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Inflation Variations in Egypt: An Asymmetrical Analysis of Pass-Through Effects

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Inflation Variations in Egypt: An Asymmetrical Analysis of Pass-Through Effects

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<u>Abstract</u>

Inflation variations has become an issue that impedes efficient resource allocation and inclusive growth in Egypt. High inflationary pressures negatively affect standards of living, poverty alleviation and finally markets' efficiency. For the past decade, Research on the causes of inflation in emerging markets has been closely linked to exchange rates pass-through (ERPT). This is due to its perceived impacts on import prices and terms of trade shocks, which lead to a pass-through effect to domestic inflation. This research aims to contribute to the literature by investigating ERPT in Egypt with a nonlinear Autoregressive distributed lag model (NARDL). Recent research on ERPT has shown that using NARDL has proven the existence of asymmetric effects of EPRT. The study uses quarterly time series data from 2006Q1-2020Q4 to examine the relationship between exchange rate movements and Inflation. For the purpose of the model, the methodology examines exchange rate and energy price movements' asymmetric effects on producer price inflation using a NARDL model. The findings revealed the following: (1) a weakly significant and symmetric ERPT in Egypt. (2) Inflation in Egypt is highly dependent on past values of itself or what the research calls "Built-in inflation". (3) a strong significant and asymmetric pass-through effect of energy prices. The implications of the findings put forth a need to move towards a fully-fledged inflation targeting regime with crucial complementary policies.

Keywords: Pass-through, Exchange rate pass-through, Inflation, Autoregressive distributed lag model, Nonlinear Autoregressive distributed lag model, Asymmetric effects.

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Acronyms	
ADF	Augmented Dicky Fuller Test
ARDL	Autoregressive-Distributed Lag
CBE	Central Bank of Egypt
CPI	Consumer Price Index
EGP	Egyptian Pound
EMs	Emerging Markets
ERPT	Exchange Rate Pass-Through
GDP	Gross Domestic Product
IFS	International Financial Statistics
IMF	International Monetary Fund
IF	Inflation Targeting
NARDL	Non-linear Autoregressive-Distributed Lag
NEER	Nominal Effective Exchange Rate
PP	Philips Perron Test
PPI	Producer Price Index
SVAR	Structural Vector Autoregression
VAR	Vector Autoregression
WPI	Wholesale Price Index

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1. Introduction

For many decades, the relationship between exchange rate and inflation has been a predominant topic of discussion in macroeconomic literature. Price stability can help emerging economies' (EMs) reach sustainable economic growth and all-inclusive development. Empirical research has documented the positive effects of low and stable inflation (Taylor, 2000). Countries with low inflationary pressures have lower and less persistent impact of pass-through shocks such as exchange rate and energy price movements. The pass-through effect is the measure of inflation responsiveness to a change in exchange rate movements (Goldberg and Knetter, 1997). Most policymakers in EMs have fear of moving towards a floating exchange rate regime due to existent high inflationary pressures. The phenomenon was first identified by Calvo and Reinhart (2002) as "fear of floating", where central banks fear large pass-through effects and liability dollarization more than inefficient allocation of resources.

Since 2003, Egypt has been suffering from a gradual rise in inflation rates. Inflation hikes in Egypt were usually preceded by a devaluation episode. Due to the persistence of these shocks, researchers predicted ERPT to be one of the major causes of inflation in Egypt (Massoud, 2014; Helmy, 2018). As shown on Figure 1 and 2, when the Egyptian pound was floated in November 2016, since then inflation gradually increased to reach 32% in 2017. Others attributed the rise in price levels to increases in food and energy prices. More specifically, as depicted in figure 3, the hike in fuel prices had a greater impact on the overall inflation level.

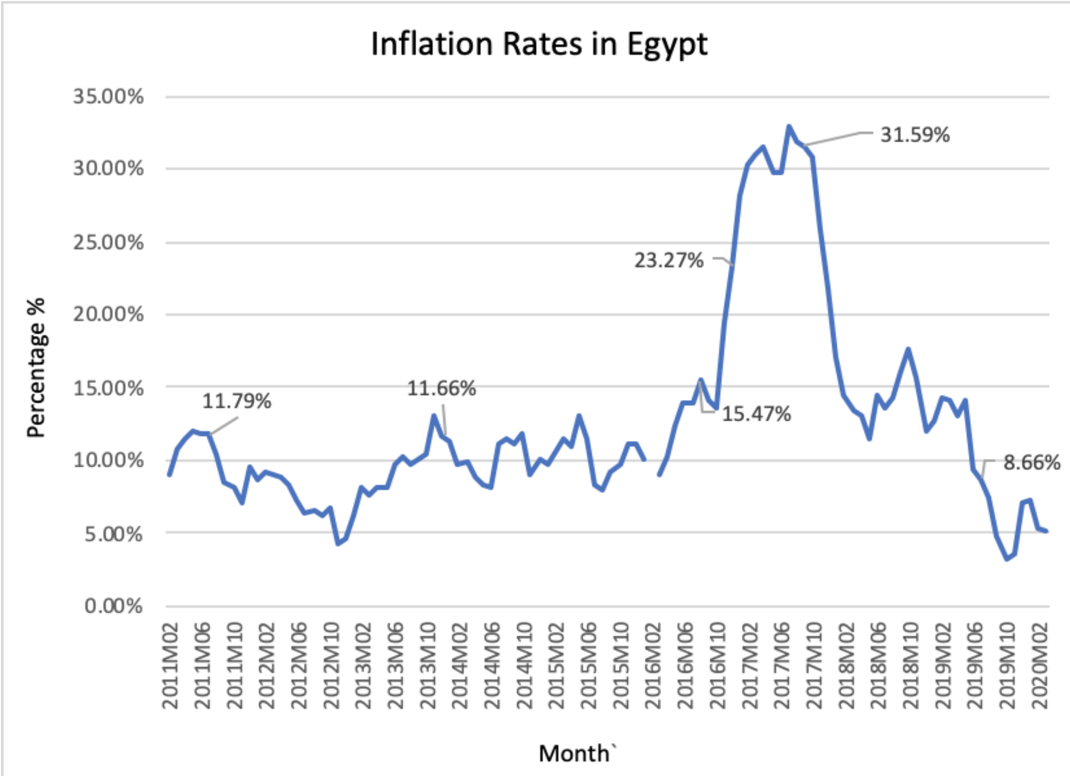

Figure-1: Data source- Central Bank of Egypt (2020)

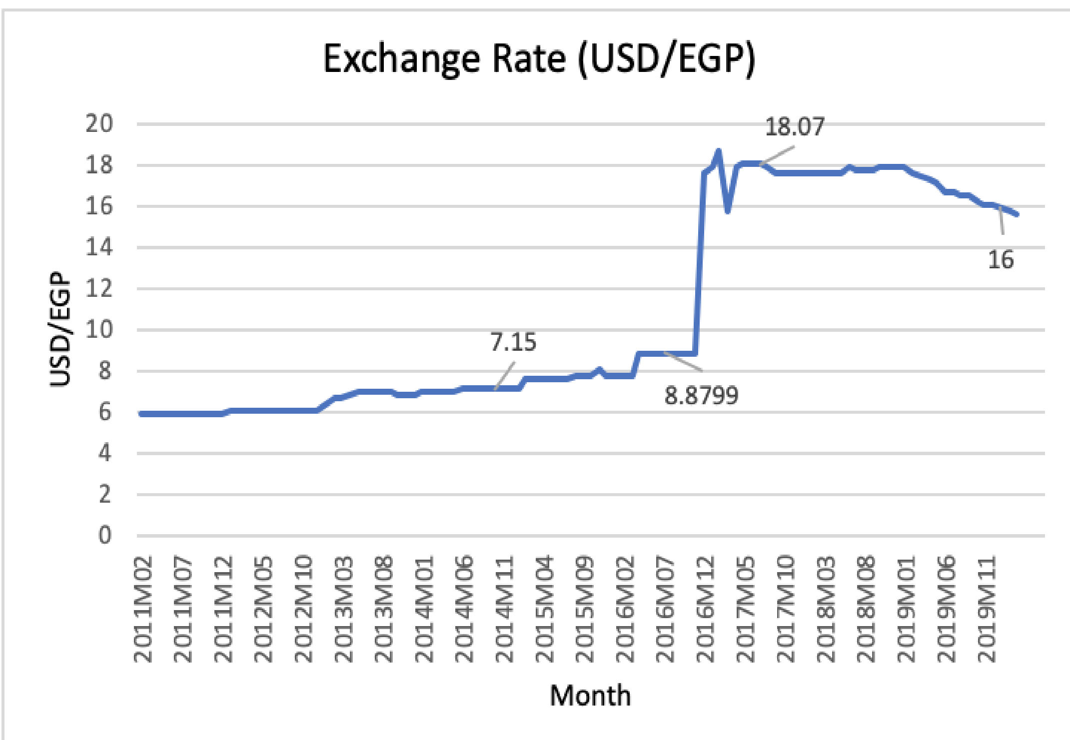

Figure-2: Data source- Central Bank of Egypt (2020)

In 2018, Government officials decided to undergo a new price mechanism to allow the Egyptian market to move with international prices (Amcham, 2018). This was after a prolonged period of administered prices making the transition even more difficult, furthermore, end users carried most of the burden. However, the cause of inflation is not the only factor to be analyzed. In fact, the prolonged period that the economy suffered before hitting single digits is another factor that should be considered. An important element that differentiates EMs from advanced markets is their vulnerability to terms of trade shock.

For many EMs, commodities account for a large share in exports and production which sometimes cause abrupt fluctuations in exchange rate movements. The influence of changes in the exchange rate on prices explains a substantial part of the gain in pricing power, especially in developing countries where import costs account for a large amount of final consumption and intermediate products (Zubaidi, 2017). Therefore, we predict that a rise in the price of imports will not cause an equal effect on inflation as a drop in the price of imports. Similarly, a depreciation in home currency might not have the same effect on inflation that an appreciation might have. The purpose of this study is as follows: (1) to relax the assumption of linearity or equally proportionate changes between price levels and pass-through shocks. (2) to examine the concept of asymmetric effects of exchange rate pass-through (ERPT) on inflation in Egypt. (3) to examine the effects of energy price movements on Inflation in Egypt. Literature on ERPT in Egypt found a weak and insignificant pass-through effect (IMF, 2004; Massoud, 2014; Helmy, 2018), which is mainly linked to the large portion of administered prices in the consumer price index. The methodology used in these studies ranged from a Vector-autoregression (VAR) to a structural VAR to examine ERPT; however, an extensive survey of the literature showed that pass-through effects were not examined non-linearly in Egypt. We find that the assumption of linear and symmetric pass-through effects on inflation is too restrictive for the case of Egypt. The aim of this thesis is to examine the asymmetries and non-linearities of pass-through effects on consumer and producer price inflation in Egypt. Adopting Delatte and Lopez-Villavicencio's Model, the study examines the aforementioned relationship using an Autoregressive-distributed lag model in a linear and non-linear form. Using quarterly data from 2006Q1-2020Q4, the model allows the researcher to identify asymmetrical effects by decomposing the variables under investigation into partial sums. To the best of my knowledge, this is the first study to adopt a nonlinear ARDL (NARDL) model to examine asymmetrical pass-through effects in Egypt. Nominal effective exchange rate and energy prices are the chosen variables of interest to assess for asymmetries in the long-run and short-run. Egypt has been experimenting with changing economic conditions such as devaluations, subsidy cuts, and most importantly new monetary policy strategies like inflation targeting. Correctly understanding the effect of pass-through shocks on domestic inflation will have important monetary policy implications.

The rest of the paper is organized as follows: Section (2) sets out the review of the review of theoretical and empirical literature. Section (3) presents an overview of Inflation dynamic in Egypt. Section (4) reports the data specification and Section (5) presents the methodology. Section (6) discusses findings and analysis. Finally, Section (7) discusses the policy implications of the findings.

