Exchange Rate Pass-through in Nigeria: Evidence from a Vector Error Correction Model

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10 June 2009

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Abstract

It is recognized in the literature that the pattern of exchange rate pass-through is a very important instrument in the design of monetary policy, particularly in response to an exchange rate shock. This paper investigates, for the first time, the degree of exchange rate-pass-through to import and consumer prices in Nigeria between 1986Q1 and 2007Q4 on the basis of vector error correction methodology. The paper found that exchange rate pass-through in Nigeria during the period under review is low, although slightly higher in the import than in the consumer prices, significant and persistent. A one percent shock to exchange rate, for instance, results in 14.3 and -10.5 percent pass-through effect to import and consumer prices four quarters ahead, respectively. This, among other things, suggests that exchange rate pass-through in Nigeria declines along the price chain, and partly overturns the conventional wisdom in the literature that ERPT is always considerably higher in developing and emerging economies than in developed economies. Although pass-through effect is envisaged to increase with greater integration of the economy into the global world in future, but, the fact that it was found to be incomplete implies that prices react less proportionately to exchange shock in Nigeria and this is very useful to policymakers, especially in the design and implementation of monetary policy.

Keywords: Exchange rate pass-through, cointegration, vector error correction, impulse responses, variance compositions, Nigeria.

JEL Classification: F31, F41

I. Introduction

The need for appropriate adjustment mechanisms to structural imbalances in many developed countries, especially after the Great Depression of 1929-1933, culminated in extensive researches on exchange rate pass-through (ERPT) with the primary objective of determining a nominal anchor for inflation and inflation expectations. It is widely believe that an understanding of the impact of exchange rate movements on prices would help to gauge the appropriate monetary policy response to currency movements. The increased openness of most developed economies and the incidence of large fluctuations in nominal

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exchange rates have led to a need for a better understanding of the determinants of the transmission of exchange rate changes into import prices.

Exchange rate pass-through refers to the effect of a change in the exchange rate to domestic prices. In other words, it is the change in domestic prices that can be attributed to a prior change in the nominal exchange rate. Balance-of-payments models normally assume a one-for-one response of import prices to exchange rates, which is known as complete exchange rate pass-through (Peter 2003). A one-to-one response of import prices to exchange rate changes is known as complete ERPT while a less than one-to-one response is known as partial or incomplete ERPT. The rate of ERPT has important implications for the effect of monetary policy on domestic prices as well as for the transmission of macroeconomic shocks and the volatility of the real exchange rate. According to An (2006) understanding of exchange rate pass-through is of extreme importance for three key reasons: first, the knowledge of the degree and timing of pass-through are essential for the proper assessment of monetary policy transmission on prices as well as for inflation forecasting. Second, the adoption of inflation targeting requires knowledge of the size and speed of exchange rate pass-through into inflations. Finally, the degree of exchange rate pass-through has important implication for "expenditure-switching" effects from the exchange rate. In other words, a low degree of exchange rate pass-through would make it possible for trade flows to remain relatively insensitive to changes in exchange rates, though demand might be highly elastic.

In general, three factors may determine the extent of pass-through of exchange rate to domestic prices: the pricing behavior by exporters in the producer countries, the responsiveness of mark-ups to competitive conditions and the existence of distribution costs that may drive a wedge between import and retail prices (Olivei, 2002 and Campa and Goldberg, 2005). For instance, when exchange rates changes, foreign firms can choose to pass exchange rate changes fully to their selling prices in export markets (complete pass-through), to bear exchange rate changes to keep selling prices unchanged (zero pass-through), or some combination of these (partial pass-through). In reality, exchange rate pass-through is far from complete. Goldberg and Knetter (1997) argued that "a price response equal to one half the exchange rate change". They discovered that only around 60 percent of exchange rate changes are passed on to import prices in the United States.

The main explanation for incomplete pass-through is that many importing and exporting firms choose to hold their prices constant and simply reduce or increase the mark-up on prices, when the exchange rate is changing. Dornbusch (1987) justified incomplete pass-through as arising from firms that operate in a market characterized by imperfect competition and adjusts their mark-up (and not only prices) in response to an exchange rate shock. Burstein *et al.* (2003) instead emphasized the role of (non-traded) domestic inputs in the chain of distribution of tradable goods. Furthermore, Burstein *et al.* (2005) pointed out the measurement problems in CPI, which ignores the quality adjustment of tradable goods to large adjustment in the exchange rate. Another line of reasoning stresses the role that monetary and fiscal authorities play, by partly offsetting the impact of changes in the exchange rate on prices (Gagnon and Ihrig, 2004).

In Nigeria, the emphasis on knowing the exchange rate pass-through is underpinned by the fact that the Nigerian economy is external sector driven such that shocks from global commodity markets have serious implications on the economy. In addition, the need to make the external sector competitive through appropriate exchange rate adjustment has made the study of exchange rate pass-through in Nigeria imperative. Recent developments in the external sector of the Nigerian economy revealed that the naira exchange rate depreciated by 24.0 percent between October 2008 and February 2009 and the pressure is still on as crude oil receipts continue to dwindle due to both demand and supply factors. Concerns are what would be the implications of these developments on inflation or the extent of exchange rate pass-through on domestic and import prices. Although empirical evidences have shown that the transmission is not unitary, the main objective of the paper is to determine the magnitude and length of exchange rate pass-through on domestic and import prices in Nigeria on the basis of vector error correction model using quarterly observations from 1986Q1 to 2007Q4. The rest of the paper is divided into five sections. Following the introduction is section two which presents review of related literature on exchange rate pass-through and a recap of major developments in exchange rate management in Nigeria. Section three focuses on methodology of the paper while the penultimate section analyzes the empirical results. The final section contains conclusions and policy recommendations of the paper.

II Literature Review

Traditional monetary theory regards excessive money creation as a common source of instability in both the exchange rate and price level. In the presence of large monetary shocks, price inflation and exchange rate depreciation should, therefore, be closely linked. Generally, scholars have accepted that, understanding the impact of exchange rate movements on prices is critical from a policy perspective in order to gauge the appropriate monetary policy response to currency movements. Empirical studies have shown that movements in the exchange rate and prices do not go one to one in the short to medium run. An extensive theoretical literature, which has developed over the past three decades, has identified various explanations why exchange-rate pass-through (ERPT) to import and consumer prices is incomplete. Empirical analyses have also provided evidence of considerable cross-country differences in the ERPT. A major argument in this respect was suggested by Taylor (2000), who put forward the hypothesis that the responsiveness of prices to exchange rate fluctuations depends positively on inflation.

