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Food price and Inflation Adjustments in Nigeria: Evidence from Threshold Cointegration

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This paper investigates two stages of transmission through which inflation stabilization policy affects headline inflation by estimating a threshold cointegration model. The paper finds that asymmetric monetary shocks passing-through food prices exerts inflationary pressure on consumer prices, and is characterized by deep asymmetric movement, large degree of stickiness in adjusting downward, while exhibiting upward momentum in correcting food price fall. In addition, asymmetries were found in consumer price adjustment as food price shock transmits substantial inflationary pressure to consumer prices, while disinflationary effect originating from a fall in food price is inconsequential. The coefficients of adjustment were found to be robust in the sub-sample. This paper concludes that an unconventional monetary policy intervention that aims at stabilizing headline inflation by means of stimulating food supply could unavoidably inflate food prices more than it could deflate it especially if the elasticity of domestic food output to money supply growth is less compared to response of food price to money supply. Hence, caution must be taken on the size differential of output response to the net rise in money supply and price adjustment to the expansion in money supply.

Keywords: Asymmetry, cointegration, inflation, momentum, monetary policy, threshold.

JEL Classification: E31, E51, E58

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1. Introduction

In recent times, there is an observed resurgence and steepness in food prices, which appeared to have occurred at the backdrop of a relatively easy monetary policy and massive fiscal stimulus. These policies were implemented by many countries following the global food supply disruption associated with the COVID-19 pandemic. This has prompted the revival of earlier arguments, that monetary conditions could account for changes in food prices (Boughton & Branson, 1991; Fuhrer & Moore,

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1992). This argument provided support to Browne and Cronin (2007) whose evidence reveals that commodity prices influence consumer prices largely because rise in money supply overshoots commodity prices. This evidence stressed the importance of long-run[3] money supply on both food and consumer prices, impliedly suggesting that food prices could primarily overshoot its initial steady state (threshold) in response to a money supply shock. Therefore, the deviation of food prices from their threshold value could have an influence on subsequent consumer price inflation. Hence, this paper holds that exogenous change in money supply could be a source of price disequilibrium in food prices, and this could also be transmitted to consumer price inflation. Thus, the combine effect of these disequilibria could influence future dynamics in headline inflation.

In the meantime, ongoing debate prompted by the evidence that the weight of food relative to non-food items in the consumer basket is higher in developing countries compared to advanced economies remains relevant (see also Food and Agricultural Organization, 2009). In one strand of the debate, it is believed that fluctuation in food price poses a greater threat to general price stability in less developed countries. Consequently, the ability to effectively manage inflation in these countries becomes limited, and this has the potential to erode monetary policy credibility (Kabundi & Mlachila, 2019). Despite the possibility of dire fallout that could arise from a very unstable food price, and the likely transmission of its associated instability into consumer prices, its exclusion from core inflation could amount to misspecification of inflation (Walsh, 2011). Thus, increasing evidence supporting the rationale for the inclusion of food price as part of core measure of inflation suggests that a larger share of food in the consumer basket makes core inflation (which excludes food price) a faulty determinant of the cost of living. Durevall *et al.* (2013) also supported this argument by suggesting that the omission of food price from core inflation could amount to "biased result and misguided policy decisions." Nevertheless, the contrary argument held by Alper *et al.* (2016), maintained that targeting headline inflation (including of food prices) can be disastrous to the credibility of central banks.

[3] This is consistent with the long run position of money supply in the equation of exchange that $\uparrow M\overline{V} = \uparrow P\overline{Y}$

Meanwhile amidst the ongoing debate, the Central Bank of Nigeria (CBN) while still being motivated to target the underlying inflation, the Bankalso considers policy option that could moderatethe relatively larger effect of food demand pressure on headline inflation. To this end, the CBN is conducting financingintervention[4] to stimulate the domestic food output with the view that rising food output will restrain the resurging food prices. In implementing this unconventional monetary policy, the CBN uses development financing as a tool which primarily effect changes on the balance sheet of the central bank. Wherein the Bank draws on it reserves by taking a fraction of the Cash Reserve Requirement (CRR) under the Differentiated CRR policy[5] and the sterilized funds arising from the implementation of the 65% Loan-to-Deposit Ratio (LDR) policy of the central bank[6], thereby reducing the liabilities and shrinking the balance sheet of the central bank, hence its net effect could be assumed to encroach on money supply. The credit channel being used was established through the contribution from Bankers Committee, and the national microfinance bank extends the credit facilities to the under-banked public and smallholder farmers as well as micro and small enterprises. Perhaps among other reasons which contribute to why the CBN is pursuing an unconventional monetary policy is to moderate the inflationary effect of rising food prices which are; rising bills for imported food induced by exchange rate depreciation and the spillover effect of food price volatility on the exchange rate (Bello *et al.* 2020). Specifically, in implementing this policy the Bank has financed several schemes among which are: Commercial Agricultural Scheme, Anchor Borrowers' Scheme, Agribusiness Scheme, Accelerated Agricultural Development Scheme, National Food Security Program, Paddy Rice Aggregation Scheme and Maize Aggregation Scheme[7].

Thus, the key argument in this paper is that, when a Central Bank's policy decision is conventionally informed by underlying inflation, nonetheless resorts to the use of

[4] The channel of transmission of this intervention is presented in the schema (chart) in Figure 2.

[5] See CBN Circular of August 2018.
Available@ https://www.cbn.gov.ng/out/2018/ccd/guidelines_for_accessing_rssf_through_crr˙and_corporate_bonds%20final.pdf).

[6] See (CBN Circular No BSD/DIR/GEN/LAB/12/070, available@
https://www.cbn.gov.ng/out/2020/bsd/letter%20to%20all%20banks%20on%20ldr.pdf).

[7] See the section on stylized facts for the aggregate financing behaviour of the CBN on these schemes

unconventional monetary policy to stimulate domestic food output, with the view that a rise in domestic food supply will smoothen the food price inflation, it faces the consequences of rising liquidity which may have dual effect. The first round-effect is the effect of exogenous money supply shock associated with net addition from the unconventional financing which could add more inflationary food demand pressure, while the second round-effect is the spill-over (or relative price effect) of the net difference between the nominal and the real adjustment of food price inflation (deflation) that is passed-on to consumer price inflation (disinflation).It is against this background that this paper seeks to investigate two important transmission stages of monetary policy. The first stage examines the transmission of changes in money supply on food price inflation and the second is the pass-through coming from food price to consumer price inflation. In each stage, the pass-through effectas well as the behaviour of threshold adjustment to long-run equilibrium is analyzed. Hence examining the cointegrating variables that exhibit varying degrees of autoregressive decay depending on the direction of motion of the cointegrating variables in both short and long run.

In developing the empirical model applied in this study, this paper identifies the dominant symmetrical error correction applied in most studies, which essentially points to the common prevalence of inflationary pressure, due to food price spikes. More so, the asymmetric cointegration which delineates between the effect of positive and negative disequilibrium on inflation were applied in the literature. Unlike these commonly applied methods, in contrast the paper distinguished inflation adjustment process that are accounting for momentum in the inflation dynamics, and further incorporates the momentum into the threshold adjustment (MTAR) of inflation, subsequently, investigating the momentum of the short- and long-term consequences of liquidity on food price and consumer inflation. For the purpose of robustness checks, the estimates of food price and inflation adjustment from the model were re-estimated for a subsample (periods in which CBN development financing window was introduced), the statistical properties of the entire sample estimates were found to be robust to the sub-sample estimates in both TAR and MTAR models. In addition, the magnitude of MTAR estimates from the subsample were relatively adjusting faster than the estimates of the entire sample, hence reinforcingthe central

message in this paper that a central bank that unconventionally stimulates domestic food output must take two important cautions. The first is the nature of responses of food prices to money supply changes, as well as the differentials between elasticity of food price and food output responsiveness to exogenous monetary policy changes associated with the unconventional stimulus. The second is the sensitivity of consumer inflation to changes transmitted from food price, including its adjustment processto long-runequilibrium.

The rest of the paper is organized as follows: Section 2 reviews of related literature. Section 3 describes the data and presents stylized facts, theoretical framework and the methodology applied in the study. Section 4 presents the results and discussion of the result, while Section 5 discusses policy implication, and Section 6 concludes the study.