2. Literature review

2.1 Conceptual Framework

Inflation is re-emerging as a global challenge facing the world's economic performance and social welfare. There is currently growing consensus about the negative impacts of inflation globally and especially in EMs. Countries with high volatility in prices suffer from higher levels of macroeconomic instability. Inflation is a variable that is closely related to nominal exchange rates, real GDP and monetary policy. Similarly, Exchange rates highly impact these macroeconomic variables in open and integrated economies.

In an open economy, Exchange rate pass-through (ERPT) is known as the effect of exchange rate changes on domestic prices. In the scope of Microeconomics, the level of pass-through reflects the extent to which external shocks affect households and firms. At a Macroeconomic level, the degree of pass-through directly affects inflation, the primary goal of most central banks, that is directly linked to monetary policy (Janine, 2014). Given it's a key indicator to assess when adopting inflation targeting, ERPT has been the center of recent literature on EMs. Developing countries use indicators like pass-through to forecast inflation determinants and assess the effects of exchange rate shocks on the price level (Kotil, 2020).

By the late 1990s, a voluminous literature on ERPT that focused on industrialized economies had documented the impacts of exchange rate fluctuations on prices (Goldberg & Knetter, 1997; Menon, 1995). Earlier research had a microeconomic focus assessing the pricing strategies of monopolistic firms using exchange rates to aggregate trade prices. This line of literature led to the basic definition of ERPT of Goldberg & Knetter (1997). It identifies the transmission of exchange rate's variation to prices of imports that are expressed in domestic currency; therefore, the concept of complete pass-through arises. Empirically, the concept of complete pass-through is not valid in application especially in advanced economies as their weights affect world prices in international trade. The transition effect is said to be complete when exchange rate variations cause the same changes in the price-level and vice versa for an incomplete effect. More formally, ERPT was defined as the percentage change in domestic prices of imported goods caused by a 1% change in the nominal exchange rate between a country and their trading partner (Bailliu and Fujii, 2004; Goldberg and Knetter, 1997). Generally, ERPT is almost complete in the case of small open economies, which by definition are nowadays most emerging markets. Small open economies usually don't have a significant weight in world markets; thus, a currency depreciation wouldn't affect world prices and it would rather affect the country's inflation rate. Additionally, recent literature has shown that the responsiveness of these countries to currency fluctuations is extremely high, which causes a high degree of pass-through. Exchange rate shocks in small countries are large and highly persistent which can hinder the central bank's targeted policies (Janine, 2014). This galvanized interest in the field of macroeconomics to assess the role of ERPT in monetary policy. Persistent trade imbalances and volatility in exchange rates shifted the research to the *"New Open Macroeconomics"* to further study magnitude and speed of ERPT in Ems. Obstfeld (2002) put forth a theoretical catalyst for macroeconomic research on the concept of pass-through by linking *Inflation targeting* (IT) to ERPT. Taylor (2000) was the first economist to empirically investigate the incomplete and delayed ERPT for aggregate import and domestic prices. His study witnessed the declining ERPT in several advanced economies since the 1980s. Taylor's hypothesis states that countries with low inflationary environments have lower levels of EPRT. This correlation implied that ERPT itself is affected by the country's monetary policy regime. He proposed that IT should be used to reduce the effects of exchange rate variations on domestic inflation. The rationale is based on adaptive market expectations; hence, economies that adopt IT succeed in keeping inflation low and stable through expectations of consistent low inflation. Firms are forced to keep their prices broadly constant in order to remain competitive in the market.

2.2 Exchange rate pass-through Transmission Mechanism

As Taylor (2000) claimed IT results in a low inflationary environment which decreases firm pricing power that ultimately lowers the degree of ERPT. Since then, the definition of ERPT has been extended to the concept of *"overall ERPT"* that addresses the impact of exchange rate movements on consumer or producer prices. McCarthy (2000) and Edwards (2006) introduced the concepts of the direct and the indirect effects of exchange rate pass-through, in other words, the transmission mechanism of ERPT to domestic inflation. As depicted in Diagram 1, there are two types of ERPT namely, the direct and the indirect channel. Firstly, the direct effect known as the *tradeable pass-through* is transmitted to producer price index (PPI) and consumer price index (CPI) through the changes in importation prices. For example, an exchange rate depreciation will increase the prices of imported intermediate goods resulting in an increase in the cost of production. Simultaneously, the prices of finished imported goods increase; hence, this leads to an increase in aggregate domestic prices measured by PPI and CPI. Secondly, the *non-tradeable pass-through* or indirect effect associates with the competitiveness of goods in foreign markets. When a national currency depreciates, domestic goods become cheaper in foreign markets leading to an increase in domestic prices. Domestic demand for substitutes increases and world demand for export increases causing an overall rise in aggregate demand, and therefore, domestic prices increases measured by CPI. Given developing countries have higher shares of imports of their final consumption and intermediate goods, exchange rate changes have higher impacts on inflation leading to higher ERPT. A declining ERPT can encourage EMs to float their currencies avoiding the so-called “Fear of floating”. Central banks in countries with low ERPT may find it easier to use monetary policy to stabilize inflation and output.

While the magnitude of ERPT is important to investigate in EMs, it is essential to assess asymmetries in price responses to exchange rate fluctuations. Standard models assume a linear association between exchange rate and inflation. Recent literature identified important channels like export price downward rigidity and firm behavior that may result in asymmetries and non-linearities (Bussière, 2007). The pass-through may be nonlinear where appreciation may result in a different proportionate price response than depreciation. Similarly, asymmetries may exist where larger fluctuations may elicit a different proportionate response to smaller fluctuations. Nonlinearities may result from downward price rigidity and strategic considerations. For instance, if the importing country’s currency is depreciating against the exporting country, the exporting country may be able to absorb a small portion of the currency movement in their mark-up. This perceived because export prices are naturally downward rigid leading the exporting country to easily increase prices rather than decrease them. In most cases, EMs like Egypt with large import bills have higher pass-through effects. Size asymmetries may arise from “menu costs” linked to frequent price movements, where only small exchange rate movements are absorbed by firms, and therefore they pass through changes that exceed a certain threshold. Finally, there are several reasons suggesting that linear assumptions are too restrictive; thus, an extension needed to be studied in Egypt that accounts for asymmetrical effects of pass-through shocks using a nonlinear model.

Exchange Rate Pass-through Transmission Mechanism

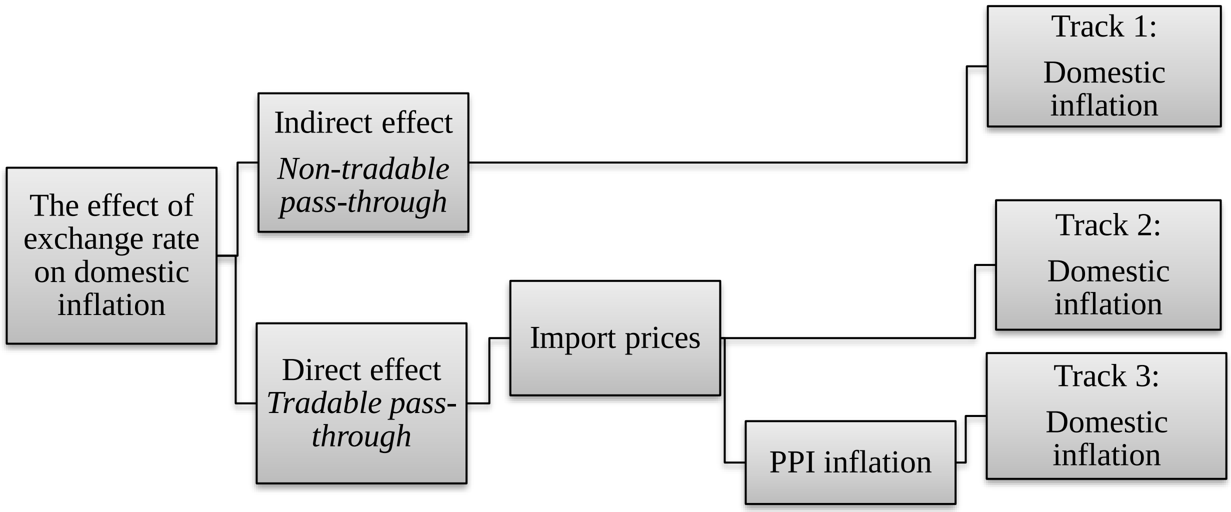

Diagram-1: Data source- The Author adopting MCcarthy's theory (1999)

2.3 Empirical Literature

To begin with, Empirical studies on pass-through were concentrated on advanced economies until recently, when it started increasing rapidly for developing countries. Generally, empirical studies with a macroeconomic focus concentrated on assessing two main points. Firstly, the factors affecting the transition mechanism of ERPT. Secondly, the literature focused on the importance of the duration and magnitude of the pass-through. For the last two decades, several studies have investigated the magnitude of the effect of exchange rate fluctuations on domestic prices. Recently, studies obtained empirical evidence on the existence of non-linear and asymmetrical effects of exchange rate movements on domestic prices. This new line of research relaxed an assumption that was too restrictive and resulted in biased findings.

Taylor (2000) investigated the evolution of ERPT in the United states based on a combination of micro and macroeconomic models. His hypothesis was the first to relate monetary policy to the magnitude of EPRT. The study found that countries with lower inflation levels that generally use inflation targeting have lower pass-through effects. Taylor suggested that firms set prices according to their expectations of future costs; hence, firms are more likely to increase prices given they predict a persistent episode of domestic currency depreciation.

Gagnon and Ihrig (2004) examine the role of inflation targeting in acting as a shock absorber for exchange rate movements in advanced countries. They estimated ERPT for 20 industrialized economies and found evidence that countries with higher price volatility experience higher inflation rates than countries with more stable inflation. Additionally, the results suggested that monetary policy had an important role in countries with declining ERPT. Central banks with higher credibility and transparency that operate under inflation targeting frameworks were able to minimize the effect of exchange rate shocks on domestic inflation. They suggested that agents understood the intentions of monetary policy and in turn were less likely to pass-through price increases resulting from exchange rate depreciation. Mishkin and Schmidt-Hebbel (2007), used panel vector autoregression on 21 industrial inflation targeting countries and 13 industrial non-*targeters*. The study found that passthrough was declining for *targeters* and constant for *non-targeters.*

McCarthy (2007) examined the pass-through effect on a sample of nine industrialized economies using the Vector Autoregression (VAR) model. The study found that countries with a higher share of imported goods were associated with higher magnitude of ERPT. The findings were interesting, which shifted empirical studies' focus towards developing countries as they have higher shares of imported goods. The studies used different variables to test the effects on price level such as CPI, PPI, import prices (IP), and wholesale price index (WPI); In addition, they used different econometric methods to investigate incomplete pass-through effects. Ozyurt (2016), examined the speed and magnitude of pass-through effects in the Euro zone. The study found evidence of a partial and declining ERPT suggesting slow nominal adjustments of prices. Savastano et al. (2005) examined the ERPT in 8 emerging markets including Egypt based on the price chain method put forward by McCarthy (1999) via an estimated VAR model. They studied the pass-through effect from the 1990s-2004 using CPI and WPI as measures of price level. For Egypt, evidence suggested that ERPT to CPI was low and insignificant statistically. On the other hand, ERPT to WPI was statistically significant and much higher ranging from 30% to 60%. In addition, the speed of EPRT in Egypt was slow. Exchange rate fluctuations took between 6 to 12 months to have a significant effect on prices (WPI) and much longer (12-24 months) to impact CPI insignificantly. These results were much lower in Egypt than other emerging markets in the sample. Several studies attributed Egypt's odd results with a large share of administered prices in the consumer price basket (CPI). The study suggested that these administered prices would weaken the transmission of exchange rate movements to domestic prices and the markups would be compressed by firms along the distribution process.

