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Exchange Rate Pass-Through to Import and Consumer Prices in Nigeria: Evidence from Threshold Regression Models

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Abstract

The continued depreciation of the Naira exchange rate since 1986 with severe consequences for domestic inflation has raised serious concerns among monetary policy makers and researchers in Nigeria. The focus of such concerns has been on the extent of pass-through of persistent exchange rate shocks to import prices and domestic prices. Therefore, this study examined the magnitude and speed of exchange rate pass-through to import and consumer prices in Nigeria using Threshold Regression Models from 1986 to 2014. The results indicated that exchange rate pass-through to import prices is substantial and complete; while pass-through from import prices to consumer prices is low, slow in speed and incomplete; and nonlinear. As a result of the slow pace in the speed of pass-through, the effect from import prices to consumer prices dissipates along the transmission chain thereby passing only a small portion to consumer prices. This study recommends the adoption of full fledge flexible exchange rate policy and the deliberate eradication of "official parallel" foreign exchange markets such as Bureau De Change (BDC) that has served as conduit pipe for insider dealings of round-tripping and arbitrage. Without the official eradication of these "sub-official" multiple markets for foreign exchange in Nigeria there will always be a widening gap between the official and the "official parallel" market rates as well as the parallel market rate; given that policy response to rigidities in the official market are slow – a situation that permits speculations and arbitrage as a result of stickiness of the official rate.

Keywords: Exchange rate, Import and Consumer Prices, Pass-through, Threshold, Regression Models

JEL Classification: F31, F310, C24, C240

Paper Classification: Research Paper

Introduction

The increasing openness of world economies made possible by globalisation of production and transactions across global markets has necessitated a growing focus on exchange rate pass-through with a specific view to appreciating the implications of huge fluctuations in the exchange rate for imports and domestic prices. Also, the growing interest in exchange rate pass-through is fundamentally to provide evidence based information in the determination of appropriate

monetary policy response to rapid fluctuations in exchange rate. The continuous incidence of large fluctuations in exchange rates across emerging and developing economies that largely depend on imported inputs has further lent credence to the need for wider perspectives in the evaluation of the transmission of exchange rate variations into import and domestic prices (Aliyu, Sanni & Duke, 2009).

There have been long drawn arguments both in the literature and policy discourse about the key inflation sources in Nigeria and exchange rate depreciation has been argued to be one of the sources of inflation. This is more so as empirical evidence has shown that there is a strong positive relationship between autonomous exchange rate and Consumer Price Index (CPI) while there is a weak relationship between the official rate and CPI (Adekunle, 2010). Also, the overall continuous depreciation of the Naira since the adoption and implementation of Structural Adjustment Programme (SAP) and the consequent sharp movements in the domestic and import prices has further indicated that exchange rate fluctuations have clear consequences for inflation in Nigeria. The major focus of SAP in Nigeria was to correct the overvaluation of the Naira Vis a Vis other convertible currencies via the establishment of the Second Tier Foreign Exchange Market (SFEM) in September 1986. SFEM was modified at different periods to Autonomous Foreign Exchange Market (AFEM) and Inter-bank Foreign Exchange Market (IFEM). In September 1986, the average exchange rate of the Naira to the US Dollar was N1.56/$1. However, at the end of 1989 when SAP goals and objectives were revised the Naira exchange rate to the Dollar stood at an average of N9.10/$1. Correspondingly, the rate of inflation grew consistently from 6.25 per cent in 1986 to an average of 29.7 per cent at the end of 1989. Inflation in Nigeria rose to an all-time high of 44.5 per cent in 1992 while the Naira exchange rate to the Dollar stood at N17.30 (Sanni, 2006).

In 2000, modifications to the foreign exchange market were introduced to engender more flexibility; following this the Naira exchange rate depreciated to N102.1/$1 and it averaged N120.9/$1 in 2002 and N133.5/$1 in 2004 respectively. Between 2005 and 2008, the Naira exchanged for the Dollar at an average of N126.43/$1. Also, between the period 2010 and 2014 the Naira exchange rate averaged N158.70/$1 (CBN, 2014). Inflation rate averaged 6.94 per cent in 2000 but rose to 12.89 per cent and stood at15.0 per cent in 2004. The rate fell to 8.22 per cent in 2006 and rose to 11.58 per cent and 13.72 per cent in 2008 and 2010 respectively (IMF World Economic Outlook, 2011). It declined to 12.2 per cent in 2012 and then to 8.0 per cent in 2014 (CBN, 2015). These statistics reflected a positive relationship between exchange rate and inflation in Nigeria within the period 1986 to 2014. It shows that huge fluctuations in exchange rate have clear implications for import prices and invariably domestic consumer prices given the dependent nature of domestic production on imported inputs. Also, Nigeria is a major importer of household consumer goods which leaves the Nigerian economy vulnerable to imported inflation. This situation is exacerbated by Nigeria's heavy dependence on revenue from crude oil sales for over 90 per cent of her foreign exchange needs. Any downward fluctuations in crude oil price have severe consequences for foreign exchange market in Nigeria as well as import and domestic prices.

Unfavourable experiences that have occurred in Nigeria economy's external sector have led to the continued dwindling of crude oil receipts due to both demand and supply factors. Such experiences have also precipitated the deterioration of the exchange rate status of the Naira. Concerns are focused first, on the implications of such experiences for domestic inflation; and second, on the degree in pass-through of foreign prices via the exchange rate to domestic and import prices. Some studies conducted on exchange rate pass-through in Nigeria used linear models, while empirical evidences on some other economies have found that exchange rate pass-through could be nonlinear. Again, most of the studies did not consider the first stage in the pass-through, which is to import prices but considered only consumer prices. This has led to

the exclusion of a fundamental aspect of the pass-through mechanism that could provide more comprehensive information on Nigeria. Therefore, the focus of this study is to investigate the magnitude and speed of exchange rate pass-through to import and consumer prices in Nigeria using Threshold Regression Models.

