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Exchange Rate Pass-Through, Inflation and Monetary Policy in Egypt[1]

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Abstract

The role of exchange rate pass-through has been dominating the heated debates over effective monetary policies, as well as exchange rate regime in general equilibrium models. Empirical literature from developed economies has shown evidence that the pass-through to prices can be incomplete in many cases. These studies have indicated that there are substantial differences between countries. Due to the lack of empirical literature for developing countries, this research contributes to the field by examining the exchange rate pass-through in Egypt from 2005 to 2018, using nine endogenous variable Vector Auto-regressive Models (VAR); this research estimates the degree and the size of exchange rate pass-through to domestic prices. In addition, we use a reduced two-dimensional VAR to estimate once for the relation between inflation (CPI) and money supply (M2) and once for the relation between inflation (CPI) and imports, along with Granger causality test to investigate causality between two variables. In the last part of the analysis, we investigate the exchange rate pass-through to inflation (CPI) in Egypt before floatation from December 2005 until October 2016 and the post floatation period, which is from November 2016 until February 2018. The results have important implications for the ability of Egypt to achieve an effective inflation-targeting regime.

JEL classification: E5; E31; E52; C3; C320

Keywords : Exchange rate pass-through, Exchange rate policy, Inflation, Monetary policy, Pass-through elasticity, Granger Causality

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1. INTRODUCTION

The exchange rate pass-through has been of interest for a long time; and has developed over the past few decades. For a long time, the debate has been over the law of one price and how prices tend to converge across different countries. Starting from the late 1980s, however, the literature on exchange rate pass-through has underlined the role of price discrimination, industrial organisation and segmentation across different products markets worldwide. Empirical studies have been conducted in developed countries to study the issue; these studies include Anderton (2003), Campa and Goldberg (2004), Campa et al. (2005), Gagnon and Ihrig (2004), Hahn (2003), Ihrig et al. (2006), McCarthy (2000), Choudhri and Hakura (2006), Frankel et al. (2005) and Mihaljek et al. (2000).

Recently, the role of pass-through has been dominating the heated debates over effective monetary policies, as well as exchange rate regime in general equilibrium models. These debates provide wide implications and effects regarding the conduct of monetary policies, transmission of shocks, stability of the macroeconomic environment, as well as ways to solve imbalances in international trade and capital flows. In addition, the debates are concerned with whether the exchange rate pass-through is endogenous or exogenous to the monetary policy in a specific country. In the case of low import price pass-through, fluctuations in the nominal exchange rate will cause smaller expenditure-switching behaviour in the monetary policy for the domestic economy. Hence, this means that the effectiveness of monetary policy can be measured in terms of its impact on stimulating the economy of the domestic country. If the exchange rate pass-through can be considered as an endogenous variable to the various macroeconomic variables, the tools used to measure the effectiveness of monetary policy might be fragile and specific for a certain regime. Accordingly, the determinants and the degree of the exchange rate pass-through to prices are highly influential and can affect the efficiency of the macroeconomic environment (Campa and Goldberg, 2005; Taylor, 2000).

The management of exchange rate pass-through to prices is an important instrument to achieve macroeconomic stability. Nonetheless, there has been limited empirical literature dedicated to studying the issue. Most of this literature has been conducted for developed countries, as mentioned earlier. This paper will study the exchange rate pass-through in Egypt from 2005 to 2018 using nine endogenous variable Vector Auto-regressive Models (VAR); we will estimate the degree and the size of exchange rate pass-through to prices. In addition, we will use a reduced form two-dimensional VAR to estimate once for the relation between inflation (CPI) and money supply (M2) and once for the relation between inflation (CPI) and imports, along with Granger causality test to investigate causality between two variables. In the last part of the analysis, we investigate the exchange rate pass-through to inflation (CPI) in Egypt before and after implementing the floating regime.

This paper has five sections; starting with the introduction, followed by a literature review for the different studies conducted in this field of research. The third section gives an overview on the exchange rate, inflation and monetary policy in Egypt. The fourth section explains the empirical analysis and results. The fifth section of this paper is the conclusion.

2. LITERATURE REVIEW

The choice of an optimal exchange rate system has been always related to the theory of optimal exchange regimes, which was developed by Mundell in 1961 and Poole in 1970. The analysis and the choice for such an exchange regime was based on how efficiently the regime will contribute to decreasing the fluctuations in domestic output in the presence of sticky prices. Nominal shocks in the economy will make the fixed exchange rate system attractive; if inflation was due to monetary shocks, this means that having a fixed exchange rate system will lead to less volatility in output. However, shocks which hit the economy affecting the prices of exports and imports, as a result of changes in supply or demand, will necessitate adjustments in equilibrium relative prices; in such a case, a flexible exchange rate system will be needed. A flexible exchange rate will allow a change in the nominal exchange rate and this, in return, can improve the effect of such shocks on employment and output. In addition, in a fixed exchange rate system, if the economy faces a downturn caused by real factors, the central bank must intervene to adjust the fall in the demand for domestic currency and increase interest rates by absorbing the excess in the supply of money. This theory in explaining the choice of optimal exchange rate regimes can provide some insights, however, it fails to explain certain cases, especially for emerging economies (Calvo and Mishkin 2003).

There are different models that have been developed to assess the optimal exchange rate policy. In these models, prices are considered exogenous in local currency or the producer currency. This means that, in the short term when prices are rigid, there will be a 100% pass-through effect represented in the prices of imported goods priced in the currency of the producer. However, if the prices are adjusted, then the pass through has no difference. The question then is, if the prices do adjust, will there be a relation between the pass-through and the currency used for pricing the goods? The pass-through of exchange rate changes into domestic prices is often related to the macroeconomic policy. This is because the degree of such a pass-through will affect relative prices, for example, if the exchange rate pass-through is high, there will be changes in the relative prices for both tradeable and non-tradeable goods and, hence, then trade balances will adjust immediately to such a movement in prices. However, in the case of low pass-through effect, the exchange rate will not assist in the trade balance adjustment. In emerging economies, the degree to which inflation increases, as a result of currency depreciation, would affect the recovery process. In cases where there is a complete exchange rate pass-through to both consumer prices and import prices, this means that the gains from exports due to depreciation in the nominal exchange rate will be offset, since there will be no change in the real exchange rate in the economy. The study of pass-through is important and will have a direct effect on monetary policy decisions (Ito and Sato, 2008).

A large body of economic literature studying exchange rate pass-through (ERPT) has been developed in the past two decades. It was believed that the condition of purchasing power parity (PPP) holds; that is the prices of goods (tradeable) in different countries, if they are converted to the same currency, will be equally priced. However, empirical evidence has shown only very weak support for this situation. Hence, given such evidence, over past decades theoretical and empirical research has developed various explanations to clarify the incomplete exchange rate pass-through. In 1987, a paper by Dornbusch attributed the incomplete pass-through to imperfect competition in the market, where firms operating in such markets alter not only the prices but also their mark-up, in response to shocks in exchange rate. Other researchers have focussed on the role of both monetary and fiscal policy to offset the effect of exchange rate on the price of goods. Moreover, Devereux and Engel (2001) and Bacchetta and van Wincoop (2003) have explored how the pricing of local currency results in a reducing the effect of exchange rate pass-through. The various studies conducted have shown that there are substantial differences between countries and, hence, this raises the question - what are the determinants of exchange rate pass-through?

Hahn (2003) has investigated the pass-through of external shocks to inflation in the EU. The framework is based on estimating pass-through of shocks to the euro domestic area using quarterly data, starting from 1970(2) to 2002(2) for 12 countries participating in the European Monetary Union (EMU). The analysis encompasses the pass-through of shocks in the exchange rate, oil prices and non-oil import prices to non-oil imports, producers and consumer prices in the euro area. Therefore, the analysis covers the pass-through of these shocks to each stage of the distribution chain (imports, producers, and consumer prices). The analysis uses Vector Autoregression (VAR) model and identifies the structural shocks using a Choleski decomposition. The result shows that the non-oil import prices response to a one percent appreciation of the Euro is strong and has a high pass-through. The impact of exchange rate shocks accounts for almost 20%, whilst covering just three quarters, the total impact of around 50% is passed-through. These outcomes are also very close to the estimation by Anderton (2003). Variance decomposition shows that all the shocks included in the estimation contribute to a large fraction of the fluctuations in prices; in addition, the historical decomposition also indicated a strong contribution of shocks to the rising level of inflation in the euro area starting from 1999. Finally, the robustness check of two sub-sample periods - 1971 to 1984 and 1985 to 2002 - indicated that the speed and size of pass-through for all shocks were constant, whilst the decomposition of variance over these periods showed that there was an increase in the contribution of shocks to the increase in inflation across euro area countries.

On the other hand, Ranki (2000) found different results when estimating the relationship between the euro exchange rate and domestic inflation in the euro area. Ranki (2000) explains the domestic inflation rate in terms of three components, which are the nominal exchange rate, domestic production, and world export prices. Ranki (2000) examined the relationship using the OLS regression for the period from January 1991 to March 2000.