Other studies on ERPT in Egypt followed the same distribution chain model by McCarthy (1999). Massoud (2014) and Helmy et al. (2018) analyze the impact of exchange rate movement on domestic inflation using a Structural vector autoregression model (SVAR), which is the method used to test the price chain model by McCarthy. This was the most popular method used to investigate ERPT as it uses economic theory to sort out contemporaneous connections between variables; additionally, the SVAR allows the researcher to use several equations with the number of variables needed. The study conducted by Massoud (2014) investigated ERPT in

Egypt between 2003 and 2013. The results found evidence of an incomplete pass-through for both variables used, namely: PPI and CPI. ERPT magnitude was modest for both variables; however, it was much larger for the CPI as the producer price index excluded imported goods. The effects of exchange rate movements were heavily reflected in the first 4 months and lasted between 9-11. Similarly, the study done by Helmy et al. (2018) covers the period 2003-2015 to examine ERPT in Egypt. The results were fairly consistent with Massoud's paper; thus, the impact of exchange rate shocks to PPI and CPI were fairly substantial but slow and incomplete. Helmy et al. (2018) also investigated the impact of the increase in import prices to domestic price level in comparison to the impact of exchange rate movements. The results were much higher for exchange rate movements reflecting that the indirect transmission channel is stronger than the direct pass-through channel. (Awad,2019) investigated the reasons behind the weak association between exchange rate shocks and inflation in Egypt that contradicts other emerging markets' results. The study relied on the SVAR and the Markov switching regression model to allow for structural breaks. The results were insignificant across the whole period (2006-2016). on the other hand, the results were significant for the sub-periods 2006-2014 and 2011-2016. The results were attributed to monetary policy intervention that affects the macroeconomic environment. Structural breaks are important to take into consideration while examining ERPT in Egypt due to changes in monetary policy regimes.

Earlier studies presumed that depreciations and appreciations are transmitted to the final price in the same magnitude. However, several recent studies have found evidence of asymmetries and non-linearities. They are widely transmitted to domestic inflation and they are 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 pass-through so as not to distort the effects of monetary policies. Razafimahefa (2012) estimated ERPT for countries in Sub- Saharan Africa. The results of the pass-through were asymmetric, incomplete, and higher in magnitude after depreciation episodes than after appreciation. He found that EPPT declined since the 1990s as a result of improvement in political and macroeconomic environments. The results reinforce the Taylor hypothesis, which states that countries with flexible exchange rate, lower inflation environments, and efficient monetary policy tend to have lower ERPT.

Frankel et al. (2012) finds proportionately higher pass through effects for devaluation above 25%, identifying a threshold effect for large depreciations. The results reinforce the theory of downward price rigidity as he found that appreciations are not passed through compared to depreciation episodes. Caselli and Agustin Roitman (2016), used local projection techniques to examine ERPT in a panel of 28 emerging markets. The study finds significant evidence of non-linarites for episodes of devaluation larger than 10% and 20%. They find ERPT coefficients equal to 18% and 25% compared to a coefficient of 6% in the linear case.

Delatte and Lopez-Villavicencio (2012), examine the impact of exchange rate changes in four major advanced countries using the Autoregressive distributed lag model (ARDL). Using the non-linear ARDL (NARDL), they found evidence that depreciation is passed through prices more than appreciation episodes. The study identifies the importance of adopting NARDL as it not only allows asymmetric cointegration so the research can assess the response of CPI inflation depending on the sign or direction of exchange rate movement, but also allows the investigation of the short-run and long-run asymmetries in the pass-through relationship. Baharumshah et al. (2017) examine the response of domestic prices to exchange rate variations using the NARDL in Sudan. The study confirms the existence of an asymmetric response of consumer prices to exchange rate movements in the long-run and short-run. Results suggest that inflation in Sudan is largely driven by depreciation episodes rather than appreciation, implying the importance of monetary policy in mitigating the impact of sharp depreciations. Based on the above results, ERPT literature based on linear estimations tend to underestimate the effect of exchange rate changes on domestic inflation. To the best of my knowledge, there are no previous studies dedicated to examining asymmetric pass-through effects for Egypt. This thesis claims that assumption of symmetry needed to be relaxed for the complexity of the Egyptian case. The Egyptian pound was devalued by more than 80% in 2016, which is well above the threshold put forth by Frankel et al. (2012). The study will adopt the econometric model advocated by Shin et al. (2011) to examine the extent of pass-through to domestic prices over the following period (2006-2020). The NARDL model will be applied to estimate pass-through effects and identify the role of exchange rate variations in determining inflation in Egypt.

3. Review of recent Inflation dynamics in Egypt

Since the early 2000s, Egypt went through crucial reform programs that were based on increasing internal and external economic performance. Throughout this period, Inflation appeared to have a gradual increasing trend with multiple double-digit episodes. Since the Arab spring in 2011, the rise in consumer price index steadily increased. During this period of political unrest, the annual average inflation rate was approximately 10% that is well above the corresponding rate of 6%-7% in the entire Mena region (Atlantic Council, 2017). Researchers pointed out many factors that were attributed to the rise in inflation such as growing fiscal deficits, increased food prices, rise in worldwide oil prices and accelerated increase in the money supply (Helmy, 2018; Noureldin, 2021).

During 2016/2017, the image changed dramatically as inflation hiked to new levels. This sharp increase was associated with the Central bank of Egypt’s (CBE) decision to devalue the pound by 13% to reach 8.8 EGP per US dollar. The CBE's decision was an attempt to relieve some of the foreign exchange pressures; however, the market differential, the difference between the official exchange rate market and the parallel black market, came close to 100% by the end of October. By the end of 2016, the CBE adopted a new managed float exchange rate regime, and therefore it finally allowed market forces to reflect its foreign currency value. Since then, the Egyptian pound started depreciating and stabilized to around 18 EGP per US dollar in November of 2016 as demonstrated by Figure 1. Following this devaluation episode, Figure 2[1] illustrates an immediate jump in inflation rates from 10% to around 23% by the end of 2016. Four months later, Inflation in Egypt marked a historical high of 31% in April, 2017. According to the International Monetary fund (IMF), Egypt had reached the highest levels of inflation in the Mena region as a whole (IMF, 2016). The economy kept suffering from double-digit inflation for around 23 months. By the end of 2018, the economy demonstrated signs of recovery with inflation finally falling to single digits (8.8%).

At the time, experts were taken by surprise as they didn't predict the rapid hike in inflation for two main reasons. Firstly, economists predicted that the pass-through effect from exchange rate to inflation wouldn't be significant as imports represented a relatively small amount of the consumer's basket. Secondly, other economists claimed that some price increases already reflected in the value of the EGP in the parallel market before the flotation. In retrospect, both assumptions were clearly not valid because not only did inflation rates dramatically increase, but also the effects of the shock were relatively persistent.

[1] *Refer to page-6 section 1 for Figure-2*

3.1 Insights on Inflation level after the devaluation episode of 2016

The "2016 shock" is used as a case study to analyze the main reasons behind the increasing inflation trend in Egypt. As depicted in figure 3, food and transportation were the most affected items in the consumer basket. After the exchange rate devaluation, the increase in transportation as an item in the CPI more than doubled. one can predict that transportation was the main cause behind the hike in inflation rate; thus, this can be attributed to a corresponding rise in energy prices.

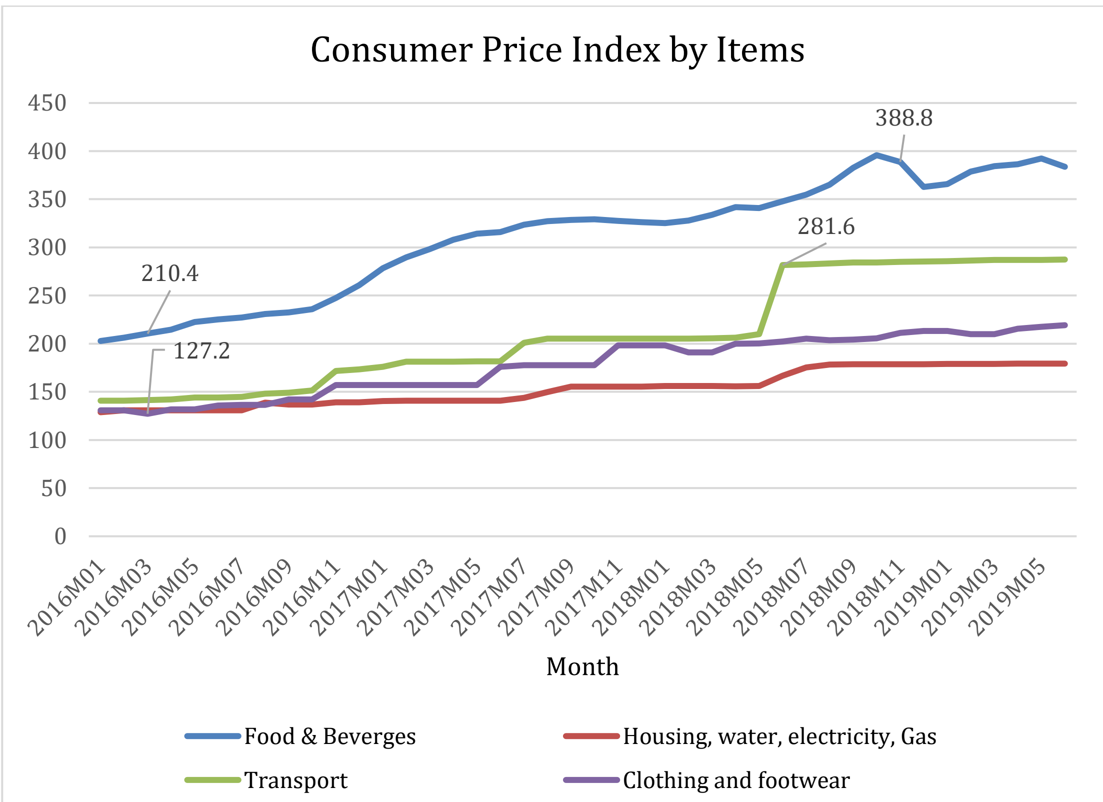

Figure-3: Data source- Central Bank of Egypt (2020)

In 2017/2018, Fuel prices started increasing in Egypt as part of a subsidy cut reforms laid out by the (IMF). Both the devaluation and subsidy cuts were under the economic reform plan said to be grown in Egypt (IMF, 2016). The IMF supported Egypt's economic reform plan by $12 billion loan under the extended fund facility. Furthermore, Egypt has reduced the cost of gasoline subsidies from 3.3 percent of GDP in fiscal year (FY) 2016/2017 to 2.7 percent in fiscal year (FY) 2017/2018. It also proceeded with its plan to increase the prices even more in the following year (Amcham, 2018).

The most influential fuel subsidy cut was in June 2018, when officials raised fuel prices by 44 percent, bringing pre-tax price-to-cost ratios for gasoline, diesel, kerosene, and fuel oil to around 73 percent (Amcham, 2018). In June, 2018, government officials approved an automatic index mechanism to alter prices for diesel, gasoline, kerosene, and fuel oil based on changes in world pricing, currency rates, and domestic consumption of imported fuel to manage the fuel market efficiently. Many economists would see liberalizing energy prices as a progressive step to establish an efficient market. However, other experts would say that the government should have slowly introduced the new pricing system not to allow for greater pass-through of energy prices. When prices are changed dramatically, the burden is mostly passed through to end users creating high inflationary pressures.