2.0 Literature Review

Multiplicities of approaches have been applied in many studies, focusing on the relationship between food price inflation and consumer inflation in many countries. Most of these studies revealed a varying degree of the impact food inflation on consumer inflation. To a certain extent, the variation in magnitude of its impact is owed to either structural differences in the economy (in which case, if it is a net importer or exporter of food from the rest of the world); or disparity in monetary policy framework (either as inflation targeter or it set-out to ensure output stability) or sometimes even the level of development across these countries (influences the weight of food in the consumption basket). Irrespective of the underlying factor that is responsible, it is worthy to note that substantial discrepancies in impact exist across countries and regions. For instance, studies such as Browne & Cronin (2007) and Ferrucci *et al.* (2010) established that food price inflation has a positive relationship with consumer prices in the US and Euro Area respectively. Although, both studies differed on the primary cause of the initial shock that is transmitted into consumer price. While the evidence in the US suggests changes in the monetary aggregate are a primary factor that is associated with both food price and consumer inflation, in the Europe area it is attributed to changes in fiscal policy and other exogenous shocks. In the same vein, Lloyd *et al.* (2015) showed that the response of retail prices to the behaviour of

world prices shows significant differences within the European Member States. This study attributes the importance of structural features in commodity price transmission as the primary factor that explains the differences in the functioning of the food sector. However, this evidence concedes that the degree of impact and magnitude of the pass-through is relatively small. Contrary to this evidence, recent studies such as Furceri *et al.* (2016); Alper *et al.* (2016) as well as Dash & Lugauer (2019) revealed that in emerging market economies as well as in less developed economies, average food price inflation is higher, more volatile, and similarly persistent than in the advanced economies. In addition, Dash & Lugauer (2019) buttressed that inflation is largely dependent on food prices in India.

Therefore, the deduction that follows from these studies entails disparity in the magnitude of pass-through from food price to consumer price which is attributed to differences in country-specificity and to the exogenous cause of the initial shock that triggers food price changes. More so, countries with a larger share of food in the consumers' basket tend to have larger pass-through than countries with smaller food weight in the consumption basket. Thus, efforts targeted at stabilizing food prices also differ across countries and therefore the response of the consumer inflation may also vary based on what different independent monetary policy does.

The dominant methodology applied in most of the available studies is the recursive Vector Autoregressive (VAR) model. For example, Baek and Koo (2009); Cachia (2014); Lloyd *et al.* (2015); Bawa *et al.* (2016); Furceri *et al.* (2016) as well as Dash and Lugauer (2019) all used the unrestricted VAR model. This approach is known to assume symmetrical adjustment in the error correction which does not account for threshold and asymmetric effect that may exist in the cointegrating relationship between consumer inflation and food price inflation, therefore prohibiting the segregation between adjustment that is either above or below the threshold of food price. However, Rodriquez & Onorante (2010) and Meyer *et al.* (2018) used an asymmetric cointegration model to examine the relationship between consumer inflation and food inflation. Both studies fail to include the policy variable that could initiate the shock in food price. Furthermore, Meyer *et al.* (2018) only relate food prices to oil price shock.

The evidence from Nigeria can hardly be different from other Less Developed Countries (LDCs). Nonetheless, many wide cross-country studies such as Schnepf (2013); Woertz *et al.* (2014); Alper *et al.* (2016) and Furceri *et al.* (2016) who provided evidence from developing countries fail to report evidence for Nigeria. However other studies such as Bawa *et al.* (2016); Asekunowo (2016), and Bada *et al.* (2016) showed evidence for Nigeria without giving relevance to the importance of food price and thresholds on consumer inflation. Also, the scope of most of these studies fail to consider the intervention of the central bank in domestic food production. Meanwhile, Doguwa (2012), and Bello and Sanusi (2019) both consider the existence and effect of threshold on inflation dynamics in Nigeria. However, the scope of both studies is devoid of the long-run and adjustment process of inflation dynamics. Recent evidence such as Tule *et al.* (2020) dwells on the effect of long-run memory in inflation dynamics without taking account of either asymmetric or threshold effect in a self-exciting inflation model. While this study considers the test for unit root order and presence of fractional cointegration as important in the adjustment process of inflation, it is worthy however to argue that both unit root and cointegration exhibit very low power in the presence of threshold adjustment (Falke & Fomby, 1997). In addition, Enders and Siklos, (2011) argued that an asymmetric model that demonstrates momentum in its error correction is superior in size, properties, and power compared to the symmetric adjustment mechanism.

The major take from available literature is that we identify the dominant application of the symmetrical error correction model which essentially points to the common prevalence of inflationary pressure due to food price spikes. Limited studies applied the threshold adjustment model which delineates between the effect of positive and negative shock on inflation as well as a possible accompanied threshold adjustment. Moreso, from the available literature application of MTAR to investigate the momentum of the dynamics and adjustment processes were lacking, this paper therefore investigates the momentum of the short- and long-term consequence of a supply-side intervention policy by a central bank in the adjustment processes of food price and consumer inflation. Hence examining the cointegrating variables in the model that exhibit varying degrees of autoregressive decay depending on the direction of motion of the cointegrating variables in both short and long run.

2.1 CBN's Monetary Policy Framework and Development Financing Window

Since the replacement of the exchange rate targeting strategy with the monetary aggregate targeting in 1973, to date, the operational framework of the CBN involves the use of indirect instrument to control and regulate the monetary aggregates. Under this framework only the monetary base and its components (which are also referred to as the operating variables) are targeted. Meanwhile interest rate adjustment and credit allocation are market determined. Thus, the optimal monetary stock that is consistent with the predetermine inflation rate and GDP growth rate is estimated. Within this framework, the CBN has a short-term target, which it also refers to as the operational target, comprising of money market interest rate, bank reserves, and currency in circulation. It also has an intermediate target which include money supply, exchange rate, and bank lending. Lastly the long-term target which consist of price stability and output growth. Essentially, achieving both or any of either the short-term or intermediate target is crucial to the attainment of the long-term targets. Therefore, changes in short-term targets such as currency in circulation may influence other intermediate targets such as money supply, and therefore the long-term targets of attaining price stability could also be affected.

Meanwhile, development finance is a vehicle of credit financing of real sector activities[8]. To this end, the CBN has deployed credit in various agricultural program such as commercial agricultural scheme, Nigerian Incentive based risk sharing system for agricultural lending and anchor borrowers' program. This credit financing is in a form of direct cash payment to domestic farmers. Thus, this financing is expected to expand money supply by increasing both currency in circulation and demand deposit. Essentially, narrow money supply will grow because of (i) the dominance of the informal activity in the agricultural sector (Bello & Sanusi 2022) and (ii) the absence of a develop agricultural commodity exchange market in Nigeria. Therefore, the unintended impact of the development financing program could infringe on the CBN short-term and intermediate targets by affecting the currency in circulation and money supply (see Figure 3, as co-movement in money supply and development financing is observed.

[8] See CBN Education Series No. 5., page 18-23

The plots in Figure 1 shows the trend and dynamics of money supply (M1=C+D)[9] and the development financing interventions over time. The top left panel presents the trajectories of currency in circulation (C) and the development finance intervention while the top right panel presents the trajectories of Currency outside[10] banking sector (C_0). The behaviour of the dynamics observed in the plots shows that the spikes and trend movement in the development financing of domestic food output is relatively consistent with the money in circulation for most part of the periods under review. This relative consistency suggests the influence of the unconventional intervention on the liquidity component of money supply.

Figure 4 conceptualizes how the effect of CBN's development finance intervention is transmitted to food price and headline inflation. The CBN considered these interventions as its unique "unconventional" policy means of reducing the supply-side inflationary pressures through raising output in agriculture and manufacturing (see CBN, 2021). The liquidly effect of these interventions are shown on the right side while the real effects are shown on the left side of the chart. The developmental financing fund is sourced from a combination of three reserves currently kept at the CBN.

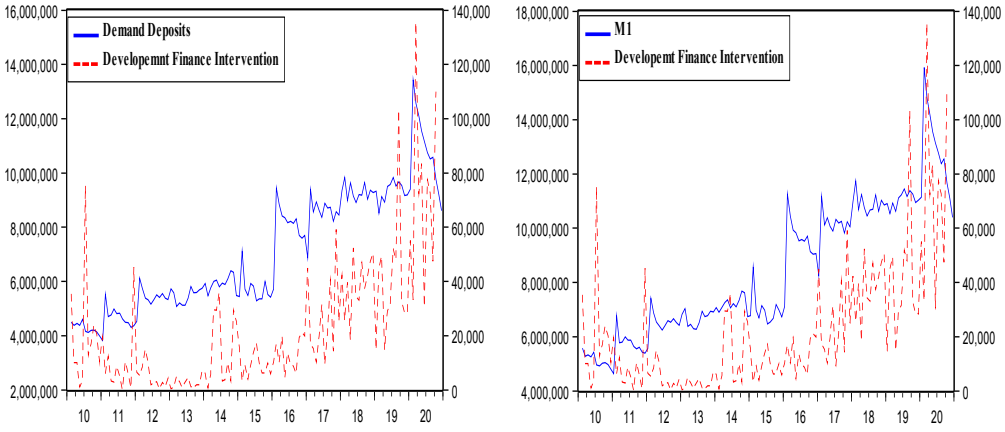

Figure 1: Trend Dynamics in Development Finance and Money Supply

[9] M1= money supply, C= currency in circulation and D= Demand deposit

[10] The inclusion of C_0 (currency outside the banking sector) is necessary to reflect the degree of informality in the domestic food production sector. As agriculture is largely informal activity in Nigeria, therefore there is more handling of cash in the credit financing of domestic farmers.