The model estimates the relationship using nominal exchange rate lagged with one period. The results with the F test for the coefficients of the exchange rate of 4.057 indicate that the exchange rate has a significant impact on the changes in the rate of inflation. The impact of both the lagged and current exchange rate can be summarised that, within the period of one month, if the euro depreciates by one unit, domestic inflation will increase by 1.097 units. This indicates that there is a complete pass-through of the exchange rate in the short run. This complete exchange rate pass-through appears in contrast to most of the other empirical studies, which predicted incomplete pass-through in the euro area.

Campa and Goldberg (2005) have provided evidence using quarterly data on import prices for 23 OECD countries from 1975 to 2003. The unweighted averages amongst the countries indicate that, on average, the exchange rate pass-through into prices of imports in the short run is 0.46 and in the long run is 0.64. These averages reveal some interesting facts about the pass-through to import prices. The exchange rate pass-through into import prices for the United States is considered low; 23% occurred in one quarter and 42% took place over the long run. For other countries, such as France, Germany and Switzerland, the coefficient estimates for exchange rate pass-through in the short run is around 60% and between 80% and 90% in the long run. It seems that smaller countries have lower stability in the exchange rate pass-through, however, there is no significant relationship found between the size of the country and the exchange rate pass-through.

Another study by Gagnon and Ihrig (2001) has looked at data for 11 industrialised countries and estimated an OLS regression to measure the relationship between exchange rate pass-through and inflation. They estimated long-term pass-through coefficients with lagged adjustment. In the coefficient estimates before 1990s, the exchange rate pass-through has values that are insignificantly different from zero, to significant values that are above 0.2 for Canada, Greece, Japan and Switzerland. A value of 0.2 indicates that when the exchange rate depreciates by 10%, there will be an increase in domestic prices by 2%. In the period prior to 1990s, the long-term exchange rate pass-through declined from 0.12, to reach 0.05 in the post 1989 period. Therefore, lower pass-through can be attributed to lower fluctuations in the level of inflation.

Ca' Zorzi, Hahn and Sánchez (2007) have studied 12 markets in Asia, Latin America, and Central and Eastern Europe to estimate the exchange rate pass-through to import prices. They have used a Vector auto-regression (VAR) model to estimate this relationship. The baseline model includes six variables, which are oil price index, output, exchange rate, import price index, consumer price index and short-term interest rate. The model is applied to each of the 12 countries in the sample. The results indicate that the exchange rate pass-through is higher for the import prices than for the consumer prices in most of the countries; hence, along the pricing chain the exchange rate pass-through seems to be declining. To compare exchange rate pass-through between emerging and developed economies, the study applies the same methodology to the US, Euro zone and Japan. The results shown in Table 10 below for the euro zone are very similar to those predicted by Hahn (2003), Anderton (2003) and Campa et al. (2005) for prices of imports. The exchange rate pass-through is very low in the US for consumer and import prices. Japan has a higher exchange rate pass-through than the US and the euro area for import prices. Comparing the exchange rate pass-through, the results indicate that the conventional wisdom that the exchange rate pass-through is higher in emerging economies than the developed one, does not always hold. The comparison shows that, specifically, Asian countries show a quite low exchange rate pass-through to consumer prices.

Furthermore, Ito and Sato (2008) studied the exchange rate pass through for the post crisis period in East Asian countries. VAR analysis has been used to study the relationship between the exchange rate and domestic prices. The study included five East Asian countries and analysed how exchange rate shocks, in the form of country currency depreciation (NEER shock), affected three variables. These are the consumer price index (CPI), the producer price index (PPI) and import prices (IMP). The effect of NEER shocks were different for the three domestic prices. The largest effect found in favour of IMP, followed by PPI, whilst the CPI response was the smallest. These results are also in line with earlier studies done on EU countries by McCarthy (2000), Hahn (2003), and Faruqee (2006). Ito and Sato (2008) also estimated the pass-through elasticities for each of the three domestic prices for the aggregate sample, as well as the post crises sample. From the pass-through elasticities, a 10% decline in the NEER caused a 4% inflation in CPI (0.4-0.41 pass-through elasticity) in Indonesia and 0.7% in Korea in the post crises period. Comparing the impulse response functions to the pass-through elasticities, it is found that the effect of depreciation in NEER on inflation in the CPI for these economies is lower than their estimates for pass-through elasticities. Indonesia had the largest response to devaluation represented in CPI inflation. These results suggested some insights into the stability of prices against shocks. Except for Indonesia, the prices of imports in all the other countries did not react to NEER shock; this can be attributed to the openness of these economies. In addition, oil imports have an effect on domestic prices; for countries which import oil, currency depreciation resulted in a significant impact on consumption prices in the country. However, for oil producing countries, devaluation of the currency led to a lower effect on domestic prices. This can explain the response in Figure 7, as to why Malaysia, an oil producing country, did not suffer from CPI inflation due to NEER shock. On the other hand, Indonesia had a large response to CPI, even though it is an oil producing country. The fact is that the prices of petroleum goods were controlled by the government and, therefore, the level of prices in the domestic market was less affected by an increase in the price of oil due to depreciation. Therefore, it is clear that monetary policy and other macroeconomic variables could have affected the post crisis inflation in Indonesia.

Bwire, Anguyo and Opolot (2013) studied the case of Uganda from 1999 to 2012, using VECM and SVAR models to estimate the exchange rate pass-through effect. The SVAR model estimated the effect of exchange rate shock as an unpredicted, temporary, exogenous depreciation on domestic inflation, output gap, oil price and 91-day Treasury bill rate, in period 0. The results showed that the exchange rate shock pass-through into domestic prices took around four quarters to show a full and persistent effect. A 4.1% exchange rate shock caused around a 0.7% increase in the level of domestic prices; this means that the elasticity of exchange rate pass through was 0.16. After almost 4 quarters, the complete impact of exchange rate shock was 1.96% and exchange rate elasticity was 0.48. The effect of exchange rate shock shows a huge increase in domestic inflation, which starts to decline after 10 quarters, however, it remains over the long term. This implied that the impact of shocks in the exchange rate on the fluctuations in level of inflation is strong and persists for a long period of time. It also showed that the prices are sticky downwards. The exchange rate shock caused a decline in the output gap with fluctuations decreasing after the ninth quarter. Therefore, the pass through of exchange rate into domestic prices was moderate, incomplete and persistent. The estimates for exchange rate elasticity were in line with results by Chaoudhri and Hakura (2001), who have estimated the pass-through elasticity to be around 0.39 for Kenya and Cameron and 0.46 for Zambia. In addition, studies for other countries, such as Ghana, found the pass-through elasticity to be around 0.79 by Sanusi (2010). Anguyo (2008) found the elascticity to be 0.056 in Uganda (low) and Kiptui et al., (2005) reported incomplete pass-through in Kenya, which ceases after four quarters, in which 46% of the changes in inflation level can be explained by the exchange rate variability.

McCarthy (2007) used data from nine developed countries, which are the United States, Japan, Germany, France, the United Kingdom, Belgium, the Netherlands, Sweden and Switzerland, to estimate the pass-through effect of exchange rate and variations in import prices. The study used a pricing model along the distribution chain, by applying a VAR model with eight variables, which are oil price inflation, the output gap, exchange rate change, import price inflation, PPI inflation, CPI inflation, short-term interest rate, and money. Exchange rate shock is defined as all past variable values added to the current values of both output gap and prices of oil. The results showed that an appreciation in the exchange rate, has an initial negative effect on the import prices for a time horizon of at least one year, for all the countries in the sample. There are some positive impacts recorded in some countries at the end of the second year. High pass-through into import prices was found in Belgium and Netherlands, where import price response exceeded one percent, whilst for Sweden and Switzerland the response was rather weak. The response in PPI was almost weak in most of the countries. The estimate showed that the pass-through of exchange rate shock into CPI is lower than that to PPI and was insignificant for the majority of the countries.

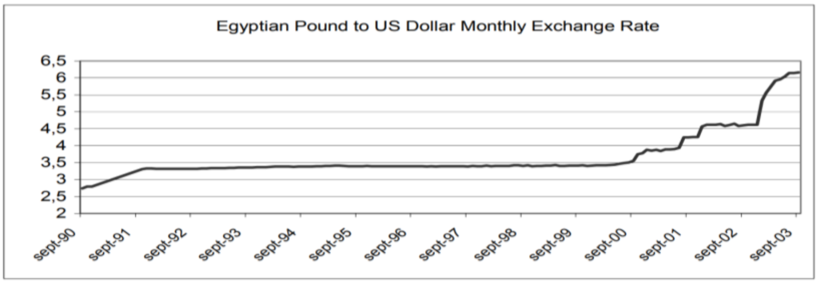
Sanusi (2010) estimated the exchange rate pass-through to consumer prices using a SVAR model for Ghana. The data used covered the period from 1983 to 2006. The response is estimated to be a structural one SD shock to each variable in the model. The estimated impact approaches the complete impact gradually through 24 quarters. The estimated effect of a one SD exchange rate shock of a 6.1% appreciation resulted in a 0.7% decline in the price level. Such an effect implies an exchange rate elasticity of 0.11. The complete pass-through effect was reached after 24 quarters causing a 4.8% decline in prices, which implies a 0.79 dynamic pass through elasticity, shown in figure 12. Therefore, Ghana had an incomplete but high and slow exchange rate pass- through into prices. The value of the pass-through in Ghana is close to the value in other countries, such as in Jamaica where the exchange rate pass-through was 80%, as reported by McFarlane (2002) and Zorzi et al. (2007) who documented a high pass-through for China to be 0.77, 0.91 for Hungary and 1.39 for Mexico.