Whether its pass-through, subsidy cuts or supply side shocks, Egypt has witnessed an increasing trend in inflation since the early 2000s. According to Noureldin (2021), increased variability in relative prices is an important factor that causes high inflationary environments in Egypt. Large adjustments in relative prices are mainly due to distorted price signals through administered prices. Countries with a history of administered prices will suffer from aggravated impacts on macroeconomic indicators such as inflation, unemployment and output due to limited domestic competition, nominal rigidities, asymmetric supply side shocks and high inflationary environments (Noureldin, 2021). As depicted in Figure 4, the nominal effective exchange rate (NEER) has been stable for a long period of time until finally declining in 2016. For this reason, the impact on inflation was aggravated as inflation expectations were already increasing leading to market uncertainty and inefficient allocation of resources. Furthermore, asymmetric effects of exchange rate shocks and supply side shocks have to be examined in Egypt. The high inflationary environment creates a market where a positive price shock (price increase) is easier to implement/pass-through as opposed to a negative price shock (price decrease).

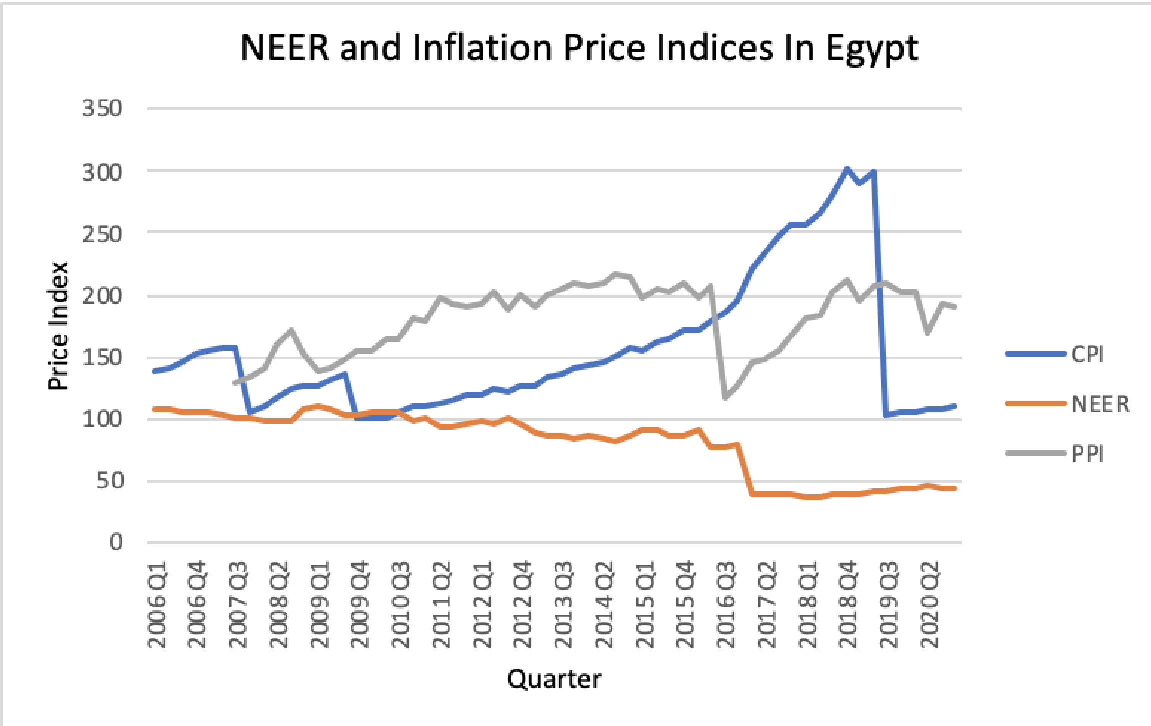

Figure-4: Data source- Central Bank of Egypt (2020) and Bruegel (2020)

4. Data specifications

The study uses Quarterly data for the period 2006Q1-2020Q4. The data is extracted from the Central Bank of Egypt time series dataset for both price indices (CPI and PPI). For the Nominal Exchange rate, Bruegel's database, economic think tank based in Brussels, was used. NEER data was extracted for EGP currency against 120 countries. For the purpose of this dataset, the NEER is defined as the foreign currency price of one unit of domestic currency. Therefore, an appreciation would imply an increase in the NEER and a depreciation would reflect a decrease in the index. For FUEL prices, the energy price index from the IMF IFS database was implemented, which includes a basket of energy products such as crude oil, Natural gas, and propone.

For the output gap, Real GDP data from the Central bank of Egypt times series dataset was extracted. We used Real GDP data to compute the output gap via the Hodrick Perscott filter. Given that GDP grows exponentially, the latter is converted into log form to detrend it. The final variable was used in a percentage form to compute the following:

$$\text{Output Gap} = \frac{RGDP_{actual} - RGDP_{potential}}{RGDP_{potential}}$$

For the purposes of the model, this technique is used twice in an identical manner: once to construct CYCLE1 using RGDP as measured by expenditure, and again to produce CYCLE2 using RGDP as assessed by factor cost. As demonstrated in Figure 5, the output gap is the difference between the actual RGDP and the potential RGDP trend created by filter, and therefore, it reflects the fluctuations in the economy’s business cycle.

Output Gap in Egypt

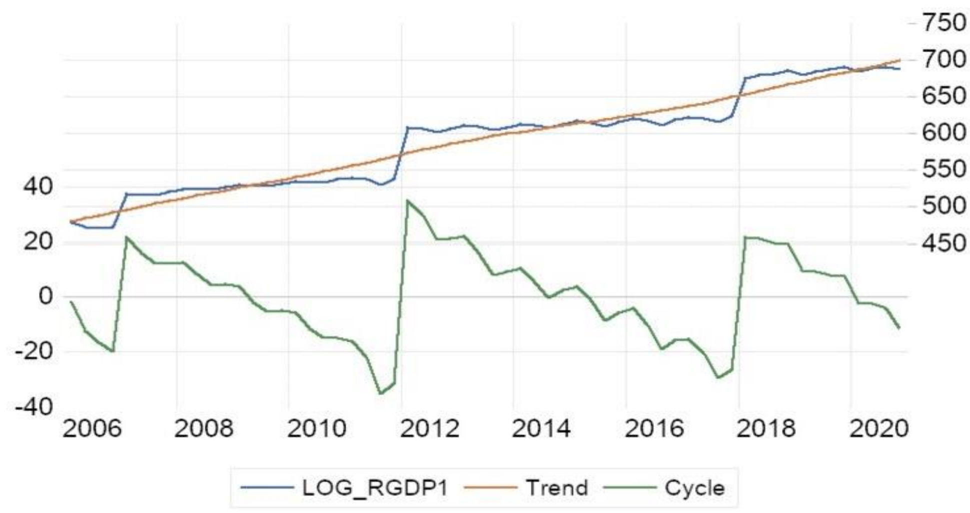

Figure-5: Data source- Author's Calculations based on the Central Bank of Egypt's database

Notes: The graph shows the real output of Egypt during the reported period (2006Q1-2020Q4) demonstrated by the blue line. The red line represents the potential output, which is most efficient level of employment for the economy. Finally, the green line is the output gap is measured as the difference between the actual and potential output, which shows positive/ negative value depending on the business cycle.

In line with the literature, all the variables in the model are used in first difference form via natural log transformations. This helps in the examination of coefficients as it transforms the variable from their units (indices) to percentage form. Also, it's efficient in canceling out the effects of extreme values leading to a "well-behaved" model. Finally, Exchange Rate pass-through is defined as the following equation:

$$ERPT = \frac{\%\ \Delta\ Domestic\ prices}{\%\Delta\ \ exchange\ rate}$$

In our specific model, this refers to the coefficient of the NEER. The following table summarizes the variables and how they are adopted in the model:

Table 1

Variable	Consumer Price Index (CPI)	Producer Price Index (PPI)	Nominal Effective Exchange Rates (NEER)	Output Gap (CYCLE)	Energy Price Index (FUEL)
Type	Dependent Variable (1)	Dependent Variable (2)	Independent Variable (1)	Independent variable (2)	Independent Variable (3)
Definition	Measures the change in the cost of a fixed basket of goods and services that are purchased by a representative sample of households.	Measure average change over time in the prices received by domestic producers for goods and services.	The value of a currency against a weighted average of a basket of foreign currencies.	Difference between an actual output in an economy and the potential output.	Fuel (Energy) Index, 2016 = 100, includes Crude oil (petroleum), Natural Gas, Coal Price and Propane Indices
Source	Central Bank of Egypt Time-Series Datasets	Central Bank of Egypt Time-Series Datasets	Bruegel database	Central Bank of Egypt Time-Series Datasets	IMF (IFS data)

5. Methodology

5.1 Baseline regression model

The empirical setting to estimate ERPT to prices is based on a reduced-form Philips curve (Chen, 2009). We adopt the Autoregressive distributed lag model (ARDL) of Pesaran and Shin (1999) and Pesaran *et al*. (2001). The specification of the model is described as follows:

$$y_t = \alpha_0 + \sum_{i=1}^{p} \alpha_{1i}\, y_{t-i} + \sum_{j=0}^{q} \beta_j X_{t-j} \quad + \varepsilon_t, \tag{1}$$

Where Xt, the regressors, is a vector of independent dynamic variables, yt is the dependent variable and εt is an uncorrelated error term with mean zero. More specifically, the following model is used:

$$CPI_t = \alpha_0 + \sum_{i=1}^{p} \alpha_{1i} CPI_{t-i} + \sum_{i=0}^{q1} \beta_{1i} NEER_{t-i} + \sum_{i=0}^{q2} \beta_{2i} CYCLE_{1,t-i} + \sum_{i=0}^{q=3} \beta_{4i} FUEL + \varepsilon_t \quad (2)$$

$$PPI_t = \alpha_0 + \sum_{i=1}^{p} \alpha_{1i} PPI_{t-i} + \sum_{i=0}^{q1} \beta_{1i} NEER_{t-i} + \sum_{i=0}^{q2} \beta_{2i} CYCLE_{2,t-i} + \sum_{i=0}^{q=3} \beta_{4i} FUEL + \varepsilon_t \quad (3)$$

Where the dependent variable is the measure of inflation (CPI/PPI) and the explanatory variables used in the model are nominal effective exchange rate (NEER), the output gap (CYCLE), and finally energy prices (FUEL). Given that α_i is the vector of estimated coefficients, α_1 is the estimate of ERPT and is predicted to be bounded between zero that indicates zero-pass-through and 1 that symbolizes complete pass-through. The study uses two different price indices to test the pass-through in Egypt. Given that import prices', pass-through channel, data are not available in Egypt, two measures of inflation are used as dependent variables in two separate models to provide a better indication of the pass-through channels of price hikes.

Under the model's specific framework in eq(2), consumer price index (CPI) is the dependent variable and the explanatory variables used in the model are nominal effective exchange rate (NEER) , the output gap (CYCLE), and finally world energy prices (FUEL). Similarly, for eq(3), we keep all the models controlled and change the dependent variable to be the producer price index (PPI) to check if the results are altered. We utilize the NEER instead of the bilateral nominal exchange rate because, unlike the nominal bilateral exchange rate, it takes into account any adjustments with Egypt's trading partners over time. For the study's dataset, a decrease (increase) in the NEER implies a depreciation (appreciation) of home's currency (Egypt);

therefore, a negative sign is expected to reflect the impact of exchange rate movements on inflation.

Following the work of Delatte and Lopez-Villavicencio (2012), the output gap (CYCLE) is included in the model as a short-run determinant to take into account the dynamics of the Phillips curve framework. The use of this variable allows us to create a model where we can examine the dynamics of both prices and inflation in a single framework. The study uses two measures for the output gap as Gross domestic product is calculated in different manners. In eq(2) where CPI is the regressand, CYCLE1 is calculated using GDP measured by expenditure to give a better representation of consumption. In eq(3), CYCLE2 is calculated utilizing GDP at factor cost to reflect the economy's production. A positive sign is expected for both variables as a positive output gap usually spurs inflation because labor costs and prices of goods increase in response to the increased demand.