General literature search on exchange rate pass-through quickly reveals that the majority of the studies made in the area are industry or product specific studies. These studies analyzed the pass-through to import prices of different products or industries on the micro level rather than focusing on the effects of aggregate price measures. While the literature on exchange rate pass-through is voluminous, however, there is no uniform definition of the term "pass-through." For instance, Goldberg and Knetter (1997) define exchange rate pass-through (ERPT) as the percentage change in local currency import prices resulting from a one percent change in the exchange rate between the exporting and importing countries. (p. 1248). Much of the existing research focuses on the relationship between movements in nominal exchange rates and import prices. A smaller but equally important strand of the literature concentrates on the macroeconomic exchange rate pass-through to aggregate price indices

Menon (1995) is probably the most comprehensive survey of the literature on exchange rate pass-through up to date. He presents an overview of empirical studies on industrialized economies, of which the most often studied is the United States. The majority of these studies conclude that exchange rate pass-through is incomplete, indeed.

The degree of pass-through does, however, vary significantly across different countries. The main factors that influence the degree of pass-through across countries are the size and the openness of the individual economies. He furthermore, reports that pass-through relationships have remained largely stable over time. Different results for a country stem primarily from the use of different methodologies, model specifications and variable selections rather than from different time periods studied. In particular there is an aggregation problem, whereby the choice of price aggregate has a potentially large impact on the result. Some studies have also found pass-through to be asymmetric, which implies that the rate of pass-through is different during exchange rate appreciations and depreciations.

McCarthy (2000) presents a comprehensive study of exchange rate pass-through on the aggregate level for a number of industrialized countries. He estimates a VAR model using import, producer and consumer-price data from 1976 up until 1998. In most of the countries analyzed, the exchange rate pass-through to consumer prices is found to be modest. The rate of pass-through is, furthermore, shown to be positively correlated with the openness of the country and with the persistence of and exchange rate change, and negatively correlated with the volatility of the exchange rate. Kim (1998) investigated exchange rate pass-through in the United States using a framework of multivariate cointegration. This study relates changes in producer prices to changes in the trade weighted nominal effective exchange rate, money supply, aggregate income and interest rates. The exchange rate is found to contribute significantly to producer prices. Similarly, Goldfajn and Werlang (2000) presented a study of 71 countries, where exchange rate pass-through into consumer prices is investigated using panel estimation methods on data from 1980 up until 1998. Both developed and emerging market economies are included in their study. They reported that the pass-through effects on consumer prices increase over time and reach a maximum after 12 months. The degree of pass-through is, furthermore, found to be substantially higher in emerging market economies than in developed economies.

Rincón (2000) is the only aggregated study made on exchange rate pass-through in Colombia. This study used the Johansen framework to estimate the pass-through effect. It uses monthly data for the period 1980 to 1998. Exchange rate pass-through is found to be incomplete. The estimated long-term elasticities of import and export prices to a change

in the exchange rate are 0.84 and 0.61 respectively. The direct long-term effect of the exchange rate on the consumer prices is found to be 0.48. Similarly, Feinberg (2000) studied exchange rate pass-through in Colombia, Korea and Morocco using industry-level data and an OLS regression technique. The sample for Colombia consists of pooled annual data for 25 industries over eight years, 1980 to 1987. The study reported a long term effect of the real effective exchange rate on pooled wage adjusted producer prices to be 0.51. The exchange rate pass-through is, thus, found to be incomplete. However, the price and exchange rate indices used made it difficult to compare the results with other studies. The time period studied is, furthermore, too short to draw any definite conclusions of the long-term relationship.

Various Agreements: Empirical and Theoretical

Over the past two decades, a large economic literature on exchange rate pass-through (ERPT) has developed. Starting from different standpoints, the empirical literature examines the role played by ERPT in small and large economies. Studies conducted for the case of developed countries include Anderton (2003), Campa and Goldberg (2004),Gagnon and Ihrig (2004), Hahn (2003), Ihrig *et al.* (2006) and McCarthy (2000). There is also a growing literature applied to emerging market economies, including cross-country comparisons as in Choudhri and Hakura (2006), Frankel *et al.* (2005) and Mihaljek *et al.* (2000). Economists have traditionally made the simplifying assumption that the prices of tradable goods once expressed in the same currency are equalized across countries, that is, the purchasing power parity condition (PPP) holds.

Empirically, however, this assumption has found in general, little support at least in the case of small samples and in the short to medium run. In line with this evidence, the theoretical literature developed over the past two decades has provided different explanations on why the ERPT is incomplete. In his seminal paper, Dornbusch (1987) justifies incomplete pass-through as arising from firms that operate in a market characterized by imperfect competition and adjusted their mark-up (and not only prices) in response to an exchange rate shock. Burstein *et al.* (2005) instead emphasized the role of (non-traded) domestic inputs in the chain of distribution of tradable goods and point to the measurement problems in CPI, which ignores the quality adjustment of tradable goods to large adjustment in the exchange rate.