3. Overview on exchange rate, inflation and monetary policy in Egypt

Each government has to decide on how to react to the open economy, in terms of maintaining a stable exchange rate regime, along with keeping growth in capital flows and adopting a monetary policy which will lead to achieving the country's goals. In fact, these three aims cannot be maintained at the same time. In the case of developing countries, capital flows are essential for stimulating economic growth; inflation should be kept down by a stable exchange rate regime, whilst monetary policy should be used to adjust macroeconomic variables in the country. Hence, the debate has evolved as to what exchange rate policy should be adopted by these developing countries. Based on IMF recommendations, developing countries should choose between two extremes - either a fixed exchange rate system or a floating regime (Fisher 2001 and Mussa 2000). On the other hand, other economists argue that these countries should instead implement an intermediary policy between the two extremes (Williamson 2000).

Egypt has adopted a fixed adjustable peg to the US dollar since the 1960s, with several operating and exchange rate adjustments in 1979, 1989 and 1990. In 1991, Egypt started an economic reform programme that changed the exchange rate regime into a managed floating regime, whilst the fact is that between 1991 and 1992, the central bank devaluated the Egyptian pound and then kept it fixed until June 2000, as shown in Figure 1 below.

Figure 1: Egyptian Pound to US Dollar monthly exchange rate (1990-2003)

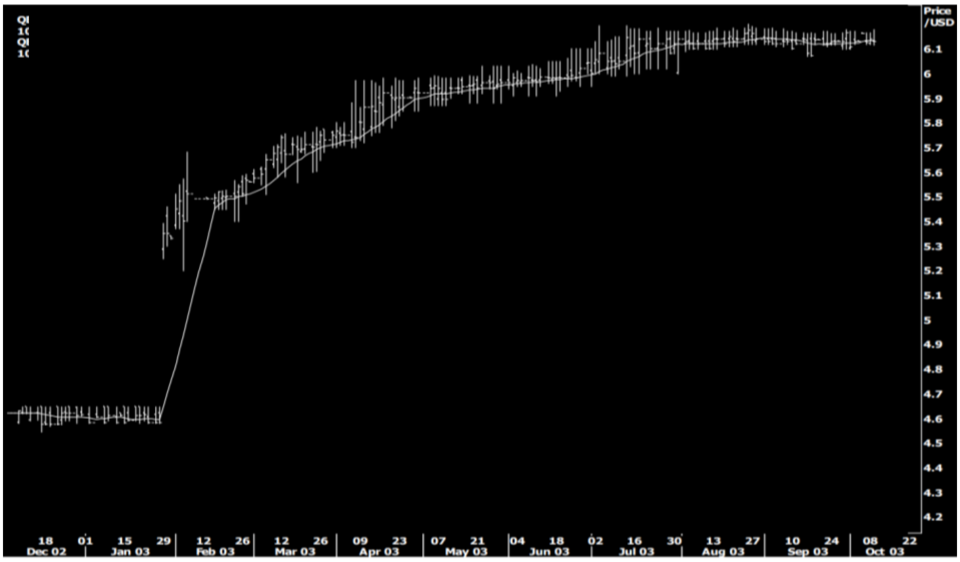


***Source**: Kamar B. and Bakardzhieva D., (2005), Economic Trilemma and Exchange Rate Management in Egypt, Review of Middle East Economics and Finance, De Gruyter, 3(2), 1-24*

To stabilise the market, in January 2001 the government announced that the exchange rate of EGP per USD will be 3.85 and introduced a crawling peg regime. The government used a three- stage devaluation operation during that period which led to a devaluation of 32% in the Egyptian pound and the exchange rate of EGP per USD reached 4.51. Even with this devaluation, the market could not stabilise due to the events of September 11, 2001, which affected tourism and Suez Canal revenues, combined with the war in Iraq and the rising violence at the Egyptian borders due to the Israeli-Palestinian conflict. All these events affected the image of Egypt, driving international investment away from the country.

On January 28, 2003, the Egyptian government announced the adoption of a free-floating regime which led to a devaluation of 33% by October, increasing the EGP per USD exchange rate to 6.15 (Figure 2). From 2000 to 2004, EGP experienced a cumulative depreciation of 68% against the US dollar. However, the inflation rate, based on the consumer price index (CPI), remained remarkably low and stable from 2000 to 2003. The CPI only started rising after July 2003. During 2004, the inflation rate increased reflecting a possible lagged pass-through effect of the cumulative depreciation.

Figure 2: Egyptian Pound to US Dollar daily exchange rate (12/2002 – 10/2003)

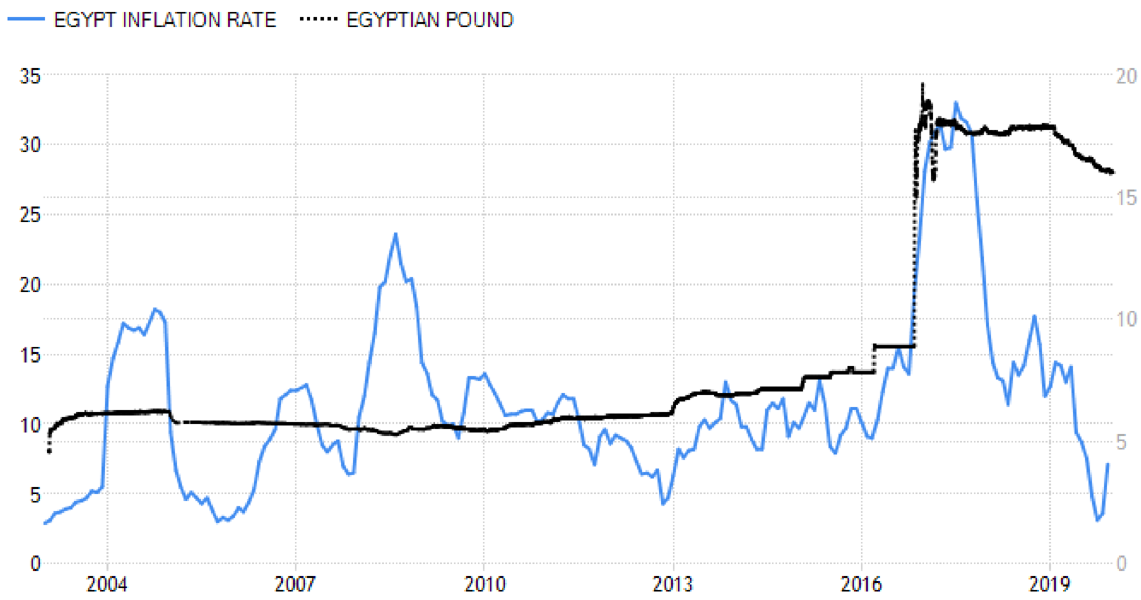


***Source**: Kamar B. and Bakardzhieva D., (2005), Economic Trilemma and Exchange Rate Management in Egypt, Review of Middle East Economics and Finance, De Gruyter, 3(2), 1-24*

The announcement of the floating exchange rate regime was needed to resolve inconsistencies in the earlier adopted policies, which included rigidity in exchange rate, inability to support the peg to USD through international reserves and the attempt to encourage investment by decreasing interest rates (Galal, 2003).

During the first half of 2005, CBE adopted a contractionary monetary policy to control the rising inflation rates. Inflation increased significantly from October 2006 until April 2007 to reach 11.47% due to the appreciation of the EGP and the tightening of monetary policy. This increase in the inflation rate was driven mainly by the impact of an Avian Flu outbreak and adjustments in administered prices, along with some domestic demand pressures arising from an increase in economic growth. In August 2008, the inflation rate gradually increased, reaching 23.62%. This increase could be attributed to the acceleration in oil product prices and international food prices. The CBE cut policy rates six times between February and September 2009, which led to lower commodity prices and lower demand, accompanied by a sharp decline in the inflation rate, falling to 10.07% by August 2009. By September 2008, the financial crises led to the depreciation of the EGP by about 6%. In December 2009, the exchange rate appreciated to its level prior to the crisis (Figure 3).

Figure 3: Egypt Inflation Rate versus the Exchange Rate (2004 – 2019)



Source*: calculated using data from Central Bank of Egypt*

The year 2011 was a turning point in terms of political transition in Egypt. During 2011, Egypt faced political uncertainty and social unrest, which kept growth rates low, impacted policy performance along with an increase in fiscal deficits, inflation and debt. As shown in Figure 3, in December 2012, the value of the Egyptian pound depreciated by 13% in the six months after the introduction of the FX auctions. The exchange rate increased from EGP 5.80 in January 2011 to EGP 6.94 and EGP 7.26 in the corresponding months of the years 2014 and 2015, respectively. During 2011 – 2015, inflation rate was very volatile, with a high inflation rate recorded in 2011, reaching 11.4%. The political instability in the country negatively affected different local markets, such as the commodity supply especially of fuel and butane gas cylinders.