The first part is a fraction of the Cash Reserve Requirement (CRR) under the Differentiated CRR policy[11]; the second source is the sterilized funds arising from the implementation of the 65% Loan-to-Deposit Ratio (LDR) policy of the central bank[12]. The last part is the contribution from Bankers Committee used to establish a national microfinance bank – NIRSAL Microfinance Bank to expand credit facilities to the underbanked public and smallholder farmers and micro and small enterprises[13]. The first two are part of banks' reserves, hence the liabilities, on the balance sheet of the CBN. The last part is a channel through which the CBN expands credit supply intervention to the riskier and the underbanked segment of the market in Agriculture, small scale manufacturing and households. The Central Bank unconventionally uses the development finance policy tools for "monetary policy" purposes targeted at raising output and aggregate supply in order to moderate inflation (CBN, 2021).

As for the transmission channel of the policy, increased development finance loans reduces reserves held by CBN and, through the credit channel, increases deposits ($\uparrow D$) of commercial banks and, hence, raises $M1$. Meanwhile credit supply by the commercial banks to the output-stimulating and employment-generating sectors like agriculture and manufacturing provides loans at a single-digit interest rate of 9%. The resultant increase in the levels of labour-wage and other factor income arising from higher employment of factor input in these sectors increases Currency in circulation

[11] The CBN operates a differentiated CRR (DCRR) policy in which commercial banks can be allowed access to their Reserves at the CBN (CRR) to lend to their customers at a single-digit interest rate in selected sectors that the CBN considers to be "output-stimulating and employment-generating" such as Health, Agriculture and Manufacturing. This decision was taken at the 119th MPC of July 2018 (CBN, 2018: CBN Circular of August 2018. Available at https://www.cbn.gov.ng/out/2018/ccd/guidelines_for_accessing_rssf_through_crr_and_corporate_bonds%20final.pdf).

[12] The 65% LDR policy requires banks to maintain a loan-to-deposit ratio of at least 65%. The Central bank charges 50% of the shortfall as additional CRR. On the one hand, this policy reduces the cost of liquidity management for the bank as well as incentivizes the banks to lend to the real rector and, on the other hand, contributes to the development finance intervention funds of the central bank (CBN Circular No BSD/DIR/GEN/LAB/12/070, available at https://www.cbn.gov.ng/out/2020/bsd/letter%20to%20all%20banks%20on%20ldr.pdf).

[13] The Bankers' Committee has contributed 2% of their annual profit for lending to the real sector at lower rate, which is used to set up the Nirsal Microfinance Bank. Some of the CBN's special intervention programmes, such as the Household Targeted Credit Facility (TCF) and Agricultural Small & Medium Enterprises Intervention Scheme (AGSMEIS) in response to the COVID-19 pandemic were administered through this microfinance bank.

($\uparrow \Delta C$), which also raises $\Delta M1$. In terms of the accompanying shocks, the general effect of the rise in money supply is transmitted as a shock, in line with the quantity theory of money.

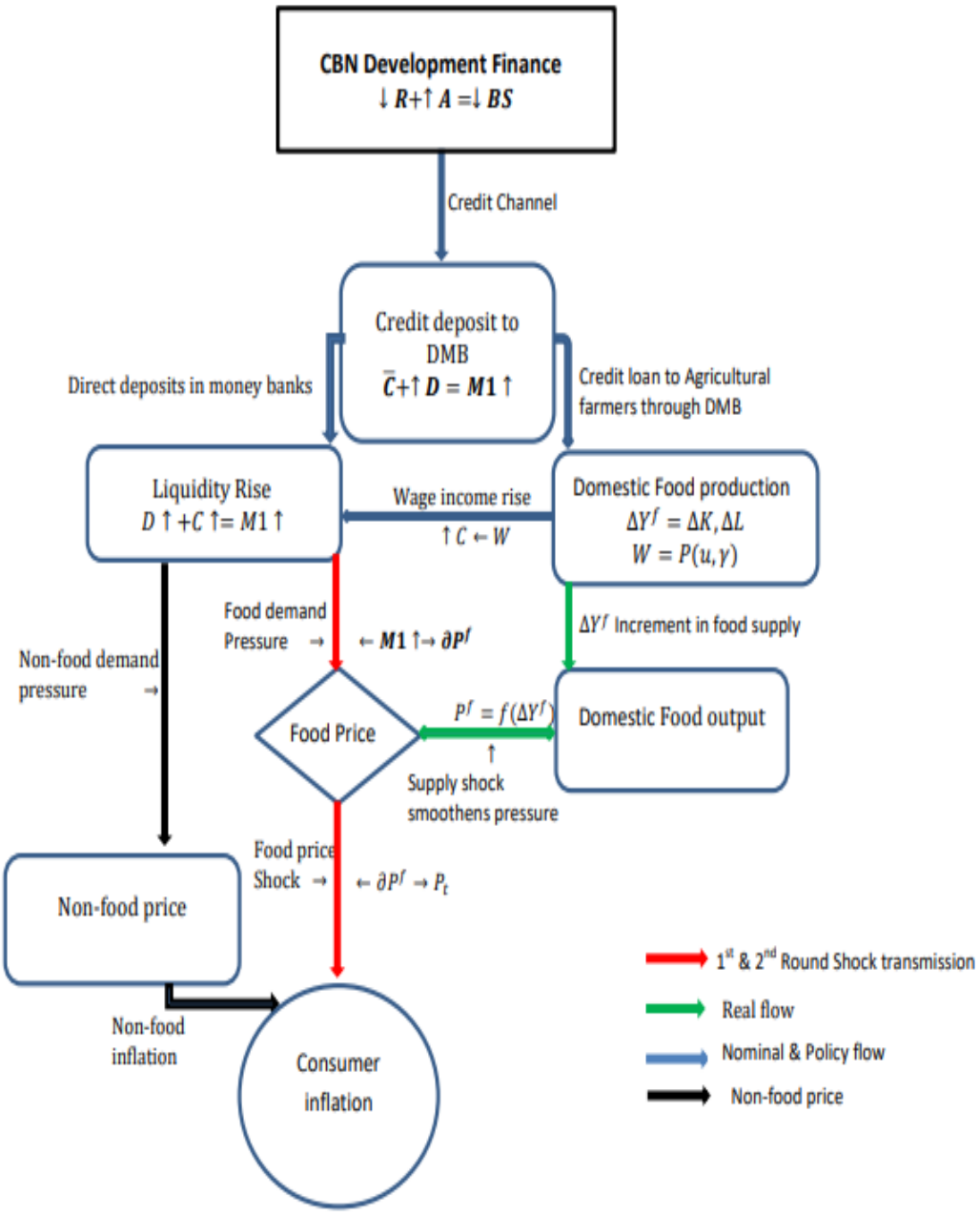

Figure 2: Conceptual Framework of Analysis

Firstly, the rising level in money supply leads to higher demand for both food (red arrow) and non-food items, hence pressure on their respective prices to rise. The built-up pressure from the rise in the demand for food, which raises food prices, is the first-round effect of the liquidity consequences of the CBN intervention. The shock that is transmitted as food price adjustment that pass-through to headline inflation is the second-round effect. The final total effect on consumer price inflation, therefore, depends on the relative magnitudes of the dampening pressure of increased domestic (food) output and the increasing pressure of the rising demand for food.

Figure 3 is a plot of the cyclical behaviour of the series (cycles were filtered and extracted using the one-sided Hodrick-Prescott, HP-1 filter). The dynamics in the series from left panel showed that money supply, food price, and consumer price cyclicality (right panel) deviates above and below the zero-bound steady-state level, suggesting the appearance of asymmetric movement in the series over time. The deviation from the zero level indicates changes in the food price and consumer price cyclicality. The relative sizes of the vertical scales suggest that the amplitude of the consumer price is greater, indicating that the consumer price cycles are bigger than that food prices. The plot equally shows that from 2000 to 2008 there is a co-movement between food price inflation and money supply in Nigeria, whereas 2009 to 2020 shows some degree of divergence. This suggests the possible existence of asymmetry that could be partly attributed to net effect of the development financing on monetary aggregate for the period under review. More so, this has pre-empted the need to subject the estimates to subsample robustness checks, so as to ascertain if the asymmetric impact of the estimated coefficients is robust to the sub-sample.

Although the cyclicality shows a contrasting departure in the time path of food price inflation and money supply as both series considerably track each other substantially between 2000 and 2008 while their trajectories diverge between 2009 and 2020, mostly likely owing to development financing window. However, there is a co-movement and synchronization between food price and consumer inflation over the entire period under investigation.