Literature Review

Exchange Rate Pass-Through implies domestic price variation that is as a result of a prior variation in nominal exchange rate (Aliyu, Sanni & Duke, 2009). Generally, exchange rate pass-through is considered as the extent to which exchange rate variations affect domestic prices (Sanusi, 2010). When there is a proportionate change in domestic prices arising from a change in exchange rate, the pass-through is said to be complete. It is incomplete when the change is less than proportionate and zero pass-through occurs, when a change in exchange rate does not affect domestic prices. There is a direct relationship between exchange rate and domestic consumer prices through prices of imported consumer goods; while the relationship is indirect through the prices of imported intermediate goods. When domestic currency appreciates, it leads to lower import prices of finished goods and inputs. Likewise, when the domestic currency depreciates, it leads to higher import prices that are transmitted to final consumer prices. Also, depreciation in domestic currency creates an upward pressure on the prices of imported inputs with consequent increase in the marginal cost of producers. Such marginal increase in production cost is passed on in form of higher prices for goods produced in the domestic economy (Mohammed, 2013).

Exchange rate pass-through was initially perceived to be theoretically one-to-one, in other words hundred percent change in foreign price is wholly passed unto domestic consumer prices. This was based on the Purchasing Power Parity (PPP) theory that was hinged on the perfect competitive market model. However, empirical studies such as Berga (2012) and Krugman (1986) found exchange rate pass-through to be incomplete. This may not be unconnected with the fact that most of the assumptions underlying the PPP theory do not exist in reality, thus, leading to contradictory outcomes from empirical studies. Some of the explanations to the incompleteness of pass-through include the exporters' Pricing-To-Market (PTM). Krugman (1986) first popularised this idea that, when there is a depreciation in the importers' currency, foreign exporters tend to reduce their export prices by reducing the margin of their profits instead of increasing the import prices as a means to stabilizing its share of the market. Similarly, some exporters are likely to invoice in the currency of the importer known as Local Currency Pricing (LCP). In such situations, prices do not often fluctuate with the variation in exchange rate (Goldberg & Knetter, 1997).

Traditionally, some economists have argued that price differentials between countries are not sustainable in the long run as market forces will equalise them and change exchange rates based on the law of one price (purchasing power parity). Thus, a complete exchange rate pass-through was assumed on the basis of this theoretical standpoint. However, Sheefeni and Ocran (2013); Sanusi (2010); Marazzi, Sheets and Vigfusson (2005); and Choudhri and Hakura (2001) have shown that exchange rate pass-through in both industrialised and emerging economies have been found to be generally incomplete and varies among countries while taking into account the size and openness of the economy. Results such as these have led to the emergence of some literatures in the last two decades explaining why exchange rate pass-through is incomplete. According to PPP theory, once converted to a common currency, national price levels should be equal. Rogoff and Obstfeld (1995) have shown that following the assumptions of the relative PPP, depreciation of one currency relative to another match the difference in aggregate price inflation between any two countries concerned. The basic idea is that if goods market arbitrage enforces broad parity in prices across a sufficient range of individual goods, then there should also be a high correlation

in aggregate price levels. The PPP is the generalisation of the law of one price (LOOP) that puts forward the argument that a good should have the same price in all countries provided that the price of such a good is in the currency.

There is a large number of studies on the exchange rate pass-through effect conducted for developed countries (Marazzi, Sheets & Vigfusson, 2005; Campa & Goldberg, 2002; McCarthy 2000) and studies conducted for developing countries (Sheefeni & Ocran, 2013; Choudhri & Hakura 2006; Canetti & Greene 1992). The findings from these studies have indicated that changes in exchange rate are not transmitted to prices by the same magnitude of the variation in exchange rate especially in the short run.

In Maka (2013) view, expectation is a key determinant of the consumer price index (CPI) inflation and nominal exchange rate. The adaptive and rational expectation hypotheses have provided a framework for the theoretical analysis of asymmetric exchange rate pass-through. It is not expected for firms during periods of currency appreciation to adjust prices in the same way as in periods of currency depreciation. Furthermore, Maka (2013) pointed out that time horizon also affects the degree of response to changes in demand by firms in a similar manner as it affects their response to changes in exchange rate within the short or long run. The argument is built on the premise that firms are faced with constraints on their production capacity in the short run and that adjustments in production capacity can only occur in the long run. Given these circumstances, most firms would focus on the maximization of profits as the objective function. Trade regulating tools such as quotas and tariff also serve as restrictions to the ability of firms to adjust production since they affect exports and imports jointly. The generally expected response to quantity adjustment rigidity faced by exporting firms in the short run is to raise prices instead of price cuts. The reason is based on the fact that domestic firms have very limited chance of raising the volume of sales in the importing country. This possibility is achieved in the case of depreciation in exchange rate and the consequences may well be a near one-to-one pass-through to domestic prices.

A closely related theory to exchange rate pass-through is the Pricing-to-Market (PTM) theory. The focus of the theory is how firms whose primary business is export, price their products in view of the receiving market as a response to a change in exchange rate. Specifically, the PTM is defined as the percentage change in prices denominated in the exporter's currency due to a one per cent change in exchange rate (Berger, 2012). This implies that higher the extent of PTM the lower the degree of pass-through of exchange rate. If circumstances arise in which there is no price-to-market, import prices would adjust by equal proportion in which the exchange rate has changed; consequently exchange rate pass-through would be adjudged as complete. Berger (2012) was of the opinion that, adjustment in prices (in the local currency of the exporter) by the same value of the change in exchange rate in the reversed direction would imply a full price-to-market. In that case pass-through in exchange rate would be zero as far as the importing country is concerned. However, Gbosh and Rajan (2006) had earlier indicated that if exporters alter the export prices in the domestic currency by a proportion smaller than the change in exchange rate, then pass-through would be incomplete.