The restoration of stability and confidence in 2015 led to some economic growth during the following year. We found that the first quarter in 2016 witnessed a 3% growth rate. Headline inflation decreased from 11%, to reach 9% in February 2016, due to monetary tightening tools adopted by the central bank of Egypt. The actual floating of the Egyptian pound took place in November 2016. This floatation led to a devaluation of the EGP by around 50% and, by July 2017, the inflation rate reached its highest level of 32%, declining again to reach 11.97% by December 2018.

4 EMPIRICAL ANALYSIS

4.1 Methodology: Vector Auto-regressive Model (VAR)

The aim of this paper is to investigate the response of price level to exchange rate shocks in Egypt. The investigated period is from 2005 to 2018. This research will examine the interaction between variables in domestic prices and exchange rate and estimate the degree and the size of exchange rate pass-through to domestic prices, using Vector Auto-regression (VAR) model. The next section will start by illustrating the model used, data description and identification procedure.

The VAR model has several advantages, compared to estimates using the single equation. The VAR model identifies structural shocks through Cholesky decomposition of innovations; it examines the shocks of different macroeconomic variables on domestic inflation. In addition, it allows the identification of pass-through effect from producer to consumer level, unlike the single equation, which investigates the effect to one price index only.

This paper investigates the pass-through effect of exchange rate into domestic prices in Egypt using VAR Model. The analysis will identify structural shocks to exchange rate, to measure the pass-through into domestic prices. The VAR baseline model is set up to include a vector of 9 endogenous variables which are imports from the USA, Europe and China, as well as Real Exchange rate, Egyptian pound per US dollar, Egyptian pound per Euro, Industrial Production Index, Money supply (M2) and consumer price index (CPI).

The main purpose of this study is to estimate the effect of exchange rate and other macro-economic shocks on domestic prices, along with the interactions between them. To identify the structural shocks, we use a Cholesky decomposition of the matrix Ω, a variance-covariance matrix of the reduced-form VAR residuals. The relationship between the reduced-form VAR residuals (μ_t) and the structural disturbances (ε_t) can be represented as below:

$$\begin{pmatrix} \mu_t^{IPI} \\ \mu_t^{Impusa} \\ \mu_t^{Impeur} \\ \mu_t^{Impchn} \\ \mu_t^{Money\ supply} \\ \mu_t^{Real\ Exchange} \\ \mu_t^{egpperusd} \\ \mu_t^{egppereur} \\ \mu_t^{CPI} \end{pmatrix} = \begin{pmatrix} S_{11} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ S_{21} & S_{22} & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ S_{31} & S_{32} & S_{33} & 0 & 0 & 0 & 0 & 0 & 0 \\ S_{41} & S_{42} & S_{43} & S_{44} & 0 & 0 & 0 & 0 & 0 \\ S_{51} & S_{52} & S_{53} & S_{54} & S_{55} & 0 & 0 & 0 & 0 \\ S_{61} & S_{62} & S_{63} & S_{64} & S_{65} & S_{66} & 0 & 0 & 0 \\ S_{71} & S_{72} & S_{73} & S_{74} & S_{75} & S_{76} & S_{77} & 0 & 0 \\ S_{81} & S_{82} & S_{83} & S_{83} & S_{84} & S_{86} & S_{87} & S_{88} & 0 \\ S_{91} & S_{92} & S_{93} & S_{94} & S_{95} & S_{96} & S_{97} & S_{98} & S_{99} \end{pmatrix} \begin{pmatrix} \varepsilon_t^{IPI} \\ \varepsilon_t^{Impusa} \\ \varepsilon_t^{Impeur} \\ \varepsilon_t^{Impchn} \\ \varepsilon_t^{Money\ supply} \\ \varepsilon_t^{Real\ Exchange} \\ \varepsilon_t^{egpperusd} \\ \varepsilon_t^{egppereur} \\ \varepsilon_t^{CPI} \end{pmatrix}$$

The structural model is identified because the k (k-l)/2 restrictions are imposed on the matrix S as zero restrictions, where k denotes the number of endogenous variables. The resulting lower-triangular matrix S implies that some structural shocks have no contemporaneous effect on some endogenous variables, given the ordering of endogenous variables.

The selection of the variables in the model is based on earlier studies, such as McCarthy (2000) and Hahn (2003). To identify structural shocks, we use a Cholesky decomposition of the variance-covariance matrix of the reduced-form VAR residuals. To correctly identify the structural shocks, the endogenous variable must be ordered first. The Industrial Production Index will come first, as it is expected to influence the other variables in the model. Next comes the demand shock, represented in import values for goods. Then comes the monetary variable, represented by Money supply. The last two places are set aside for the real exchange rates and the domestic price, represented by the consumer price index (CPI). In the light of literature on the pass-through of exchange rate into prices, the domestic price variable is always placed last, as it is usually influenced by all the other variables in the system.

4.2 Data Description

The data consists of monthly observations from 2005 to 2018. The data is obtained from Thomson Reuters data base at the German University in Cairo. The VAR baseline model will include a vector of nine endogenous variables, which are import prices from USA (IMPUSA), imports from EU (IMPEUR), imports from China (IMPCHN), Real Exchange rate (REALEXC), Egyptian pound per US dollar (EGPPERUSD), Egyptian pound per Euro (EGPPEREUR), Industrial Production Index (IPI), Money supply (M2) and consumer price index (CPI).

The estimation procedure starts with testing the time series properties of variables and measuring whether the variables in the system are stationary or not, using the Augmented Dickey Fuller (ADF) unit root test for all variables in the system. IPI, M2 and CPI are found to be stationary at level, whilst the rest of the variables are found to be stationary at first differences. The ADF statistics are shown in the Table 1 below. Based on the unit root test, we will take the first difference for all variables, except for IPI, M2 and CPI.

Table 1: Augmented Dickey Fuller (ADF) test for unit roots

	ADF Statistics	Comment
IPI ***(At level)***	-12.76	I(0)
IMPCHN ***(At 1st Difference)***	-9.01	I(0)
IMPUSA ***(At 1st Difference)***	-17.94	I(0)
IMPEUR ***(At 1st Difference)***	-9.87	I(0)
M2 ***(At Level)***	-12.87	I(0)
REALEXC ***(At 1st Difference)***	-10.78	I(0)
EGPPERUSD ***(At 1st Difference)***	-9.56	I(0)
EGPPEREUR ***(At 1st Difference)***	-9.32	I(0)
CPI ***(At Level)***	-7.79	I(0)

Second, the optimal lag length for VAR is identified based on lag length criteria test, which includes the log-likelihood test (LR), the Schwarz information criterion (SC), the Akaike information criterion (AIC), Final Prediction Error (FPE) and Hannan-Quinn information criteria (HQ). Based on the result in Table 2 below, a lag length of 5 will be used as indicated by the LR test.

Table 2: VAR Lag Order Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-4503.537	NA	1.63e+15	60.57097	60.75241*	60.64468
1	-4339.361	306.3142	5.36e+14	59.45451	61.26898	60.19170*
2	-4252.610	151.3781	5.02e+14	59.37732	62.82480	60.77797
3	-4161.727	147.6080	4.52e+14*	59.24466*	64.32516	61.30879
4	-4085.315	114.8758	5.08e+14	59.30623	66.01975	62.03383
5	-4003.412	***113.2346*** *	5.50e+14	59.29412	67.64065	62.68518

The VAR model has been tested for autocorrelation using the LM test. The test results, in Table 3 below, shows that there is no autocorrelation at lag of 5.

In addition, we tested for Heteroscedasticity using the White Test. Table 4 shows that there is no Heteroscedasticity problem found in the model.