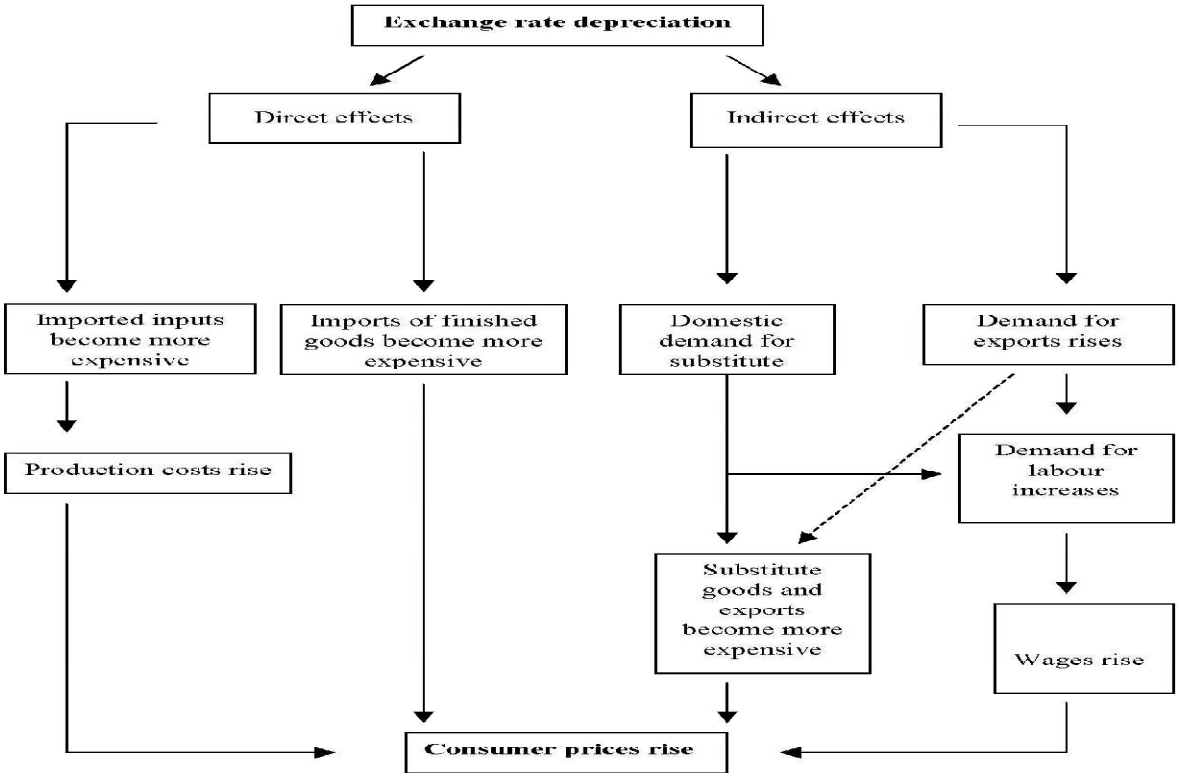
Another line of reasoning stresses more on the role that monetary and fiscal authorities play, by partly offsetting the impact of changes in the exchange rate on prices (Gagnon and Ihrig, 2004). Devereux and Engel (2001) and Bacchetta and van Wincoop (2003) instead explored the role of local currency pricing in reducing the degree of ERPT. Corroborating these various theoretical approaches, the empirical literature for both advanced and emerging economies has found evidence of incomplete ERPT. These studies also find evidence of considerable differences across countries, leading naturally to the question of what are the underlying determinants of pass-through. Taylor (2000) in particular has put forward the hypothesis that the responsiveness of prices to exchange rate fluctuations depends positively on inflation. The rationale for this involves a positive correlation between the level and persistence of inflation, coupled with a link between inflation persistence and pass-through. The latter link can be expressed as follows: The more persistent inflation is, the less exchange rate movements are perceived to be transitory and the more firms might respond via price-adjustments. The evidence across different studies appears overall supportive of the Taylor hypothesis.

Another important determinant of ERPT, from a theoretical standpoint is the degree of trade openness of a country. The most immediate connection between the two variables is positive: the more a country is open, the more movements in exchange rates are transmitted via import prices into CPI changes. However, the picture becomes more complex once we take into account that inflation could be negatively correlated with openness, as empirically found by Romer (1993). This gives rise to an indirect channel, whereby openness is negatively correlated with inflation and, taking into account Taylor's hypothesis, the degree of pass-through. The direct and indirect channels go in opposite directions and the overall sign of the correlation between pass-through and openness can thus be either positive or negative.

Figure 1 adapted from Lafleche (1996) presents a schematic view of the direct and indirect channels of exchange rate pass-through. The direct channel, which works through import price affects price of imported intermediate goods, which ultimately affects cost of production or the consumer goods. The indirect channel according to Lafleche (1996) works through high demand for substitute goods or makes exports more competitive. At the end, exchange rate pass-through is expected to be incomplete in the

short term and complete in the long term as both import and consumer prices adjust to exchange rate depreciation.

Figure 1: Direct and Indirect Channels of Exchange Rate Pass-through to Consumer Prices



Source: Adapted from Lafleche (1996).

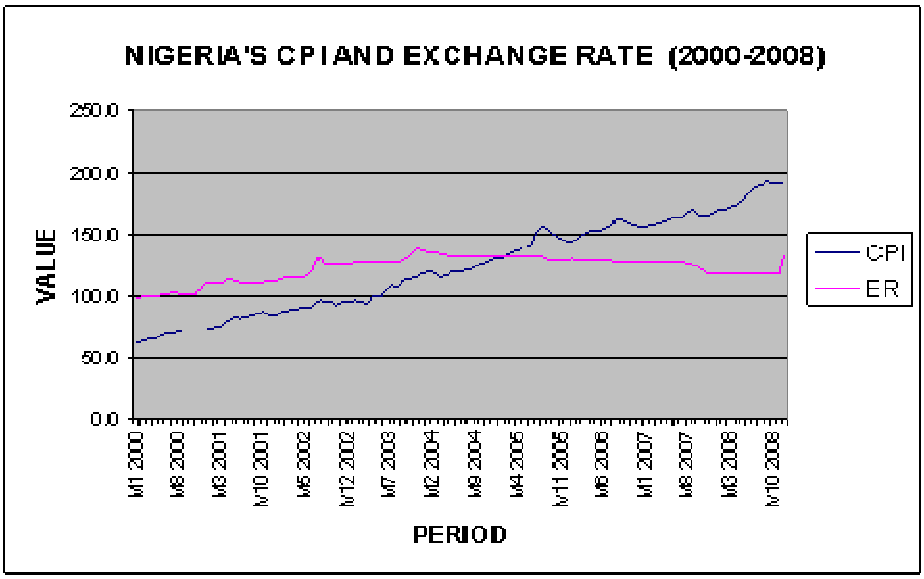
Review of Inflation and Exchange Rate Policies in Nigeria

The bank has over the years used monetary targeting to achieve price stability. Open Market Operations (OMO) was complemented by cash reserve ratio and repurchase agreements. Others include: Cash Reserve Ratio and the adjustment of the Minimum Rediscount to signal the direction of dictated by monetary conditions. Interest Rate Draw Back was introduced to reduce the cost of high borrowing by farmers in 2002.

In 2006, broad money grew by 30.6 percent compared with a target of 27.8 percent for the year and narrow money grew by 20.3 percent. the Monetary authorities faced severe challenges maintaining price stability, particularly due to the statutory allocations to the three tiers of government and the monetization of the excess crude proceeds, the

population census and pre-election spending. Among the measure taken during this period focused on meeting the Policy Support Instrument (PSI) Target. These included the introduction of the non-discountable Special Nigerian Treasury Bills, gradual increase in interest rates at the open and discount window by a 100 basis point in June, upward adjustment of the MPR mid-year which was later replaced by the Monetary Policy Rate (MRR) introduced in December 2006.

Figure 2: CPI and Exchange Rate in Nigeria



The Policy rate was adjustment downward towards the end of the year. The inflation rate dropped to 8.5 at end of the year. The 2006 monetary policy framework was continued in 2007 with the main trust being containing excess liquidity in the banking system. The Bank met its targets under the PSI and exited same in June 2007. The Bank continued its monetary targeting policies into 2008 but is however considering inflation target in future.