Some studies have empirically verified the response of domestic prices to shocks in exchange rate in Nigeria. First, Aliyu et, al. (2009) used Vector Error Correction Model (VECM) to evaluate exchange rate pass-through in Nigeria. The results indicated that exchange rate pass-through to domestic prices is low, and slightly higher and rapid pass through to import prices than in consumer prices. The study concluded that transmission of variations in exchange rate in Nigeria diminishes throughout the price chain. Second, Adekunle (2010) investigated the relationship

between exchange rate and domestic inflation (proxy by Consumer Price Index) in Nigeria using Granger causality technique. The findings showed that there is a positive and significant relationship between exchange rate and CPI.

Furthermore, Omojimite and Oriavwote (2012) investigated exchange rate pass-through to domestic prices in Nigeria using Vector Error Correction (VEC) model with data from 1970 to 2009. The findings showed that exchange rate volatility induced domestic inflation in Nigeria. Ogundipe (2013) also applied the VEC model in studying the pass-through of foreign price changes to inflation in Nigeria. The study found a substantially large exchange rate pass-through to inflation in Nigeria. Mohammed (2013) used Structural Vector Auto-Regression (SVAR) to study the extent of exchange rate pass-through to domestic consumer price inflation in Nigeria between 1986Q1 and 2013Q1. The study revealed that exchange rate pass-through in Nigeria is incomplete and relatively low. However, the study showed that the speed of adjustment to structural shocks, such as the exchange rate, output, monetary policy rate and money supply shocks were high and the effects of such shocks were also highly volatile. Similarly, Zubair, Okorie and Sanusi (2013) used SVAR to estimate the dynamics of the transmission of changes in exchange rate to domestic prices in Nigeria from 1986 to 2010. The findings of the study indicated that during the period the transmission of variations in exchange rate to prices was incomplete, weak and sluggish in Nigeria. The study further indicated that it would take about eight quarters for the full impact of the pass-through to be felt in the economy.

The empirical studies on Nigeria reviewed above, have clearly relied on linear models. Studies on other countries such as Goldberg and Knetter (1997) have, however, showed that exchange rate pass-through could be nonlinear. Thus, this study finds its relevance in using non-linear models to estimate the value and rate of adjustment in exchange rate pass-through to import and prices of domestic goods and services in Nigeria. Studies such as Adekunle (2010), Omojimite and Oriavwote (2012), Adedayo (2012), Ogundipe (2013); and Mohammed (2013) did not consider the first stage in the pass-through, which is to import prices but proceeded to consumer prices, thus missing an important part of exchange rate pass-through behavior. This study considers pass-through to import prices first because of its implications for the large number of imported inputs dependent firms operating in Nigeria and consequently consumer prices. Again, all the studies on Nigeria reviewed did not consider the issue of asymmetry in the behavior of pass-through of exchange rate in Nigeria. This study considered asymmetry because studies like Krugman (1986); and Goldberg and Knetter (1997) on exchange rate pass-through have found that in some cases; there tend to be higher pass-through during appreciation than during depreciation. In some situations also, there could be zero/low pass-through during small changes in exchange rate and higher pass-through during higher changes in exchange rate.

Theoretical Framework

Purchasing power parity (PPP) provides a suitable theoretical framework in ERPT studies due to its macroeconomic perspective over other alternatives like the Pricing-To-Market (PTM) of Paul Krugman. Following Berga (2012), the study adopts the PPP as a theoretical framework because of its focus on the determination of exchange rate and its provision for comparing the cost of goods and services among countries on average basis. The theoretical assumptions are based on the perceived behaviours attributable to businesses that are focused on import and exports of goods and services on the basis of existing price differentials across countries. The theory in essence considers that the current account transactions of any country have significant implications for the exchange rate value of its currency. Note that the purchasing power parity theory is related to the principle of the "law of one price". To explain the theory, it is best, first, to review the idea behind the law of one price.

The law of one price says that goods that have similar characteristics could be sold in different markets at equal price provided that the cost of transportation is equal to zero and that there are no significant differences in taxes in the affected markets. The theoretical argument that underlay the principle of one price presupposes that similar goods sold in markets that are integrated with zero transport cost and non-differentials in taxes should attract similar prices. In the event that price differentials exist in the markets, entrepreneurs seeking to make profits would then be encouraged to transfer their purchase from the market with low price to the market with higher price. When such actions are sustained on a long term basis, there would be a convergence of prices in the integrated markets.

Several reasons have been advanced that question the validity of the claims of the law of one price especially with reference to markets in the same country. First, there is the possibility that differentials in domestic prices can be substantial when current exchange rates are applied directly to imported goods. Such a possibility can be explained when transport costs are greater than zero in the movement of goods across borders. Also, taxes differ from country to country, while non-tradable input variations can significantly account for large differences in domestic prices when imported items are directly converted at current exchange rates. Consequently, it can be argued that the purchasing power parity theory is the application of the law of one price viewed from the aggregate and global perspective.

Based on the propositions of Berga (2012), the starting point in the study of the link between exchange rate and domestic prices is the law of one price (LOP) which states that the price of identical commodities sold in different markets should be the same when converted into the same currency. The mathematical expression of LOP is given as:

$$Pt = Et\ Pt^* \qquad (2.1.1)$$

Where Pt = domestic price index, Et = nominal exchange rate, while Pt* = foreign prices. The validity of this relationship is confirmed in the case of the purchasing power parity theory using price indices across countries. When considered in logarithmic form, the LOP takes the form:

$$pt = \gamma et + \gamma pt^* \qquad (2.1.2)$$

Where pt, pt*and et are the natural logarithm of import price, export price and nominal exchange rate respectively. The LOP implies that $\gamma = \lambda = 1$ in which case changes in the exchange rate completely pass through to the domestic price of the traded good. This simple expression forms the basis of analysing the long run pattern of exchange rate pass-through.