Table 3: VAR Residual Serial Correlation LM Test

Null hypothesis: No serial correlation at lag h						
Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	101.4830	81	0.0615	1.275052	(81, 564.7)	0.0629
2	104.0651	81	0.0431	1.310370	(81, 564.7)	0.0442
3	102.3375	81	0.0548	1.286723	(81, 564.7)	0.0561
4	87.91106	81	0.2809	1.091876	(81, 564.7)	0.2843
5	85.14900	81	0.3547	1.055099	(81, 564.7)	0.3583

Table 4: VAR Residual Heteroscedasticity Tests (Levels and Squares)

Joint test:		
Chi-sq	df	Prob.
4154.254	4050	0.1238

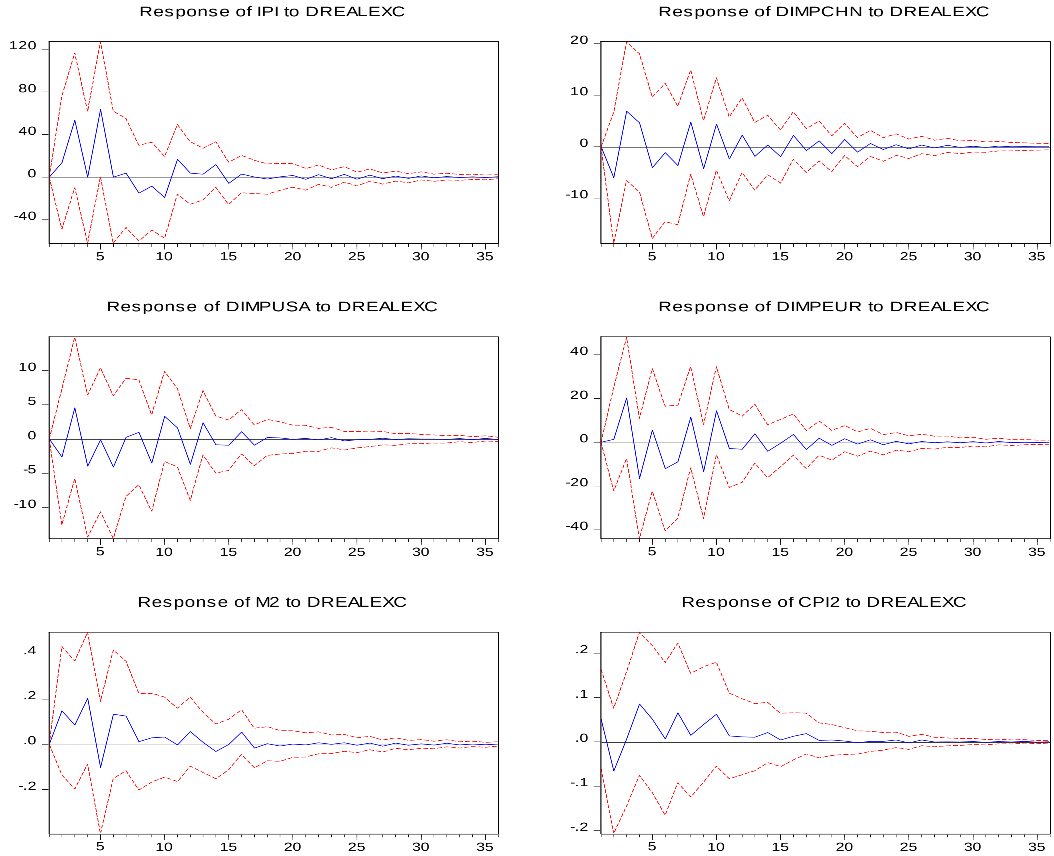
4.3 Empirical findings VAR Model

This section estimates the degree of pass-through from real exchange rate to 9 variables in Egypt, between 2005 and 2018. An increase in the real exchange rate is defined as an appreciation of the Egyptian pound. The VAR baseline model is estimated for all the variables and then the impulse response functions for changes over 36 months are analysed. In addition, exchange rate pass- through elasticity is calculated to measure the accumulated response and the degree of pass- through into prices. Also, variance decomposition is presented to identify the importance of exchange rate in explaining changes in the prices.

For the impulse response functions, the shocks are standardised to 1%; therefore, the vertical axis in the impulse response function in Figure 4 represents a percentage change in the variable, with respect to a 1% shock of the real exchange rate (DREALEXC). The dotted line in the figures represents a 2-standard error (S.E.) confidence band around the estimate.

As shown in Figure 4, the impact of exchange rate shock on IPI, imports, M2 and CPI is large during the first year. By the end of the second year, the impact tends to diminish for all the variables. For the IPI, the response is large but insignificant. The pass-through to all imports and M2 is large and lasts for the first 12 months. The pass-through to CPI is weak and, statistically, the estimates are insignificant. The response is largest for imports and IPI and smallest for CPI.

Figure 4: Response to Cholesky One S.D. (d.f. adjusted) Innovations – 2 S.E.



In addition to the response functions, it is informative to assess the pass-through of exchange rate using the dynamic exchange rate elasticity, calculated by the values of the impulse response functions:

$$\mathbf{PT_{t,t+j}} = \sum_{j=1}^{t} \mathbf{P_{t,t+j}} \Big/ \sum_{j=1}^{t} \mathbf{E_{t,t+j}}$$

Where $\mathbf{P_{t,t+j}}$ denotes the impulse response of the price change to the exchange rate shock after j months and $\mathbf{E_{t,t+j}}$ denotes the corresponding impulse response of the exchange rate shock. The dynamic exchange rate elasticity shows the cumulative responses of the price change to the exchange rate shock after j months, normalised by the corresponding responses of the exchange rate change. Table 5 below shows the pass-through elasticity to CPI.

The pass-through elasticity is zero for the first 6 time horizons for all imports and starts to show some response afterwards, where the exchange rate pass-through elasticity to imports is negative for imports from China, the USA and EU - except for the first 18 month time horizon for the imports from China.

The highest elasticity was for the imports from the USA. The pass-through elasticity to CPI for the 1 and 6-month horizons is quite low. At the 12-month horizon, the elasticity increases and reaches 0.275. By the end of the 24th month, the elasticity is at its highest, reaching 0.32 and remains the same afterwards. The results here indicate that the pass-through to CPI is substantial but considered slow.

Table 5: Exchange rate pass through Elasticity to imports and CPI

Period	T1	T6	T12	T18	T24	T30	T36
IMPCHN	0.000	0.129	1.063	0.290	-0.123	-0.261	-0.300
IMPUSA	0.000	-3.434	-5.825	-4.764	-4.723	-4.715	-4.749
IMPEUR	0.000	-0.700	-2.962	-1.714	-1.827	-1.955	-2.082
CPI	0.027	0.075	0.275	0.317	0.323	0.322	0.323

4.4 Variance Decomposition

The variance decomposition (VD) from the VAR analysis in Table 6 provides further analysis of the transmission of exchange rate pass-through. After 36 months, the VD results of imports from China (DIMPCHN), USA (DIMPUSA) and Europe (DIMPEUR) show that the exchange rate shocks only explain 2.46%, 2.06% and 3.62% respectively of the variations in these 3 variables. 61.45% of the variations in imports from China were due to its own shock and 55.50% of the variations in imports from the USA also resulted from its own shock. However, the VD of imports from Europe (DIMPEUR) shows that 20.78% of the variation was due to shocks in imports from China, 25.16% due to shocks in imports from the USA and 27.53% due to its own shock.

Moreover, the VD results for the consumer price index (CPI2) indicate that only 2.3% of the variations was due to shocks in exchange rates, whilst shocks in monetary policy (M2) explain 20.75% of the variations, shocks in imports from China (DIMCHN) explain 8.94% and its own shock explains 31.70% of the variations.

Table 6: Variance Decomposition VAR Model

Variance Decomposition of DIMPCHN						
Period	DIMPCHN	DIMPUSA	DIMPEUR	M2	DREALEXC	CPI
36	61.45	6.20	6.94	3.53	2.46	5.79
Variance Decomposition of DIMPUSA						
Period	DIMPCHN	DIMPUSA	DIMPEUR	M2	DREALEXC	CPI
36	17.18	55.50	2.71	1.55	2.06	3.64
Variance Decomposition of DIMPEUR						
Period	DIMPCHN	DIMPUSA	DIMPEUR	M2	DREALEXC	CPI
36	20.78	25.16	27.53	3.61	3.62	4.94
Variance Decomposition of CPI						
Period	DIMPCHN	DIMPUSA	DIMPEUR	M2	DREALEXC	CPI
36	8.94	4.87	5.36	20.75	2.30	31.70

4.5 Monetary Policy and Inflation: Two-dimensional VAR

Monetary policy has an important impact on the changes in domestic inflation, hence we re-estimate its effect, using a two-dimensional VAR for the period from 2005 to 2018 using monthly data. The VAR lag criteria suggests an optimal lag of 2, based on the lowest Akaike information criterion (AIC). as shown in Table 7 below.

Table 7: VAR Lag Order Selection Criteria – M2

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-485.7037	NA	2.012662	6.375212	6.414826	6.391304
1	-466.1339	38.37223*	1.642042	6.171685	6.290525*	6.219960*
2	-461.9008	8.189568	1.637106*	***6.168637****	6.366705	6.249096

The LM test for residuals serial correlation could not reject the hypothesis of no autocorrelation at lag of 2. The White test result shows that there is no heteroscedasticity detected, hence residuals are homogenous (see Tables 8&9).

Table 8: VAR Residual Serial Correlation LM Tests - M2

Null hypothesis: No serial correlation at lag h						
Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	4.942604	4	0.2932	1.241922	(4, 290.0)	0.2932
2	4.262322	4	0.3717	1.069734	(4, 290.0)	0.3717

Table 9: VAR Residual Heteroscedasticity Tests (Levels and Squares) - M2

Joint test:		
Chi-sq	df	Prob.
31.29936	24	0.1453

The VAR estimate indicates that the money supply has a significant positive impact on domestic inflation, suggesting that an increase in the money supply will lead to an increase in inflation, as shown in table 10 below. Looking at the impulse response function, a 1% shock in monetary policy leads to a significant immediate impact on inflation of 33% (0.33). The full effect is realised after 10 months, which is about 105% (1.05) of accumulated response to the policy shock. This means the transmission of the shock is gradual and complete (see Figure 5 and Table 11).

