) test of residual serial correlation, Jarque-Bera's normality test and the Breusch-Pagan-Godfrey's heteroskedasticity test. We test for long-run asymmetry using the Wald test to check the validity NARDL model. The null hypothesis of symmetry $(H_0: \omega_1^+ = \omega_1^-)$, where $(\omega_1^+ = -\frac{\beta_2^+}{\beta_1})$ and $(\omega_1^- = -\frac{\beta_2^-}{\beta_1})$. If long-run symmetry cannot be rejected, then there is no evidence of asymmetric impacts of exchange rate changes in the model. Stability diagnostics, including the cumulative sum of recursive residuals (CUSUM) test and the cumulative sum of squares of recursive residuals (CUSUM of squares) test are also conducted.

5. Empirical results and discussion
This section presents the empirical results of the applied econometric model.

5.1. Stationarity tests
The results of the augmented Dickey-Fuller (ADF) unit root test are presented in table (1). The results reveal that all the variables are non-stationary at level except the output gap (GAP) which is stationary at level at the 1% significance level. This

implies that none of the included series is integrated of an order greater than one, which validates the bounds test approach for cointegration.

Table (1): ADF unit root test

Variable	ADF-statistic			
	Level		First difference	
	Constant	Constant and trend	Constant	Constant and trend
LnCPI	0.025046	-2.156494*	-3.504279**	-3.437822*
LnEX	-0.373554	-2.930076	-5.086392***	-5.062626***
GAP	-4.940155***	-4.954637***	-5.986900***	-5.917978***
LnM	-0.247613	-1.989293	-3.205218**	-3.176197*
LnFPI	-1.355145	-2.247804	-6.846058***	-6.792453***

Notes: ***, **, and * indicate that the estimated coefficient is statistically significant at the 1%, 5%, and 10%, respectively.

5.2. Deterministic specifications

To estimate the NARDL model, we impose a maximum of six lags on each of the included variables and use the AIC criterion to select the optimum number of lags. Table (2) reports the number of lags (p, q1, q2, q3, q4, q5) that are included in the estimated NARDL regression. The AIC criterion select NARDL (5, 6, 6, 2, 6, 6) model.

Table (2): Order of lags included in NARDL model based on the AIC criterion.

Variable	*Ln CPI*	$LnEX^+$	$LnEX^-$	*GAP*	*Ln M*	*Ln FPI*
Number of lags	5	6	6	2	6	6

5.3. The bounds test for cointegration

Table (3) reports the F-statistic of the cointegration bounds test along with the 95% critical bounds for the asymmetric ARDL model. The results reveal a nonlinear long-run cointegration relationship between consumer price index, exchange rate, output gap, money supply and food price index since the F-statistic is greater than the upper bound of the critical value at the 1% significance level.

Table (3): Results of the Cointegration bounds test.

F-Bounds Test			Null Hypothesis: No levels relationship			
			n= 50		n =55	
Test Statistic	Value	Significance	I(0)	I(1)	I(0)	I(1)
		10%	2.259	3.264	2.226	3.241
		5%	2.67	3.264	2.617	3.743
F-statistic	7.263570***	1%	3.593	4.981	3.543	4.839

Note(s): The lower and upper bound critical values are obtained from Pesaran et al. (2001).

5.4. Estimation of Long run relationship and short run dynamics

The long-run and short-run asymmetric effect of exchange rate changes on consumer prices are presented in table (4). The asymmetric long-run results presented in Panel A of table (4) suggest that there is an asymmetry in exchange rate pass-through to consumer prices in Egypt in the long-run. The findings reveal that domestic currency depreciation has an inflationary impact on consumer prices, whereas an increase of exchange rate by 1% results in an increase of consumer prices by 0.31% at a 1% significance level. The exchange rate pass-through is incomplete during the periods of depreciation. On contrast, a decrease in the exchange rate (appreciation of the Egyptian pound) has a statistically insignificant effect on consumer prices. The output gap has an insignificant effect on consumer prices in the long run. Furthermore, money supply and external price shocks represented by international food prices have inflationary impacts on consumer prices in the long run at significance levels 1% and 10% respectively.