Based on this fundamental relationship, studies such as Goldberg and Knetter (1997); and Campa and Goldberg (2002) developed more advanced models to analyse the extent of the transmission of the variations in exchange rate to domestic price. These studies considered the extent to which changes in exchange rate are transmitted to the prices of traded goods as well as the margin of profit accruable to producers. The concentration of industries and the acquisition of larger market shares formed a major part of the indices used by the studies above to interpret the differences in the channel of transmission. Therefore, Goldberg and Knetter (1997); and Campa and Goldberg (2002) analysis started from the basic model:

$$Pt = \gamma et + \varepsilon t \qquad (2.1.3)$$

Where, εt = error term, γ = coefficient of pass-through of exchange rate. Note that the degree of the coefficient of pass-through depends on γ value. If prices of imports respond on a one-to-one basis to changes in exchange rate, then there is complete pass-through; thus $\gamma=1$, while if the coefficient is less than one ($\gamma < 1$) pass-through is said to be incomplete.

Methodology

The focus of this study is to trace how fluctuations in the Naira exchange rate are transmitted to import and consumer prices in Nigeria. Thus, exchange rate, import prices and domestic consumer prices are the variables of interest for empirical analysis in this study. Theoretically, this study assumes that exchange rate shocks are initially passed into import prices and then to producer input prices and ultimately to final consumer prices. The study used secondary data which includes nominal GDP as a measure of domestic economic activities (demand shocks). The choice of nominal GDP is to enable observation of detailed fluctuations in aggregate output. Also, monthly import data was used to estimate the size and implications of pass-through to prices of imported goods and services; while monthly data of consumer price index (CPI) was used to measure the size as well as the effects of pass-through to prices of domestic goods and services. In addition, monthly nominal effective exchange rate of the Naira was used to measure exchange rate fluctuations. This was considered appropriate in view of the total effect of exchange rate changes measured in a country as Nigeria with diversified trading partners whose distinct currencies vary in a disproportionate manner.

Model Specification

From the above, model is constructed which is rooted from the functional relationship embedded in the Purchasing Power Parity (PPP) framework. The suggestion that short-run price adjustment in markets is influenced by changes in the variable cost and that of the long-run adjustment to both variable and fixed cost is assumed in the import price dynamics.

$$p^{imp} = f(\Delta \boldsymbol{e}, \boldsymbol{\pi} A = \pi r^2, y) \qquad (3.1.1)$$

Equation 3.1.1 shows that import price (p^{imp}) depends on the changes that occur in nominal exchange rate ($\Delta \boldsymbol{e}$), consumer price index (CPI) denoted by ($\boldsymbol{\pi}$) and aggregate output change (y). Keeping other factors affecting import prices constant, to identify the pass-through of variations in exchange rate to prices of imports, the expression is presented in the following way:

$$lnp_t^{imp} = f(ln\boldsymbol{e}_{t-i}) \qquad (3.1.2)$$

Where i = (1, 2 ...n). Equation (3.1.2) is the functional relationship denoted by f between the log of import prices (lnp_t^{imp}) and the log of nominal exchange rates ($ln\boldsymbol{e}_{t-i}$). It shows that the prices of imports in the economy are determined by the lag value of nominal exchange rates. Appreciation in exchange rates may reduce the import prices while depreciation may lead to increase in the imports prices. Therefore the model is expressed as follows:

$$lnp_t^{imp} = \alpha_0 + \alpha_1 lnp_{t-1}^{imp} + \alpha_2 \ln e_t + \alpha_3 ln\pi_t + \alpha_4 lny_t + \varepsilon_t \qquad (3.1.3)$$

Where lnp_t^{imp} is the log of import prices, $ln\boldsymbol{e}_t$ is the log of nominal exchange rate, $ln\pi_t$ is the log of inflation, lny_t is the log of aggregate output and ε_t is the error term. Having internalized the lag dependent variable in equation (3.1.3), the equation becomes a Self-Exciting threshold model (SETAR). Using the indicator function ***1(.)*** which is a dummy variable, the expression as:

$$lnp_t^{imp} = \alpha_0 + \alpha_1 lnp_{t-1}^{imp} + \alpha_2 \ln \boldsymbol{e}_t + \alpha_3 ln\boldsymbol{\pi}_t + \alpha_4 lny_t + \sum_{j=0}^{m} 1,(q_t, \gamma).\delta_j Z_t + \varepsilon_t \qquad (3.1.4)$$

Where q_t is the threshold variable, lne_t is the nominal exchange rate, while lnp_t^{imp} denotes import price variable and γ represents the threshold values, z_t is a variable that coefficient could change across regime, and a delay variable "$.\delta$". In a condense back-shift operator equation (3.1.1) is same as:

$$lnp_t^{imp} = X''_t\alpha + \sum_{j=0}^{m} 1,(q_t,\gamma).\delta_j Z_t + \varepsilon_t \quad (3.1.5)$$

Where $X'_t\alpha = \alpha_0 + \alpha_1 lnp_{t-1}^{imp} + \alpha_2 lne_t + \alpha_3 ln\pi_t + \alpha_4 lny_t$. The nonlinear coefficients $\alpha_0, \alpha_1, \alpha_2, \delta, \gamma$ from equation (3.1.5) is now condensed as $\boldsymbol{\alpha, \delta, \gamma}$ which can be estimated as:

$$s(\alpha,\delta,\gamma) = \sum_{t=1}^{r}\left(lnp_{t-1}^{imp} + X''_t\alpha - \sum_{j=0}^{m} 1,(q_t,\gamma).\delta_j Z_t\right) \quad (3.1.6)$$

Note that we start by the optimal number of regimes are estimated using a model search section criteria.