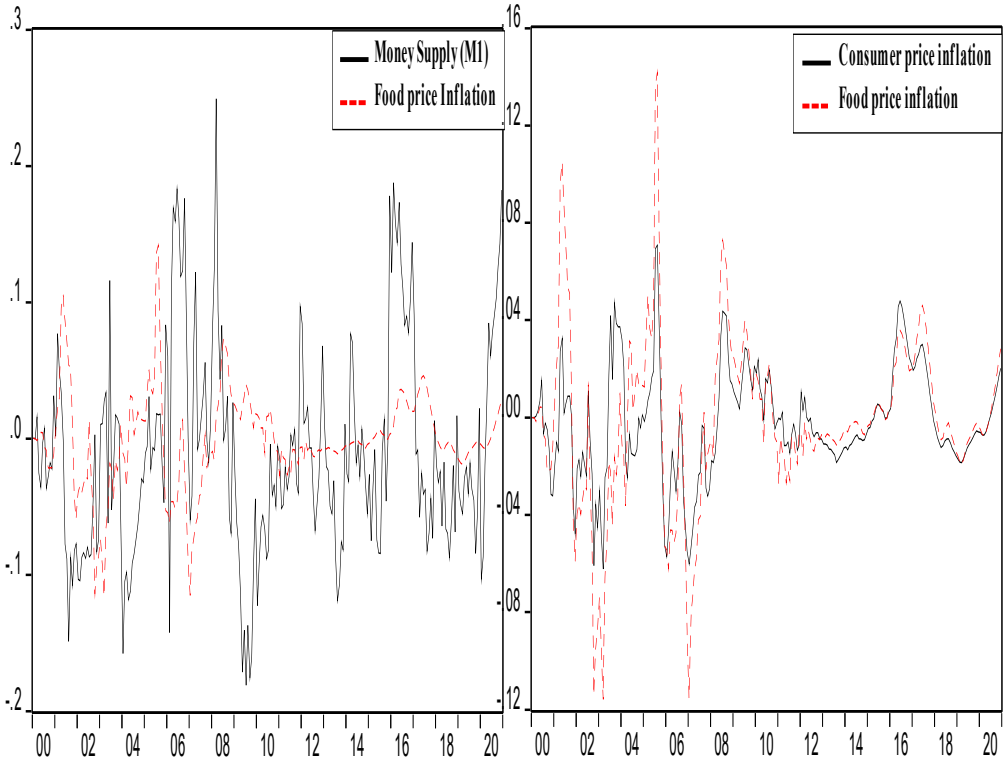

Figure 3: Cyclicality and Co-movement

This suggests the relevance of food inflation in dictating headline inflation while raising suspicion that the anti-cyclicality effect expected in money supply through it effect on food supply shock is generating procyclicality along the way.

Figure 4 shows the growth of food price inflation relative to headline inflation[14]. The points that lie above one (1) indicates that food price inflation is higher than headline hence showing the increasing influence food price has been gaining over the headline inflation from the fourth quarter of 2012 to 2020 in Nigeria. This observation corroborates Alper *et al.* (2016) who showed similar evidence for Less Developed Countries (LDCs). Perhaps this explains why the headline inflation has been rising over this period, making it increasingly difficult for the central bank to achieve its single-digit target for inflation in Nigeria.

[14] M1=C+D, therefore, either Δ C or Δ D will lead to Δ M1.

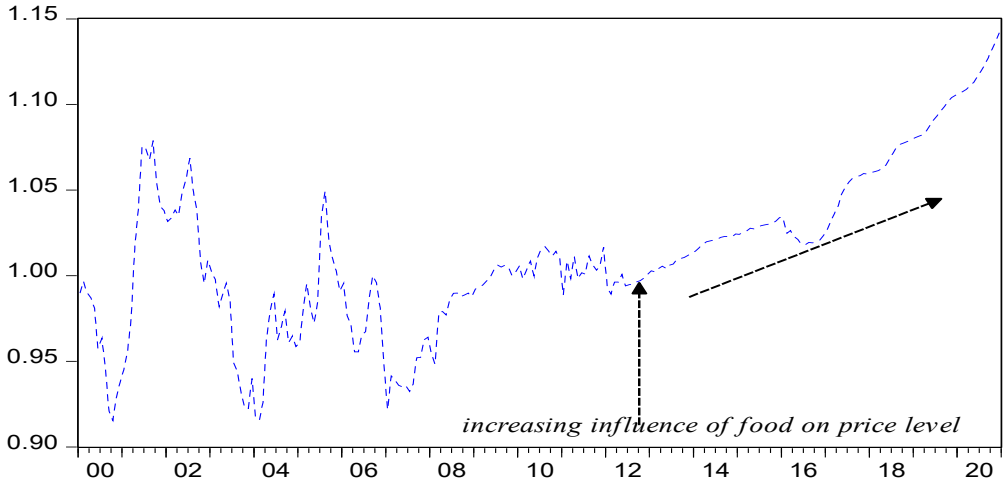

Figure 4: Growth of Food Price Inflation Relative to Headline Inflation

3.0 Data and Methodology

This section is concerned with the description of the data used, model specification, and the method of estimation applied.

3.1 Data

Time series data were sourced from the Central Bank of Nigeria Database in monthly frequency[15] from January 2000 to December 2020, that is, 252 observations. We obtained data for composite Consumer Price Index (CPI), food price index, and narrow money supply in billions of naira. The importance of using a narrow money supply is founded by the nature of the CBN intervention which requires direct disbursement of money to clusters of farmers in form of cooperative using the credit channel, therefore believing that the net-effect[16] of the intervention policy could either raise currency-in-circulation (C) or demand deposit (D) or both. All the data were log-transformed to normalize the series. The stochastic properties of the series were tested using the breakpoint unit root test which allows for verifying the existence of unit root including breaks due to nonlinearity in the series. Each series were further partitioned into two parts: the positive and negative partitions sums, such that, the

[15] This was computed as $\frac{foodpriceinflation}{headlineinflation} x100$

[16] The use of monthly data espouses frequent shocks that are inherent in volatile commodity prices such as food (see Cachia, 2014). Use of lower frequency data such as annual would have concealed and smoothened shocks that are likely to be apparent on a daily or weekly basis when food is traded.

positive partition makes up the series that is above the threshold while the negative partition represents series that is below the threshold.

3.2 Theoretical Framework

This study bears some theoretical considerations in line with the existing frameworks often used by monetary authorities. These include (i) the inflation targeting framework and (ii) the aggregate monetary targeting framework. Both frameworks explicitly provide clear channel of analyzing conventional monetary policy. However, for the purpose of this study, the paper will adapt a framework in line with two conditions: (a) the monetary policy framework[17] currently being used by the CBN, (b) the effort by CBN in undertaking unconventional intervention to stabilize domestic food prices by stimulating the domestic food output. In the case of the inflation targeting framework, (which is typically a reaction function, specified as a Taylor's type rule or the New Keynesian Policy rule), is considered unsuitable on ground of condition (a) stated above, that is, it lacks an explicit specification of money supply, and therefore it is inconsistent with the current monetary policy framework of the CBN. In addition, all Taylor-type monetary policy rule, which are closure rule in the New Keynesian model (in the form of a reaction function), are specified with nominal interest rate as endogenous policy variable, while exogenous policy variables are in deviated forms. This does not provide a simple means of nesting the unconventional monetary policy channel. Meanwhile, the aggregate monetary targeting framework with an explicit (endogenous) specification of money supply provides suitable and appropriate means of augmenting the transmission of the policy intervention carried out by the CBN. Although, there are two models under the monetary targeting framework, the Keynesian IS-LM model, and the quantity theory of money, because of their treatment of money supply both are relevant, particularly for this study. However, the IS-LM treatment of money is too implicit, this creates difficulty in nesting a specific channel into the model. In contrast, the quantity theory of money, although too simplistic,

[17] Owing to the largeness of informal activities in the domestic food production sector in Nigeria (Bello & Sanusi, 2019), we assumed that the net effect of the CBN intervention policy will have raising consequences on C more than D. Similarly, we also note that the function of money as means of exchange is more embedded in the Narrow money supply (where M1= C+D), while time deposit and other quasi-money or near money asset belonging to broad and broader money supply, M2 and M3 reflect function of money as store of value.

but can be easily adapted by augmenting a specific channel for the purpose of the policy action that directly interferes with liquidity and food price inflation. Therefore, this paper follows the Furceri *et al.* (2016) specification of food price channel which is nested into the quantity theory of money model. The essence is to see the direct effect of changes in money supply due to development financing that target food price inflation and the second is to see how the changes in food price are passed onto consumer price inflation. The exposition of the channel according to Furceri *et al.* (2016) is such that:

$$P_t = P_t^n w_t^{\delta} \tag{1}$$

Where P_t represents the headline inflation, w_t is the ratio of food (P_t^f) to non-food (P_t^n) price index and δ denotes the share of food in the consumption basket. Nesting (1) into the quantity theory and assuming velocity of exchange (V) remains constant when actual output is near its potential level, this means that:

$$\Delta M_t \overline{V} = \Delta Y_t \tag{2}$$

Where M_t is the exogenous money supply which account for aggregate demand, while Y_t is the aggregate level of nominal output in the economy. Thus, in the long-run, monetary changes which affect demand will have little or no influence on real output (Friedman, 1977). Therefore, the effect of changes in monetary aggregates will only have a nominal effect due to demand pressure, causing a change in only the price level P_t, equation 2 can now be expressed as:

$$\Delta M_t = \Delta P_t \overline{y}_t \tag{3}$$

Then equation (3) is the long-run monetarist position, suggesting a perfect correlation between the price level and money supply[18], and by implication, all things being