Table 10: Vector Autoregression Estimates – M2

Standard errors in ( ) & t-statistics in [ ]

	M2	CPI2
M2(-1)	0.000258 (0.09014) [0.00286]	0.067863 (0.04374) [1.55151]
M2(-2)	0.071478 (0.08927) [0.80065]	0.104417 (0.04332) [2.41048]
CPI2(-1)	-0.027663 (0.18168) [-0.15226]	0.316411 (0.08815) [3.58926]
CPI2(-2)	0.054372 (0.17622)	0.067388 (0.08551)

	[0.30855]	[0.78811]
C	1.149377	0.366669
	(0.23253)	(0.11283)
	[4.94287]	[3.24974]
R-squared	0.006944	0.240295
Adj. R-squared	-0.019895	0.219762
Sum sq. resids	414.3170	97.54744
S.E. equation	1.673153	0.811852
F-statistic	0.258729	11.70311
Log likelihood	-293.3064	-182.6650
Akaike AIC	3.899430	2.453137
Schwarz SC	3.998464	2.552171
Mean dependent	1.265713	0.951810
S.D. dependent	1.656753	0.919102
Determinant resid covariance (dof adj.)		1.535131
Determinant resid covariance		1.436435
Log likelihood		-461.9008
Akaike information criterion		6.168637
Schwarz criterion		6.366705
Number of coefficients		10

Figure 5: Accumulated response of CPI to M2 Innovation using Cholesky (d.f. adjusted) Factors

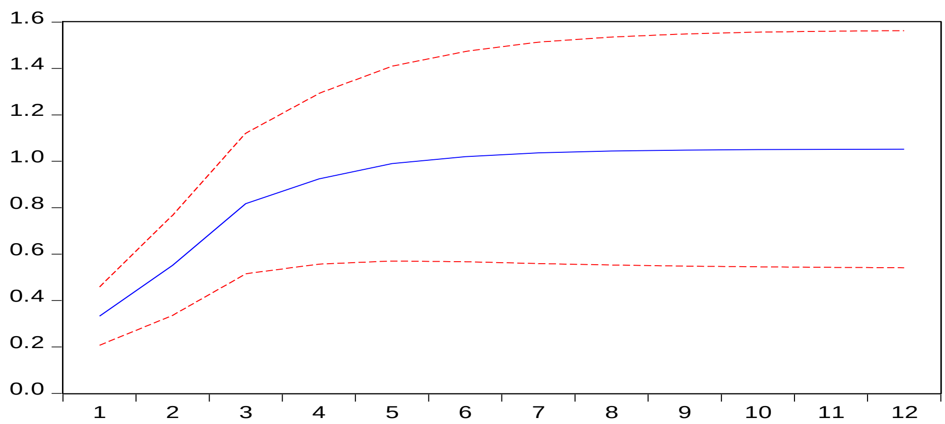


Table 11: Impulse Response of Domestic Inflation to One SD M2 Shocks

Period t	Impulse Response of CPI
1	0.333
2	0.552
3	0.817
4	0.924
5	0.989
6	1.019
7	1.036
8	1.044
9	1.048

10	1.050

The variance decomposition can be used to explain the percentage of variation in inflation. Table 12 below indicates that the changes in money supply (M2) contribute to 16.8% of the changes in inflation at period t =1 increasing gradually to explain around 28.35% of changes in inflation after one year, whilst the remaining variation in inflation is explained by its own shock.

Table 12: Variance decomposition of Inflation

Period t	M2	CPI2
1	16.80	83.199
2	20.82	79.18
4	27.92	72.08
6	28.32	71.68
8	28.34	71.66
10	28.35	71.65
12	28.35	71.65

To confirm the direction of the relationship between money supply and domestic prices, Granger causality test is applied at the optimal lag of 2. The test rejects the null hypothesis that M2 does not Granger cause CPI2, hence money supply causes changes in domestic prices. However, the test fails to reject the null hypothesis that CPI2 does not Granger cause M2 (see Table 13). Therefore, the relationship is unidirectional from money supply to domestic prices.

Table 13: Pairwise Granger Causality Tests – M2

Lags: 2		
Null Hypothesis:	F-Statistic	Prob.
CPI2 does not Granger Cause M2	0.04808	0.9531
M2 does not Granger Cause CPI2	3.90808	0.0222

4.6 Import and Inflation: Two-dimensional VAR

To explore the relationship between imports and inflation in Egypt, we apply a two-dimensional VAR model. Imports are divided into 3 categories, based on trading volume; hence, we include imports from China, imports from the USA and imports from Europe in separate VAR models.

We start by the 2-dimensional VAR, which includes imports from China (DIMPCHN) and CPI, using monthly data from 2005 till 2018. The VAR Lag Order Selection Criteria suggests an optimal lag of 3, based on the lowest Akaike information criterion (AIC) (Table 14).

Table 14: VAR Lag Order Selection Criteria – IMP

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1070.474	NA	5060.372	14.20495	14.24491	14.22118
1	-1049.125	41.84904	4021.546	13.97517	14.09506*	14.02387*
2	-1042.990	11.86431	3909.549	13.94688	14.14670	14.02806
3	-1037.197	11.04847*	3818.132*	***13.92314****	14.20289	14.03679

The residuals in the model are homogenous based on White test results and there is no serial correlation between residual, as indicated by the LM test, as shown in Tables 15&16 below.

Table 15: VAR Residual Heteroscedasticity Tests (Levels and Squares) – IMP

Joint test:		
Chi-sq	**df**	**Prob.**
38.72972	36	0.3475

Table 16: VAR Residual Serial Correlation LM Tests - IMP

Null hypothesis: No serial correlation at lag h						
Lag	**LRE* stat**	**df**	**Prob.**	**Rao F-stat**	**df**	**Prob.**
1	5.022290	4	0.2850	1.262303	(4, 282.0)	0.2850
2	2.130922	4	0.7117	0.532852	(4, 282.0)	0.7117
3	0.941513	4	0.9185	0.234937	(4, 282.0)	0.9185

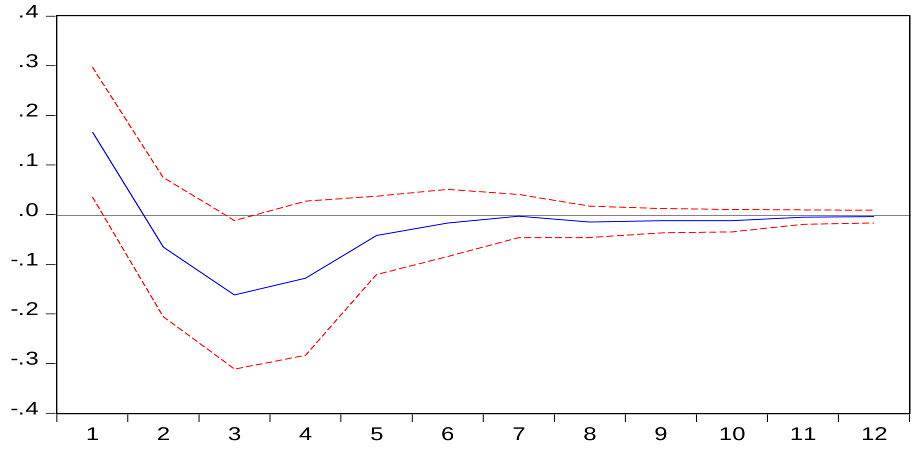
The VAR estimates, in Table 17 below, indicate that there is a significant impact of imports from China on the changes in inflation in the first 2 months. The impulse response function, in Figure 6 below, shows that the effect is statistically significant during the first 2 months and it takes approximately 11 months for the effect of China's imports to transmit. The response to the shocks is between 16.6% and 12.8% during the first 4 months and then the response decreases immediately. The transmission of shocks to domestic prices here is incomplete. The estimate shows a negative relation between inflation and imports from China; hence an increase of imports from China leads to a decrease in inflation. This finding is in line with Dexter et al. (2005) who conducted a study on the US economy and concluded that exports have a direct relationship with inflation and imports have an inverse relationship with inflation. In addition, Gruben and Mcleod (2004) showed that, when imports increase, inflation falls in the subsequent period in high income OECD and developing countries. Moreover, Wheeler (2008) has studied the impact of imports from China on UK inflation and found that these imports significantly reduced CPI inflation; also, Kamin et al (2006) found the same impact on US consumer prices.