On the other hand, inflation is a function of many variables among which are:

$$\boldsymbol{\pi} = f(\Delta \boldsymbol{e}, p^{imp}, y) \quad (3.1.7)$$

Where consumer price index (CPI) is denoted by ($\boldsymbol{\pi}$), while lnp_t^{imp} denotes import price variable and $\Delta \boldsymbol{e}$ denotes change in nominal exchange rate, and aggregate output change (y). Keeping other factors affecting import prices constant, for the purpose of identifying the exchange rate pass-through from import prices to consumer prices, the expression is captured as:

$$ln\pi_t = f(lnp_{t-i}^{imp}) \quad (3.1.8)$$

Where i = (1, 2 ...n). Note that equation (3.1.8) is the functional relationship between consumer prices (CPI) and the import prices as defined above. Therefore the model is also expressed as:

$$\boldsymbol{ln\pi_t} = \beta_0 + \beta_1 \boldsymbol{ln\pi_{t-1}} + \beta_2 \ln \boldsymbol{e_t} + \beta_3 lnp_t^{imp} + \beta_4 lny_t + u_t \quad (3.1.9)$$

Where $ln\pi_t$ is the log of CPI, lne_t is the log of nominal exchange rate, lnp_t^{imp} is the log of import prices, y_t is the log of aggregate output and u_t is the error term. Having internalized the lag dependent variable in equation (3.1.9), the equation becomes a Self-Exciting threshold Autoregressive model (SETAR) with a *delay "d"*, thus the expression is written as:

$$ln\pi_t = \beta_0 + \beta_1 ln\pi_{t-i} + \beta_2 lne_t + \beta_3 lnp_t^{imp} + \beta_4 lny_t + \sum_{j=0}^{m} 1,(q_t,\gamma).\delta_j Z_t + u_t \quad (3.1.10)$$

Where q_t is the threshold variable, lnp_t^{imp} is the import prices, Z_t is the variable that coefficient could change across regime and γ represents the threshold values. In a condensed back-shift operator, equation (3.1.10) is same as:

$$ln\pi_t = X''_t\beta + \sum_{j=0}^{m} 1,(q_t,\gamma).\delta_j Z_t + u_t \quad (3.1.11)$$

Where $X''_t\,\beta = \beta_0 + \beta_1\, ln\pi_{t-1} + \beta_2\, \ln e_t + \beta_3\, lnp_t^{imp} + \beta_4\, lny_t$.

The nonlinear coefficients $\beta_0, \beta_1, \beta_2, \beta_3, \beta_4, \delta, \gamma$ from equation (3.1.11) is condensed as β, δ, γ which can be estimated as:

$$s(\beta,\delta,\gamma) = \sum_{t=1}^{r}\left(lnp_{t-1}^{imp} + X''_t\,\beta - \sum_{j=0}^{m} 1,(q_t,\gamma).\delta_j\, Z_t\right) \qquad (3.1.12)$$

A priori Expectation

The key equations in the model to be estimated are equation 3.1.3 (same as 3.1.6) and equation 3.1.9 (same as 3.1.12). The target coefficients from equation 3.1.6 are, α_0, α_1, α_2, δ, and γ where α_0, denotes the intercept of the function, α_1, α_2, a_3, a_4 are the coefficients of the variables that determine import prices. These coefficients explain the magnitude of the effect of the respective variables on import prices. The coefficient (α_2) of the nominal exchange rate (Δe) is of great significance in the model. This is because its value determines the magnitude of the pass-through of variations in exchange rate to prices of imports. The greater the coefficient, expressed in percentage, the higher the pass-through and vice versa. γ, denotes the threshold variable which shows the point at which a regime change takes place from one regime to another while δ denotes the rate at which movement from one regime to another takes place. In other words, it shows how long exchange rate shocks takes to pass-through to import prices.

Similarly, the target coefficients from equation 3.1.9 (same as 3.1.12) include, β_0 , β_1 , β_2 , β_3 , β_4 , δ, and γ where β_0, denotes the intercept of the function, β_1 , β_2 , β_3 ,and β_4 are the coefficients of the variables affecting or determining domestic consumer prices. These coefficients explain the magnitude of the effects of the respective variables on domestic consumer prices. Also, the coefficient (β_3) of import prices (lnp_t^{imp}) is of great importance. Its value determines the magnitude of pass-through from import prices to consumer prices. The greater the coefficient, expressed in percentage terms, the higher the pass-through and vice versa. γ, denotes the threshold that indicates the point at which a change has taken place from one regime to another while δ denotes the rate at which movement from one regime to another takes place. This shows how long it takes for any shock in exchange rate to pass-through to prices of imported items; and from import prices to domestic prices.

Diagnostic Test and Estimation Method

The study used two diagnostic tests for data stationarity before estimating the models: Augmented Dickey Fuller (ADF) and Philip Perron tests. The two variant tests were used to check the possibility of outliers among data used that may not be captured using a single test. A model selection criteria test to determine the number of regimes in the period as well as the threshold variable was carried out using the Sum of Square Residual (SSR).

In estimating the specified SETAR model, this study used the threshold estimation technique as in Balke and Wohar (1998), Ismail and Isah (2006); and Posedel and Tica (2007). The justification for the use of the threshold estimation is based on the study's focus on short-run dynamics

in prices as against long-run equilibrium. Also, the strength of threshold estimation is inherent in the ability of a SETAR model to provide an important attribute that allows for having both estimates of the Autoregressive (AR) linear component and the nonlinear component which is responsible for switching the dependent variable (domestic inflation) from one regime to the other. The technique also provides a superior feature in telling the duration of time periods that exist between any two successive regimes (Krager & Kugler, 1993; Chappel, Padmore, Mistry & Ellis, 1998).

As a non-linear time series model, self-exciting threshold autoregressive model has been chosen because of its capacity to produce dynamic asymmetric processes. The estimation of the model requires the choice of a threshold. The selection of threshold in this study was based on Enders (2004) three step methodology summarised as: Step one: arrange in descending order the values of the threshold variables. Step two: Estimate a TAR model by the use of nominal exchange rate values in succession as thresholds. Save the sum of squared residuals for every threshold after estimation. Step three: successive values of the sum of squared residuals should be graphed. The existence of a single threshold would reflect a single trough when graphed. Enders (2004) suggested model selection criteria were used in this study. These studies suggested that the model with the lowest sum of squared residuals, and the model with largest t-ratio respectively, is the most accurate nonlinear data generating process (Posedel & Tica, 2007). Also, the model was subjected to stability test to check whether the estimated model is stable or not; and the inference for the stability was drawn on the basis of Cusum and Cusum square test. The Cusum and Cusum square line plots are presented in Appendix I.