[18] See CBN Education in Economic Series No. 2, Research Department (2016) for the CBN institutional framework for monetary policy in Nigeria in: section 7 sub-section 7.1, paragraph 2 & Figure 3 in pages 19-20 of the. Available at: https://www.cbn.gov.ng/out/2017/rsd/cbn%20education%20in%20economics%20series%20no.%202%20monetary%20policy.pdf.

equal, the long-run price level is purely determined by exogenous money supply (the it associated demand). Effectively, the headline inflation in equation 1 is consistent with the general price level in equation (3), resulting in an identity:

$$M_t = P_t = P_t^n w_t^{\delta} \tag{4}$$

After log-transformation and differencing:

$\ln M_t = m_t$ while $\ln P_t = p_t$ and $\ln\left(P_t^n w_t^{\delta}\right) = p_t^n + \delta ln w_t$ also $\Delta p_t = \pi_t$ similarly $\Delta p_t^n = \pi_t^n$ therefore the identity in equation 4 can be rearranged as:

$$\Delta m_t = \pi_t^n + \delta \Delta \log w_t = \pi_t \tag{5}$$

Note[19] that for a central bank that intervenes, through the use developmental financing to stabilize domestic food prices, such financing is assumed to have a direct net effect on food price alone because the financing window through credit channel, will encroach on money supply and by implication net effective demand. Therefore, for mathematical convenience and simplification, it is taken that $\pi_t^n = 0$. Thus:

$$\Delta m_t = \delta \pi_t^F = \pi_t \tag{6}$$

This implies that in the long run, the first stage pass-through (that is, first-round effect) of possible changes in money supply to food price is represented by the left side of equation 6, $\{\ \pi_t^F = f(\Delta m_t)\}$, while the second-round effect, is the transmission of adjusted in food prices (due to liquidity shock) to consumer inflation captured by the right side of equation 6, $\{\ \pi_t = f(\pi_t^F)\}$. This gives

$$\pi_t^F = \gamma_0 + \gamma_1 m_t + \varepsilon_t^m \tag{7a}$$

The corresponding long-run deviated form is given as

$$\pi_t^F = \gamma_0^* + \gamma_1^- m_t^- + \gamma_2^+ m_t^+ + \xi_t^m \tag{7a*}$$

[19] There is a one-to-one correlation between money supply and price level in the long-run (see McCandless & Weber, 2001).

While the second stage pass-through (second-round effect) from food price to the consumer price is:

$$\pi_t = \mu_0 + \mu_1 \pi_t^F + \varepsilon_t^F \tag{7b}$$

Similarly, the long-run nonlinear form of equation 7b is given as

$$\pi_t = \mu_0^* + \mu_1^- \pi_t^{F-} + \mu_2^+ \pi_t^{F+} + \xi_t^F \tag{7b^*}$$

The specification of equations 7a & 7b is based on Enders & Siklos's (2001) asymmetric cointegration test which is an extension of the symmetric Engle & Granger (1987) test. ε_t^m and ε_t^F in both equations are the residuals that account for the departures from the long-run equilibrium thresholds in the respective equations. γ_1^- and γ_2^+ are the coefficients of negative and positive monetary supply shocks while μ_1^- and μ_2^+ are the respective coefficients of food price deviation that is below and above the long-run equilibrium threshold. ξ_t^m and ξ_t^F are the disturbances[20] in the respective stage of asymmetric pass-through. Therefore, specification of the error correction Threshold Autoregressive (TAR) model as proposed by Enders & Siklos (2001) is presented in equation 8:

$$\Delta\varepsilon_t = I_t \beta_1 \varepsilon_{t-1} + (1 - I_t)\beta_2 \varepsilon_{t-1} + \varepsilon_t \tag{8}$$

Where I_t is the Heaviside indicator which depends on the pass memory of the disturbances (ε_{t-1}). Thus, the Heaviside indicator function is defined by

[20] Recall that w_t is the ratio of food price (P_t^F) to non-food price (P_t^n) , therefore $\delta\Delta\log w_t = \delta\Delta\log P_t^F - \delta\Delta\log P_t^n = \delta\Delta p_t^F - \delta\Delta p_t^n$, for simplification of the model and mathematical convenience since the policy is not channeled to non-food component we reduce the non-food price weight to zero $\delta\Delta p_t^n = 0$. Note that this assumption also follows from the evidence that share of food in the consumption basket in LDC is relatively larger (see Alper, Hodari & Uppal, 2016), suggesting that there is a relatively larger movement in P_t^F than in P_t^n for the LDCs [2964] $\delta\Delta\log w_t = \delta\pi_t^F - 0$, $\delta\Delta\log w_t = \delta\pi_t^F$ this means that dynamics in consumer prices can be approximated by $\delta\pi_t^F$. Mathematically this is an imposition of a conditional limit, implying that as changes in food prices dominates non-food then consumer price inflation approached food price inflation.

$$I_t = \begin{Bmatrix} 1 if \varepsilon_{t-1} \geq \tau \\ 0 if \varepsilon_{t-1} < \tau \end{Bmatrix} \qquad (8^*)$$

Where τ is the threshold and note that nuances in equation 8 (ε_t) can take either ε_t^m or ε_t^F depending on the cointegrating equation (7a or 7b). The nuances in both transmissions are independent and identically distributed with zero mean and constant variance. The necessary condition for long-run cointegration in equation (8) is when both β_1 and β_2 are non-positive (that is $\beta_1 < 0$ and $\beta_2 < 0$) and the sufficient condition is when $(1+\beta_1) < 1$ for all possible value of τ. Under these conditions, the variables in both equations will coincide with the attractor.

Bear in mind that equation (8) is too restrictive and may not sufficiently account for the entire adjustment process of the changes in the errors $(\Delta\varepsilon_t)$ to the long-run equilibrium. To address this defect, the residual errors are assumed to follow the white noise process (Enders & Siklos, 2011).

$$\Delta\varepsilon_t = I_t\beta_1\varepsilon_{t-1} + (1-I_t)\beta_2\varepsilon_{t-1} + \sum_{i=1}^{p-1} \vartheta_i \Delta\varepsilon_{t-i} + \varepsilon_t \qquad (9)$$

For CBN's effort to keep food prices stable through the use of unconventional monetary policy, which assumed to have net effect on money supply, the adjustment specification of the indicator function will have to be modified to capture this discretionary behaviour. This is because the intervention policy meant for accelerating domestic food production could compel $\Delta\varepsilon_t$ to depict high momentum in either the falling or rising prices level, depending on the net effect of an increase in money supply on food prices and its pass-through to consumer prices. This means that the definition of the Heaviside function is modified as:

$$M_t = \begin{Bmatrix} 1 iff \Delta\varepsilon_{t-1} \geq \tau \\ 0 iff \Delta\varepsilon_{t-1} < \tau \end{Bmatrix} \qquad (9^*)$$

Next is to specify the asymmetric error correction model which incorporates the pass-through of both stages.

3.3 Model Specification

The adjustment model takes account of two important aspects of the transmission stages. The first is the short-run deviations in the exogenous variable(s) in both models which explains the difference between the transmission of negative and positive shock to the endogenous variable. The second aspect espouses the difference between negative and positive threshold adjustments in both equations. The threshold adjustment model is specified as follows:

First-round effect

$$\pi_t^F = \theta + \delta^{\pi^{F-}} E_{t-1}^- + \delta^{\pi^{F+}} E_{t-1}^+ + \sum_{i=1}^{p} \alpha_i^- \pi_{t-i}^{F-} + \sum_{i=1}^{p} \alpha_i^+ \pi_{t-i}^{F+} + \sum_{i=1}^{p} \vartheta_i^- \Delta m_{t-i}^- + \sum_{i=1}^{p} \vartheta_i^+ \Delta m_{t-i}^+ + \upsilon_t^m \quad (10a)$$

Second-round effect

$$\pi_t = \varphi + \delta^{\pi-} E_{t-1}^- + \delta^{\pi} + E_{t-1}^+ + \sum_{i=1}^{p} \rho_i^- \pi_{t-i}^- + \sum_{i=1}^{p} \rho_i^+ \pi_{t-i}^+ + \sum_{i=1}^{p} \psi_i^- \pi_{t-i}^{F-} + \sum_{i=1}^{p} \psi_i^+ \pi_{t-i}^{F+} + \omega_t^{\pi} \quad (10b)$$

Where $\delta^{\pi^{F-}}$ and $\delta^{\pi^{F+}}$ are the threshold adjustment parameters for negative and positive deviations from equilibrium food price, while $\delta^{\pi-}$ and $\delta^{\pi-}$ are that of consumer price adjustment. Δm_t^- and Δm_t^+ are negative and positive asymmetric pass-through from money supply changes to food price in equation 10a, while π_t^{F-} and π_t^{F+} are the corresponding negative and positive asymmetric changes transmitted from food price to consumer inflation. υ_t^m and ω_t^{π} are the residuals from equations 10a and 10b.

