Revisiting the Exchange Rate Pass-Through
to Domestic Inflation in Egypt:
Why Is the Statistical Association Weak in the Short Run?

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Abstract

This study investigates the question of "Why is the statistical association between exchange rate shocks and domestic inflation in Egypt weak?" The study relies on two econometric models, the SVAR model and the Markov switching regression model. Presenting results of statistical analysis showing that the exchange rate pass-through to domestic inflation in Egypt is weak and insignificant over the study's whole period (2006Q1-2016Q3), but is significant for the sub-periods of 2006Q1-2010Q4 and 2011Q1-2016Q3. We explain the variations of both level and speed of exchange rate pass-through between the sub-periods by two factors: (i) monetary policy intervention to maintain targets for foreign exchange rates and real GDP growth; and (ii) structural change in the time series data resulting from a change in the macroeconomic policies.

Key words: price stability; exchange rate pass-through; structural VAR model; Markov switching regression model

JEL classification: E61; E58; F41; C32

1. Introduction

For many decades the Central Bank of Egypt (CBE) has pegged its foreign exchange (FX) rates. During the period of 1960-2000, a variety of FX pegs were experimented with, including the conventional peg in the 1960s, the crawling peg in the 1970s and 1980s, and the crawling bands in the 1990s (Kamar and Bakardzhieva, 2005). Beginning in 2001 the CBE embarked on gradual devaluations and formally announced partial floatation of the domestic currency in January 2003. Some researchers argue that the CBE continued targeting the FX rate even after 2003, believing it to have been conducted by maintaining an implicit target and through the practice of a sterilized intervention policy under a managed floating system (Awad,

2010; Moursi et al., 2007).[1]

With the Arab Spring uprising, the level and speed of domestic currency depreciation in Egypt turned higher and lasted longer. Specifically, with the eruption of the January 25th upheaval in 2011 and the events that followed it, the parallel market for foreign exchange with a premium strongly revived reaching 82.4%.[2] After successive devaluations of the Egyptian pound against the US dollar (5.79 EP in January 2011, 6.02 EP in January 2012, 6.87 EP in January 2013, 6.93 EP in January 2014, 7.13 EP in June 2014, 7.54 EP in February 2015, 7.72 EP in December 2015, and 8.77 EP in March 2016),[3] the CBE had no option but to accept further and significant devaluations of the domestic currency. On March 14, 2016, the CBE decided to devaluate domestic currency in conjunction with raising short-term nominal interest rates by 150 basis points.[4]

Despite CPI inflation going up from 9.1% in February 2016 to 15.47% in August 2016 and at the same time the premium between official and unofficial FX rates having hit 82.4%, the MPC decided not to devaluate domestic currency and kept interest rates unchanged. MPC's decision was based on its assessment that the impact of pass-through of the latest FX rate movements to CPI inflation would be limited, as the rise in the CPI inflation refers to price increases of regulated items, especially electricity, in addition to increases in the prices of fresh vegetables.[5] Te CBE's core inflation, which already excludes both regulated and volatile items from the headline CPI inflation, rose from 7.5% in February 2016 to 13.25% in August 2016. Thus, the explanation by the CBE for a limited pass-through of the FX rate to the CPI inflation is not convincing and both contradict theory and practice.[6]

Many studies in Egypt highlight the weak relationship between exchange rate shocks and CPI inflation, often explaining it by the large share of subsidized and regulated prices in Egypt's CPI, which are believed to be roughly one third to one half of items in the CPI (Savastano et al., 2005; Massoud, 2014; Helmy et al., 2018). However, such an explanation for the insignificant response of the CPI inflation to the exchange rate shocks does not fit the periods after the January 25th upheaval in 2011. During the period 2011Q1-2016Q3, many regulated and subsidized prices moved up including electricity, fuel, transportation, and many other goods and services, yet the exchange rate pass-through (ERPT) to the CPI is statistically low and insignificant as confirmed by the empirical results of this present study.

Aside from quantifying the pass-through of recent exchange rate movements to CPI inflation in Egypt, the challenge of this study is to explain why the statistical association between exchange rate movements and CPI inflation is weak. To our knowledge, there is no previous study entirely dedicated to investigating this question, especially in the case of Egypt.

This study relies on both the SVAR model and the Markov switching regression model to analyze the association between ERPT and domestic inflation in Egypt, examining two schemes for the association between exchange rate and CPI inflation. The first scheme is the 'price chain' model of McCarthy (1999),[7] where Egypt is treated as a small open economy, and the reaction function of the CBE and the demand for money function appear in the analysis. The second scheme includes

the variables reported in Choudhri and Hakura (2001), expressed by equation 1. We run the analysis using quarterly data over the period of 2006Q1-2016Q3 and two sub-periods: 2006Q1-2010Q4 and 2011Q1-2016Q3.

The remainder of this paper is as follows. Section 2 explores previous studies on ERPT to domestic inflation in Egypt. Section 3 discusses models, variables, and data. Section 4 analyzes and discusses the empirical results. Section 5 offers concluding remarks.

2. Literature Review

ERPT is defined as the percentage of change in the local currency price of imported goods resulting from a 1% change in the nominal exchange rate between a country and their trading partners (Bailliu and Fujii, 2004; Goldberg and Knetter, 1997). Previous studies on ERPT conclude that there is no consensus on specific determinants that lead to a low ERPT. Some studies in the literature suggest that the import price pass-through to CPI inflation is determined by microeconomic factors, e.g., market structure and demand elasticities.[8] The policy implication of such results is that monetary policy has little to do to minimize the negative impact of ERPT on domestic inflation.

