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Distributional Influence of Exchange Rate Pass-Through on Inflation in Nigeria: Evidence from Quantile Regression Model

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Abstract
The study investigated the distributional influence of exchange rate pass-through (ERPT) on inflation rate in Nigeria. Monthly data ranging from January 1999 to December 2021 which was extracted from the Central Bank of Nigeria statistical bulletin was used. The unique contribution of the study lies on the fact that it utilizes quantile regression model (QRM) to ascertain the ERPT to inflation at diverse quantiles. The results show that ERPT distributionally influences inflation in Nigeria positively and significantly at diverse quantiles (quantiles 10th, 25th. 50th, 75th and 90th). It demonstrates that ERPT to inflation is size-based and it is sensitive to the duration of financial market turmoil. The study recommends a proactive policy response towards exchange rate management as well as a robust macroeconomic policy regulation. Furthermore, to tackle food inflation, Government should strengthen its agricultural and industrial policies to boost domestic production and hence reduce overreliance on imported goods.
Keywords: Distributional influence, ERPT, Quantile regression, Inflation
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1. Introduction

The influence of exchange rate changes on inflation and economic activity has been one of the key obstacles to managing economic policy around the globe, in particular, for emerging and developing nations. Exchange rate changes are thought to cause internal economic distortions and have an impact on a nation's ability to compete economically. The detrimental impacts of exchange rate imbalances have been extensively investigated in the literature, yet authorities frequently hesitate to make changes because they fear a negative impact on the economy, mostly because of pass-through effects (Calvo and Reinhart 2002; Ball and Reyes 2008; Comunale and Kunovac, 2017).

Exchange rate pass-through (ERPT) is the term used to describe how much exchange rate fluctuations are passed on to import prices and then to consumer pricing. Since the channel associated with ERPT is one of the pathways through which monetary policy impulses get passed on to the actual economy as well as price stability in the medium term, assessing the degree of pass-through to domestic prices is especially crucial for the conduct of monetary policy. Inflation is affected by exchange rates in a number of ways. By having an effect on imported consumer items, it first transferred straight to consumer prices. For instance, as the value of the currency falls, the cost of imported items rises, contributing to an overall increase in consumer-price inflation. The usefulness of this channel, which links import costs and consumer prices directly, is largely dependent on the pricing decisions made by foreign producers exporting to the other regions. Second, because some imported items are utilized as inputs in the national economy, a decline in the value of the currency results in increased production costs, which in turn, affect domestic intermediate and final goods manufacturing stages as well as domestic consumer pricing. The usefulness of this channel, which directly connects import prices to producer prices and indirectly connects import prices to consumer prices, is heavily reliant on the pricing behavior of domestic prices (Compa and Goldberg, 2010; Ben, Cheikh and Rault, 2017; Osbat et al., 2019).

Since the middle of the 1980s, the Nigerian currency market has undergone varied degrees of turmoil (CBN, 2021), with the worst example being since 2015. Various schemes for exchange rates have been implemented to stabilize the market ever since the structural adjustment program (SAP) was implemented in the nation in the 1980s. The market has experienced episodes of decline in exchange rates, which is significant (Figure 1).