The Fuel price index is included as an independent variable due to the fact that it's an essential input for production. Given that Egypt imports energy products such as coal and peat, world energy prices should impact overall price levels. Therefore, FUEL is used to capture supply side shocks and to examine the pass-through of energy prices to inflation. An increase in energy prices will raise production costs, resulting in an increase in domestic inflation, which we predict to lead to a positive coefficient.

The regressors are allowed to have various lag structures denoted by p and qi, i=1,2,3. We use the Schwarz information criterion for the choice of the lags (p, q1, q2, q3) given its consistent model selection property in finite-dimensional models Shao (1997). The ARDL (p,q,q,q) model for CPI_t/PPI_t, $NEER_t$, $CYCLE_t$, and $FUEL_t$ provides a few advantages compared to the VAR that is widely used for ERPT's studies in Egypt. The most well-known edge offered by the

ARDL is that it can combine I(0) AND I(1) variables, in addition to fractionally integrated series. The VAR model requires that variables to be integrated of the same order. This requirement creates a "pre-test bias" where a variable of a different integration can't enter the model. Unit root tests are inconclusive regarding the stationarity of a time series. This is particularly relevant in the study as we use short time series data, where the variables used are subject to structural breaks.

ARDL based on Pesaran (1999) entirely covers both the short-term and long-relationships of the variables being tested. This approach has interesting characteristics compared to the standard ECM approach. Firstly, the original Engle-Granger is a two-step approach that is likely to be less efficient than the ARDL bounds test one-step solution. Secondly, the long-run relationship test procedure, used below, differs from conventional multivariate cointegration techniques as it performs better on small samples. Whereas, usual cointegration procedures are more useful with large samples only. Given that this approach can allow for a mix of I(0) and I(1) variables in a long-run relationship instead of a cointegrating relationship, The "bounds test" methodology is more appropriate for this study. The bounds test is conducted via the following regression:

$$\Delta CPI_t = \alpha_0 + \sum_{i=1}^{p} \alpha_{1i} \Delta CPI_{t-i} + \sum_{i=0}^{q1} \beta_{1i} \Delta NEER_{t-i} + \sum_{i=0}^{q2} \beta_{2i} CYCLE_{1,t-i} + \sum_{i=0}^{q3} \beta_{4i} \Delta FUEL + \varepsilon_t \quad (4)$$

$$\Delta PPI_t = \alpha_0 + \sum_{i=}^{p} \alpha_{1i} \Delta PPI_{t-i} + \sum_{i=0}^{q1} \beta_{1i} \Delta NEER_{t-i} + \sum_{i=0}^{q2} \beta_{2i} CYCLE_{2,t-i} + \sum_{i=0}^{q=3} \beta_{4i} \Delta FUEL + \varepsilon_t \quad (5)$$

The bounds test is used to examine the long-run relationship given it's the most appropriate in our context. It's a test for cointegration based on a F-test of the null hypothesis that the coefficients on the level variables are jointly equal to zero $H_0: \delta_0 = \delta_1 = \delta_2 = \delta_3 = 0$. The results reflect a long-run relationship among the variables given that the null hypothesis is rejected.

This test provided by Pesaran et al. (2001) includes two asymptotic critical value bounds. The test provides an upper and lower bound regardless of whether the regressors are I(0), I(1) or mutually integrated. If the computed statistic is higher than the upper critical values, there is evidence of a long-run relationship irrespective of the variables' order of integration. However, if it's below the upper bound, then we can't reject the null hypothesis of no long-run relationships. Finally, if the computed statistic lies between the bounds, inconclusive inferences may be implied depending on the order of integration of the variables. If there is evidence of cointegration, an error correction model (ECM) can be estimated, where the variations in CPI_t and PPI_t are related to the previous period's disequilibrium and any changes triggered by fluctuations in the determinants of inflation for both equations respectively. The ECM term would be the lagged residual $(\varepsilon_{t-1})$from the long run regression and its coefficient would be the speed of adjustment parameter. The ECM coefficient is expected to be negative and it should have a value that is less than 1. It's important to examine because it reflects how the dependent variable returns to equilibrium after short-run deviations.

5.2 Asymmetry under the ARDL framework

Literature on ERPT suggests that the symmetric linear combination, eq(2) and (3), of stochastic variables described above may be too restrictive. For this issue to be addressed, this study adopts a nonlinear ARDL (NARDL) following the recent empirical work of Delatte and Lopez-

Villavicencio (2012) & Baharumshah et al. (2017). This model suggested by Shin et al. (2011) accounts for asymmetric effects by including partial sums of the regressor under assessment. The times series $NEER_t$ is decomposed into positive ($NEER_t^+$) and negative ($NEER_t^-$) partial sums, where NEER+ indicates an appreciation and NEER- implies a depreciation. For this specific model, it will correspond to:

$$NEER_t^+ = \sum_{j=1}^{t} \Delta NEER_j^+ = \sum_{j=1}^{t} \max(\Delta NEER_j, 0), \sum_{j=1}^{t} \Delta NEER_j^- = \sum_{j=1}^{t} \min(\Delta NEER_j, 0) \quad (6)$$

Where ($REER_t^+$) and ($REER_t^-$) are the partial sum processes of appreciations and depreciations respectively. Partial sums for the price of energy (FUEL+) and (FUEL-) are utilized as the results of the linear model implied the existence of fuel prices pass-through. FUEL+ will reflect energy price hikes and FUEL- will imply price drops; thus, the following model:

$$FUEL_t^+ = \sum_{j=1}^{t} \Delta FUEL_j^+ = \sum_{j=1}^{t} \max(\Delta FUEL_j, 0), \sum_{j=1}^{t} \Delta FUEL_j^- = \sum_{j=1}^{t} \min(\Delta FUEL_j, 0) \quad (7)$$

Therefore, we check for asymmetric effects for both variables. Eq(4) and (5) can be modified using the partial sums computed from eq(6) and (7) to allow for asymmetric level relationships. The relationship defined in the following equation will allow a long-run relationship between prices and negative and positive variations of the exchange rate, controlling for the rest of the underlying regressors.

$$\Delta CPI_t = \alpha_0 + \sum_{i=1}^{p} \alpha_{1i} \Delta CPI_{t-i} + \sum_{i=0}^{q1} \beta_{1i}^{+} \Delta NEER_{t-1}^{+} + \sum_{i=0}^{q1} \beta_{2i}^{-} \Delta NEER_{t-1}^{-} + \sum_{i=0}^{q2} \beta_{3i} \Delta CYCLE1_{t-i}$$
$$+ \sum_{i=0}^{q1} \beta_{3i} \Delta CYCLE1_{t-i} + \sum_{i=0}^{q1} \beta_{4i}^{+} \Delta FUEL_{t-1}^{+} + \sum_{i=0}^{q1} \beta_{5i}^{-} \Delta FUEL_{t-1}^{-} + \varepsilon_t$$

(8)

$$\Delta PPI_t = \alpha_0 + \sum_{i=1}^{p} \alpha_{1i} \Delta PPI_{t-i} + \sum_{i=0}^{q1} \beta_{1i}^{+} \Delta NEER_{t-1}^{+} + \sum_{i=0}^{q1} \beta_{2i}^{-} \Delta NEER_{t-1}^{-} + \sum_{i=0}^{q2} \beta_{3i} \Delta CYCLE2_{t-i}$$
$$+ \sum_{i=0}^{q1} \beta_{4i}^{+} \Delta FUEL_{t-1}^{+} + \sum_{i=0}^{q1} \beta_{5i}^{-} \Delta FUEL_{t-1}^{-} + \varepsilon_t$$

(9)

As in the linear case, the model may exhibit asymmetries over both the long run and the short run or only one of either. For the long-run test procedure, the bounds test will be conducted following the same explained methodology testing for a linear regression.

Finally, Long-run symmetries can be tested using the Wald test with the addition of the new multipliers in eqs(6) and (7). If long-run symmetry is not rejected which means $\beta_1^{+} = \beta_2^{-}$, then there is no evidence of asymmetrical effects in the model. This is used as a robustness to check whether the ARDL or NARDL model is more appropriate for both regressions.

5.3 Dynamic Multipliers

Given that the study finds evidence of asymmetric effects, one can derive an interesting pattern of asymmetry from the NARDL laid out in eq(8) and (9) using the positive and negative partial sums of NEER and FUEL.

$m_h^+ = \sum_{j=0}^{h} \frac{dp_{t+j}}{dNEER_t^+}, \quad m_h^- = \sum_{j=0}^{h} \frac{dp_{t+j}}{dNEER_t^-}$, h=0,1,2…….

$m_h^+ = \sum_{j=0}^{h} \frac{dp_{t+j}}{dFUEL_t^+}, \quad m_h^- = \sum_{j=0}^{h} \frac{dp_{t+j}}{dFUEL_t^-}$, h=0,1,2…….

By model construction, as $h \to \alpha, m_h^- \to \beta_2^-$ and $m_h^+ \to \beta_1^+$ where $\beta_2^-$and $\beta_1^+$are the negative and positive asymmetric long-run coefficients. The same applies for $\beta_4^-$and β_5^+ for the FUEL coefficients. The multipliers, as noted by Shin et al. (2011), allow us to see unequal adjustment routes and/or durations of disequilibrium, providing vital information to both long- and short-run asymmetry. As a result, after an economic shock, the multipliers describe patterns of adjustment from the initial equilibrium to the new equilibrium (i.e., a depreciation or appreciation). The multipliers are derived from the error correction coefficient (ECM term coefficient) and the impact and reaction asymmetries.

6. Results and discussion

In this section, the researcher uses two tests for checking the stationarity of the time series, namely the Augmented Dicky-Fuller test and the Phillips-Perron (PP) test. We then estimate an ARDL model in the linear and the nonlinear form (NARDL) using Consumer price Index (CPI) as the dependent variable as shown in Table 3. Afterward, we test for the existence of cointegration among all variables using the bounds test. Similarly, we estimate the same models, ARDL and NARDL, using Producer price Index as the regressand and the same tests are used to check for long-term and short-term relationships among all variables. Finally, Wald tests are utilized to check for the existence of asymmetrical effects and to examine which model (ARDL/NARDL) is more appropriate for the specified regression.

6.1 Unit Root test

Firstly, Table 2 demonstrates the results of the ADF and PP tests for the presence of a unit root. The results indicate that all variables are stationary in the first difference except for the output gap, CYCLE1 and CYCLE2, that is stationary in level. Moreover, none of the variables are I(2) and there is a mix of I(1) and I(0). Based on the evidence presented, the ARDL model appears to be appropriate for this dataset. The model is proven successful with inflation dynamics in Egypt due to high levels of price variability, which lead to high inflationary environments (Noureldin, 2021). Given the ARDL includes lags of both the dependent and the independent variables, the model is most suitable for the study. Literature on ERPT suggests that NARDL can be used to allow for asymmetries in the effects of exchange rate shocks on domestic inflation (Delatte and Lopez-Villavicencio, 2012). Moreover, it easily allows for that by decomposing the targeted regressors into partial sums.