The determinants and hence the effect of ERPT in general vary across countries and time. The size of the economy, the level of domestic inflation, the monetary policy regime, the exchange rate volatility, the real GDP volatility, the domestic market concentration, the substitutability of imports, and the degree of openness are the most common determinants of ERPT. ERPT is expected to be lower when the economy is large, domestic inflation is low, the Central Bank (CB) adopts an inflation targeting regime, the exchange rate is more volatile, the aggregate demand is more volatile, the domestic industries are more segmented, and the degree of openness of the economy is low.[9]

Table 1 shows previous studies on ERPT in Egypt. Although few, most previous studies on the effect of ERPT on domestic prices in Egypt are based on McCarthy (1999), where ERPT is tracked down to each stage of the price chain (or the distribution chain), including import prices, producer prices, and consumer prices.

Savastano et al. (2005), Massoud (2014), and Helmy et al. (2018) base their analyses of ERPT to domestic inflation in Egypt on the distribution chain put forth by McCarthy (1999). They conduct their analysis of ERPT by using a SVAR model and monthly data. The study by Massoud (2014), which covers the period of 2003-2013, does not reach a specific conclusion on the level of ERPT in Egypt. Moreover, the responses of CPI inflation and the producer price index (PPI) inflation to exchange rate shocks are insignificant.

Table 1. Previous Studies on the Pass-Through of Exchange Rate to Domestic Price in Egypt

Author & Year	Model & Data Frequency	ERPT		ER index			Supply shock	Demand shock		Model's Variables Distribution Chain				External shock	Monetary policy stance	
		S	L	BER	NEER	REER	Pm^{oil}	GDP	GAP	ER	pm	pp	pc	pc^f	m	i
Massoud (2014)	VAR-monthly	NA	NA	X	X		X		X	X	X^a	X	X		X^b	X^b
Choudri and Hakura (2001)	New-open economy Macroeconomic models-OLS	21%	24%		X					X			X	X		
Savastano et al. (2005)	SVAR-monthly	6%-27%	11%		X		X	X		X		X^c	X			
Kraay (2008)	Disaggregated CPI-monthly on the period 2000-2005		19%	X	X					X	X	X	X			
Helmy et al. (2018)	SVAR-monthly monthly on the period 2003-2015	12.63%		X	X			X		X	X	X	X	X		X

S	Short-run	pc	Consumer prices
L	Long-run	pc^f	Foreign consumer prices
BER	Bilateral exchange rate (EGY/$)	m	Money supply
NEER	Nominal effective exchange rate	i	Interest rate
REER	Real effective exchange rate		
NA	Not available		
pm^{oil}	Price of imported oil		
ER	Exchange rate		
pm	Import prices		
pp	Producer prices		

a value of imports. b money supply M1 and lending interest rate, respectively. c wholesale price index.

The study by Savastano et al. (2005), which covers the period 1995-2004, estimates the ERPT to the CPI inflation by 6-27% for the short run (twelve months) and 11% for the long run (24 months), despite being insignificant over all horizons. Moreover, the study by Helmy et al. (2018), which covers the period 2003-2015, estimates the contemporaneous ERPT to CPI inflation by 12.63% under an implied assumption that there is no reaction by the CBE to the nominal exchange rate movements. Clearly, such an assumption contradicts the reality where the CBE regularly intervenes to maintain some targets for the nominal exchange rate. After the inclusion of the monetary policy reaction, however, the CPI reaction to the exchange rate shocks shows an insignificant response.

Choudhri and Hakura (2001) examine the relationship between ERPT and CPI inflation using quarterly data from a sample of 71 developing and developed countries. Using a general equilibrium framework, which is based on new-open economy macroeconomic models and incorporates imperfect competition and price inertia, they derive the theoretical association between inflation and ERPT. The derived log-linear form of the pass-through relation from their analysis is:

$$logP_t = \beta_1(L)logP_{t-1} + \beta_2(L)logFX_t + \beta_3(L)logP_{t-1}^F + \varepsilon_t \ , \qquad (1)$$

where P_t, FX_t, and P_t^F stand for the domestic CPI, the nominal effective exchange rate, and the foreign CPI, respectively. The average long-run ERPT in a group of moderate inflation countries including Egypt is 35%. For Egypt, the ERPT ranges between 21% and 24% for both the short run and long run, respectively.[10]

Kraay (2008) assesses the welfare implications of changes in the consumer prices that accompanied the movement in the exchange rate over the period 2000-2005. First, he estimates the disaggregated exchange rate pass-through regressions from monthly CPI, disaggregated into 160 different price indices. Then the estimates are linked to the household survey to investigate their welfare effects. The long-run ERPT is estimated as 9%, and the resultant average welfare loss due to exchange rate-induced price increases is estimated to be 7.4% of initial expenditure.

In a nutshell, the SVAR model is the most empirical approach used by previous studies on Egypt to quantify ERPT. In addition, most previous studies on ERPT in Egypt share a common conclusion that ERPT to CPI inflation is not significant. With a radical change in the macroeconomic policy in Egypt, the time series data are expected to undergo structural break. Another methodology to quantify ERPT, especially when the time series undergoes structural change, is the Markov switching approach. However, no previous study on ERPT in Egypt has adopted the Markov switching approach to quantify ERPT.