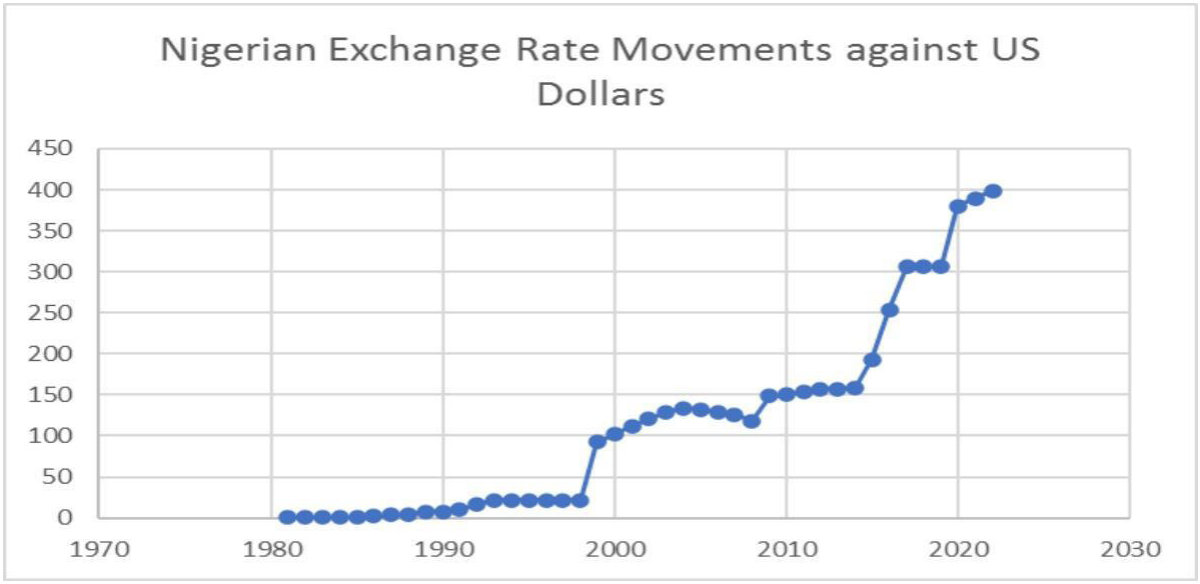

Figure 1: Nigerian Exchange Rate Movements between 1981 and 2022
Source: Authors Plot from CBN (2022)

Obviously, Nigeria's currency has declined significantly during the past few years (Agu, 2009). Between 1981 to 1998, which may be viewed as a period of little adjustments, the market was quite stable. The Nigerian naira sank from 21.9 in 1998 to 92.6 in 1999 and then steadily increased to 153.6 in 2014. This represented a mild change in currency rate depreciation between those years. The market experienced substantial fluctuations between 2015 and 2022, which has been labeled as a time of a currency crisis (CBN, 2022). During this period, there is an upsurge in official rate of exchange by 151.52 percent to ₦398.79 in 2022 (CBN, 2022). During this same time (2015 and 2022), the country's inflation rate rose from 12.3% in 2015 to its all time high of 17.7%, representing 43.9 percent rise within just seven years. This situation has reinvigorated the existing scholarly debate amongst researchers and policy makers on the link between exchange rate and inflation, hence this study.

Several studies exist on the ERPT to inflation rate in advanced and growing economies (Ha, Stocker and Yilmazkuday, 2019; Aisen, Manguinhane and Simione, 2021) but only few studies exist in the context of Nigeria. The existing studies in Nigeria such as Tiamiyu (2022) and Adedokun, Ogbaekiirigwe and Tiamiyu (2022) considered the sign-based asymmetric perspective of ERPT to inflation while other studies focus on the shock response aspect (Bada, et al, 2016). Empirically, it has been shown that response variable can be determined by size-based asymmetry (Koenker & Bassett 1978; Cho et al. 2015, 2019). This aspect of study has been conducted in many environmental-growth nexus research (Anochiwa, et al., (2022), stock market-policy-induced uncertainty nexus (Ozcelebi, 2020), but not much has been carried out on the ERPT-inflation connectivity especially in the context of the African region and hence this investigation.

In view of this, the study offers unique contribution and adds to prior studies of ERPT to inflation by utilizing quantile regression model (QRM) to estimate the size-based influence of ERPT on inflation in Nigeria. Secondly, it is empirically proven that a wrong estimation can be estimated if the structural break is not accounted for in the stationarity test (Perron, 1989; Odionye, et al, 2019). Thus, this study accounts for structural breaks in the series using Zivot-Andrews (1992) test of stationarity. The QRM has been widely used in empirical research because of its advantages since introduced by Koenker and Bassett (1978). The quantile regression is more robust when the conditions of linear regression are not met or when the series are not normally dispersed (Koenker and Bassett 1978; Cho et al., 2019). Following the introductory section is the section two which reviews the relevant literature, section three converses the data-generating process and method, section four focuses on empirical outcomes, while section five concludes with policy recommendations.