Results and Discussion

The results of unit root test using Augmented Dickey Fuller (ADF) and the Philips Perron (PP) methods are summarized in Table 4.1. The test results show that the ADF and PP indicated presence of unit root at levels in the inflation, exchange rate and aggregate output data. However, the data achieved stationarity at first difference for both ADF and PP; while the import data achieved stationarity at levels. This suggests that there is no significant difference in the stationarity results in the series using the two methods.

Table 4.1: Result of Unit Root Test

	ADF		PP		
Variables	**Levels**	**First diff.**	**Levels**	**First diff.**	**Comment**
lnπ	0.185 (0.998)	-18.593 (0.000)	0.985 (0.999)	-18.593 (0.000)	I(1)
lnimp	-4.002 (0.009)		-10.60 (0.000)		I(0)
lnexr	-1.937 (0.632)	-17.481 (0.000)	-2.089 (0.549)	-17.509 (0.000)	I(1)
lny	2.402 (1.000)	2.908 (0.045)	2.696 (1.000)	-9.169 (0.000)	I(1)

Source: *Own Computation*

Based on Enders (2004) process of selection of threshold that uses a three step method that is intuitive, the determination of the optimal lag length and the corresponding regimes that best fit the model are presented in Table 4.2. From the result the lag length of five (5) periods is the optimal lag as suggested by the minimum Sum of Squared Residuals (SSR) of the model which is

3.003. The number of regimes used was based on the model selection criteria results that suggested the presence of four (4) regimes in the series which covers from 1986 to 2014.

Table 4.2: Result of Model Selection Criteria

Threshold Variable	SSR	Regimes
lnπ(-5)	3.003658	4
lnπ(-4)	3.055398	4
lnπ(-3)	3.292515	4
lnπ(-6)	3.336788	4
lnπ(-2)	3.345040	4

Source: *Own computation*

a) Pass-Through of Exchange Rate to Prices of Imports

The result of sequentially determined nonlinear thresholds showing pass-through of variations in exchange rate to prices of imports is presented in Table 4.3. As indicated on Table 4.3, four (4) threshold values were estimated. The first threshold value of 9.63 per cent represents the lowest threshold value estimate. This value represents the threshold from the exchange rate passé-through to import prices linearly over 105 months before switching to a new regime at the threshold value of 10.99 per cent. This is based on the fact that both coefficients of exchange rate and output growth are statistically significant at 1 per cent, 5 per cent and 10 per cent level. However, price shocks that can trigger a regime change at the estimated threshold stems from either exchange rate shock or output accommodation through monetary policy actions. Thus, the pass-through of changes in exchange rate to prices of imports is substantial at 104 per cent as indicated in Table 4.3.

The result of the second import price regime is between the threshold value of 9.63 per cent and 10.99 per cent. Also, the result shows that exchange rate pass-through switches to this regime when import prices equals 9.63 per cent but less than 10.99 per cent and the length of the regime spans 72 months. At this regime only the output variable is statistically significant at 1 per cent, 5 per cent and 10 per cent. This implies that the threshold variable (import price) can be triggered to a new regime only by increase in output demand. The implication is that the pass-through of changes in exchange rate to prices of imports is zero during this regime. Price shocks that can trigger a regime change at the estimated threshold can only come from increase in the demand for the economy's output.

Table 4.3: Result of Nonlinear Threshold Regression: ERPT to Import Prices

Variable	Coefficient	Std. Error	t-Statistic	Prob.
lnp_t^{imp}(-5) < 9.632836--105 obs				
lne_t	1.045416	0.125529	8.328073	0.0000
lny_t	0.298400	0.104312	2.860654	0.0045
9.632836 <= lnp_t^{imp} (-5) < 10.98592 -- 72 obs				
lne_t	-0.096643	0.070581	-1.369260	0.1719
lny_t	1.019640	0.055558	18.35277	0.0000

10.98592 <= lnp_t^{imp} (-5) < 12.35084 -- 70 obs				
lne_t	0.020075	0.190295	0.105493	0.9161
lny_t	1.006641	0.131532	7.653210	0.0000
12.35084 <= lnp_t^{imp} (-5) -- 72 obs				
lne_t	1.484706	0.320738	4.629030	0.0000
lny_t	0.115342	0.202560	0.569419	0.5695
Non-Threshold Variables				
α_0	4.788829	0.173205	27.64827	0.0000

Source: *Own Computation*

Within the span of seventy two (72) months, a new price regime (third) was established between the threshold value of 10.99 per cent and 12.35 per cent. This regime is triggered at import prices equal or greater than 10.99 per cent but below 12.35 per cent threshold value. The regime lasted for 70 months before reaching the next threshold. Again, at this regime, the only variable that is statistically significant at 1 per cent, 5 per cent and 10 per cent is output. Exchange rate pass-through to imports prices is also zero at this regime. Thus, price shocks that can trigger a regime change at the estimated threshold can only come from output demand increase. Similarly, after the 70 months of the third regime, the fourth regime sets in when imports price rise to a threshold of 12.5 per cent. In this regime, which lasted about 72 months, exchange rate is the only variable that appears to be statistically significant at 1 per cent, 5 per cent and 10 per cent. This implies that there is a substantial pass-through of changes in exchange rate to prices of imports of 148 per cent. This clearly suggests that there is low exchange rate pass through to import prices in Nigeria

b) Exchange Rate Pass-Through from Import Prices to Consumer Prices

As indicated in Table 4.4, four (4) threshold values were estimated. The first threshold value of 2.33 per cent represents the lowest threshold value estimate. This value represents the inflationary threshold in the economy and by extension it signifies that inflationary trend prevails linearly over 81 months without switching to a new regime until it reached the threshold value of 2.33 per cent. The threshold at this value means the general price rise must be kept at less than the threshold of 2.33 per cent and any further increase in the general price level, which exceeds or equals this threshold will trigger a regime change in inflationary trend.