Table 2: AUGMENTED DICKEY-FULLER (ADF) AND PHILLIPS PERRON (PP) UNIT ROOT TESTS

	Levels		First difference		
Variable Name	Intercept (no trend)	Intercept & trend	Intercept (no trend)	Intercept & trend	Conclusion
CPI	-1.853	-1.873	-7.632***	-7.66***	I(1)
PPI	-2.758	-2.77	-8.518***	-8.546***	I(1)
NEER	-2.082	-0.644	-7.757***	-7.808***	I(1)
FUEL	-2.534	-1.916	-6.726***	-6.746***	I(1)
CYCLE1	-3.313***	-3.28***	-7.591***	-7.469***	I(0)
CYCLE2	-3.116***	-3.087***	-7.341***	-7.277***	I(0)

PP Unit Root Test

	Levels		First difference		
Variable Name	Intercept (no trend)	Intercept & trend	Intercept (no trend)	Intercept & trend	Conclusion
CPI	-2.024	-1.906	-7.632***	-7.66***	I(1)
PPI	-2.69	-2.77	-8.573***	-8.591***	I(1)
NEER	-2.214	-0.656	-7.756***	-7.806***	I(1)

FUEL	-2.646	-2.091	-6.835***	-6.773***	I(1)
CYCLE1	-3.41***	-3.376***	-7.95***	-7.961***	I(0)
CYCLE2	-3.273***	-3.245***	-7.676***	-7.583***	I(0)

*Notes: the SIC is used for lag selection is used for the ADF test. For the PP test, automatic bandwidth selection is implemented using the Newey-West bandwidth selection. The variables are consumer price (CPI), producer price index (PPI), nominal effective exchange rate (NEER), Fuel price index (FUEL), and the output gap (CYCLE1 and CYCLE2). ***, **, and * respectively mark statistical significance at the 1, 5, and 10 percent levels of significance.*

6.2 ARDL and NARDL models for CPI inflation

In table 2, the estimates for the linear and nonlinear regression with CPI as the dependent variable are presented. According to the SIC, the chosen lag structure is ARDL (1, 0, 0, 0) for the variable's CPI, NEER, CYCLE1, and FUEL respectively. This lag structure minimizes the SIC to a value of -0.524, suggesting compatibility with a parsimonious model. One lag was chosen for the dependent variable, CPI, and zero lags for the independent variables.

Table 3: Autoregressive Distributed Lag Model-Estimates using CPI as Regressand

Linear Model (ARDL)			**Nonlinear Model (NARDL)**		
Variable Name	Coefficient	t-statistic	Variable Name	Coefficient	t-statistic
CPI (-1)	0.852	9.841***	CPI (-1)	0.861	8.709***
NEER	-0.052	-0.707	∆NEER+	-1.211	-1.344
CYCLE1	0	-0.721	∆NEER-	-0.132	-1.066
FUEL	0.028	0.412	CYCLE1	0	-0.228
			∆FUEL +	0.036	0.411
			∆FUEL-	-0.129	-0.905

*Notes: the sample period utilized for estimation is 2006Q1-2020Q4. The variables are consumer price (CPI), nominal effective exchange rate (NEER), Fuel price index (FUEL), and the output gap (CYCLE1). For the nonlinear model, NEER and FUEL variables are decomposed into partial sum to check for evidence of asymmetries. NEER+ reflects an appreciation of the EGP while NEER- reflects a depreciation in the EGP. For the FUEL, FUEL+ imply prices increases while FUEL- imply price decreases. The SIC is used for lag selection of both models. ***, **, and * respectively mark statistical significance at the 1, 5, and 10 percent levels of significance*

The findings revealed that changes in Egypt's exchange rate doesn't significantly affect consumer price inflation either in the linear or non-linear regression. Although ERPT is not significant, the coefficient has the expected sign. A negative ERPT coefficient indicates that a

1% decrease in nominal effective exchange rate caused an increase in the consumer price index of 5.2%. This is consistent with Savastano et al. (2005) research suggesting a weak relationship between exchange rate shocks and the CPI in Egypt. The large share of administered prices in Egypt's CPI may have contributed to this result. A substantial fraction of items with administered prices would tend to compress markups along the distribution process and impede the transmission of exchange-rate shocks, at least briefly, along the price chain represented by diagram 1 presented in section 2.1.

Another finding was the positive and highly significant lag of the inflation level, which demonstrated persistence over time. As Taylor (2000) points out, this could be a sign of the economy's high inflationary environment. The rest of the regressors (CYCLE 1 and FUEL) are insignificant. The results indicate that the pass-through effects of fuel prices are not significant, and therefore fuel price movements don't have a significant effect on Inflation. This result is inconsistent with the economy's trade dynamics as Egypt is a net importer of hydrocarbons, Thus, movements in energy prices should increase/decrease Egypt's import bills and lead to a corresponding effect on domestic inflation.

In terms of the model's diagnostics test, the LM test statistic returned a p-value of 0.8407, which indicates that the residuals are free from serial correlation. The errors of the model are homoscedastic according to the Breusch-Pagan-Godfrey heteroskedasticity test, which returned a p-value of 0.199. The model as a whole is significant with an R2 of 76.6% and an adjusted R2 of 74.8% for the symmetric ARDL. It's interesting to notice that the R2 increased in the NARDL model to 77.3%. The Bounds test returned an F-statistic of 0.874 using both models (ARDL/NARDL) which is lower than the lower bound I(0) at all significance levels. In this case, we fail to reject the null hypothesis and we can't run the conditional ECM regression, thus, there is no evidence of cointegration in the long-run as depicted in Table 4.

The findings suggest that a major cause for the hike in consumer price index is caused by adaptive expectations or "Built-in Inflation". Given that Egypt consistently suffers from high inflation rates, economic agents expect inflation rates to continue increasing in the long run. When the price of goods and services increases, worker's predict higher prices and demand higher wages to maintain their standards of living. The rise in wages leads to a further increase in prices of goods and services, and therefore the spiral continues to become a vicious trap for Egyptian economy.

Table 4: Bounds Test

Linear Model (ARDL)				**Nonlinear Model (NARDL)**			
Level of significance	Lower limit	Upper limit	F-statistic	Level of significance	Lower limit	Upper limit	F-statistic
10%	2.08	3	0.874	10%	2.08	3	0.874
5%	2.39	3.38		5%	2.39	3.38	
2.50%	2.7	3.73		2.50%	2.7	3.73	
1%	3.06	4.15		1%	3.06	4.15	

Notes: The bounds test is utilized to test for cointegration among the variables. The variables are consumer price (CPI), nominal effective exchange rate (NEER), Fuel price index (FUEL), and the output gap (CYCLE1). An F-statistic lower than the lower limit means that we fail to reject the null hypothesis.

6.3 ARDL and NARDL models for PPI inflation

Table 4, we report the estimates for the ARDL and NARDL regressions using the PPI as a measure of inflation. The results of this regression put forth some differences between the linear and nonlinear models. Firstly, the chosen lag structure for the linear model according to the SIC is ARDL (1, 0, 0, 2) for the variables PPI, NEER, CYCLE2, AND FUEL respectively. On the other hand, the chosen lag structure for the nonlinear model is NARDL (1, 0, 0, 0, 2, 0) for the variables PPI, NEER+, NEER-, CYCLE2, FUEL+, FUEL- respectively. The difference in lag structure gives preliminary results that indicate the persistence and significance of positive energy price shocks over negative energy prices movements.

Table 5: Autoregressive Distributed Lag Model-Estimates using PPI as Regressand

Linear Model (ARDL)			**Nonlinear Model (NARDL)**		
Variable Name	Coefficient	t-statistic	Variable Name	Coefficient	t-statistic
PPI (-1)	0.763	9.637***	PPI (-1)	0.621	5.124***
NEER	-0.093	-2.56**	∆NEER+	-0.272	-0.47
CYCLE2	0	0.296	∆NEER-	0.011	0.158
FUEL	0.211	3.584***	CYCLE2	0	0.449
FUEL (-1)	-0.228	-3.026***	∆FUEL+	0.394	2.661**
FUEL (-2)	0.15	2.431**	∆FUEL+ (-1)	-0.506	-2.494*
			∆FUEL+ (-2)	0.356	2.537**
			∆FUEL-	0.115	1.335

*Notes: the sample period utilized for estimation is 2006Q1-2020Q4. The variables are consumer price (PPI), nominal effective exchange rate (NEER), Fuel price index (FUEL), and the output gap (CYCLE2). For the nonlinear model, NEER and FUEL variables are decomposed into partial sum to check for evidence of asymmetries. NEER+ reflects an appreciation of the EGP while NEER- reflects a depreciation in the EGP. For the FUEL, FUEL+ imply prices increases while FUEL- imply price decreases. The SIC is used for lag selection of both models. ***, **, and * respectively mark statistical significance at the 1, 5, and 10 percent levels of significance.*

We can observe that the use of the PPI altered the results of the model for both regressions. The results revealed a negative and statistically significant impact of exchange rate fluctuations on producer price inflation. These results are in line with the findings of the Savastano et al. (2005), which shows Egypt to be a special case when it comes to ERPT. According to the conceptual framework, exchange rates have more of a direct effect on PPI as opposed to CPI, thus, ERPT is higher and statistically significant on producer price inflation. The NEER returned a coefficient of -0.093, which implies that the ERPT in Egypt is around 9.3%. CYCLE2 or the output gap is not significant. Energy shocks exhibit a positive and significant impact on producer price inflation. The results indicate a positive pass-through of 20.1% on inflation level, which means that a 1% increase in fuel prices caused a 20.1% rise in producer price inflation. This is an expected result as Egypt is an oil importing country and oil price movements should lead to macroeconomic instability such as inflation. Both lags of the FUEL variable are significant, which indicates a persistent effect on inflation level. This is consistent with the recent Egyptian government's decision to remove energy subsidies. This plan started as part of a $12 billion loan program with the IMF to reform the economy in 2016. The removal of subsidies has increased fuel prices steadily over the past years as demonstrated in section 3.

To get a deeper understanding of the impact of the shocks under investigation, the NARDL model is utilized for further analysis. Both positive and negative values of the NEER are statistically insignificant, which indicates that the ERPT is not statistically significant using this model. However, the coefficients of both variables increase in comparison with the linear model. For appreciation episodes, the ERPT is around 27.2%, while a 1% depreciation of the Egyptian pound affects producer inflation by 1.1%. For exchange rate shocks, the results are in favor of the linear ARDL model.

The findings revealed the presence of asymmetric effects for energy shocks. FUEL+, Fuel price hikes, has a positive and statistically significant coefficient equals 39.4%, while FUEL- has a positive and statistically insignificant coefficient. The results indicate that an increase in energy prices caused an increase in producer price inflation. On the other hand, a decrease in fuel prices caused a corresponding decrease in inflation level. Fuel price hikes have a higher coefficient compared to FUEL- that returned a value of 11.5%; Additionally, the lags of FUEL+ are significant with high coefficients. The findings are consistent with our hypothesis that positive shocks are transmitted to inflation level more than negative shocks. Moreover, Within the Egyptian economy, producers find it easier to pass-through price hikes episodes rather than drops in price level.

The same diagnostic tests are applied to the estimates. The LM-test statistic returned a p-value of 0.727, which suggests that the residuals are free from serial correlation. The Breusch-Pagan-Godfrey test returned a p- value of 0.812 suggesting homoscedastic errors. The whole model is significant with an R2 of 75.6% and an adjusted R2 of 72.4%. Table 6 reports the Bounds test that returned an F-statistic of 3.435 in the ARDL and 3.596 in the NARDL model. For the ARDL, the F-statistic is higher than the I(1) upper bound at the 10% significance level; therefore, we can observe evidence of a stable long-run relation between the variables. Also, the NARDL exhibits evidence of a long-run relation among variables as the F-statistic exceeds the upper bound at the 5% and 10% significance levels. This may suggest that the NARDL's ECM regression is a better forecasting model.