2. Empirical Review

Several researchers in advanced and emerging nations of Europe and Asia have conducted empirical studies linking ERPT to domestic price while very few studies exist in the continent of Africa. Notably amongst the prior studies in African continents are Helmy, Fayed and Hussien (2018) for Egypt, Aisen, et al., (2021) for Mozambique, and Bada, et al., (2016), Tiamiyu (2022), and Adedokun, et al., (2022) all for Nigeria. These past studies either adopted VAR, structural VAR or nonlinear ARDL in their estimation techniques without considering the eventuality of size-based influence of ERPT. This study therefore differs from the previous studies by considering the distributional influence of ERPT on inflation in the context of Nigeria.

Ha, et al., (2019) examined the ERPT to inflation in selected 47 developing and emerging nations. The study

highlighted the importance of the investigated link as its outcome will aid the government authority to make well-informed policy. The investigation adopted the structural factor-augmented VAR estimation approach in its analytical technique. The study's outcome indicates that diverse local and world-based shocks trigger and are triggered by ERPT. Also noted by the research, is that a country's uniqueness in the area of government vitality plays a key role in the transmission of ERTP to price index. This, outcome gives credence to country-specific study.

In another related study, Aisen, et al., (2021) evaluated the connection between ERPT and inflation in the context of Mozambique. The study employed autoregressive distributed lag approach. It observed that ERPT is significantly higher in the era of inflation prone as well as being susceptible to world-based shocks. This outcome aligns with Ha, et al., (2019) in the area of ERPT highly related to world-based turmoil. Mujica and Saens (2016), in the case of Chile Chile explored the Chow test to ascertain the influence of regime-change in ERPT to inflation targeting using a static model framework. The study's outcome indicates a case inflation targeting significantly reducing ERPT at the early stage. It further indicates that ERPT to inflation is sensitive to inflationary environment and policy response of the investigated country. Helmy, et al, (2018) employed the structural VAR estimation approach to examine the ERPT to inflation in Egypt. The investigation observed a low and incomplete ERPT to inflation, regardless the price index, in the investigated country. It further found out that the ERPT is more on the consumer price than on the import and producer prices.

In the context of Nigeria, Bada, et al., (2016) studied the ERPT to inflation employing the quarterly series from 1995 to 2015. It adopted the conventional VAR estimation procedure and found ERPT to inflation in Nigeria to be incomplete and low. In another related investigation, Tiamiyu (2022) explored the asymmetric and symmetric connectivity between ERPT and inflation in Nigeria. In the study, the researchers adopted the linear and nonlinear ARDL approaches to execute the link between the investigated series. The research outcome demonstrates a significant asymmetric influence of elevated ERPT on inflation rate while in the case of symmetric model, it is inconsequential. Similarly, Adedokun et al., (2022) examined, in the context of Nigeria, the link between ERPT and inflation using the linear and nonlinear version of ARDL approaches. The study observed similar results with that of Tiamiyu (2022) that ERPT asymmetrically influences inflation significantly while it is insignificantly affecting inflation symmetrically in the country.

3. Data and Methodological Issues

The study made use of time series data sourced from Central Bank of Nigeria statistical bulletin (2021). The study used monthly data which covered the period 1999-January to 2021-December. The variables of the study include the exchange rate (EXR) of the Nigerian naira vis-à-vis the US dollar, inflation rate (INFR) and interest rate (INTR).