Exchange rate policies have focused on achieving exchange rate stability. The Retail Dutch Auction System (RDAS) which preceded the Wholesale Dutch Auction System (WDAS) was used by the Bank to achieve the some measure of stability in the foreign exchange market and curb exchange rate volatility. It was first introduced in 1987 and reintroduced in 2002. The Bank introduced a Wholesale Dutch Auction System (WDAS) on February 20, 2006 as a framework for managing the foreign exchange resources, to further liberalize the foreign exchange market and consolidate the gains of the retail

DAS, in a move to gradually deregulate the forex market. The ultimate objective of the WDAS is to institutionalize inter-bank market structure through relative liquidity and efficiency of the market. It was an inter-bank forex market for both spot and forward foreign currency transactions and had a decentralized allocation of forex determined by market participants. The framework also further liberalized the direct sale of foreign exchange to Bureau de change. The Basic Travel allowance was increased from US$2,500 biannually to US$5,000 per quarter, and Personal Travel Allowance (PTA) from US$2,000 biannually to US$4,000 per quarter. The Exchange rate under the regime stabilized, it appreciated by 6.6 percent at end 2006 to N126.65 percent over the end period rate of N132.05 in 2005. The convergence of the multiple exchange rates was achieved for the first time and at the same time demand pressure moderated by 9.9 percent.

As a result of the weakening external sector due to the drop in the international price of crude oil, the exchange rate depreciated in November 2008 and at end December it was N132.6/US$ as demand pressure resurfaced at the foreign exchange market. In February 2009, the Bank reintroduced, the RDAS to curb exchange rate volatility.

III. Research Methodology

The literature is replete with a number of estimation techniques on the issues of exchange rate pass-through. Either single equation models or systems of equations for one specific country, or else set up single equation models for a larger set of countries (e.g. Choudhri and Hakura, 2006 and Mihaljek *et al.,* 2000). Equally, a number of empirical studies have applied the cointegration and vector autoregressive methodology; McCarthy (2000), (2003) and Ca' Zorzi, Hahn and Sanchezis (2007). In this study also, we apply the vector error correction methodology. First, we introduce the baseline VAR model from which the VECM evolves. A standard reduced-form VAR model representation is expressed as follows:

$$Y_t = c + \sum_{i=1}^{p} \Phi_i Y_{t-1} + \varepsilon_t \qquad 3.1$$

where Y_t represents the vector of endogenous variables, c is a vector of constants, Φ_i denotes the matrices of autoregressive coefficients and ε_t is a vector of white noise

processes. According to Anguyo (2008) identification of the structural shocks is achieved through appropriate ordering the variables of interest and applying a Cholesky decomposition to the variance covariance matrix of the reduced form residuals ε_t.

Data Description

Quarterly data was collected all the series from 1986Q1 to 2007Q4 on the Nigerian economy. In all, six variables were used in the regression in the baseline VECM and a total of five in the secondary model. These include an exchange rate variable, *er,* an oil price index, *oilp*, an import price index *imp*, an index for openness of the economy, *opn,* an output, y_t, a consumer price index, *cpi* , and a short-term interest rate, *ir*. The exchange rate variable is measured in nominal terms where the rate reflects the value of the naira in terms of the United States (US) dollar. The US Wholesale price index was used as a proxy for the import price in Nigeria while simple average of three spot crude oil prices was used as a proxy for international oil price. Data was obtained from the International Financial Statistics (IFS) for the two variables. Openness index was measured as the ratio of total trade by Gross Domestic Product (GDP) and this comes from the CBN Statistical Bulletin. y_t stands for GDP and was taken in nominal terms. Consumer price index and short term interest are the composite price index for all commodities and the three month deposit rate and all were obtained from the CBN Statistical Bulletin and the Annual Reports and Statements of Accounts various issues.

While the exchange rate and the two price variables, albeit, *imp* and *CPI* are instrumental in the analysis, the output variable, oil price and the degree of openness are included, as rationalized in the literature, to capture effects on the real and external sectors of the economy. This is particularly so given the crucial role oil price to macroeconomic performance of the Nigerian economy and the deregulation policy pursued since July, 1986. The inclusion of the interest rate allows the money market, including the impact of monetary policy, to influence the pass-through relationship. Lastly, all the variables are in a logarithm transformation so as to infer elasticities explanation from the results.

The empirical analysis starts by checking the time series properties of the variables using the Augmented Dickey Fuller (ADF) and Phillips and Perron (PP) tests to establish the order of integration of the series before embarking on the cointegration tests. This

becomes necessary in order to avoid the incidence of spurious regression estimates. Economically speaking, cointegration of two or more variables implies a long-term or equilibrium relationship among them, given by their stationary linear combination (called the cointegrating equation). The tests involve estimation of the following regression equation given in 3.2.

$$\Delta x_t = \alpha + \beta_t + \delta x_{t-1} + \Sigma \Delta x_{t-1} + \varepsilon_t \qquad 3.2$$

where x in the above equation is the variable under consideration. Normally, variables at level are nonstationary according to Engle and Granger, while the first differences are stationary at the 1% statistical significance level. Furthermore, equation 3.3 gives the Johansen (1991) maximum likelihood procedure. The procedure is based on a vector error correction model (VECM) and is represented in following form:

$$\Delta X_t = \mu + \sum_{t=1}^{p} \Gamma_i \Delta X_{t-i} + \Pi X_{t-p} + \xi_t \qquad 3.3$$

where Δ is the first difference lag operator, X_t is a (kx1) random vector of time series variables with order of integration equal to one, $I(1)$, μ is a (kx1) vector of constants, Γ_i are (k x k) matrices of parameters, ξ_t is a sequence of zero-mean p- dimensional white noise vectors, and Π is a (k x k) matrix of parameters, the rank of which contains information about long-run relationships among the variables. If the Π – matrix has reduced rank, implying that $\Pi = \alpha\beta'$, the variables are cointegrated, with β as the cointegrating vector. If the variables were stationary in levels, Π would have full rank. The cointegration rank in this study is conducted with the maximum eigenvalue and trace test. The asymptotic critical values are given in Johansen and Juselius (1990) and MacKinnon-Haug-Michelis (1999).

Theoretically, the expected signs of the vector coefficients from the VECM are expressed as:

$$er = f(\overset{+}{oilp}, \overset{-}{imp}, \overset{-}{opn}, \overset{+}{y_t}, \overset{-}{cpi}, \overset{+}{ir}) \qquad (3.4)$$

All things being equal, a rise in the crude oil prices positively affects oil receipts in the Nigerian economy and accretion to foreign reserve, and cause appreciation in the level of the exchange rate. Higher import prices, especially in import dependent economy, greater openness of the economy and a rise in consumer price index all cause depreciation of the

exchange rate, while a rise in the level of productivity and higher money market interest rate result in appreciation of the exchange rate.