4.0 Result and Discussion

This section is focused on the presentation of descriptive statistics and the estimated results from the models.

4.1 Results of Preliminary Test

The result of the descriptive statistics presented in Table 1 shows a measure of the central tendency of the series. The result indicates that there is equality between the mean of food prices and consumer prices. This signifies some degree of consistency in the movement for averages of food and consumer goods basket. However, the

average money supply was found to be substantially larger than other series with a significantly smaller deviation from the means for food and consumer prices. This means there is greater variability in monetary aggregate than food and consumer prices.

Table 1: Unit root test & Descriptive statistics

Variables	ADF Unit root test		Descriptive Statistics				
	Log	Δ log	Max.	Min.	Mean	Std. dev.	Obs.
Money supply (₦)	-3.521(0.394)	-19.282(<0.01)	16.58	12.89	15.119	0.982	252
Food price	-4.656(0.087)	-13.393(<0.01)	6.01	3.37	4.679	0.033	252
Consumer price	-3.899(0.214)	-13.709(<0.01)	5.87	3.38	4.668	0.048	252

The result of the unit root test shows that all the series were integrated of order one at a 5% level of significance. This fulfills the requirement for the Enders & Siklos asymmetric cointegration test. Therefore, the paper proceeds with the asymmetric cointegration test in line with Enders & Siklos (2001).

4.2 Results of Threshold Cointegration Test

The results for the asymmetric cointegration test are presented in Tables 2a and 2b. Each table reports the TAR and MTAR results based on two (restricted and unrestricted) threshold conditions. The restricted threshold value, tau (τ), from both tables follow from the estimation of equations 8 and 9 with the corresponding Heaviside indicator in 8* & 9*. Firstly, setting tau as zero[21], while secondly, the unrestricted threshold ($\tau \neq 0$), in each case, τ values were data determined, after ten thousand Monte Carlo (10,000) simulations. The accompanied statistics from both tables were computed for each threshold value and the parameters ($\beta_1 \wedge \beta_2$) capturing deviations above and below the equilibrium threshold. The necessary and sufficient condition for the stationarity of ε_t set by Petrucelli & Woolford (1984) has been calculated for all possible values of the threshold (τ). Thus, having met this condition, it suffices to consider $\tau = 0$ as the long-run equilibrium of the general price in the food price inflation[22]. The estimated coefficients ($\beta_1 \wedge \beta_2$) are assumed to follow an

[21] Note for the avoidance of tautology in the specification, ε_t could imply either ε_t^m or ε_t^F

[22] The restriction τ =0 follows from the wide established belief that macroeconomic variables adjust

asymptotic multivariate normal distribution in line with Tong (1990).

The evidence for the theoretically restricted threshold in Table 2a fails to reject the null hypothesis ($\beta_1 = \beta_2 = 0$) of no threshold cointegration and therefore the assumed theoretical equilibrium threshold of tau equal zero ($\tau = 0$) does not exist for both TAR and MTAR specification using Nigeria's data.

Table 2A: Result of ES Asymmetric Cointegration test between Money Supply & Food Price

Model	**Estimates:**			**t-Max**	**F-Joint (Φ)**
Restricted ($\tau = 0$)	Tau (τ)	Above- $\tau(\beta_1)$	Below- $\tau(\beta_2)$		
TAR:	0.00	-0.075	-0.072	-2.11*(-1.91)	5.74*(6.35)
MTAR:	0.00	-0.081	-0.065	-2.01*(-1.99)	6.25*(6.12)
Unrestricted ($\tau \neq 0$)					
TAR:	0.075	-0.095	-0.058	-1.85*(-1.91)	6.85*(6.35)
MTAR:	0.023	-0.113	-0.057	-1.81*(-199)	7.94*(6.12)

*Signifies statistical significance of the estimates, ES denotes Enders & Siklos. Optimal lag length determination applies the AIC criteria and threshold values were computed after 10,000 simulations from the data

However, a data determined threshold after 10,000 Monte Carlo simulation for unrestricted tau (τ) found a positive tau value for TAR and MTAR which suggests the equilibrium threshold for money supply and food price inflation is in a region above the theoretically assumed zero equilibrium threshold. Thus, the test result presented in Table 2a shows that the necessary condition for convergence between money supply and food price inflation has been achieved, as both parameters $\beta_1 \wedge \beta_2$ for TAR and MTAR were found to be non-positive. This is further supported by convergence criterion, called the t-max statistics, which were found to be -1.85 and -1.81 respectively for TAR and MTAR. Both were observed to be relatively larger than Enders & Siklos's critical values of -1.91 and -1.99 for TAR and MTAR. This reinforces the necessary condition for cointegration between the two variables of interest. In the

back to a steady-state at the zero level, hence denoting long-run threshold (see Enders & Siklos, 2001).

same vein, a formal test that provides a sufficient condition for threshold equilibrium between money supply and food price inflation, captured by F-statistics (phi) with a null for the joint coefficient test of no cointegration $\beta_1 = \beta_2 = 0$, shows that the computed statistics were above Enders & Siklos critical values at 5%. This means the null ($\beta_1 = \beta_2 = 0$) must be rejected for TAR and MTAR and therefore, the inference that asymmetric cointegration between money supply and food price inflation exist in Nigeria for the period under review, remains valid. Hence, this result is consistent with Browne & Cronin (2007), although their estimate is from a symmetric model using U.S. data, however their symmetric cointegration does not take account of asymmetries and threshold in the cointegrating data which makes our cointegrating test superior.

Table 2B: Result of ES Asymmetric Cointegration test between Food price & Consumer Price

Model	**Estimates:**			**t-Max**	**F-Joint (Φ)**
Restricted ($\tau = 0$)	Tau (τ)	Above- $\tau(\beta_1)$	Below- $\tau(\beta_2)$		
TAR:	0.00	-0.093	-0.038	-1.57(-2.12)	5.83(5.87)
MTAR:	0.00	-0.080	-0.039	-1.99(-2.00)	6.48(6.38)
Unrestricted($\tau \neq 0$)					
TAR:	-0.011	-0.114	-0.049	-1.86(-2.12)	7.01(5.87)
MTAR:	0.007	-0.099	-0.046	-2.05(-2.00)	8.08(6.38)

Optimal lag length determination applies the AIC criteria and threshold values were computed after 10,000 simulations from the data

Table 2B presents the asymmetric cointegration test between food price inflation and consumer price inflation. The Monte Carlo simulation indicates a negative tau value for TAR and a positive tau for the MTAR model. This means that there is a stack contrast between the equilibrium thresholds for the model, depending on the nature of the adjustment. The deviation from the established threshold values indicates that both parameters $\beta_1 \wedge \beta_2$ for TAR and MTAR are negative which suggests preliminary evidence of asymmetric cointegration. Similarly, the t-max statistics did not show otherwise for the TAR model, however, in the case of MTAR, the critical values of

Enders & Siklos (2001) were slightly greater than the computed t-max statistics.

4.3 Results of Food Price and Consumer Inflation Threshold Adjustments

The estimates from equations 10a and 10b are presented in Table 3a, which shows the results of asymmetric transmission of exogenous shocks from money supply to food prices (left side), and the result of asymmetric pass-through from food price inflation to consumer price inflation (right side). It also includes the asymmetric threshold adjustment for the TAR and the MTAR models. The results of both models attained parsimony by applying the Hendricks general to specific criteria, therefore only parsimonious coefficients that are consistent with theory and statistics were reported. In addition, for the purpose of robustness checks the estimates from the model were compared with estimates for the sub-samples taken between 2010 and 2020.