3.1 Model Specification

The study was embarked to establish the distributional influence of exchange rate pass-through (ERPT) on inflation rate in Nigeria. The study relied on the quantile regression as was suggested by Koenker and Basset (1978). The quantile regression is more robust and most appropriately applicable when the conditions of linear regression are not met or when the series are not normally distributed. Its benefit is not only in the robustness but also in the ability of the estimation procedure to compute the impacts at various points or quantiles of the conditional outcome distribution. Thus, the Quantile regression offer the distributional effect of exchange rate across diverse quantiles on inflation rate in Nigeria. The standard specification of the relationships is as follows:

$$INFR = f(EXR, INTR) \qquad (1)$$

Where, EXR, INFR, and INTR represent exchange rate, inflation rate, and interest rate respectively, interest rate is the control variable in the model to avoid omission of important variable. .The econometric forms of above equations are stated below:

$$INFR_t = \alpha_0 + \alpha_1 EXR_t + \alpha_2 INTR_t + \mu_{1t} \quad (2)$$

The variables are as defined in Eqn. 1 while, α denotes the estimated coefficient to be evaluated, μ is the white noise stochastic term. Following Koenker and Basset (1978), the Quantile regression is expressed as linear function of the covariates in Eqn.3, for the i^{th} quantiles as:

$$y_i = x_i^{!}\alpha_{\phi} + \mu_{\phi}, \quad quant_{\phi}(y_i / x_i) = x_i^{!}\alpha_{\phi} \qquad \phi \in (0,1) \qquad (3)$$

Here, y_i is the dependent variable (inflation rate) and $x_i^{!}$ denotes the independent (exchange rate variation and other controls variables of the model) Quant$_{\phi}$ ($y_i|x_i$) indicate the quantile of y_i, conditional on the independent vectors of x_i. The error term is unspecified. It is only implicit that $\mu\phi_i$ fulfils the quantile

constraint $quant_{\phi}(\mu\phi_i / x_i) = 0$. The ϕth regression quantile (0< ϕ <1) of y gives solution to minimization of the absolute sum of deviations of residuals thus:

$$\min_{\alpha} \frac{1}{n}\left\{ \sum_{i:y_i \le x_i'\alpha} \phi \,|\, y_i - x_i'\alpha \,| + \sum_{i:y_i \le x_i'\alpha} (1-\phi) \,|\, y_i - x_i'\alpha \,| \right\} \qquad (4)$$

The disparity of ϕ traces the whole distribution of test scores and we can estimate the distributional effect of exchange rate pass-through on inflation rate at any given percentile. The important characteristic of this technique is that the marginal impacts of the covariates, known by $\alpha\phi$ may vary over quantiles (giving different values of ϕ). In the case where $y_i = x_0\alpha_i + \mu_i$ (with μ_i assumed homoscedastic), the marginal impacts at all quantile does not vary. Deviation in the estimated group effects through the quantiles of the conditional distribution scores may be showing evidence of heterogenous effects. Consequently, we estimate inflation rate as a function of exchange rate pass-through at different quantiles (ϕ = 0 .1, 0.25, 0.5, 0.75, 0.9), and determine whether there exists homogeneity in the ERPT to inflation rate by evaluating the equality of the coefficients α in the quantiles. Additionally, the symmetric test is carried out on the distributional parameter using the Wald test which asymptotically tracks a Chi-square distribution.

4. Results and discussions

4.1 Descriptive statistics

Several scientific presentations often start with some initial descriptive statistics that primarily lay the groundwork for more reliable estimations. Accordingly, summary statistics were applied to the appropriate series for this analysis. This test basically reveals the structure of the dispersion as well as the series' behavioral pattern, amid other factors. In particular, the statistical descriptions provide evidence that highlights whether the series are typically normal or not. In summary, the test result is presented in Table1.

Table 1: Descriptive Statistics

Series	Mean	Maximum	Minimum	Skewness	Kurtosis	Jarque-Bera	Probability
EXR	182.89	411.7	86.0	1.15	3.04	60.85**	0.000
INFR	12.41	21.10	5.14	0.15	2.33	6.09*	0.048
INTR	17.18	24.84	9.0	3.11	4.55	31.38**	0.000

Source: Authors' Computation

Given that the Jarque-Bera statistics is significant (Table 2), it demonstrates that the series departs from normal distribution. In particular, our results support the selection and use of quantile model, which is strong and yield reliable estimates despite anomalous distribution (Koenter and Bassett,1987; Cho et al, 2019; Odionye, et al., 2023a; Odionye and Chukwu, 2023). The Kurtosis indicates normal peak for exchange rate (EXR) while the other variables indicate abnormal peak. It further reveals that the enlisted series are positively skewed.