IV. Results and Discussions

This section presents the empirical results of the regressions equations specified in equations 3.2, that is, stationarity tests and 3.3, that is, the Juselius cointegration test and the vector error correction results. Albeit, two versions of the specification in equation 3.3 were estimated, a baseline model, which consists of all the six variables and, an alternative or confirmatory model, which excludes index of oil price shock in the regression. The second model seeks to examine the degree of exchange rate pass-through without the influence of oil price. In addition, relevant tests of significance and overall efficiency of the models were carried out.

Unit Root Tests

Table 1 presents the empirical results of the Augmented Dickey Fuller and the Phillip Perron tests. Using the specification in equation (1), the regressions were run for all the series at both level and first difference and, with constant and trend in the equation. While on the one hand the appropriate lag level applied in the stationarity or unit root test follows the SIC criterion, the AIC and Cholesky criterion were adhered to in the selection of the lag length and ordering of the variables, respectively.

Table 1: Unit Root Tests

	Level		*First Difference*		
Model	ADF Test Statistic	PP Test Statistic	ADF Test Statistic	PP Test Statistic	ADF/PP C.V
Er	-1.75	-1.85	-8.33*	-8.33*	-4.07
Oilp	-0.84	-0.84	-10.6*	-10.6*	-4.07
Imp	-1.46	-0.81	-3.72**	-3.79**	-3.46
Opn	-0.90	-0.78	-9.74*	-9.77*	-4.07
y_t	-0.74	-3.68**	-10.4*	-22.4*	-4.07
Cpi	-2.05	-2.52	-10.2*	-19.3*	-4.07
Ir	-3.56	-2.51	-6.43*	-6.26*	-4.07

* indicates significance at 1 percent level using MacKinnon critical values
Note: Lag length was chosen in line with the Schwarz information criterion which imposes a larger penalty for additional coefficients. It is given by SC = $2l/T + (k \log T)/T$. where l is the log likelihood, T is the number of observations and k is the number of coefficients.

From table 1 above, the results show that except for y_t, which was found to be stationary at level at the 5 percent, all the other variables are characterized by unit root. Meaning, at level, we fail to reject the null hypothesis of a unit root except for y_t. At first difference, however, the results tell us to reject the null hypothesis of a unit root in favor of the alternative, which says the variables are stationary at the 1 percent level of significance. The only exception is the case *imp*, which is stationary at the 5 percent level. The results from the two tests, that is, the ADF and the PP tests, besides agreeing on the level at which the variables attain stationarity, yield very close *t*-statistic values for the test, sometimes as close as the same.

Cointegration tests and VECM Results

The next step is the cointegration test. The estimation of equation 3.3 yields the following results presented in Table 2. The results suggest the existence of three and two cointegrating equations based on the trace and maximum eigenvalue statistics at the 1 percent level for the baseline model and two and one cointegrating equations for the alternative model as implied by the trace and maximum eigenvalue at the 1 percent level. The Osterwald-Lenum critical values were applied. The emergence of more than one cointegrating equations is expected given that the two models include at least one variable, which is stationary at level and, another one, which although stationary at first difference is, however, at a lower level of confidence, that is, at the 5 percent level.

Table 2: Cointegrating Relations (*Baseline Model)*

Hypothesized No. of CE(s)	Max-Eigen Statistic	Critical Value [Eigen] at 1%	Trace Statistic	Critical Value [Trace] at 1%
None	78.03525*	51.57	213.1153*	133.57
At most 1	52.97474*	45.10	135.0801*	103.18
At most 2	35.62340	38.77	82.10531*	76.07
At most 3	24.21261	32.24	46.48191	54.46
At most 4	14.26624	25.52	22.26931	35.65
At most 5	7.759581	18.63	8.003068	20.04
At most 6	0.243487	6.65	0.243487	6.65
Alternative model				
None	49.71625*	45.10	127.0513*	103.18
At most 1	35.74527	38.77	77.33509*	76.07
At most 2	22.07428	32.24	41.58982	54.46
At most 3	16.57123	25.52	19.51554	35.65
At most 4	2.680377	18.63	2.944308	20.04
At most 5	0.263932	6.65	0.263932	6.65

Notes: the variables included in the regressions are: exchange rate, oil price index, index of openness, import price index, gross domestic product, consumer price index and interest rate, Lag length=4 (determined by AIC). The linear trend assumption is: Intercept + trend in CE, Significance level: * = 1% in line with Osterwald-Lenum critical values.

The unit root tests and indeed the Johansen cointegration tests provide strong evidence of possible long-run equilibrium relationships among the variables in our models. Under this circumstance, favoring a VAR in level or first differences, as opposed to VECM may lead to misspecification because cointegration is established. More so, our analysis focuses on the long-term equilibrium relationships as opposed to the short-term dynamics. It has been argued in the literature, that neither the estimation of VAR in levels nor the VECM specifications are exempt from problems (see, *e.g.*, Favero, 2001, Marcet, 2005; Ca' Zorzi, Hahn and Sachez, 2007). For instance, the VECM would yield inconsistent estimates if the wrong cointegration vector is imposed on the model. Hence, in our analysis of the vector of β coefficients of the VECM model below, although other cointegrating equations were scrutinized, the most consistent and significant results come the first cointegrating equation.

Table 3: Results of Cointegration Analysis

	Baseline Model				***Alternative Model***			
	C. Vector	Adj. coefficient	Test for W. Exog.	Test for Exclu.	C. Vector	Adj. coefficient	Test for W. Exog.	Test for Exclu.
Er	1.000	1.912*	22.99	23.77	1.000	1.545*	13.83	12.94
		(4.53)	[0.00]	[0.00]		(5.20)	[0.00]	[0.00]
Oilp	0.586*	0.737	1.320	3.156				
	(2.96)	(1.19)	[0.25]	[0.07]				
Opn	-0.988*	-0.273	0.488	13.36	-0.680**	0.035	0.006	3.174
	(-5.24)	(-0.63)	[0.48]	[0.00]	(-2.87)	(0.88)	[0.94]	[0.07]
Imp	-2.530**	0.019	2.114	3.367	-1.249	0.027	6.058	0.460
	(-2.14)	(1.11)	[0.15]	[0.12]	(-0.65)	(2.15)	[0.01]	[0.49]
Cpi	-0.134	-0.087	0.400	1.315	-0.467	0.069	0.369	3.951
	(-1.06)	(-0.49)	[0.53]	[0.25]	(-2.01)	(052)	[0.54]	[0.05]
y_t	0.894*	-0.286	2.060	12.29	0.607	-0.132	0.625	1.391
	(4.15)	(-1.19)	[0.15]	[0.00]	(1.62)	(-0.71)	[0.43]	[0.24]
Ir	0.826*	-0.909	4.871	18.82	0.814*	-0.534	2.378	13.615
	(8.30)	(-1.91)	[0.03]	[0.00]	(4.91)	(1.50)	[0.12]	[0.00]
Adj. R^2	0.777				0.788			
AIC	-1.019				-1.116			
SIC	0.0012				-0.231			

*(**) denote rejection of the hypothesis at the 1 and 5 percent levels
( ) and [ ] denote t-ratios and probability values respectively.