The first stage of transmission focuses on the asymmetric pass-through of money supply. The result shows that the asymmetric threshold adjustment (TAR) coefficients are -0.65 and -0.87 for the positive food price (when food price disequilibrium is above threshold) and negative food price adjustment (when food price disequilibrium is below threshold) respectively. Both were found to be negative and statistically significant, which means both adjustment coefficients bear the correct sign and are statistically valid. Thus, these estimates capture the speed of food price adjustment due to changes in money supply. The magnitude of the estimates indicates that about 65 per cent of the food price deviations above equilibrium due to positive changes to money supply are corrected monthly, while 87 per cent of the food price deviations below equilibrium consequent upon a negative change to money supply are eliminated monthly. The size differential between the two coefficients translate to differences in the speed of adjustments between resurging and receding food prices adjustment due to liquidity associated shock from change in money supply. This adjustment differential implies that the TAR model shows faster autoregressive decay for the negative deviation than for positive deviation, therefore implying a time variation in speed of adjustment exist for the negative deviation which amounts to about 1.3 months (5 weeks) faster compared to the positive deviation. This signifies that any food price hike will decay at a slower rate than associated food price spikes coming from negative discrepancies. Thus, the inference from the empirical evidence

suggests that the long-run food price adjustment is contingent on short-run liquidity level in Nigeria, meaning that a stronger food demand reenforced by liquidity influences food prices more than rise in food supply through development financing. This finding is robust to subsamples (see table 3b) and it also corroborates Browne & Cronin (2007) who established similar finding for the US economy.

Similarly, the result shows the coefficients of the momentum in the asymmetric adjustments are -0.81 and -0.92 for the positive and negative deviations (from the MTAR model), both coefficients are carrying the correct sign and are statistically significant. This suggests that the speed of food price adjustments exhibit momentum when reverting back to equilibrium, therefore food price disequilibrium adjustments are not only fast in adjusting either below or above equilibrium, but the adjustments process are equally sustained with a momentum of about 81% and 92 per cent for the upward and downward adjustment respectively. This means that the positive and negative discrepancies that dis-equilibrate the food prices due to money supply shock have an accelerated adjustment with a momentum that forces the fall in the food price to transit faster than the food price hikes (this is also robust to subsamples, see table 3b). Thus the effect of the increase in money supply that could potentially lead to a positive food supply shock and consequently smoothens or cause food price is relatively transient compared to the food demand pressure associated with the increase in money supply that leads to food price inflation. This signifies that the effect of the CBN unconventional policy tends to keep a food price rise longer than a fall food price. An important deduction from these findings is that the effect of liquidity rise consequent upon increase in money supply elevates food demand pressure almost immediately (instantaneous), while food supply shock that may inhibit such pressure has a time-lag that does not effectively render the desired impact of the positive supply shock. This could largely be attributed to the fact that farm produce takes time to get ready into the market while money demand for food takes no time.

The result of the estimated coefficients of the asymmetric shocks that captures the asymmetric pass-through shows that the lag endogenous coefficients of the positive and negative food price shocks are both positive and statistically significant, which means that food price inflation and disinflation exhibits persistence in both directions,

that is, when food prices are below or when they are above equilibrium threshold there is persistence in the food inflation (disinflation). Therefore, this suggests that food price inflation will persist (month-on-month) from one month to the next when food prices are rising, while food disinflation will equally persist in the same manner when food prices are falling. The coefficients of negative and positive money supply shocks were found to be -0.025 and 0.075 respectively, both of which bear theoretically correct sign, however only the coefficient of the positive change to money supply was found to be statistically significant, while that of the negative changes was statistically insignificant. This means that negative discrepancies in money supply which is tantamount to a decrease in money supply was not transmitted into food price disinflation. This finding confirms the effect of the unconventional monetary policy on money supply that subsequently pass-through to food prices, which is, it only leads to increase in the liquidity that translates to food price inflation. While as the result suggests no evidence of decrease in money supply that is transmitted to food price for the period under review[23].

As the result shows, the magnitude of the coefficient of the positive money supply shock is 0.075, which indicates that a positive shock (a unit rise) in money supply, which effectively implies a positive net increase in the monetary aggregate, is transmitted to food price inflation by 7.5% monthly. This suggests that an exogenous monetary policy shock through unconventional (development financing) intervention expands monetary aggregates above the long-run equilibrium threshold (excess in liquidity) and this is effectively pass-on as food demand pressure that translates to a 7.5% hike in food price inflation. This signifies that on the average the effect arising from a liquidity intervention carried out by the CBN in the domestic food production sector has an inflationary-effect. In addition to the finding showing that food price asymmetric adjustment has a deeper threshold adjustment when food prices rise than when they fall and the momentum of the adjustment is higher when the food price falls. Thus, the CBN must take caution in its use of the development

[23] While this remains true as a basic economic principle to allow for a known equilibrium threshold such that, tau takes the value of zero ($\tau = 0$), we however apply the Monte Carlo simulation to also determine τ from the available data. The essence is to draw a comparison and elicit more information about the threshold adjustment and possible region where it comes to rest.

financing tool in raising the domestic food output which in part is characterized with a time-lag in smoothening food demand pressure. An important noting for this paper is that from the potential adverse effect of inflating food prices, especially looking at the net effect of the policy, a greater rise in the money supply without an appreciable or corresponding increase in food output. The persistent nature of the food price hike captured by the autoregressive coefficient of food price; excess liquidity may have a spiral effect on food inflation in the long-run.

Table 3A: Result of threshold adjustment and asymmetric pass-through

Coefficient	Threshold adjustment between money supply & food price		Threshold adjustment between food price & consumer price	
	TAR	M-TAR	TAR	M-TAR
	-0.6502	-0.8061	-0.0047	-1.0635
	(0.000)	(0.000)	(0.000)	(0.000)
	-0.8689	-0.9248	-0.7866	-0.8449
	(0.000)	(0.000)	(0.000)	(0.000)
	Money supply to food prices PT		Food price to consumer price PT	
Intercept	0.006			0.008
	(0.003)***			(0.017)**
α_1^-	0.280		ρ_3^-	-0.138
	(0.003)***			(0.041)**
α_1^+	0.226		ρ_1^+	0.139
	(0.006)***			(0.044)**
ϑ_3^-	-0.025		ψ_3^-	-0.074
	(0.56)			(0.462)
ϑ_3^+	0.075		ψ_6^-	-0.173
	(0.009)***			(0.076)*
			ψ_1^+	0.269
				(0.001)***

Note: *, **&*** indicates statistical significance at 10%, 5% and 1% respectively. P-values are enclosed in parenthesis, PT refers to Pass Through.

The second transmission stage is also captured in Table 3a. This stage deals with the asymmetric threshold adjustment and the asymmetric shocks transmitted from food price inflation to consumer inflation. The result shows that the coefficient of the threshold adjustment of the TAR model were -0.0047 and -0.79 for positive and negative deviation respectively and both were found to be carrying the correct sign and they are statistically significant. Hence the observed differentials in the adjust-

ment coefficients imply the presence of asymmetric threshold. The size of the estimated coefficient of positive consumer price adjustment indicates that only about 0.5% of the deviation that went above the equilibrium consumer prices is corrected monthly by a fall in food price inflation. The relative smallness in the magnitude of the threshold adjustment parameter signifies downward stickiness of consumer price adjustment, possibly non-food share of the headline inflation plays a role in the movement of the general price level as well. Thus, the stickiness might be attributed to non-food price rigidity.

Table 3B: Result of Sub-samples threshold adjustments and Robustness checks

	Threshold adjustment between money supply & food price		Threshold adjustment between food price & consumer price	
Coefficient	TAR	M-TAR	TAR	M-TAR
	-0.629	-0.809	-0.0015	-1.15
	(0.035)	(0.000)	(0.000)	(0.000)
	-0.996	-0.949	-0.642	-0.846
	(0.013)	(0.000)	(0.000)	(0.000)

Note: the sub-sample estimates were based on the period when the use of the development financing widow was intensified and plot in figure 3. *, **&*** indicates statistical significance at 10%, 5% and 1% respectively. P-values are enclosed in parenthesis.

The magnitude of the coefficient of the negative asymmetric threshold consumer price adjustment indicates that about 79% of the deviations that went below the consumer inflation threshold are reverted to equilibrium due to food price rise monthly. This implies that the TAR model shows deep asymmetric movement in consumer price inflation when food prices are rising, thus the autoregressive decay is faster for the negative deviations than the positive deviations. In measuring the relative differences in speed of threshold adjustment between positive and negative deviations, it was found that adjustment of consumer prices when the deviation is below equilibrium is 158 months faster compared to when it is the deviation is above. This means that the threshold adjustment of the discrepancies (arising from the disequilibrium) that are below the equilibrium are corrected due to rising food prices is relatively higher. More so, suggesting that the adjustment is characterized by deep asymmetric movement in consumer price fall, hence translating into faster autoregressive decay in negative discrepancies for the TAR model, this are effectively robust to the sub-

sample estimates in Table 3b.

The estimates of the M-TAR model for the consumer price asymmetric threshold adjustments were also found to be statistically significant with the coefficients as -1.1 and -0.84 for the positive (above) and negative (below) threshold adjustments. This result signifies the presence of momentum and spiky asymmetric movement in consumer price adjustment, which is partly due to the food price positive spikes found to be more amplified than negative ones. The asymmetric spike variation in food prices ascend by 22% towards the positive discrepancies from the equilibrium than it gravitates towards negative discrepancies from equilibrium. This suggests evidence of greater momentum in the adjustment of the positive deviations above the equilibrium threshold. Implying that food price inflation are the major driver of consumer price inflation in Nigeria for the period under investigation, this finding is robust to the subsample finding, in addition it corroborates Bello & Sanusi (2019) which espouses the dominance of food price inflation in the headline inflation.