4.2 Test of Stationarity

It is pertinent to test for stationarity of the series in order to ascertain the time-series feature of the enlisted series. Both the conventional test of unit root and stationarity test accounting for break were utilized. Presented in Table 2 is the summary of both tests.

Table 2: Summary of Unit Root Test

	Conventional URT			**Unit Root Test with Structural Break**		
Series	**ADF Test**	**Critical Value**	**I(d)**	**Z-A Test**	**Break Period**	**I(d)**
EXR	-13.0527**	-3.4541	I(1)	-5.285	2016_M5	I(0)
INFR	-2.9765*	-2.8719	I(0)	-16.521	2008-M1	I(1)
INTR	-16.5346	-3.4541	I(1)	-16.589	2003_M1	I(I1)

*Source: Authors' Computation. * and ** denotes series is stationary at 5% and 1% level of significance repectively. Z-A test stands for Zivot-Andrews unit root test with structural beak*

Table 2 indicates that the series are combination of level stationary and first-difference station process. This inconsistence upshot from the unit root test (between ADF and Z-A) indorses the assertion that unit root results are inclined to structural break, as failure to account for structural break produces an incorrect inference (Perron, 1989; Odionye, et al, 2019; Odionye, et al, 2023b). However, considering that the series exhibit the mixture of order of integration as well as the dispersion from normality as evidence in Table 1, the choice of quantile-based

test is established (Koenker and Bassett, 1978. Cho et al, 2015, Odionye, et al., 2023a).

4.3 The Quantile Regression (QR) Results

As previously mentioned, the QR technique is the estimation approach relied upon to execute the distributional influence of ERPT on inflation in Nigeria. Instructively, the appropriate empirical results are abridged in Table 3.

Table 3: Quantile Regression Result (Median)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
EXR	0.031846	0.004259	7.478242	0.0000
INTR	0.367844	0.069870	5.264686	0.0000
C	0.113483	2.036777	0.055717	0.9556
Pseudo R2 = 0.169	Pseudo Adj. R2 = 0.162	Quasi-LR 62.10 (0.000)		

Source: Author's computation

From the results obtained in Table 3, exchange rate has positive and significant impact on inflation rate Nigeria. This implies that increase in Nigerian exchange rate will trigger general increase in the prices of goods and services within the country. Specifically, a median change in exchange rate significantly increases inflation rate by 0.03 percent. This supports the general view that a fraction of exchange rate shock passes-through to inflation rate in a country. This outcome aligns with the findings of Helmy et al, (2018) for Egypt and Bada, et al, (2016) for Nigeria. The Pseudo R-square is 17%, the adjusted R-square is 16%. Thus, 16% variation in the conditional median in inflation rate is due to exchange rate swing. Quasi-LR statistic value is 62.1025 and the p-value is statistically significant since the p-value is less than 0.05, it indicates that the model is stable.

Table 4: quantile regression result

Variables	Quantile	Coefficient	Std. Error	t-Statistic	Prob.
EXR	0.100	0.049327	0.003686	13.38064	0.0000
	0.250	0.045277	0.002670	16.95593	0.0000
	0.500	0.031846	0.004259	7.478242	0.0000
	0.750	0.025748	0.003215	8.009862	0.0000
	0.900	0.024720	0.004909	5.035491	0.0000
INTR	0.100	0.776172	0.117475	6.607138	0.0000
	0.250	0.759648	0.082671	9.188825	0.0000
	0.500	0.367844	0.069870	5.264686	0.0000
	0.750	0.529729	0.078842	6.718851	0.0000
	0.900	1.001539	0.114925	8.714744	0.0000
C	0.100	-14.21773	2.713434	-5.239754	0.0000
	0.250	-11.71494	1.901272	-6.161632	0.0000
	0.500	0.113483	2.036777	0.055717	0.9556
	0.750	0.528731	1.793132	0.294865	0.7683
	0.900	-3.401616	2.571210	-1.322963	0.1870