3. Model and Variables

Similar to Savastano et al. (2005), this study adopts the SVAR model to examine ERPT in Egypt using the following variables: oil price (proxy for external shocks), real GDP, official nominal exchange rate with the US dollar, producer price

index, and consumer price index. Unlike Savastano et al. (2005), we incorporate an additional three variables to make the model on Egypt comply with the VAR-based distribution chain put forward by McCarthy (1999, 2007). They are import prices, reaction function of monetary policy, and the demand for money function. Because of limited data on import prices, we calculate a proxy for Egypt's import prices from the following formula:

Import prices (in terms of Egyptian pounds)

= Foreign consumer prices (i.e., CPI^{USA})   (2)

x Dollar price in terms of Egyptian pounds (i.e., $FX_t^{£/\$}$)[11]

The inclusion of import prices in the model is quite important as imports represent the channel through which exchange rate movements are transmitted to other variables of the distribution chain. In addition, the inclusion of monetary policy reaction to movements of other model's variables, including exchange rate movements, reflect the impact of monetary policy actions on the path and volatility of exchange rates, especially when maintaining double targets for exchange rates and inflation in the case of Egypt (Awad, 2010). Finally, the inclusion of the demand for money function relates the growth of money supply to the rest of the model's variables. Given the demand for money, movements in the short-term interest rate require a change in money supply. On the other hand, a change in price level and/or a change in real GDP will shift the demand for money, and thereby the interest rate will change, given the amount of money supply. Hence, a change in the nominal interest rate both because of shifts in the supply of and the demand for money will affect aggregate demand in the next periods.[12]

We use the money market overnight deposit rate to measure the monetary policy stance and the M1 growth rate to equilibrate the demand for money in the money market. All variables, except for interest rate, are introduced in logs and first differences to render them stationary. The baseline identification scheme of the SVAR model's variables is as follows:

$$
\begin{bmatrix}
\Delta log P_t^{oil} \\
\Delta log RGDP_t \\
\Delta log FX_t^{\$/£} \\
\Delta log IM_t \\
\Delta log PPI_t \\
\Delta log CPI_t \\
i_t \\
\Delta log M1_t
\end{bmatrix}
= E_{t-1}
\begin{bmatrix}
\Delta log P_t^{oil} \\
\Delta log P_t^{elec} \\
\Delta log E_t^{£/\$} \\
\Delta log IM_t \\
\Delta log PPI_t \\
\Delta log CPI_t \\
i_t \\
\Delta log M2_t
\end{bmatrix}
+
$$ (3)[13]

$$\begin{bmatrix} \varepsilon_t^S \\ \alpha_1 \varepsilon_t^S + \varepsilon_t^d \\ \beta_1 \varepsilon_t^S + \beta_2 \varepsilon_t^d + \varepsilon_t^E \\ \gamma_1 \varepsilon_t^S + \gamma_2 \varepsilon_t^d + \gamma_3 \varepsilon_t^E + \varepsilon_t^{IM} \\ \delta_1 \varepsilon_t^S + \delta_2 \varepsilon_t^d + \delta_3 \varepsilon_t^E + \delta_4 \varepsilon_t^{IM} + \varepsilon_t^{PPI} \\ \varphi_1 \varepsilon_t^S + \varphi_2 \varepsilon_t^d + \varphi_3 \varepsilon_t^E + \varphi_4 \varepsilon_t^{IM} + \varphi_5 \varepsilon_t^{PPI} + \varepsilon_t^{CPI} \\ \rho_1 \varepsilon_t^S + \rho_2 \varepsilon_t^d + \rho_3 \varepsilon_t^E + \rho_4 \varepsilon_t^{IM} + \rho_5 \varepsilon_t^{PPI} + \rho_6 \varepsilon_t^{CPI} + \varepsilon_t^{MP} \\ \omega_1 \varepsilon_t^S + \omega_2 \varepsilon_t^d + \omega_3 \varepsilon_t^E + \omega_4 \varepsilon_t^{IM} + \omega_5 \varepsilon_t^{PPI} + \omega_6 \varepsilon_t^{CPI} + \omega_7 \varepsilon_t^{MP} + \varepsilon_t^{MD} \end{bmatrix}$$

Here, $E_{t-1}(.)$ is the expectation of a variable's conditional available information at period t-1. The shocks are supposed to not be serially correlated and not correlated with each other during the same period. The SVAR model is able to identify the shock of each variable.

As the level and speed of ERPT depend on the interaction of many variables, tracking ERPT among some distinctive periods may identify the main factors behind it. Thus, the study uses quarterly data over the period 2006:Q1-2016:Q3 to examine ERPT for the whole period and for two sub-periods, 2006Q1-2010Q4 and 2011Q1-2016Q3. We collect quarterly data on real GDP, $RGDP_t$, exchange rates, $FX_t^{\$/£}$, the producer price index, PPI_t, the consumer price index, CPI_t, the interest rate, i_t, and money supply, $M1_t$ from the Economist Intelligence Unit. Crude oil world prices, P_t^{oil}, are from IMF-IFS. The above ordering of variables, put forth by McCarthy (1999, 2007), denotes the structure of "price chain" through which the effect of exchange rate shocks can be identified at each stage of the distribution process. In other words, the order of the model's variables expresses the transmission mechanisms of ERPT to CPI inflation.