Table 6: Bounds Test

Linear Model (ARDL)				**Nonlinear Model (NARDL)**			
Level of significance	Lower limit	Upper limit	F-statistic	Level of significance	Lower limit	Upper limit	F-statistic
10%	2.37	3.2	3.435	10%	2.08	3	3.596
5%	2.79	3.67		5%	2.39	3.38	
2.50%	3.15	4.08		2.50%	2.7	3.73	
1%	3.65	4.66		1%	3.06	4.15	

Notes: The bounds test is utilized to test for cointegration among the variables. The variables are consumer price (PPI), nominal effective exchange rate (NEER), Fuel price index (FUEL), and the output gap (CYCLE2). An F-statistic lower than the lower limit means that we fail to reject the null hypothesis

The cointegration relationship reported in table 7 is useful in forecasting the determinants of producer price inflation for both models. NEER and FUEL in the linear model are slightly significant determinants of PPI over the long term. This is consistent with the Taylor hypothesis suggesting that high inflationary environments like Egypt, an emerging market, have more persistent episodes of inflation after pass-through shocks. The study demonstrates that oil price shocks are important determinants of inflation levels in Egypt. For the NARDL, FUEL+ is the only significant determinant of producer price inflation over the long run. This is expected as the pass-through of oil shocks to oil-importing countries is high. Furthermore, the effect has been aggravated by the recent subsidy removal program for fuel prices in Egypt. Given that FUEL- is insignificant, the findings of the long run model are consistent with short run results for the presence of asymmetric effects on inflation. The result is compatible with the concept of export price rigidity and firm behavior introduced by (Bussière, 2007). The exporting countries of energy such as fuel and hydrocarbons might absorb a small portion of price movement in their mark up. In this scenario, the prices of energy, the export, are downward rigid meaning that exporting countries easily increase prices rather than decrease them. Therefore, Egypt pays the bill of the international price shocks leading to a persistent effect on producer price inflation. The NEER is insignificant in the nonlinear model, which implies that the symmetric ARDL is a better fit for exchange rate shocks. The error correction model is reported in table 8 to check the stability of long-term parameters. The coefficient of the ECM term in both models is negative and between zero and 1, which indicates that the variables return to long-run equilibrium following short run deviations. In the ARDL, the ECM term is -0.236 and is statistically significant with a p-value 0.000. The small magnitude of the coefficient proposes slow correction for past equilibria reflecting the strong persistence of PPI after exchange rate and fuel price shocks. For the NARDL model, the ECM term is -0.378 and is statistically significant with a p-value 0.000. Similarly, the small magnitude suggests the persistence of inflation after energy shocks.

Table 7: Long-run Estimates

Linear Model (ARDL)			**Nonlinear Model (NARDL)**		
Variable Name	Coefficient	t-statistic	Variable Name	Coefficient	t-statistic
NEER	-0.369	-2.104*	∆NEER+	-0.719	-0.45
CYCLE2	0.001	0.302	∆NEER-	0.03	0.163
FUEL	0.563	2.18**	CYCLE2	0.001	0.454
			∆FUEL+	0.646	3.088***
			∆FUEL-	0.305	1.358

*Notes: the sample period utilized for estimation is 2006Q1-2020Q4. The variables are consumer price (PPI), nominal effective exchange rate (NEER), Fuel price index (FUEL), and the output gap (CYCLE2). For the nonlinear model, NEER and FUEL variables are decomposed into partial sum to check for evidence of asymmetries. NEER+ reflects an appreciation of the EGP while NEER- reflects a depreciation in the EGP. For the FUEL, FUEL+ imply prices increases while FUEL- imply price decreases. ***, **, and * respectively mark statistical significance at the 1, 5, and 10 percent levels of significance.*

Table 8: Estimations of Error Correction Model (ECM)

Linear Model (ARDL)			**Nonlinear Model (NARDL)**		
Variable Name	Coefficient	t-statistic	Variable Name	Coefficient	t-statistic
PPI (-1)	-0.236	-2.933***	PPI (-1)	-0.378	-3.118***
NEER	-0.093	-2.56**	∆NEER+	-0.272	-0.47
CYCLE2	0	0.296	∆NEER-	0.001	0.158
FUEL (-1)	0.133	2.83***	CYCLE2	0	0.449
D(FUEL)	0.211	3.584***	∆FUEL+(1)	0.244	3.093***
D(FUEL (-1))	-0.15	-2.431**	∆FUEL-	0.115	1.335
ECM	-0.236	-4.32***	D(FUEL)+	0.394	2.661**
			D(FUEL (-1))+	-0.356	-2.537**
			ECM	-0.378	-5.348***

*Notes: the sample period utilized for estimation is 2006Q1-2020Q4. The variables are consumer price (PPI), nominal effective exchange rate (NEER), Fuel price index (FUEL), and the output gap (CYCLE2). For the nonlinear model, NEER and FUEL variables are decomposed into partial sum to check for evidence of asymmetries. NEER+ reflects an appreciation of the EGP while NEER- reflects a depreciation in the EGP. For the FUEL, FUEL+ imply prices increases while FUEL- imply price decreases. ***, **, and * respectively mark statistical significance at the 1, 5, and 10 percent levels of significance.*

6.4 Robustness check

For robustness purposes, we use the Wald test to check if the results are consistent with the choice of models. We check the existence of asymmetry effects of exchange rate and fuel prices in the short run. The Wald test is utilized in the short-run only for the model using PPI as the regressand. The test wasn't done for long run symmetry nor for the model using CPI as the findings were insignificant. Based on the models, the findings suggest that the ARDL is too restrictive using eq(3). The Wald test reported in table 9 suggests that the NARDL is the most suitable model for energy price shocks (FUEL). This conclusion is made because FUEL is shown to have asymmetric effects on producer price inflation. With regards to NEER multipliers, we fail to reject the null hypothesis of symmetry implying that a linear ARDL is the preferred model.

Based on the above findings, Figure 6 demonstrates the dynamic multipliers for FUEL based on eq(9) . The multiplier shows the new equilibrium for PPI following the positive and negative shocks of Fuel prices for up to 15 years. Given that zero is inside the confidence interval for the illustrated multiplier, the results of the calculations are inferred to be insignificant. Although one can observe that the positive component (FUEL+) has a stronger impact on inflation compared to FUEL-, the diagram is insignificant. The short time period under study may have contributed to the insignificance of the multiplier. Indeed, the results should be carefully analyzed as the dataset under investigation is a short-interval relative to other time-series analysis.

Table 9: Short-run Symmetry Test

Variable	Type of asymmetry	Wald/F-statistic	Conclusion
NEER	Short-run	0.231(0.632)	Symmetry
FUEL	Short-run	5.257(0.026)	Asymmetry

Notes: For the NEER, the F-statistic of the Wald test is not significant, which means that we fail to reject short-run symmetry: NEER+=NEER-. For FUEL, the F-statistic of the Wald test is significant, implying that there is evidence of asymmetry: FUEL+≠FUEL-

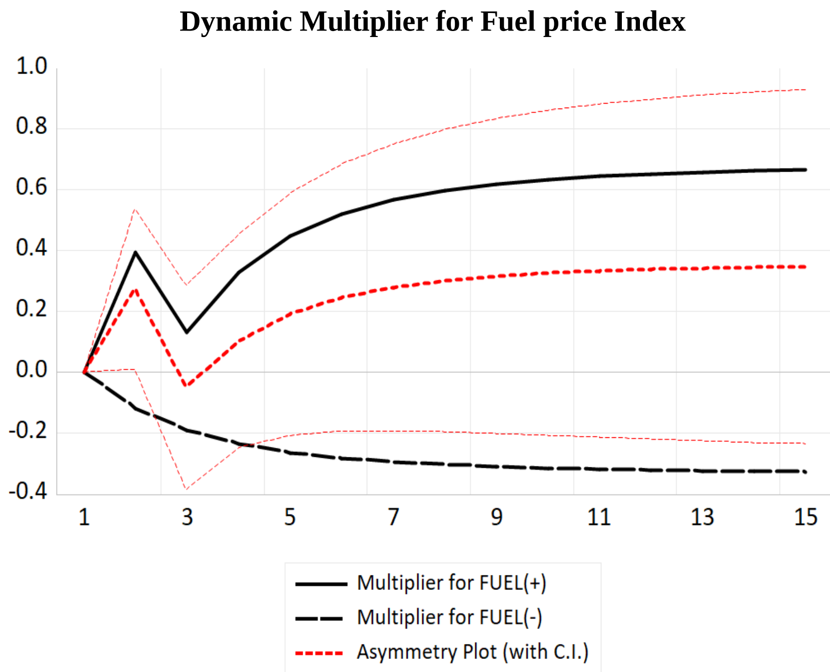

Figure-6: Data source- The Author's Calculations based on data on the IMF IFS database

$$CPI_t = \alpha_0 + \alpha_1 NEER_t + \alpha_2 CYCLE_{1,t} + \alpha_3 FUEL_t + \alpha_4 TRADE\ BALANCE\ + \varepsilon_t \quad (13)$$

$$PPI_t = \alpha_0 + \alpha_1 NEER_t + \alpha_2 CYCLE_{2,t} + \alpha_3 FUEL_t + \alpha_4 TRADE\ BALANCE\ + \ \varepsilon_t \quad (14)$$

To ensure that our findings are consistent with the complexity of the Egyptian economy, eqs (13) and (14) are re-estimated with the addition of (TRADE BALANCE) as one of the independent variables. Inflation in developing economies could be affected by movements in the trade balance. A rise in imports could increase the burden of ERPT on the economy leading to a more persistent episode of inflation. However, as depicted in the appendix section, the addition of the variable didn't alter the results of the model. The findings revealed an insignificant relationship between the aforementioned relationship. Therefore, the results are consistent with the analysis of the original model.

7. Concluding remarks and policy implications

7.1 Concluding remarks

The purpose of this thesis is to investigate the impact of pass-through shocks on inflation dynamics in Egypt. More specifically, the aim of the study was to analyze if the impacts of exchange rate and energy price movements were asymmetrical or symmetrical on inflation level in Egypt. These hypotheses were tested using time series analysis that included ARDL and NARDL models. The model used quarterly data from 2006Q1 to 2020Q4 that were extracted from the CBE, Bruegel, and IMF IFS. We adopted the methodology used by (Delatte and Lopez-Villavicencio, 2012) that is a reduced form of the Phillips curve to analyze short-run and long-run relationships among the following variables: CPI/PPI, NEER, CYCLE1/CYCLE2/, and finally FUEL. Our study followed the research of (Savastano, 2005; Massoud, 2014; Helmy, 2018), which used different price indices to determine the effects of pass-through shocks on inflation in Egypt. This method is mostly attributed to the specific case of Egypt's economy as the consumer basket used in the CPI measurement includes several products with administered prices.

The findings of the ARDL model revealed a weak and significant relationship between inflation and exchange rate shocks suggesting a weak ERPT in Egypt. However, the results are carefully analyzed as our model is limited by data availability. Import prices should be included to give a better indication of exchange rate pass-through; however, our model is limited by the time series data provided by the CBE. There are no official entities in Egypt that release data on the prices of either imports or exports in the frequency required by a time series model.

Although the results indicated an insignificant relationship between CPI and NEER, our finding revealed a negative long-run relationship between exchange rate shocks and PPI using the bounds test. These findings suggest that exchange rates movements are an important determinant of price levels in Egypt. For FUEL price movements, our results indicate a positive significant relationship with PPI in both the long-run and short-run. The study finds that energy price movements is a crucial determinant of producer price inflation.

The findings of the NARDL model were not altered compared to the ARDL model using the CPI as a dependent variable. However, for the PPI, the results varied and demonstrated a stronger and more significant relationship with the positive energy shocks (FUEL+) in the short-run and long-run. Fuel price increases were shown to have higher and more persistent impacts on PPI as opposed to drops in Fuel prices. With regards to exchange rate movements, the results were insignificant indicating that the linear model (ARDL) was a better fit. To check the robustness of our findings, the Wald test was used to test for short-run symmetry. The test provides evidence that energy price movements (FUEL) have asymmetrical effects on inflation, which shows that the assumption of symmetry was too restrictive for the case of Egypt. On the other hand, Exchange rate fluctuations showed no evidence of asymmetry indicating that its impact is symmetric on inflation.