Table (4): Estimated long run and short run parameters of the NARDL model

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Panel A: Long-run coefficients				
LNEX_POS	0.310512***	0.047355	6.557143	0.0000
LNEX_NEG	0.540158	0.564164	0.957447	0.3518
GAP	-0.005107	0.004550	-1.122397	0.2773
LNM	0.448315***	0.020112	22.29085	0.0000
LNFPI	0.224139*	0.121515	1.844537	0.0826
C	-9.502913***	0.351221	-27.05678	0.0000
Panel B: Short-run coefficients				
D(LNCPI(-1))	0.381414***	0.102487	3.721578	0.0017
D(LNCPI(-2))	0.993856***	0.121747	8.163303	0.0000
D(LNCPI(-3))	0.764576***	0.141349	5.409119	0.0000
D(LNCPI(-4))	0.409653***	0.105642	3.877732	0.0012
D(LNEX_POS)	0.099365***	0.026429	3.759674	0.0016
D(LNEX_POS(-1))	-0.021322	0.025546	-0.834645	0.4155
D(LNEX_POS(-2))	-0.118930***	0.024698	-4.815369	0.0002
D(LNEX_POS(-3))	-0.064745**	0.026767	-2.418800	0.0271
D(LNEX_POS(-4))	0.031235	0.028665	1.089659	0.2911
D(LNEX_POS(-5))	0.121540***	0.031188	3.897047	0.0012
D(LNEX_NEG)	-0.439092**	0.182482	-2.406216	0.0278
D(LNEX_NEG(-1))	-0.803265***	0.189890	-4.230161	0.0006
D(LNEX_NEG(-2))	-0.600011**	0.242489	-2.474383	0.0242
D(LNEX_NEG(-3))	-1.530131***	0.268036	-5.708681	0.0000
D(LNEX_NEG(-4))	-0.751426***	0.240026	-3.130610	0.0061
D(LNEX_NEG(-5))	-0.899592***	0.260383	-3.454883	0.0030
D(GAP)	-0.000266	0.002499	-0.106452	0.9165
D(GAP(-1))	0.005172*	0.002577	2.006593	0.0610
D(LNM)	0.114479*	0.062115	1.843003	0.0828
D(LNM(-1))	0.112968	0.083263	1.356758	0.1926
D(LNM(-2))	-0.310101***	0.089691	-3.457414	0.0030

D(LNM(-3))	-0.420618***	0.105505	-3.986694	0.0010
D(LNM(-4))	-0.751795***	0.103940	-7.232939	0.0000
D(LNM(-5))	-0.625716***	0.118842	-5.265094	0.0001
D(LNFPI)	-0.178639***	0.038255	-4.669629	0.0002
D(LNFPI(-1))	-0.175271***	0.040586	-4.318565	0.0005
D(LNFPI(-2))	-0.346658***	0.044922	-7.716921	0.0000
D(LNFPI(-3))	-0.291666***	0.051648	-5.647194	0.0000
D(LNFPI(-4))	-0.141363***	0.029854	-4.735188	0.0002
D(LNFPI(-5))	-0.157180***	0.036392	-4.319081	0.0005
ECT_{t-1}	-0.714031***	0.086090	-8.293991	0.0000
Panel C: Diagnostic tests				
Adjusted R-squared			0.905614	
Serial Correlation			2.042571 [0.1722]	
Heteroskedasticity			0.381224 [0.9926]	
Normality (Jarque-Bera)			2.039958 [0.3606]	
Asymmetry wald test			4.607246 [0.0318]	

Notes: ***, **, and * indicate that the estimated coefficient is statistically significant at the 1%, 5%, and 10%, respectively.

The results of short-term dynamics are summarized in Panel B of table (4). The estimated coefficient of the error-correction term is negative and statistically significant at the 1% significance level which supports the existence of a long-run relationship between the consumer prices and the included explanatory variables. The error correction term shows a high speed of convergence in the long run dynamics of the variables. The speed of adjustment is 0.71, which means that following a shock, it takes about 1.4 years for the cointegrating relationship to converge to its steady state equilibrium.

5.5. Diagnostic checks

The results of the diagnostic checks are presented Panel (c) in table (4). The Lagrange multiplier (LM) test of residual serial correlation statistic and the F-statistic of the Breusch-Pagan-Godfrey test applied for testing homoscedasticity show no evidence of serial correlation or heteroskedasticity in the error term. In addition, Jarque-Bera's normality test provided no evidence to reject the normality assumption. A NARDL asymmetric effects test is conducted to test symmetry in the effect of the exchange rate on consumer prices in the long run. The results show that the null hypothesis of symmetry in effect is rejected as the p-value of the chi-square statistic is less than the 5% significance level.