Figure 1. The Mechanisms of Exchange Rate to Import, Producer, and Consumer Prices
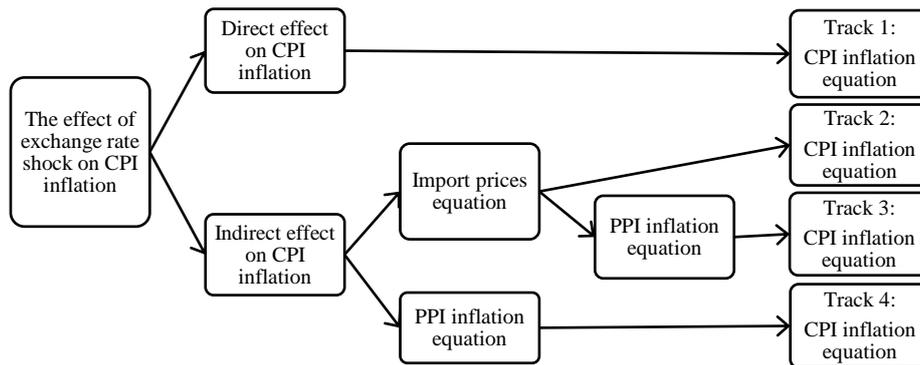

Figure 1 shows the transmission mechanisms of ERPT to import, producer, and consumer prices. A shock in the exchange rate at period *t* (that cannot be explained by the exchange rate at period *t*-1 plus contemporaneous information about demand, supply, and exchange rate shocks)[14] will affect CPI inflation both directly and

indirectly.

The indirect effect comes from two variables in the inflation equation: the effect of exchange rate shock on import prices and the effect of exchange rate shock on producer prices (or PPI inflation). As import prices also affect PPI inflation, the total effect of PPI inflation on CPI inflation is the sum of both the effect of the exchange rate on PPI inflation and the effect of import prices on PPI inflation at period *t*.

Tracks 2 and 3 (Figure 1) describe the transmission mechanisms of ERPT to CPI inflation through the import price channel. CPI inflation rises, because domestic currency depreciation causes an increase in domestic prices in both final and intermediate imported goods included in the basket of consumer goods. The effect of the final imported goods component on CPI inflation depends on its weight in the basket of consumer goods, whereas the effect of the intermediate imported goods component on CPI inflation depends on both its weight in domestically-produced goods and the weight of domestically-produced goods in the basket of consumer goods.

Tracks 1 and 4 indicate the effect of ERPT upon CPI inflation without passing through the import price channel, which can be explained by the change in the price of tradable goods produced domestically. The depreciation of domestic currency will increase the domestic prices of tradable goods produced domestically despite their price in the international market not changing. As these goods are included in both the consumers' basket of final goods and in the process of production as intermediate goods, both CPI inflation and PPI inflation will rise.

Against this background, the level of ERPT to consumer prices depends not only on the degree of the economy's openness, but also on the relative weight of tradable goods in CPI and PPI. In addition, if the government subsidizes a significant portion of consumers' goods, then ERPT to consumer prices is expected to be lower or statistically insignificant. Importantly, the insignificance of ERPT in such a case does not mean that it does not exist. It does exist, but most of the burden now appears to be within the government budget in the form of large allowances for subsidized goods. However, the final effect on CPI inflation depends on the methods of financing such an increase in the government budget.[15]

In light of the above issues, when a country maintains a significant portion of subsidized and regulated goods' prices, the ratio of ERPT to CPI inflation should be lower. If the burden on the government budget is mounting and thus the government decides at some point in time to cut or remove subsidies, then currency depreciation will result in higher pass-through to CPI inflation. Consequently, the ratio of ERPT to CPI inflation will differentiate in level and speed over time. Aside from examining ERPT using the SVAR model, we can employ the Markov switching approach to see whether a structural change does exist during the periods of study and to quantify the level of ERPT under different regimes.

4. Empirical Results

Table 2 shows the stationary variables at 5% and 10% significance levels. The Augmented Dickey-Fuller and Kwiatkowski-Phillips-Schmidt-Shin unit root tests indicate that all variables are integrated order zero or I~ (0). We estimate a structural VAR model with the above-mentioned ordering of variables over the period of 2006Q1-2016Q3. The lag length detected by the LR test statistic, FPE test, and HQ information criterion is one lag, where the model satisfies the stability condition that no root lies outside the unit circle.

Table 2. Test Results for Unit Roots

Variables	Augmented Dickey-Fuller			Kwiatkowski-Phillips-Schmidt-Shin		
	Without Trend	With Trend	Lag Length using AIC	Without Trend	With Trend	Bandwidth using Bartlett Kernel
$\Delta logP_t^{oil}$	-5.03*	-5.01**	1	0.2**	0.11**	11
$\Delta logRGDP$	-9.07*	-8.96*	2	0.21*	0.13**	12
$\Delta logFX_t^{\$/£}$	0.95	-0.71	7	0.49**	0.13*	3
$\Delta logIM_t$	1.46	0.28	2	0.46**	0.138*	3
$\Delta logPPI_t$	-4.79**	-4.72**	2	0.2**	0.14**	10
$\Delta logCPI_t$	-2.45	-2.27**	3	0.14**	0.143**	8
i_t	-1.76	-3.12*	1	0.57**	0.08	5
$\Delta logM1_t$	-5.6**	-5.54**	1	0.12**	0.11**	6

** and * indicate significance at the 5% and 10 % levels, respectively.

Table 3 shows the level and speed of ERPT to import price, PPI inflation, and CPI inflation. Following Savastano et al. (2005), we define the level of ERPT to any variable at horizon *h* quarters as the ratio of accumulated responses of the variables to an exchange rate shock at horizon *h* quarters relative to the accumulated response of the exchange rate to its own shock at the same horizon of *h* quarters.