Table 4 demonstrates that exchange rate distributes heterogeneously its shocks to inflation significantly at diverse quantiles. In specific terms, at the 10^{th}, 25^{th}, 50^{th}, 75^{th} and 90^{th} percentiles, 0.05, 0.04, 0.03. 0.03 and 0.03 percentage of shocks in exchange rate are transmitted to inflation in the country. This suggests that the percentage shocks in exchange rate transmitted to inflation rate declines as the percentile change increase. This represents low ERPT to inflation and supports the findings of findings of Helmy et al, (2018) for Egypt and Bada, et al, (2016) that ERPT to local price is low. The outcomes confirm the heterogenous distribution of ERPT to inflation in Nigeria.

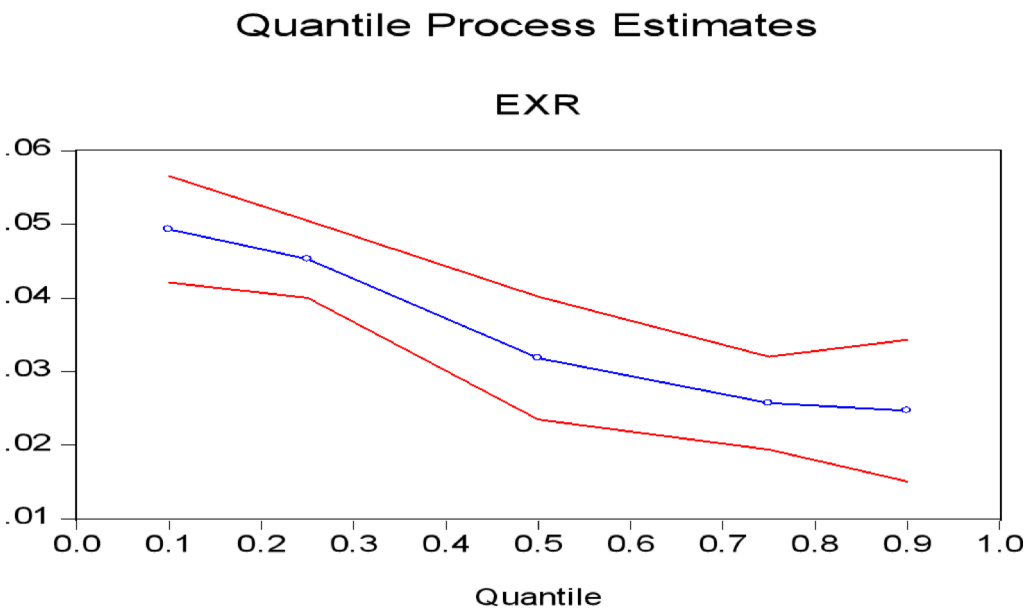

Fig.2. quantile graph of inflation and exchange rate

The graph above shows the relationship between inflation rate and changes in exchange rate in Nigeria. It shows a slowly decreasing relationship between inflation rate and exchange rate flux across diverse quantiles. However, it remains in the positive region throughout the periods of the quantiles.

5. Conclusion and Policy Implications

The study investigated the distributional influence of ERPT on inflation Nigeria utilizing monthly series between 1999_JAN and 2021_DEC. The study, following the recent happening in the Nigerian foreign exchange rate market, utilized the QRM to estimate the size-based influence of the enlisted series on inflation. The results revealed diverse distributional influences of exchange rate swings on inflation in the country. It further confirms the world-wide view that a fraction of the exchange rate swings is passed-through to inflation. Moreso, the ERPT is low and heterogenous which suggests that it is sensitive to percentile change.

Considering that exchange rate passes-through directly to inflation rate in the country, the right monetary-fiscal policy mix should be put in place to avoid ad-hoc and excessive foreign exchange rate swings and hence control domestic price changes. Robust and timely policy response in required to stabilize the country's exchange rate as changes in exchange rate will transmit to domestic prices. Also, the government as a matter of urgency should formulate policies that will enhance agricultural product in country to ensure food supply and hence address food shortage and food inflation (Agu, 2021; Madichie & Agu, 2022).

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