Table 3 provides a summary of the results of the two models; baseline and supplementary models, in terms of their cointegrating vector coefficient, that is, (β) and the corresponding adjustment coefficient, which is, the (α). In addition, the Chi-square and corresponding probability values for the weak exogeneity and exclusion tests are also reported. Appropriate lag length was selected based on the AIC and SIC criteria.

Results show that all variables enter significantly well in the long-run vector in the baseline model except the *cpi*, which although is correctly signed, is insignificant statistically. Changes in import prices and openness were found to have more adverse effect on the level of exchange rate than any of the variables in the model. From the cointegrating equation 3.5, for instance, a 1 percent change in two variables results 2.3 and 0.98 percent depreciation in the level of the exchange rate respectively. Furthermore, a 1 percent change in GDP, interest rate and oil price result in 0.89, 0.83 and 0.59 percent change/appreciation in the level of exchange rate respectively and all are consistent with the *a priori* expectation. The long run exclusion test reports high Chi-square values for all the vector coefficients except *cpi,* and three variables; *oilp, opn* and *cpi,* are weakly exogenous in the model. It is reasonable, according to Maesofernandez, Osbat and Schnatz (2001), to expect oil price to be weakly exogenous as it is difficult to conceive that the other variables have any influence on it but that of the latter two is counterintuitive.

$$er = -0.82 + 0.59*oilp - 0.99*opn - 2.53*imp - 0.13cpi + 0.89*y_t + 0.83*ir \quad 3.5$$

and,

$$er = -0.09 - 0.68*opn - 1.25imp - 0.47cpi + 0.67y_t + 0.81*ir \quad 3.6$$

The exclusion of oil price in the *alternative* model although yields less number of significant vector coefficients, yet all were found to be correctly signed, and in numerical terms, the values were very close to those in the baseline model. The vector coefficient of *opn* and *ir*, in particular, are both correctly signed significant and statistically. Result from cointegrating equation 3.6 reveals that a 1 percent change in openness index and interest rate results in depreciation/appreciation in the exchange rate by 0.68 and 0.81 percent, respectively. The joint significance of index of openness and interest rate coefficients in both models underscores the importance in the determination of exchange

rate in the long run hence government's stance on liberalizing foreign trade and payments, and financial sector consolidation/reforms are veritable instruments towards achieving exchange rate stability in the long run.

Meanwhile, we test the nature of causality among the selected macroeconomic variable using the VECM Granger's causality/Wald Block exogeneity test. While the pairwise test tests the degree of causality among two variables, the block exogeneity excludes the influence of all other endogenous variables in the VECM other than the lag of dependent variable under consideration. Table *A1* (in the appendix) reports the results of the tests. Of particular importance from the analysis is the strong causality/dependence of exchange rate to oil price, openness, import prices and the short term interest. The block exogeneity test shows the significant role of past information in the determination of the degree of causality in the level of exchange rate, openness and import prices.

A preliminary investigation of the nature of correlation of the VECM residuals reveals the results presented in Table 4. From the results, the off-diagonal elements, except link between oil price and openness index, which does not make much economic sense, and *cpi* and y_t, are less significant or close to zero. This implies that no contemporaneous correlation is being ignored by the VECM.

Table 4: Results from the VECM Residual Correlations

	er	*oilp*	*Opn*	*Imp*	*Cpi*	y_t	*ir*
Er	1						
Oilp	0.10679	1					
Opn	-0.0505	0.65394	1				
Imp	0.42845	0.22052	0.16844	1			
Cpi	0.21971	0.12031	-0.3159	0.08654	1		
y_t	0.16991	0.16023	0.26033	0.4720	-0.6073	1	
Ir	0.45830	0.23674	0.12918	0.25493	-0.0691	0.35322	1

Researchers' computation from VECM regression output.

Furthermore, for purposes of investigating white noise errors, normality tests, multivariate serial correlation and White's heteroskedasticity tests were calculated. Table *A2* reports the results of normality test where the Jarque-Bera test statistic tells us to accept the hypothesis of normally distributed residuals. In addition, both the LM and White's heteroskedasticity tests presented in same Table *A2* tell us to accept the null

hypothesis of no serial correlation and homoskedastic residuals, respectively. The ADF test, at level reveals stationary residuals also. Thus, on account of these tests, our residuals from the baseline model have satisfied all the required tests and can be safely used for forecast. Similar tests carried out on the residuals of the alternative model – results not reported, but, available on request also fulfill these conditions. Next is to use the impulse response and variance decomposition function to assess the extent of exchange pass-through to import and domestic prices.

Impulse Response Functions and Variance Decompositions

In this section we present the results of impulse response and variance decomposition functions over different horizons. Impulse response functions, on the one hand, trace the effect of a shock emanating from an endogenous variable to other variables in the VECM while variance decompositions, on the other hand, provide information about the relative importance of each random innovation in affecting the variables in the VECM. Table 5 and Figure 3 and 4 (in the appendix) display the response of import and consumer prices and the exchange rate itself to a 1- percent shock in the nominal exchange rate (an increase corresponds to a depreciation in the exchange rate), after 2, 4, 8 and 12 quarters.

Results show that exchange rate pass-through is relatively high, significant and persistent more in import than in consumer prices in both the baseline and the alternative models, although the sign is negative in the case of the latter. The results further reveal that ERPT is incomplete in Nigeria. For instance, 4 quarters ahead ERPT to import and *cpi* are 0.147 and -0.105, respectively. This implies that a 1 percent exchange rate deprecation results in 14.7 percent and 10.5 percent increase in the level of import and consumer prices, respectively. This appears generally plausible and in line with findings of empirical studies in the area. An (2006), for instance, found that ERPT declines at different stages of distribution or pricing chain - import, producer and consumer prices in eight major industrialized countries. In our case also, the fact that ERPT is higher in import prices than CPI implies that pass-through declines along the pricing chain in Nigeria. However, Barhoumi (2006) investigates exchange rate pass-through in 12 developing countries, including Nigeria, and his results suggest that ERPT in Nigeria is very low in both short and long term. However, contrary to the general trends in the literature where exchange

rate pass-through declines along the pricing chain, his results show that *cpi* rises more than the import price in Nigeria.