Table 3. Level and Speed of Exchange Rate Pass-Through During the Periods 2006Q1-2016Q3

Exchange rate pass-through	Level %					Speed %				
	Horizon/Number of quarters					Horizon/Number of quarters				
	1	2	3	4	8	1	2	3	4	8
Period 2006Q1-2016Q3										
Import price	106	102.5	98.9	99.1	97.8	108.4	104.8	101.1	101.3	100
PPI inflation	-1.9	-0.46	-2.2	-19.5	-47.5	4	0.9	4.6	41	100
CPI inflation	-6.1	14.8	21.7	10.5	-7.1	86	-208.4	-305.6	-148	100
Period 2006Q1-2010Q4										
Import price	108	95.8	99	97	87	-2124	-2110	113.8	111.5	100
PPI inflation	91	197.5	129.7	58.5	-3.3	-2757	-5984	-3930	-1772	100
CPI inflation	12.6	106	94	60.4	38.7	32.8	-2274	242.9	156	100
Period 2011Q1-2016Q3										
Import price	101.7	100	88.6	89	91	111.7	109.9	97.4	97.8	100
PPI inflation	-29	-12.8	-16	-21	-17	170.6	75.2	94.1	123.5	100
CPI inflation	-5.4	28.4	36	15.8	19.6	-27.5	144.9	183.7	80.6	100

The speed of pass-through denotes the ratio of the pass-through coefficient at

horizon *h* quarters to the long-term pass-through coefficient, which is the level of pass-through at horizon 8 quarters. To maximize comparisons, the level and speed of ERPT are estimated for the whole period of 2006Q1-2016Q3 and for two sub-periods, 2006Q1-2010Q4 and 2011Q1-2016Q3.

The ratio of ERPT to import prices is complete and significant along all the periods as shown by Table 3, where the build-up of an exchange rate shock to import prices exceeds 100% after one quarter. However, the accumulated response of PPI inflation and CPI inflation to a structural one standard deviation innovation of exchange rate varies between the two sub-periods. For the whole period of 2006Q1-2016Q3, the responses of PPI inflation and of CPI inflation to exchange rate shocks are not significant. In addition, the response of PPI inflation to exchange rate shocks is anomalous when domestic currency depreciation pushes PPI inflation down.

The above results on the level of ERPT to CPI inflation are consistent with the results of previous studies on Egypt's economy. The estimates of short-run ERPT over the whole period of 2006Q1-2016Q3 of 21.7% and 10.5% for three quarters and four quarters, respectively, are in line with the findings by Choudhri and Hakura (2001), Savastano et al. (2005), and Helmy et al. (2018), as reported in Table 1. In addition, similar to Savastano et al. (2005) and Helmy et al. (2018), the responses of PPI inflation and CPI inflation to exchange rate shocks are insignificant for the whole period of 2006Q1-2016Q3.

By estimating the model separately for each sub-period, 2006Q1-2010Q4 and 2011Q1-2016Q3, the results show different responses of PPI inflation and of CPI inflation to exchange rate shocks. For the period of 2006Q1-2010Q4, the level and speed of ERPT to CPI inflation are complete and significant until the second quarter (106% and 274% for level and speed, respectively). However, both the level and the speed of ERPT to CPI inflation decline along the period 2011Q1-2016Q3 compared with the previous one. The build-up of an exchange rate shock to CPI inflation is not complete (but significant) and reaches its peak of 36% at quarter 3, while the speed is less and reaches its peak of 183.7% at quarter 3 compared to 274% at quarter 2 for the period 2006Q1-2010Q4.

As for ratio of ERPT to PPI inflation, it is complete and significant until quarter 3 for the period 2006Q1-2010Q4. For the period 2011Q1-2016Q3, however, it is not significant and shows an anomalous response to exchange rate shocks. Two factors may explain the differences in ERPT between the two sub-periods:

4.1 Monetary Policy Intervention to Maintain Targets for Foreign Exchange Rate and Real GDP Growth

Referring to the literature review, ERPT is first determined by many factors including the level of domestic inflation, exchange rate volatility, and real GDP volatility (see, endnote 8). Therefore, we attribute the decline in ERPT to both CPI inflation and PPI inflation during the period 2011Q1-2016Q3 compared with the previous period to the decline in CPI inflation itself and the rise in the volatility of both the exchange rate and real GDP.

Table 4 shows the mean and the standard deviation of CPI inflation, exchange

rate growth, and growth in real GDP. The mean of CPI inflation declines from 3% for the period 2006Q1-2010Q4 to 2% for the period 2011Q1-2016Q3, whereas the standard deviation is nearly constant. As for the exchange rate and real GDP, the standard deviation and the mean for the period 2011Q1-2016Q3 are greater than those in the period 2006Q1-2010Q4.