In addition, Table 3a also shows the asymmetric transmission of food price inflation to consumer prices. The result reveals that the coefficient of the lag endogenous variable for positive deviation is 0.14 and is also statistically significant at a 5 per cent level. This means that there is persistence in consumer price inflation by as much as 14 per cent when the price level rises above the equilibrium threshold. Similarly, the result indicates that the lag endogenous negative deviation is 0.14 and is also significant at a 5 per cent level. This signifies that 14 per cent of the fall in price level is attributed to persistence in consumer price disinflation. This means that inflation inertia prolongs the deflationary period when price levels drift below equilibrium. The equality in the sizes of the persistent parameters suggests that the rate of persistency for inflationary and deflationary periods is symmetrical for the period under review.

Furthermore, the result shows that the coefficients of asymmetric pass-through of food price inflation that originate from negative shocks due to a food price fall are transmitted quarterly (as indicated by the parsimonious lag coefficients in the result from Table 3a). In both the first and second quarters, the coefficients of negative food price shocks were found to be negative, hence bearing the theoretically correct signs. However, the negative food price shock in the first quarter is statistically insignifi-

cant. This suggests that in the initial period, negative discrepancies from equilibrium associated with a fall in food prices are not transmitted to consumer prices. Hence, a benefit of any food price fall in the initial period, will not amount to a decline in consumer inflation. However, in the second quarter, the magnitude of the coefficient of negative food price shock was found to be -0.173 and it is statistically significant at 5 per cent. This indicates that for every unit of food price fall below the equilibrium threshold, a 17 per cent decrease is transmitted as consumer price disinflation. This implies that for every two consecutive periods of food price decline below equilibrium, only the effect of the second quarter (period) is passed-on to consumer prices as disinflation. This also suggests that in the use of the unconventional intervention, only a sustained long period of food supply increase will be required for food price deflation in order to effect a 17 per cent consumer price disinflation. Otherwise short period of supply glut often observed at the onset of harvest may likely not yield the desired food price deflation that could translate into consumer price disinflation.

On the other hand, the result of the coefficient of positive food price shock in the first period was found to be 0.269, and the p-value indicates that asymmetric parameter is statistically significant and carries the correct sign. Consequently, the size of the parameter indicates that for every deviation in food price above the equilibrium threshold (disequilibrium) due to food price rise, transmits about 27 per cent increase into consumer prices as inflation. The effect of the first lag means that there is an immediate inflationary pressure in consumer prices that is associated with positive discrepancies above equilibrium threshold due to the food price inflation in the economy.

Thus comparatively, the size of positive food price change was found to be substantially larger than negative change, with a net difference of about 10 per cent. This means that magnitude of asymmetric pass-through from food price inflation to consumer prices is greater than that of food price deflation by 10 per cent. Besides, the sensitivity of consumer price is (in first period) is faster when food price increases than when it falls consecutively (in first and second period), which means that the elasticity of consumer price inflation to the food price increase is greater than food price decrease. These results lean support towards the US, the Euro area,

other multi-regional evidence, and Nigeria which were reported in Browne & Cronin (2007) Ferrucci *et al.* (2010), Cachia (2014), and Bello and Sanusi (2019) respectively.

In summary, this paper identifies the existence of asymmetries in the two important stages of transmission under consideration. The first is the transmission between money supply and food prices, while the second is the transmission between food price inflation (deflation) and consumer price inflation. The key findings from this paper points on the broad implication of the CBN's unconventional monetary policy using development financing intervention tool to spur up domestic food production. The first finding is that the established presence of asymmetric threshold adjustment in both stages, with varying degrees of momentum in the adjustment process across each stage of shock transmission means that the responsiveness of price adjustment to the changes in money supply is asymmetrical in both the first and the second round. In the first transmission stage (first-round effect), the speed of threshold adjustment when food prices are below equilibrium is 1.3 months (5 weeks) faster compared to when food prices are above equilibrium, hence food prices were found to exhibit momentum when they were below equilibrium, therefore food prices adjust faster when they fall below equilibrium. Furthermore, the evidence reveals that negative changes to money supply is not transmitted into food price disinflation while positive changes to monetary supply was found to significantly pass through to food price inflation by 7.5%, suggesting that for every unit increase in money supply, food price rises above equilibrium threshold by 7.5%. The second is the recognized the presence of a relative price effect in the second transmission stage, which exhibits deep movements of consumer price inflation when food prices are rising, as well as the presence of significant spiky asymmetric movements from food prices to consumer prices. Essentially, when food prices are above equilibrium, the spikes are more accelerating than when they are below, hence it is inferred that food price has momentum when it is above equilibrium. In addition, the size of food price inflation was substantially larger compared to food price deflation with a net difference of 10%, signifying more sensitivity (elasticity) of consumer inflation to a food price increase because it transmits more inflationary pressure to consumer prices than a food price fall.

5.0 Conclusion and Policy Recommendations

The ongoing debate that food prices are too volatile to allow for effective management of headline inflation continues to receive attention, and has very much remained a contentious issue for central banks in the wake of rising global food inflation. However, bearing the relative greater weight of food in the consumption basket in the developing economies, the CBN is looking beyond the underlying causes, and it is tackling the headline causes of inflation. Overtime the central bank has commit to the use of development financing to stimulate domestic food output, with the view that food supply shock will reign on food price inflation. More so, the bank believes it can leverage the greater weight of food in the consumption basket to moderate on headline inflation downward. It is in the light of this, this paper investigates the possible effect of this policy (along two transmission stages). The first is the asymmetric pass-through from money supply changes to food prices, while the second is the pass-through effect from food price inflation (deflation) to consumer price inflation. Both stages were analyzed along with the associated threshold adjustment taking place. This paper assumes that the net-effect of the unconventional intervention embarked by the CBN possibly precipitated in raising the liquidity level in the economy, and the following effects were found within the channels under investigation. The first round-effect is a nominal adjustment in respect of food prices due to the liquidity shock that was accompanied by food demand pressure. This adjustment is characterized by a deep asymmetric movement with higher momentum in the food price adjustment. The nominal adjustment of food prices comes 5 weeks ahead of the real adjustment accompanying the intended supply-side response of the intervention which ought to relief the food demand. More so the relatively lesser momentum does not catch up with the nominal adjustment inflating food prices. In the second round, food price inflation plays a key role, as the evidence showed that food price inflation continues to encroach on general price stability by as much as 7.5%. The consumer price adjustment are characterized by spiky asymmetric movement with a grater momentum in moving consumer price inflation above equilibrium threshold, attempt in reversing the policy by reducing liquidity (contracting monetary aggregate) will have no disinflationary effect on food prices. Hence, the paper concludes that long-run food price adjustment is contingent on short-run liquidity level, more so, inflated

food price transmits inflationary-pressure to consumer prices thereby prompting a likelihood of a spiral effect on food price inflation in the long-run.

Raising the level of money supply with the view that liquidity could stimulate potential domestic food output which is expected to rein in food price inflation, and consequently leading to food price disinflation, may result in higher food demand pressure especially if food price adjustment to the increase in money supply is relatively more elastic. Accordingly, our evidence has shown that long-run food price adjustment is contingent on short-run liquidity level in Nigeria. This is consistent with Browne & Cronin (2007) who established similar finding for the US economy.

Thus, the broad implication that underpins this paper is that, the effect of liquidity rise consequent upon increase in money supply is it elevates food demand pressure almost immediately. Suggesting that, the food price elasticity to rise in money supply is more than the expected potential elasticity of domestic food output to rise a in money supply for the period under review. The possible explanation in the presumed higher food price elasticity could be attributed to time-lag that exist between the increase in money supply and the effective time expected food output response, which is not the case in food price, because its response is faster.

This paper established that a decrease in money supply is not transmitted to food prices, while increase in money supply is significantly transmitted into food prices for the period under review, this attests to the fact that the unconventional intervention might have continuedly raise money supply without recourse to reduction in money supply, hence leading to food price inflation. Thus, the CBN must take caution in its use of the development financing tool for the purpose of raising the domestic food output which in part is characterized with a time-lag in smoothening food demand pressure. An important noting for this paper is that from the potential adverse effect of inflating food prices, especially looking at the net effect of the policy. And the persistent nature of the food price hike captured by the autoregressive coefficient of food price, excess liquidity may have a spiral effect on food inflation in the long-run.

This paper recommends that in the use of unconventional monetary policy to stimulate domestic food output, the CBN must take cognizance of the relative difference in

elasticity of food price adjustment to liquidity and the food price response to the expected potential food output gains from the policy, which is expected to smoothen the rising food prices, as well as the consequential elasticity of consumer price inflation to food prices adjustment.

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