5.6. Stability of the long-run relationship

The cumulative sum of recursive residuals (CUSUM) and the CUSUM of squares (CUSUMSQ) tests were applied to test for parameter stability. Figure (2) plots the CUSUM and CUSUM of squares statistics for testing the stability of the estimated long-run relationship. The results clearly indicate the absence of any

instability of the coefficients during the investigated period since the plots of the two statistics are confined within the 5% significance critical bounds.

Figure (3): Plots of CUSUM and CUSUMSQ statistics for coefficient stability.
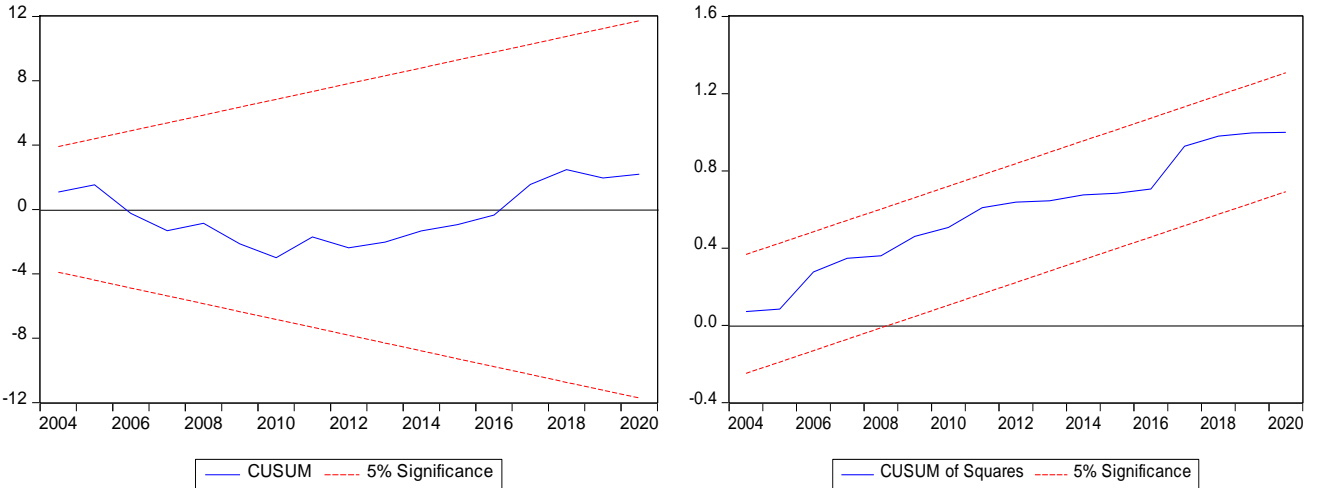
5.7. Goodness of fit

The adjusted R^2 for our regression is reported in Panel c of table (4). The adjusted $R^2 = 0.90$ which reflects the goodness of fit of our model.

6. Conclusion and policy recommendations

The relationship between exchange rate changes and consumer prices inflation has been a long-standing monetary policy concern for most developing economies. This study used an asymmetric ARDL model to examine the exchange rate pass-through (ERPT) to consumer prices in Egypt during the period (1960-2020).

The findings of the study revealed the existence of cointegration between consumer prices, exchange rate, output gap, money supply and international food prices. In addition, an asymmetric exchange rate pass-through to domestic consumer prices was found in the long run. The exchange pass-through was found to be incomplete, about 31%, in the periods of depreciation. This incomplete impact can be attributed to the fact that the CPI in Egypt is composed of a relatively large number of subsidized commodities and goods with administered prices, which is expected to weaken the transmission of exchange rate shocks. Moreover, the exchange rate pass-through was found to be statistically insignificant in the period of domestic currency appreciation. These results are consistent with the stickiness of prices downwards.

These results have implications for consumers and policymakers. The pass-through of exchange rate changes to consumer prices suggests that part of the cost of exchange rate depreciation is borne by consumers. Therefore, persistent exchange rate depreciation may have chronic consequences on consumption patterns, standards of living, profitability of firms, as well as tax revenues. Concludingly, it is imperative for the Egyptian monetary authorities to monitor the behavior of the exchange rate consistently and adopt efficient and timely exchange rate management policies to reduce exchange rate fluctuations and ensure the stability of consumer prices.

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