The results further show that exchange rate pass-through to exchange itself is high, persistent and significant. This implies that exchange rate depreciation leads to further depreciation in the exchange rate. This is also consistent with the expectation and the predicaments in the foreign exchange market in Nigeria, especially in the Bureau de Change segment of the market. Barhoumi (2006) reports a 5 quarters ahead response of exchange rate to a 1 percent shock in exchange rate of 0.147 for Nigeria. This compares well with the results reported of 0.210 and 0.179 above in the baseline and alternative models, respectively.

Table 5:
Accumulated Effects of Domestic Price Indices and Exchange Rate to a One-percent Exchange Rate Shock

Baseline Model	**After**			
	2 quarters	4 quarters	8 quarters	12 quarters
Import Prices	0.013	0.143	-0.028	0.286
Consumer Prices	-0.065	-0.105	-0.107	-0.281
Exchange Rate	0.136	0.210	0.257	0.448
Alternative Model	**After**			
	2 quarters	4 quarters	8 quarters	12 quarters
Import Prices	0.017	0.147	0.002	0.220
Consumer Prices	-0.056	-0.088	-0.062	-0.231
Exchange Rate	0.116	0.179	0.222	0.382

Source: Calculations by the authors

Elsewhere, Rowland (2004) reports that ERPT is incomplete in Colombia, and import prices respond more to shock in exchange rate followed by producer and then consumer prices in the order of 80, 28 and 15 percent within the period of 12 months, respectively.

Nkunde (2006) examines the exchange rate pass-through to inflation in Tanzania using a structural vector autoregression (SVAR) framework. His results show that pass-through to inflation remained persistent, implying that exchange rate movements had a small but prolonged impact on inflation. In Uganda, Anguyo (2008) found that contrary to conventional wisdom that ERPT is always considerably higher in "emerging" than in "developed" economies; exchange rate pass-through to inflation in Uganda was low, significant and persistent.

Table 6

Results of Variance Decomposition: How much does Exchange Rate explain?

Baseline Model	After			
	2 quarters	4 quarters	8 quarters	12 quarters
Import Prices	0.712	22.06	29.99	34.98
Consumer Prices	16.98	12.42	6.771	8.054
Exchange Rate	62.57	44.54	30.87	25.37

Alternative Model	After			
	2 quarters	4 quarters	8 quarters	12 quarters
Import Prices	2.321	8.155	22.41	21.49
Consumer Prices	11.63	7.069	5.385	8.031
Exchange Rate	64.57	46.49	29.30	25.08

Source: Calculations by the author.

Results from the variance decomposition presented in Table 6 show that contemporaneously, exchange rate accounts for 100 percent of its variance. This declines to 62.6 percent in the short term. While the influence of *cpi* declines from 16.9 percent in the short term to 12.4 percent, that of import price increases in the medium and the long term. Results of the variance decomposition from the alternative model, strongly correlates that of the baseline model. The increasing dominance of the import price in the

determination of the exchange rate variance is a reflection of the import dependent nature of the Nigerian economy.

V. Conclusion and Recommendations

This paper investigates the pattern of exchange rate pass-through to import and consumer prices in Nigeria between 1986Q1 and 2007Q4 based on vector error correction model. It was recognized in the literature that the degree of exchange rate pass-through is a very important variable when designing monetary policies, particularly in response to an exchange rate shock. The paper situates the need for an empirical study in the area given that the Nigerian economy in general and the exchange rate management in particular, has since July, 1986 been deregulated. As policymakers were grappling with the new policy, exchange rate continues to depreciate. The opening up of the economy through trade liberalization tremendously boosts the flow of foreign trade. Undoubtedly, these developments, we feel have serious implications on the link between exchange rate and general price level in the economy.

The paper set out by checking the time series properties of the variables to avoid incidence of spurious regression and conducts a cointegration test based on the Johansen framework. On the basis of ADF and PP tests, the hypothesis of unit root was rejected for all the variables at first difference and a stable long run equilibrium relationship. Furthermore, Granger causality test reveals strong correlation between exchange rate and the key variables, in particular, oil price, import price and short term interest rate. Using the impulse response function, we establish the degree of exchange rate pass-through to import and consumer prices in the paper to be incomplete, persistent and significant. ERPT was found to be higher in import prices than *cpi* and this suggests that pass-through declines along the pricing chain in Nigeria. Exchange rate to exchange rate response was found also to be relatively strong and situates well within the perimeter of empirical findings in the area.

The findings of the paper are relevant to the Central Bank given its task of achieving a stable exchange rate system through appropriate intervention in the market and efficient management foreign reserves. Furthermore, price stability being one of the cardinal

objectives of the Central Bank could be achieve if the pattern of exchange rate pass-through is clearly and correctly identified. Incomplete pass-through implies that price agents in the market only transfer a part not all of the effect of exchange rate depreciation to consumers. As we approach the long run, however, and given the continuous increase in the share of imports in total trade and the integration of the economy into the global world, the pass-through effect is bound to increase in the future. An (2006) discovers that a greater pass-through coefficient is associated with an economy that is smaller in size with higher import shares, more persistent and less volatile exchange rates, more volatile monetary shocks, higher inflation rate, and less volatile GDP.

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Table A1: Results from VECM Pairwise Granger Causality Tests, 1986Q1–2007Q4: Baseline Model

	Dependent variable							Block exogeneity
Excluded Variables ↓	***er***	***oilp***	***opn***	***imp***	***cpi***	***yt***	***ir***	***All***
er		2.676 (0.613)	2.502 (0.644)	1.972 (0.741)	4.544 (0.337)	2.663 (0.616)	5.116 (0.276)	**118.80 (0.000)**
oilp	**20.975 (0.000)**		**12.987 (0.011)**	5.058 (0.281)	6.201 (0.185)	8.055 (0.089)	7.295 (0.121)	22.799 (0.532)
opn	**15.329 (0.004)**	2.847 (0.584)		8.374 (0.078)	6.776 (0.148)	3.875 (0.423)	3.975 (0.409)	**62.863 (0.000)**
imp	**34.198 (0.000)**	5.393 (0.249)	**9.477 (0.050)**		3.068 (0.547)	1.495 (0.828)	0.395 (0.983)	**43.487 (0.009)**
cpi	2.4127 (0.660)	1.672 (0.796)	4.126 (0.389)	7.988 (0.092)		7.169 (0.127)	0.484 (0.975)	14.348 (0.938)
y_t	1.3119 (0.859)	1.520 (0.823)	3.128 (0.537)	5.425 (0.246)	3.887 (0.422)		3.788 (0.435)	28.906 (0.223)
ir	**25.229 (0.000)**	3.784 (0.436)	7.496 (0.111)	**20.978 (0.000)**	0.878 (0.928)	3.283 (0.512)		30.832 (0.159)

1/ The block Granger causality test for exclusion of a variable is based on a Wald test, which follows a χ^2 distribution; The null hypothesis is "no Granger causality". "All" refers to the exclusion of all the endogenous variables from the VECM other than the lags of the dependent variable. Significant test statistics (at 5 percent or better level) are in bold. P-values are in parenthesis.