Furthermore the result shows that monetary policy actions that maintain price stability below the threshold value of 2.33 per cent must be inclined to managing the stability of the exchange rate as well as output rise that could emanate from the accommodating posture of the Central Bank of Nigeria. This is based on the coefficients of exchange rate and output variables that are statistically significant at 1 per cent, 5 per cent and 10 per cent level. However, the coefficient of import is not statistically significant which suggests that price shocks that can trigger a regime change at the estimated threshold stems from either exchange rate shock or output accommodation by the monetary authority. Consequently, the choice of import to trigger regime change at the estimated threshold would be ineffective.

The result of the second price regime exists between the threshold value of 2.33 per cent and 3.23 per cent. Also, the result shows that inflation switches to this regime when inflation equals 2.33 per cent but less than 3.23 per cent and the length of the regime spans for 48 months. At this regime all the variables are statistically significant at 1 per cent, 5 per cent and 10 per cent. This implies that the threshold variable (inflation) can be triggered to effect a change to a new regime by any of import, output and/or exchange rate. It should be noted that any reduction in import could a short fall in supply that could further put pressure on excess demand inflation for imported items; thus, exacerbating domestic inflation.

Within the span of fifty three (53) months, a new price regime was established between the threshold value of 3.32 per cent and 3.59 per cent. This regime is triggered when inflation value equals or is greater than 3.23 per cent but remains below 3.56 per cent threshold value. This regime has the shortest threshold difference (between the lower and the upper threshold). This short threshold difference implies that inflation dynamics will inadvertently be less restrictive in switching to another regime and therefore monetary authorities are faced with faster price changes as a result of inflationary shock that emanates from imported commodities and expansionary policy that accommodates output rise. When such output accommodation is validated by the Central Bank, this inflationary threshold will be short lived. The last threshold value of 3.56 per cent happens to be the most stable regime that lasted for about 137 months (about 12 years) without inducing another regime change.

Table 4.4: Result of Nonlinear Threshold Regression: ERPT from Import price to Consumer price

Variable	Coefficient	Std. Error	t-Statistic	Prob.
$ln\pi_t$ (-5) < 2.334697 -- 81 obs				
lnp_t^{imp}	-0.052141	0.034980	-1.490595	0.1371
lny_t	0.710221	0.064799	10.96038	0.0000
lne_t	0.242892	0.052979	4.584669	0.0000
2.334697 <= $ln\pi_t$ (-5) < 3.238678 -- 48 obs				
lnp_t^{imp}	-0.266245	0.037386	-7.121430	0.0000
lny_t	0.462993	0.041743	11.09159	0.0000
lne_t	1.353786	0.091786	14.74936	0.0000
3.238678 <= $ln\pi_t$ (-5) < 3.569532 -- 53 obs				
lnp_t^{imp}	0.179850	0.037553	4.789170	0.0000
lny_t	0.390806	0.080702	4.842600	0.0000
lne_t	0.013021	0.026096	0.498951	0.6182
3.569532 <= $ln\pi_t$ (-5) -- 137 obs				
lnp_t^{imp}	0.002710	0.023528	0.115162	0.9084
lny_t	0.624451	0.031180	20.02756	0.0000
lne_t	0.127708	0.052025	2.454715	0.0147
Non-Threshold Variables				
β_0	-0.918685	0.149549	-6.143037	0.0000

Source: *Own Computation*

The estimated results presented so far have indicated that there is nonlinearity in the pass-through given by the successive regime switches in the model. This regime lasted for about seven years (1986 to 1993) out of the 28 year period under review. The first threshold value of 2.33 per cent represents the lowest threshold value estimate. Inflationary trend in this regime could be attributed to the other variables.

In the second regime, the result indicated that the coefficients of exchange rate, imports and output growth are statistically significant at 1 per cent, 5 per cent and 10 per cent level. The result of the second price regime exists between the threshold value of 2.33 per cent and 3.23 per cent. Also, the result showed that exchange rate pass-through switches into this regime when inflation equals 2.33 per cent but less than 3.23 per cent and the length of the regime spans 48 months. This implies that the threshold variable (import price) can be triggered to a new regime by all the three variables (import prices, output demand and exchange rate). There is import prices pass-through to consumer prices of about 27 per cent in this regime. The pass-through in this case, however, is positive (in other words, there is exchange rate appreciation), which results to a reduction in consumer prices following a negative relationship it exhibited with inflation. This implies that a fall in inflation leads to a fall in supply in the economy with adverse consequences for demand side inflation. Thus, the inflationary trend within this regime can be attributed to other variables outside the model.

However, in the third regime, the pass-through declined substantially from the preceding regimes to around 1.3 per cent. This low pass-through could be attributed to the fixed exchange rate regime adopted between 1993 and 1998 – the period that the third regime falls into by about three years (1996 – 1998). Additionally, the regime switched from 3.23 per cent to 3.56 per cent. The regime spans 53 months out of the 28 year period under review. During this regime the variables that were statistically significant at 1 per cent, 5 per cent and 10 per cent are output and import prices. This implies that the threshold variable (import price) can be triggered to a new regime by an increase in either domestic output demand or import prices or both. The fourth regime shows a zero import price pass-through to consumer prices. At this regime the variables that are statistically significant at 1 per cent, 5 per cent and 10 per cent are output and exchange rates. By implication, the threshold variable (import price) can be triggered to a new regime by an increase in either domestic output demand or exchange rate or both. Therefore, there is low exchange rate pass-through from import prices to consumer prices in Nigeria.