Table 4. Volatility of Exchange Rate and Real GDP Growth Rate

Variables	Exchange rate growth	Real GDP growth	CPI inflation
Period 2006Q1-2010Q4			
Mean	0.0006	0.007	0.030
S.D.	0.0146	0.027	0.019
Period 2011Q1-2016Q3			
Mean	0.0180	0.008	0.020
S.D.	0.0310	0.050	0.011

We perform the Lo and MacKinlay variance ratio test, which compares variance differences of the time series data calculated over different intervals. The test does not reject the null hypothesis of a random walk for CPI inflation, while the null hypothesis of a random walk for exchange rate growth and real GDP growth is rejected at the 5% significance level;s i.e., the probability distribution of variance differences are not the same and variance differences are not mutually independent.

Second, the rise in the volatility of both the exchange rate and real GDP is caused by inconsistent responses of monetary policy to exchange rate movements and real GDP growth over the two periods. The analysis of variance decomposition sheds light on the relative contribution of each variable in the variance decomposition of other variables. Table 5 highlights the variance decomposition of exchange rate growth, real GDP growth, and CPI inflation during the above-mentioned two sub-periods.

Table 5. Average Variance Decomposition (%) over Four Quarters

Variables	RGDP	FX	Import price	PPI	CPI	Interest rate	M1
Variance decomposition (2006Q1-2010Q4)							
FX	8.33	69.21	6.23	1.64	7.62	3.65	3.29
CPI	34.13	16.67	0.67	13.76	30.59	0.23	3.93
RGDP	50.55	1.88	9.50	8.30	16.22	4.98	8.52
Variance decomposition (2011Q1-2016Q3)							
FX	9.75	64.19	3.16	18.03	3.66	0.41	0.76
CPI	7.63	29.29	6.24	5.90	50.64	0.24	0.026
RGDP	63.91	15.59	10.43	6.68	0.07	0.62	2.67

While the relative contribution of the interest rate in the variance decomposition of both real GDP growth and exchange rate growth declines from 3.65% and 4.98%, respectively, for the period 2006Q1-2010Q4 to 0.4% and 0.6%, respectively, for the period 2011Q1-2016Q3, it is nearly constant for the CPI inflation (around 0.2%) over the two periods. In other words, the rise in the volatility of both the exchange rate and real GDP growth (hence, the lower the level and the speed of ERPT to domestic inflation) during the period 2011Q1-2016Q3 is due to a

less response of the interest rate to exchange rate and real GDP shocks. Interestingly, the monetary policy intends to maintain targets for the exchange rate and real GDP growth, and CBE intervening to achieve these targets could produce inflation by raising both the level and speed of ERPT to domestic inflation.

4.2 Structural Change in the Macroeconomic Time Series Data

Macroeconomic variables are subject to structural breaks, because of policy change, exchange rate regime change, and economic shocks. Using annual macroeconomic time series data spanning the years from 1970 through 2015, Ogbonnaya and Otta (2018) find structural breaks in Nigeria's macroeconomic time series data. To minimize the potentiality of breaks in time series data, their study recommends the adoption of regime switching models. Similarly, Allaro et al. (2011) examine the structural break in Ethiopia using annual macroeconomic time series data spanning from 1974 to 2009. The finding by their study is that the structural break in the time series occurred after eleven years of the regime shift.

Some empirical studies on Egypt detect structural breaks in the macroeconomic time series data, referring to the macroeconomic policy change (Awad, 2014; Awad and Soliman, 2016; Elshamy, 2016; Awad and Eied, 2017). The introduction of economic reform and structural adjustment program beginning from 1991 represents the most radical change for Egypt's macroeconomic policy. In 2003, the Egypt government issued a new law for the central bank, the banking sector, and the monetary sector through which the CBE is granted legal instrument independence to manage monetary policy. Nonetheless, the CBE is partly obliged to finance budget deficits. After the January 25th upheaval in 2011, Egypt's currency witnessed successive and rapid devaluations until the end of 2016. In addition, during the period after 2011, its fiscal policy witnessed radical changes to reduce the chronic budget deficit, thereby skyrocketing many regulated and subsidized prices.[16]

Previous studies including Savastano et al. (2005), Massoud (2014), and Helmy et al. (2018) explain the weak relationship between exchange rate shocks and CPI inflation by the large share of subsidized and regulated prices in Egypt's CPI. Indeed, this explanation may fit the periods before 2011 where fiscal policy did not witness significant changes. After the January 25th upheaval in 2011, however, this explanation is no longer valid as many subsidized and regulated prices were raised by the government.

Cutting subsidies, on one hand, will adversely affect aggregate demand and hence produce a contractionary effect, especially when the government intends to maintain a budget cut. On the other hand, successive devaluations of the domestic currency will produce an expansionary effect on aggregate demand. Thus, the countervailing effects of macroeconomic policies (i.e., the exchange rate policy and the fiscal policy) on aggregate demand and hence domestic inflation could weaken the association between exchange rate shocks and CPI inflation.

The Markov-switching regime model offered by Hamilton (1989), also known as the regime-switching model, is one of the most popular models adopted by empirical studies to deal with the non-linearities of economic time series, especially

exchange rate as well as inflation rate time series.[17]

The non-linearities considered by Hamilton (1989) arise with discrete shifts in the regime across which the dynamic behavior of the series is markedly different. In other words, the economy may either be in a fast growth or slow growth phase, with the switch between the two based on the outcome of a Markov process. Khemiri and Ali (2013) adopt the Markov switching approach to examine ERPT in Tunisia. Their study identifies two regimes for inflation in Tunisia associated with low and high pass-through levels for the period 2001-2009.