Table 17: Vector Autoregression Estimates - IMP

Standard errors in ( ) & t-statistics in [ ]

	DIMPCHN	CPI2
DIMPCHN(-1)	-0.178240	-0.001716
	(0.08278)	(0.00091)
	[-2.15314]	[-1.89359]
DIMPCHN(-2)	0.089569	-0.002416
	(0.08762)	(0.00096)
	[1.02227]	[-2.51904]
DIMPCHN(-3)	-0.257166	-0.001251
	(0.09063)	(0.00099)
	[-2.83767]	[-1.26082]
CPI2(-1)	7.738477	0.370885
	(7.72687)	(0.08457)
	[1.00150]	[4.38550]
CPI2(-2)	2.901381	0.128542
	(8.13928)	(0.08908)
	[0.35647]	[1.44292]
CPI2(-3)	-1.105574	0.116193
	(7.77591)	(0.08511)
	[-0.14218]	[1.36525]
C	-3.908917	0.385396
	(10.4910)	(0.11482)
	[-0.37260]	[3.35642]
R-squared	0.147026	0.252233
Adj. R-squared	0.111485	0.221077
Sum sq. resids	793809.8	95.09308
S.E. equation	74.24667	0.812631
F-statistic	4.136848	8.095580
Log likelihood	-861.0923	-179.3467
Akaike AIC	11.49791	2.468169
Schwarz SC	11.63779	2.608043
Mean dependent	4.194245	0.961845
S.D. dependent	78.76707	0.920759
Determinant resid covariance (dof adj.)		3487.311
Determinant resid covariance		3171.478
Log likelihood		-1037.197
Akaike information criterion		13.92314
Schwarz criterion		14.20289
Number of coefficients		14

Figure 6: Impulse response of Inflation to shocks in imports from China using Cholesky (d.f. adjusted) Factors



The Granger causality test at the optimal lag of 3 confirms that we reject the null hypothesis, that imports from China do not Granger cause changes on inflation, hence the imports here cause variations in inflation. However, the test fails to reject that inflation Granger cause changes in imports from China. Therefore, the relation is unidirectional, running from Chinese imports to inflation, as shown in Table 18.

Table 18: Pairwise Granger Causality Tests - IMP

Lags: 3		
Null Hypothesis:	F-Statistic	Prob.
DIMPCHN does not Granger Cause CPI2	3.18770	0.0257
CPI2 does not Granger Cause DIMPCHN	0.57441	0.6327

Using the VAR model, we estimated the impact of imports from the EU and USA on inflation, using an optimal lag of 4 and 1 respectively. The residuals are homogenous and there is no serial correlation detected. The impulse response shows an insignificant effect on inflation for both imports. The Granger causality test also showed that we could not draw a conclusive decision regarding the direction of the relationship for imports from these two countries.

4.7 Real Exchange Rate and Inflation: Two dimensional -VAR

Here, we estimate a two-dimensional VAR, using monthly data for the real exchange rate and consumer price index once, for the period that preceded implementation of the floating regime and then we estimate the effect for the period after the actual floating of the Egyptian Pound.

For the period that preceded the floating regime, the investigated period is between December 2005 and October 2016. In order to select the correct lag, we use the VAR lag order selection criteria. The criteria indicates a lag of 2, based on AIC and FPE and a lag of 7, based on the LR shown in table 19 below. To eliminate serial correlation and heteroscedasticity, the model will use the lag of 7.

Table 19: Two dimensional VAR - Lag Order Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-414.5724	NA	1.982046	6.359883	6.403780	6.377720
1	-398.7689	30.88309	1.655230	6.179678	6.311366*	6.233189 *
2	-393.9075	9.351656	1.633700 *	6.166527*	6.386008	6.255712
3	-391.5836	4.399447	1.676262	6.192116	6.499389	6.316975
4	-391.5178	0.122571	1.780439	6.252181	6.647246	6.412713
5	-389.6411	3.438343	1.839760	6.284596	6.767454	6.480803
6	-388.7160	1.666581	1.929186	6.331541	6.902191	6.563422
7	-382.9416	***10.22639****	1.878954	6.304452	6.962894	6.572006

The estimated model has been tested for residual serial correlation, using LM test and residual heteroscedasticity tests using the White test. These tests have indicated that the residuals are not auto-correlated and are homogenous (Table 20 and Table 21). The two-dimensional VAR model estimates, using a lag of 7, are shown in Table 22 below.

Table 20: Two dimensional VAR - Residual Serial Correlation LM Tests

Null hypothesis: No serial correlation at lag h						
Lag	**LRE* stat**	**df**	**Prob.**	**Rao F-stat**	**df**	**Prob.**
1	1.871792	4	0.7593	0.467813	(4, 226.0)	0.7593
2	0.722360	4	0.9485	0.180081	(4, 226.0)	0.9485
3	4.029008	4	0.4021	1.011767	(4, 226.0)	0.4021
4	7.540757	4	0.1099	1.908407	(4, 226.0)	0.1099
5	9.872257	4	0.0426	2.511407	(4, 226.0)	0.0426
6	2.978639	4	0.5614	0.746265	(4, 226.0)	0.5614
7	7.648282	4	0.1053	1.936080	(4, 226.0)	0.1054

Table 21: Two dimensional VAR - Residual Heteroscedasticity Tests (Levels and Squares)

Joint test:		
Chi-sq	df	Prob.
94.96449	84	0.1942

Table 22: Two dimensional VAR Estimates

Standard errors in ( ) & t-statistics in [ ]

	DREALEXC	CPI2
DREALEXC(-1)	0.299592 (0.09208) [3.25368]	-0.079526 (0.04039) [-1.96885]
DREALEXC(-2)	-0.189780 (0.09843) [-1.92810]	-0.063529 (0.04318) [-1.47131]
DREALEXC(-3)	0.068554 (0.10022) [0.68404]	0.012494 (0.04396) [0.28420]
DREALEXC(-4)	0.042081 (0.10101) [0.41660]	0.036273 (0.04431) [0.81860]
DREALEXC(-5)	-0.089938 (0.09969) [-0.90217]	-0.067378 (0.04373) [-1.54072]
DREALEXC(-6)	0.106296 (0.10198) [1.04237]	0.044114 (0.04473) [0.98614]
DREALEXC(-7)	-0.308326 (0.10243) [-3.01007]	-0.016151 (0.04493) [-0.35943]
CPI2(-1)	-0.163090 (0.21783) [-0.74872]	0.307119 (0.09555) [3.21408]
CPI2(-2)	0.415753 (0.22836) [1.82060]	0.053753 (0.10018) [0.53658]
CPI2(-3)	0.422749 (0.23382) [1.80799]	0.040242 (0.10257) [0.39233]

CPI2(-4)	-0.225181 (0.24109) [-0.93401]	-0.040378 (0.10576) [-0.38178]
CPI2(-5)	0.320086 (0.24140) [1.32595]	0.101650 (0.10590) [0.95990]
CPI2(-6)	-0.387151 (0.24301) [-1.59318]	-0.085097 (0.10660) [-0.79828]
CPI2(-7)	0.444078 (0.22853) [1.94316]	-0.009318 (0.10025) [-0.09295]
C	-0.294832 (0.38308) [-0.76963]	0.605061 (0.16805) [3.60053]
R-squared	0.231805	0.180176
Adj. R-squared	0.139092	0.081232
Sum sq. resids	334.9468	64.45536
S.E. equation	1.699256	0.745419
F-statistic	2.500234	1.820990
Log likelihood	-247.3707	-139.4267
Akaike AIC	4.005659	2.357660
Schwarz SC	4.334880	2.686881
Mean dependent	0.373911	0.880038
S.D. dependent	1.831388	0.777674
Determinant resid covariance (dof adj.)		1.512701
Determinant resid covariance		1.186114
Log likelihood		-382.9416
Akaike information criterion		6.304452
Schwarz criterion		6.962894
Number of coefficients		30

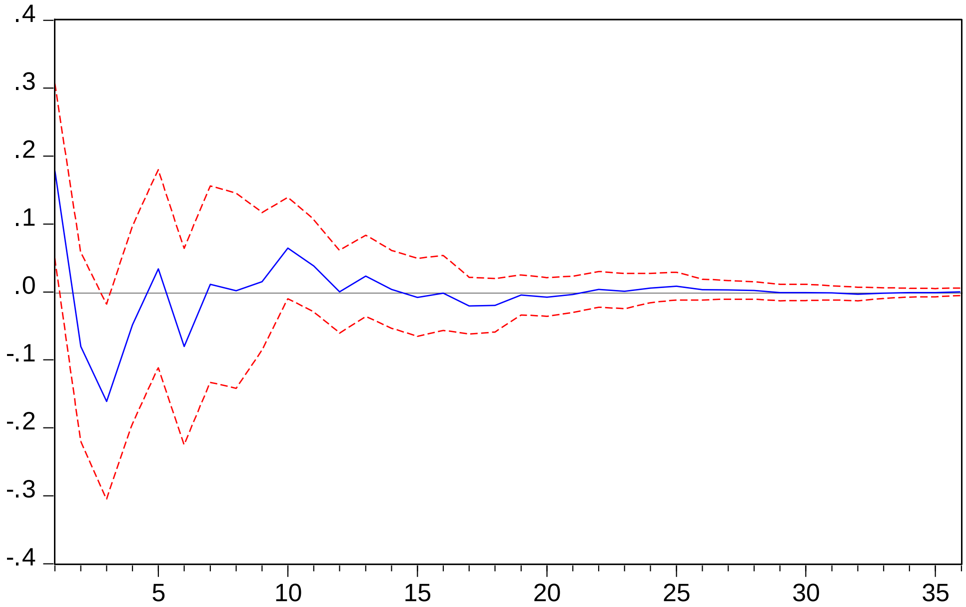
Based on the VAR model, the impulse responses of exchange rate to consumer price are estimated, as shown in Table 23 and Figure 7 for a 1% shock in exchange rate. The pass-through to CPI is rather low, with the highest response of approximately 0.2 recorded in the first month but insignificant. This low pass-through result is in line with other studies for developing countries, such as Ca'zorzi et al (2007) who studied China, Hong Kong, Korea, Taiwan, Singapore, Turkey and Argentina, in addition, Ito and Sato (2008) who found similar results for Thailand, the Philippines, and Malaysia.