Speed, Nonlinearity and Asymmetry in Exchange Rate Pass-Through in Nigeria

From the foregoing results and discussions of the sequentially determined nonlinear thresholds the rate of pass-through of variations in exchange rate to imports and domestic prices is slow. For instance, Pass-through from exchange rate to import prices is complete (about 104 per cent) in the first regime, but precipitated over the period of 105 months before it pass-through to consumer prices at a lower rate in the second regime. The low speed is the basis for which it could not be passed to consumer prices in the first regime until the second and third regimes respectively. It took about 247 months duration for the effects of exchange rate shock to dissipate. Similarly, the pass-through to prices of imports is equal to zero and it took about 212 months to further pass-through to domestic prices during the fourth regime as far as the estimated model is concerned. This finding is consistent with that of Aliyu, et. al; (2009). Thus, it is established that the transmission of changes in exchange rate to prices of imports and domestic prices is weak in Nigeria.

Successive regime switching in the estimated model provides evidence that establishes the nonlinearity in the transmission of variations in exchange rate to prices of imports and prices of locally made goods in Nigeria. There are about four regime switches across the period under review showing the nonlinear behaviour of the ERPT in Nigeria.

Asymmetry in exchange rate pass-through is identified from two sources: size of variation in exchange rate and direction of exchange rate change. Given the results of the sequentially determined nonlinear thresholds in this study; there is no proof of asymmetry with specific reference to pass-through of variations in exchange rate in Nigeria during the 28 years covered by this study. There is no evidence of asymmetry either in terms of appreciation/depreciation or in terms of size of change in the exchange rate. Available data indicates that exchange rate in Nigeria has witnessed longer periods of successive depreciation over a 20 year duration from 1986 before it witnessed marginal appreciation between 2005 and 2006 as well as very short interval of appreciation before 2014. Thus, ascertaining asymmetry with respect to direction may not be easily established in view of lack of substantial appreciation within the period under review. Thus, evidence from this study points to symmetry in the transmission of variations in exchange rate to prices of import in Nigeria.

Conclusion and Recommendation

Based on the findings from this study, exchange rate pass-through to import prices is substantial and complete; while pass-through from import prices to consumer prices is low, slow in speed and incomplete in Nigeria for the period 1986(Q1) to 2014(Q4). As a result of the slow pace in the speed of the pass-through, the effect from import prices to consumer prices dissipates along the transmission chain thereby passing only a small portion to consumer prices. Again, the study also found symmetry in the pass-through to import prices as there was no evidence of asymmetry either in terms of appreciation/depreciation or in terms of the value of exchange rate change. These findings are consistent with results from Aliyu, et. al, (2009) and Mohammed (2013) that established low pass-through to consumer prices for Nigeria. Also, pass-through to consumer prices in Nigeria as established in this study is consistent with the findings for some African countries such as Ghana (Sanusi, 2010). The obvious explanation for the weak and sluggish transmission of the variations in exchange rate to prices in Nigeria is that importers of consumer goods adopt pricing-to-market strategy.

In view of these findings, this study recommends that Nigerian monetary authorities should adopt a full fledge flexible exchange rate policy and the deliberate eradication of official parallel foreign exchange markets such as the Bureau De Change (BDC) that has served as a conduit pipe for insider dealings of round-tripping and arbitrage. Without the official eradication of these "sub-official" multiple markets for foreign exchange there will always be a widening gap between the official and the "sub-official" market rates as well as the parallel market rate. This is necessary given that policy response to rigidities in the official foreign exchange market are slow – a situation that permits speculations and arbitrage as a result of the stickiness of the official rate that warrants continuous widening of the gap between the different rates.

This study also recommends that, despite the low and slow pass-through, the fiscal authorities should provide tax holidays to new industries engaged in production of essential consumer goods. This will strengthen and encourage domestic production and reduce imports, thereby further reduce the level of pass-through. Also, given the nonlinearity of the transmission of the variations in exchange rate to domestic prices, Nigeria monetary authorities should closely monitor the pattern of movement in exchange rate in order to provide appropriate and timely policy response.

There is also the need for the monetary authorities and the ministry of finance to sustain the pursuit of monetary and fiscal policies that are predictable.

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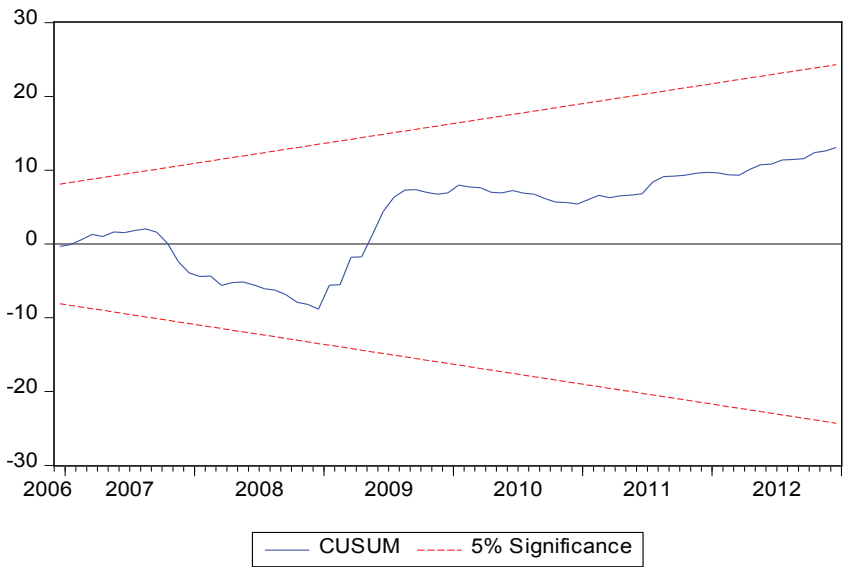
Appendix I

Cusum and Cusum Square Stability Test Line Plots



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