Under Hamilton (1989 and 1990) economic variables do not affect the transition probabilities, and so the transition probabilities are fixed. However, the extension of Hamilton (1989) allows for time-varying transition probabilities (Filardo, 1994; Diebold et al., 1999). By allowing the regime change with fixed transition probabilities, Hamilton (1989) fits the case of Egypt where the dynamic behavior of the time series is likely to undergo discrete shifts in response to macroeconomic policy change.

Following Hamilton (1989), we use the Markov Switching regression technique to estimate ERPT to CPI inflation over the period 2006Q1-2016Q3 from the baseline VAR model's variables (hereafter scheme 1) and from the variables of equation 1 reported by Choudhri and Hakura (2001) (hereafter scheme 2). Table 6 summarizes the results of the Markov switching regressions for the two schemes. Under scheme 1, the Markov switching regression identifies two regimes: the fast growth inflation regime (regime 2 with probability of 54%) and the slow growth inflation (or deflation) regime (regime 1 with probability of 46%). As the probability of switching from one regime to another is very close, as shown by Table 6, the two regimes mutually run over shorter periods. However, ERPT to CPI inflation varies between the two regimes at 15% and 55.4% for regime 1 and regime 2, respectively.

Table 6. Markov Switching Regression over the Period 2006Q1-2016Q3

Dependent Variable: D_LCPI	Regime 1 Coefficient	Prob.	Regime 2 Coefficient	Prob.			
Scheme 1: Baseline model's variables*							
C	-0.002	0.5109	0.023	0.000	Constant transition probabilities		
D_L_OILP	-0.033	0.00	-0.015	0.018		1	2
D_L_RGDP	-0.110	0.00	0.274	0.000	1	0.46	0.54
D_L_FX	-0.150	0.00	0.554	0.000	2	0.52	0.48
D_L_PPI	0.247	0.00	0.577	0.000	Constant expected durations		
D_L_M1	0.123	0.00	-0.052	0.190		1	2
I	0.001	0.00	-0.0003	0.202		1.85	1.92
Scheme 2: Variables of equation							
C	0.013284	0.000	0.021	0.000	Constant transition probabilities		
LAG_D_L_FX	0.231402	0.000	0.204	0.031		1	2
LAG_D_L_CPI	0.016579	0.889	0.337	0.036	1	0.70	0.30
LAG_D_L_CPIUS	0.519530	0.002	1.087	0.046	2	0.54	0.46
					Constant expected durations		
						1	2
						3.3	1.86

*Import prices are excluded, because of a high correlation with the foreign exchange rate.

Under scheme 2, there are also two regimes. The probability for regime 1 (the slow growth inflation regime) is 70%. In addition, the probability that regime 2 (the fast growth inflation regime) switches to regime 1 is 54%. ERPT is 23.1% and 20.4% for regime 1 and regime 2, respectively.

Table 7 compares the estimation results of ERPT to CPI inflation over the period 2006Q1-2016Q3. The results from the Markov switching model under the slow growth regime (schemes 1 and 2) and the results from the SVAR model are very close, where ERPT to CPI inflation ranges between 15-23%. This result is consistent with the findings of previous studies on ERPT in Egypt as shown by Table 1 (i.e., Choudhri and Hakura, 2001; Savastano et al., 2005; Kraay, 2008; Helmy et al., 2018). In addition, the 55.4% ERPT under the fast growth regime of scheme 1 is consistent with Kraay (2008). According to Kraay (2008), the nominal exchange rate vis-à-vis the US dollar depreciated cumulatively by 52.2% during the period 2000-2005, whereas CPI inflation rose by 27.6%; i.e., ERPT is, ceteris paribus, 52.87%.

Table 7. ERPT to CPI Inflation over the Whole Period of 2006Q1-2016Q3

Regime	Markov Switching model		SVAR model	
	Scheme 1	Scheme 2	Q2	Q3
Slow growth regime	15%	23%	14.8%	21.7%
Fast growth regime	55.4%	20.4%		

The variations of ERPT between the two sub-periods under the SVAR model (as mentioned above) and the variations of ERPT within each scheme under the Markov switching model (as shown in Tables 6 and 7) underscore the existence of the time series structural change. Therefore, ERPT to CPI inflation is weak for the whole period.

5. Conclusion

This study revisits the exchange rate pass-through to domestic inflation in Egypt. Aside from quantifying the pass-through of recent exchange rate movements to CPI inflation, we investigate the question of "Why is the statistical association between exchange rate shocks and domestic inflation in Egypt weak? The study is motivated by the findings of previous research on the weak relationship between exchange rate shocks and domestic inflation in Egypt.

The weak relationship between exchange rate shocks and CPI inflation during recent years, especially from cutting subsidies on many goods and services by the government, casts doubt on the argument of previous studies that the weak relationship refers to the large share of regulated and subsidized prices in Egypt's CPI. To analyze the association between the exchange rate and domestic inflation, this study relies on two econometric models: the SVAR model and the Markov switching regression model. The study examines two schemes for the association between exchange rate and CPI inflation: the 'price chain' model's scheme of McCarthy (1999) and Choudhri and Hakura's (2001) pass-through relation scheme.