Overall, Inflation in Egypt is highly dependent on its past values, and therefore is highly dependent on adaptive expectations. Egypt is a developing country with a negative trade balance and minimal effects on world prices. Consequently, the economy is affected by pass-through shocks due to downward price rigidity and low market power. This means that importing countries usually pay the bills of price shocks as opposed to exporting economies. As a result, producers will find it easier to increase prices rather than decrease them. Egypt has been stuck in a trap of high inflationary environment that caused persistent effects of pass-through shocks. When the economy is hit with any kind of shock, economic agents expect higher inflation in the long-run and that raises prices above normal levels. The finding imply that monetary policy should be utilized to decrease overall inflation expectations.

7.2 Limitations and Future Research

Firstly, the study is limited by data availability and short-interval variables. The research is limited by the availability of an important price Index, which is Import price Index. The central bank of Egypt and other official institutes such as CAPMAS and the ministry of planning don't compile data on the prices of Imports. The prices are not published whether aggregated or disaggregated, which inhibits the analysis of the first link of exchange rate movements to inflation that is importation prices. Additionally, this is crucial in the case of energy prices as Egypt's balance of trade is highly affected by FUEL prices. Given that Egypt is moving towards exporting certain types of natural gas, it is also importing certain types of fuel products such as refined gasoline. The volatility of energy prices as an input will affects domestic inflation in Egypt; and therefore, our research suggests an investigation of energy prices on Inflation in Egypt using disaggregated data of different energy products. Secondly, the results should be carefully analyzed as this is a relatively short-interval time series analysis. The study tries to address this issue by using an ARDL model that is proven highly robust to short-interval data. However, the insignificance of the output gap (CYCLE) could be attributed to structural breaks in the economy such as 2011 Arab spring and the 2016 devaluation.

7.3 Policy Implications

Exploring the role of monetary policy in relieving inflationary pressures of pass-through shocks on the economy is crucial in EMs research. Based on the study's findings, inflation episodes are aggressive and persistent as a result of exchange rate and supply-side shocks. Nowadays, Egypt is also suffering from the global pandemic and the Russian-Ukraine war with inflation trending upwards again. Given the high inflationary environment Egypt has been trapped in, Domestic and international shocks can be more difficult to overcome and inflation levels take more time to return to long-run equilibrium. Policy makers in Egypt started moving towards inflation targeting, which has shown empirically that it is correlated with lower inflationary environments (Taylor, 2000).

A fully-fledged inflation targeting framework is recommended with crucial complementary policies. Nowadays, the CBE has moved towards inflation targeting by setting quantitative targets for inflation for certain sub-periods. The outcomes of inflation targeting could improve by moving towards fully-fledged inflation targeting. There are two preliminary requirements identified by the IMF for a country to implement the aforementioned method. Firstly, the independence of the central bank is key to having effective monetary policy. In retrospect, there are no central banks entirely free of government influence, however, it must have the freedom of choosing the appropriate monetary instruments to reach the targeted rate of inflation. Secondly, the central bank must be willing and able not to target other indicators such as wage, unemployment or exchange rates. For instance, an exchange target or a managed exchange rate results in price distortions that create market inefficiencies. These market inefficiencies are a place for speculations and adaptive expectations, which in turn result in higher inflation. Therefore, moving towards a floating exchange rate regime would complement the primary goal of the CBE. Given that both requirements are fulfilled, the central bank can move toward fully-fledged inflation targeting by indicating clearly to the public that hitting the inflation target is the CBE's primary objective. Countries that have successfully implemented the above method have lower inflationary environments, favorable macroeconomic performance, and their economies were more resilient in turbulent environments (IMF, 2016).

For the efficiency of monetary policy to improve, social welfare and fiscal policies should complement the monetary framework. Social welfare policies are important to act as a cushion for vulnerable agents that are most affected by inflationary episodes. Most Egyptian families don't own financial assets to hedge against inflation; therefore, the impacts of inflation on the most vulnerable should be considered by policymakers. Programs like "Takfol and Karma", which provides conditional cash transfers as a monthly income to Egyptian families, should be expanded to increase outreach and make sure that the conditions are implemented in a favorable manner.

While Monetary and fiscal policies are key to price stability, the fundamentals of the economy are crucial in volatile economies like Egypt. Policymakers should aim to increase the production capacity of the Egyptian economy to sustain price and economic stability. The core essence of pass-through effects are the movements of international prices relative to domestic prices and the persistent effects of these movements. Given that policymakers focus on domestic production and on raising the economy's share of world market, the economy will become more resilient to pass-through effects such exchange rate movements and commodity price movements. This will not only decrease the share of imported goods in the economy, but also increase purchasing power and standards of living. Increasing production capacity in the Egyptian economy will enable monetary policy to deliver its long-term goal of low stable inflation and sustain it. Therefore, policymakers and the CBE should encourage and provide incentives for entrepreneurs with an aim of domestic production. Finally, policy coordination within an economy is crucial to achieve sustainable positive outcomes.

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Appendix

Dependent Variable: CPI
Method: ARDL
Date: 03/28/22 Time: 21:50
Sample (adjusted): 2006Q2 2020Q4
Included observations: 59 after adjustments
Maximum dependent lags: 4 (Automatic selection)
Model selection method: Schwarz criterion (SIC)
Dynamic regressors (4 lags, automatic): NEER CYCLE2 FUEL TRADE_BALANCE
Fixed regressors: C
Number of models evalulated: 2500
Selected Model: ARDL(1, 0, 0, 0, 0)
Note: final equation sample is larger than selection sample

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
CPI(-1)	0.850559	0.087902	9.676256	0.0000
NEER	-0.054578	0.082694	-0.660006	0.5121
CYCLE2	-0.000809	0.001523	-0.531027	0.5976
FUEL	0.024768	0.071624	0.345806	0.7309
TRADE_BALANCE	-0.005286	0.071788	-0.073628	0.9416
C	0.900600	1.117331	0.806028	0.4238

R-squared	0.765309	Mean dependent var	4.994193
Adjusted R-squared	0.743168	S.D. dependent var	0.315673
S.E. of regression	0.159978	Akaike info criterion	-0.731412
Sum squared resid	1.356433	Schwarz criterion	-0.520137
Log likelihood	27.57666	Hannan-Quinn criter.	-0.648939
F-statistic	34.56579	Durbin-Watson stat	1.888651
Prob(F-statistic)	0.000000		

*Note: p-values and any subsequent tests do not account for model selection.

Dependent Variable: CPI
Method: ARDL
Date: 03/28/22 Time: 21:52
Sample (adjusted): 2006Q2 2020Q4
Included observations: 59 after adjustments
Maximum dependent lags: 4 (Automatic selection)
Model selection method: Schwarz criterion (SIC)
Dynamic regressors (4 lags, automatic): NEER_POS NEER_NEG CYCLE2 FUEL_POS FUEL_NEG TRADE_BALANCE
Fixed regressors: C
Number of models evalulated: 62500
Selected Model: ARDL(1, 0, 0, 0, 0, 0, 1)
Note: final equation sample is larger than selection sample

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
CPI(-1)	0.768415	0.100776	7.624959	0.0000
NEER_POS	-1.395448	0.936340	-1.490322	0.1424
NEER_NEG	-0.232350	0.146718	-1.583652	0.1196
CYCLE2	0.000729	0.001695	0.430038	0.6690
FUEL_POS	-0.058404	0.111754	-0.522608	0.6036
FUEL_NEG	-0.151927	0.151359	-1.003750	0.3203
TRADE_BALANCE	-0.119533	0.149400	-0.800083	0.4274
TRADE_BALANCE(-1)	0.282696	0.152222	1.857131	0.0692
C	-0.216251	1.054634	-0.205048	0.8384

R-squared	0.788828	Mean dependent var	4.994193
Adjusted R-squared	0.755040	S.D. dependent var	0.315673
S.E. of regression	0.156237	Akaike info criterion	-0.735313
Sum squared resid	1.220502	Schwarz criterion	-0.418401
Log likelihood	30.69174	Hannan-Quinn criter.	-0.611604
F-statistic	23.34672	Durbin-Watson stat	1.824506
Prob(F-statistic)	0.000000		

*Note: p-values and any subsequent tests do not account for model selection.

Dependent Variable: PPI
Method: ARDL
Date: 03/28/22 Time: 21:16
Sample (adjusted): 2007Q4 2020Q4
Included observations: 53 after adjustments
Maximum dependent lags: 4 (Automatic selection)
Model selection method: Schwarz criterion (SIC)
Dynamic regressors (4 lags, automatic): NEER CYCLE2 FUEL
TRADE_BALANCE
Fixed regressors: C
Number of models evalulated: 2500
Selected Model: ARDL(1, 0, 0, 2, 0)
Note: final equation sample is larger than selection sample

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
PPI(-1)	0.764402	0.090897	8.409497	0.0000
NEER	-0.094495	0.041044	-2.302310	0.0260
CYCLE2	0.000259	0.000895	0.289757	0.7733
FUEL	0.211262	0.063839	3.309312	0.0018
FUEL(-1)	-0.229174	0.077167	-2.969845	0.0048
FUEL(-2)	0.150655	0.063207	2.383537	0.0214
TRADE_BALANCE	-0.002971	0.092135	-0.032247	0.9744
C	0.987079	0.918694	1.074438	0.2884

R-squared	0.756299	Mean dependent var	5.191700
Adjusted R-squared	0.718390	S.D. dependent var	0.156378
S.E. of regression	0.082985	Akaike info criterion	-2.002052
Sum squared resid	0.309894	Schwarz criterion	-1.704649
Log likelihood	61.05437	Hannan-Quinn criter.	-1.887685
F-statistic	19.95037	Durbin-Watson stat	2.044343
Prob(F-statistic)	0.000000		

*Note: p-values and any subsequent tests do not account for model selection.

Dependent Variable: PPI
Method: ARDL
Date: 03/28/22 Time: 21:16
Sample (adjusted): 2007Q4 2020Q4
Included observations: 53 after adjustments
Maximum dependent lags: 4 (Automatic selection)
Model selection method: Schwarz criterion (SIC)
Dynamic regressors (4 lags, automatic): NEER_POS NEER_NEG CYCLE2
FUEL_POS FUEL_NEG TRADE_BALANCE
Fixed regressors: C
Number of models evalulated: 62500
Selected Model: ARDL(1, 0, 0, 0, 2, 0, 0)
Note: final equation sample is larger than selection sample

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
PPI(-1)	0.626679	0.123685	5.066724	0.0000
NEER_POS	-0.274138	0.584717	-0.468840	0.6416
NEER_NEG	0.010717	0.073393	0.146021	0.8846
CYCLE2	0.000475	0.000919	0.516733	0.6080
FUEL_POS	0.383152	0.154562	2.478949	0.0172
FUEL_POS(-1)	-0.509448	0.205393	-2.480355	0.0171
FUEL_POS(-2)	0.367906	0.146797	2.506215	0.0161
FUEL_NEG	0.108870	0.090389	1.204456	0.2350
TRADE_BALANCE	-0.030022	0.097834	-0.306872	0.7604
C	2.048578	0.978020	2.094617	0.0421

R-squared	0.762859	Mean dependent var	5.191700
Adjusted R-squared	0.713225	S.D. dependent var	0.156378
S.E. of regression	0.083743	Akaike info criterion	-1.953867
Sum squared resid	0.301553	Schwarz criterion	-1.582114
Log likelihood	61.77749	Hannan-Quinn criter.	-1.810909
F-statistic	15.36965	Durbin-Watson stat	1.867788
Prob(F-statistic)	0.000000		

*Note: p-values and any subsequent tests do not account for model selection.