The insignificance of exchange rate pass-through could be attributed to the fact that the CPI basket includes goods where the government administers their prices. Also, subsidies provided by the government contribute to low and insignificant pass-through.

Table 23: Impulse Response of Domestic Inflation to One SD exchange rate shock

Period	Response of CPI (in %)
1	0.1782
9	0.0152
18	-0.0199
27	0.0028
36	0.0002

Figure 7: Impulse response of Consumer prices to exchange rate Innovation using Cholesky (d.f.adjusted) Factors



In order to know the direction of the causality, we use the pairwise Granger causality test using the optimal lag of 7, as indicated by the VAR model lag selection criteria. Based on the test statistic in Table 24 below, we cannot reject the null hypothesis that DREALEXC does not Granger cause CPI2, hence, real exchange rate does not cause changes in CPI. However, we can reject the null hypothesis that CPI2 does not Granger cause DREALEXC, hence CPI causes changes in the real exchange rate. This finding is in line with the study by Khin et.al (2017) for Malaysia. In addition, the Achsani et.al (2010) study for the United Kingdom, France, Germany, Netherland, Belgium, Denmark, Sweden, Norway, the USA, Canada and Mexico found that inflation Granger-cause changes in the real exchange rates. In addition, Oriavwote and Eshenake (2012) find the same result in Nigeria, indicating a causal relationship running from inflation to real exchange rates. On the other hand, Madesha et.al (2013) and Amoah et.al (2015) showed that inflation and exchange rate are found to Granger-cause each other in Zimbabwe and Ghana respectively. Rashid and Husain (2013) showed that the exchange rate does not have any cause-effect relationship with the rate of inflation in Pakistan.

Table 24: Pairwise Granger Causality Tests

Lags: 7		
Null Hypothesis:	F-Statistic	Prob.
DREALEXC does not Granger Cause CPI2	1.73590	0.1073
CPI2 does not Granger Cause DREALEXC	2.30221	0.0311

We now run the two-dimensional VAR model for the period after the actual floating of the Egyptian Pound took place from November 2016 until February 2018. We use monthly data of nominal exchange rates (Egyptian Pound versus US Dollar and Egyptian Pound versus Euro) to see whether there will be any differences instead of the real exchange rate and CPI, which showed no significant results when we run the model. The VAR lag orders all selection criteria except LogL suggesting an optimal lag of 1, as shown in Tables 25 and 26 below.

Table 25: Two dimensional - VAR Lag Order Selection Criteria- (EGP per USD)

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-62.31448	NA	10.63215	8.039310	8.135884	8.044255
1	-54.94221	***11.97993**	***7.035733**	***7.617777**	***7.907498**	***7.632613**

Table 26: Two dimensional - VAR Lag Order Selection Criteria- (EGP per EUR)

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-63.13443	NA	11.77968	8.141804	8.238377	8.146749
1	-55.29269	***12.74282**	***7.350817**	***7.661586**	***7.951307**	***7.676422**

The VAR estimates show that the exchange rate pass-through for the Egyptian Pound, versus the 2 currencies to CPI, is weak in both cases and insignificant, as shown in Tables (27&28). We found the same result when we did not separate the currencies. One explanation here could be that the investigated period is too short to show a significant effect on inflation.

Table 27: Two dimensional VAR Estimates (EGP per USD)

Standard errors in ( ) & t-statistics in [ ]

	DEGPPERUSD	CPI2
DEGPPERUSD(-1)	-0.017650	0.016057
	(0.33614)	(0.18198)
	[-0.05251]	[0.08823]
CPI2(-1)	-0.274545	0.535636
	(0.56524)	(0.30602)
	[-0.48572]	[1.75033]
C	1.067929	0.776860
	(1.15612)	(0.62593)
	[0.92372]	[1.24114]
R-squared	0.030312	0.274670
Adj. R-squared	-0.118870	0.163081
Sum sq. resids	86.58295	25.37897
S.E. equation	2.580742	1.397222
F-statistic	0.203190	2.461439
Log likelihood	-36.21113	-26.39368
Akaike AIC	4.901391	3.674209
Schwarz SC	5.046252	3.819070
Mean dependent	0.545854	1.785354
S.D. dependent	2.439802	1.527297
Determinant resid covariance (dof adj.)		4.989329
Determinant resid covariance		3.293737
Log likelihood		-54.94221
Akaike information criterion		7.617777
Schwarz criterion		7.907498
Number of coefficients		6

Table 28: Two dimensional VAR Estimates (EGP per EUR)

Standard errors in ( ) & t-statistics in [ ]

	DEGPPEREUR	CPI2
DEGPPEREUR(-1)	-0.138233	-0.027380
	(0.32662)	(0.17091)
	[-0.42323]	[-0.16020]
CPI2(-1)	-0.205023	0.578126

	(0.57224)	(0.29943)
	[-0.35828]	[1.93074]
C	1.223843	0.727016
	(1.16311)	(0.60861)
	[1.05222]	[1.19455]
R-squared	0.050532	0.275666
Adj. R-squared	-0.095540	0.164230
Sum sq. resids	92.56344	25.34414
S.E. equation	2.668382	1.396262
F-statistic	0.345937	2.473757
Log likelihood	-36.74546	-26.38269
Akaike AIC	4.968183	3.672836
Schwarz SC	5.113043	3.817696
Mean dependent	0.736906	1.785354
S.D. dependent	2.549376	1.527297
Determinant resid covariance (dof adj.)		5.212768
Determinant resid covariance		3.441241
Log likelihood		-55.29269
Akaike information criterion		7.661586
Schwarz criterion		7.951307
Number of coefficients		6

5. CONCLUSION

This paper estimated the exchange rate pass-through to domestic prices in Egypt from 2005 until 2018, using the Vector autoregressive model (VAR). The model included nine endogenous variables, which are imports from the USA, Europe and China, as well as Real Exchange rate, Egyptian pound per US dollar, Egyptian pound per Euro, Industrial Production Index (IPI), Money supply (M2) and consumer price index (CPI). The VAR analysis through the impulse response functions showed that the exchange rate pass-through was found to be lowest for CPI and highest for imports. The pass-through elasticity to inflation was found to be slow but significant by the 24^{th} month. The slow pass-through to CPI can be attributed to the fact that the CPI basket of goods contains many goods, which are subsidised by the government, along with prices of goods, which are also administered by the government. The variance decomposition for CPI revealed that money supply (M2) and imports from China (IMPCHN) explain the majority of the variations in CPI, whilst the rest of the variations are explained by variations in CPI itself.

Therefore, we then estimated a two-dimensional VAR to explore the relation between CPI and M2 and on another occasion between CPI and imports from China. The two-dimensional VAR showed that the M2 has a significant positive effect on CPI in Egypt. The impulse response function showed that shock in monetary policy leads to a significant immediate impact on inflation, of which the full effect is realised after 10 months. The Granger causality test confirmed that the relationship is unidirectional from money supply to CPI. Moreover, the two-dimensional VAR revealed that imports from China (IMPCHN) have a significant effect on CPI in the first 2 months. The impulse response function showed that the effect is statistically significant during the first 2 months and it takes approximately 11 months for the effect of China's imports to transmit. The Granger causality test has confirmed the relationship is unidirectional; imports from China cause changes in CPI. We have also explored the effect with respect to imports from the USA and Europe; however, both were insignificant.

In the last part of the empirical analysis, we have separated the data into two time series, which are the period before the floating of the Egyptian pound, that is from December 2005 until October 2016 and the post floatation period, which is from November 2016 until February 2018. Here, we have again used a reduced form VAR with only two dimensions, which are real exchange rate and CPI, to explore whether there will be differences in the results relative to what we found in the first part of the analysis. For the period which preceded the floating regime, the pass-through to CPI was found to be slow with the highest response of approximately 0.2 recorded in the first month, however, it was insignificant. Furthermore, the pass-through to CPI after implementing the floating regime was insignificant. We have also explored the exchange rate of EGP versus USD and once versus EUR and their effect on CPI. However, the VAR estimates showed that the exchange rate pass-through for the Egyptian Pound, versus the 2 currencies to CPI, is weak in both cases and insignificant. We believe that this could be partially attributed to the short period which we investigated after the floatation.

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