Based on the results of the statistical analysis, we conclude that ERPT to

domestic inflation in Egypt is weak and insignificant over the whole period of the study (2006Q1-2016Q3). This result is consistent with the findings by previous studies on Egypt, yet ERPT to domestic inflation is strong and significant for the sub-periods of 2006Q1-2010Q4 and 2011Q1-2016Q3. However, the level and speed of ERPT to domestic inflation varies from one sub-period to another. We explain the weak ERPT and the variations of the level and speed of ERPT between sub-periods by two factors: (i) The first is monetary policy intervention to maintain targets for the foreign exchange rate and real GDP growth. In this regard, the study concludes that a monetary policy that intends to maintain targets for the exchange rate and real GDP growth will result in inflation by raising both the level and speed of ERPT to domestic inflation. This conclusion likely occurs when monetary policy intervention results in a decrease in both exchange rate volatility and real GDP growth. (ii) The second is a change in macroeconomic policies including simultaneous changes in exchange rate policy and fiscal policy, which produce countervailing effects on aggregate demand, and thereby the association between exchange rate shocks and CPI inflation is weak for the whole period. Over the sub-periods, however, the variations of statistical association between exchange rate shocks and CPI inflation can be explained by separate changes in fiscal policy and exchange rate policy.

The results of statistical analysis should be interpreted cautiously, since they are limited to the case of Egypt and the time horizon of the study. Generalizing the above conclusion should be based upon additional investigations in other countries similar to Egypt.

Determining the level and speed of ERPT to domestic inflation is important to monetary policy, especially when the goal of price stability takes priority among other objectives. The results presented herein have important implications to monetary policy makers. (i) Targeting the exchange rate to minimize ERPT to domestic inflation will itself cause inflation. (ii) Under policy change and hence structural change, reliable estimates for ERPT to domestic inflation should focus only on the short run. (iii) The coordination between monetary and fiscal policy decisions is highly important to avoid contradictions and negative consequences on real variables. Cutting subsidies or raising taxes in conjunction with both currency devaluation and raising the interest rate will adversely affect both aggregate demand and supply, thereby incurring negative consequences on real GDP and the employment rate.

Notes

1. Many countries, especially those with pegged exchange rate regimes, adopt a sterilization policy to maintain the goal of price stability. For instance, the oil-exporting gulf cooperation council countries, with the exception of Qatar and United Arab Emirates during a few months of 2007 and 2008, sterilized the effect of the changes in foreign reserves on their domestic base money to maintain the goal of price stability (Nakibullah, 2011).

2. At the time of drafting this paper (October 3, 2016), the formal rate of US dollar was 8.77 Egyptian pounds, while the average rate in the parallel market was 16 Egyptian pounds.

3. Daily official exchange rates are collected from the CBE website available at http://www.cbe.org.eg.

4. Clearly, the decision of raising nominal interest rates in conjunction with the decision of devaluating domestic currency intends to stabilize aggregate demand and hence domestic inflation. However, because of the widening premium between official and unofficial FX rates, the aggregate supply was adversely affected even before the decision for devaluation as the cost in the large numbers of raw materials and intermediate goods imported from abroad turned higher.

5. See MPC press releases in March 2016 and September 2016. Available at http://www.cbe.org.eg.

6. On November 3, 2016, the CBE made the decision to float the domestic currency. The decision was made after the government turned to the IMF for a US$12 billion loan over three years, conditional on cutting government debt and energy subsidies, introducing a value-added tax, and floating the domestic currency. Consequently, the nominal exchange rate vis-à-vis the US dollar depreciated by more than 90% and the CPI inflation subsequently skyrocketed.

7. A shortened version of McCarthy (1999) is McCarthy (2007). This paper relies upon McCarthy (1999), because it is the original, longer version.

8. For a survey of this literature, see Goldberg and Knetter (1997).

9. For more details, see McCarthy (1999), Feinberg (1986), Goldberg and Knetter (1997), Engel and Rogers (1998), Mann (1986), Choudhri and Hakura (2001 and 2012), and Caselli and Roitman, (2016).

10. Choudhri and Hakura (2012) examine ERPT for several developing and developed countries using another different methodology. They adopt a dynamic general equilibrium model and a VAR model to quantify ERPT into import and export prices. The results by the two models are similar where the exchange rate pass-through to import prices is incomplete and larger than the pass-through to export prices.

11. The differenced logarithmic value from the two sides yields the growth rate of import price in domestic currency (i.e., = the rate of CPI inflation or deflation in the U.S. + the rate of change in the exchange rate)

12. Notice that the order of M1 in identification scheme 3 comes last. Therefore, its effect on other variables comes with a lag of one period (or one quarter).

13. In the course of the estimation process of identification scheme 3, oil price is treated as an exogenous variable since Egypt's economy is supposed to be a small open economy.

14. A shock in such a case may occur, because of a decision by the CBE to devaluate the currency, or capital outflows triggered by declining the security situation, or a decline in the international reserves of the CBE in conjunction with growth in the trade balance deficit, etc.

15. The effect of government spending varies between developed and developing countries. While crowding out is more prevalent in the face of a variation of government spending in advanced countries, private consumption and inflation vary more closely with government spending in developing counties (Kandil, 2009).

16. For instance, in July 2014 the Egyptian government announced unprecedented increases in the energy prices paid by businesses and households. As this reform represents a bold break from the past, Clarke (2014) calls it the "big bang reform".

17. See Engel (1994), Blix (1999), Marsh (2000), Ismail and Isa (2007), Kumah (2007), Khemiri and Ben Ali (2013), Baharumshah et al. (2017), and Marodin and Portugal (2018).

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