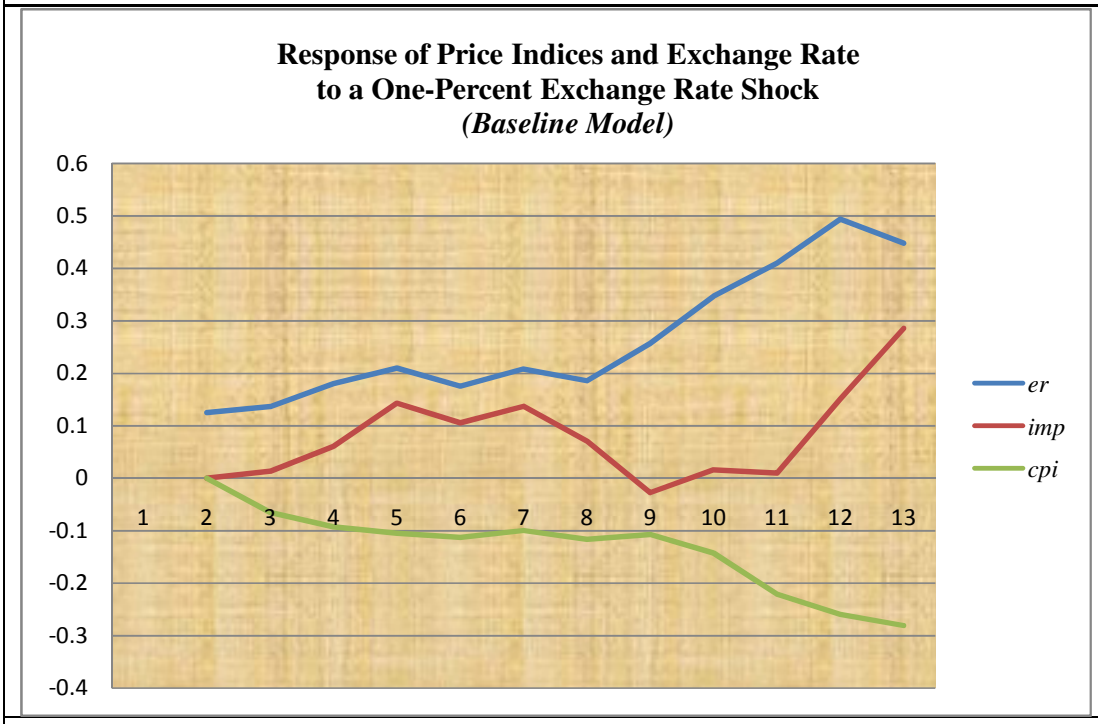
Table *A2*

Residual Tests of the VECM Model

Test	Test Statistic	Probability
Multivariate Normality		
Lütkepohl test	$\chi 2(7) = 284.34$	0.6463
Whites Heteroskedasticity		
No cross terms	$\chi 2(63) = 1642.54$	0.3685
Autocorrelation		
LM test	LM(63) = 53.318	0.3118
Unit Roots		
ADF test residual ε_1	ADF(0) = -9.062	0.000
ADF test residual ε_2	ADF(0) = -8.061	0.000
ADF test residual ε_3	ADF(0) = -8.364	0.000
ADF test residual ε_4	ADF(0) = -7.323	0.000
ADF test residual ε_5	ADF(0) = -7.558	0.000
ADF test residual ε_6	ADF(0) = -7.586	0.000
ADF test residual ε_7	ADF(0) = -8.418	0.000

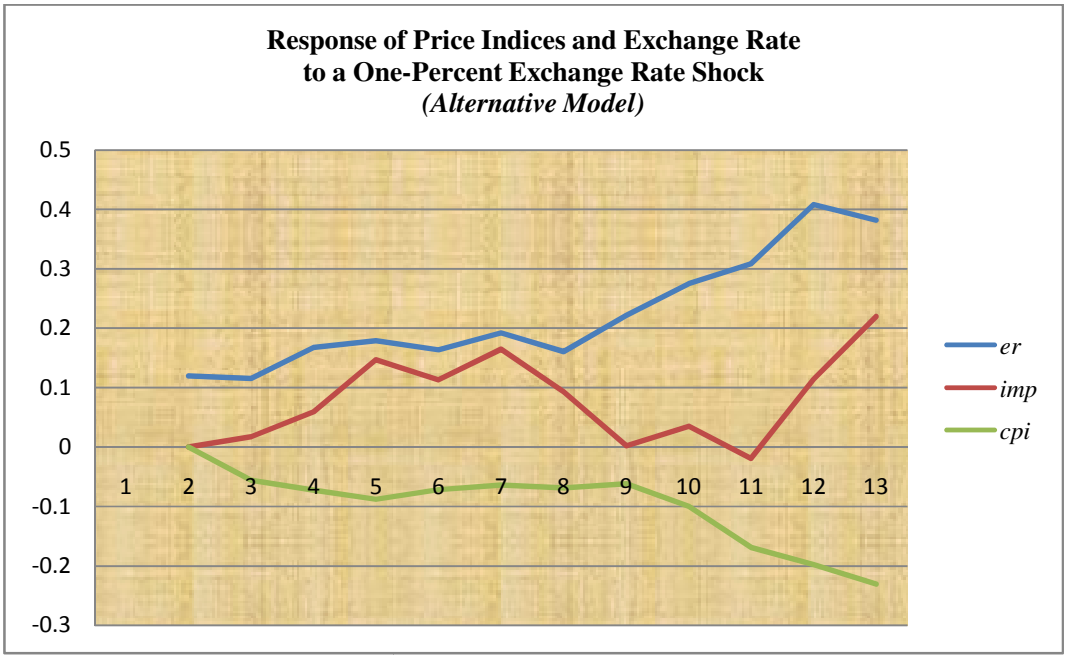
Source: Calculations by the authors.

Figure 3:



Source: Researchers' computations

Figure 4:



Source: Researchers' computations