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Analysis of Food Inflation in Indonesia using the Nonlinear Autoregressive Distributed Lag Approach

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ABSTRACT

Food Inflation remains one of the most persistent sources of price volatility in Indonesia and poses a significant challenge for macroeconomic stability and household welfare. This study conducts quantitative empirical time series research to examine the asymmetric effects of Money Supply (M2) and Farmers Terms of Trade (FTT) on Food Inflation. The analysis uses monthly data from 2011 to 2023 obtained from Bank Indonesia and Statistics Indonesia and applies the Nonlinear Autoregressive Distributed Lag (NARDL) model, which is appropriate for capturing asymmetry and accommodating variables integrated at different orders. The selection of M2 is based on monetary theory which states that changes in liquidity influence aggregate demand and inflation, while the use of FTT is supported by agricultural and development literature showing that farmers purchasing power affects food production capacity and food price dynamics. The results reveal significant asymmetric effects in both the short and long run. Increases and decreases in M2 both raise Food Inflation, and the stronger effect during declining M2 reflects downward price rigidity and the dominance of quasi money in Indonesia. A decline in FTT significantly increases long run inflation through constraints on agricultural input access and reduced food supply. The findings also confirm inflation persistence. These results imply that liquidity management and policies that strengthen farmer purchasing power are essential to stabilize food prices. The study recommends integrating monetary policy with agricultural support measures to mitigate future food inflation pressures.

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A. INTRODUCTION

Inflation remains a central macroeconomic challenge due to its implications for price stability, economic growth, and household welfare (Halim et al., 2022; Ha & So, 2024). Therefore, monetary authorities consistently formulate policies to maintain inflation within controllable limits. This commitment is reflected in the National Medium Term Development Plan or Rencana Pembangunan Jangka Menengah Nasional (RPJMN) 2020–2024, which targets a general inflation rate of 2.5% ±1% by 2024, and in the National Long Term Development Plan or Rencana Pembangunan Jangka Panjang Nasional (RPJPN) 2005–2025, which emphasizes the importance of macroeconomic stability as the foundation for sustainable development (Bappenas, 2020). Although Indonesia successfully maintained year-on-year inflation at 2.61 percent in December 2023 (BPS, 2024), food inflation remains structurally vulnerable due to supply disruptions, seasonal variation, and dependence on strategic commodities. These conditions make food inflation not only volatile but also highly sensitive to external and domestic shocks.

Recent episodes further illustrate these vulnerabilities. For instance, El Niño conditions in 2023 disrupted domestic rice production and triggered the government to authorize additional rice imports to stabilize soaring prices (USDA, 2023). Moreover, previous studies indicate that El Niño shocks have a significant positive effect on rice prices in Indonesia, underscoring the sensitivity of food inflation to climate-related supply shocks (Hasudungan et al., 2021). Similarly, Trisulo et al. (2025) emphasize that supply chain disruptions, trade restrictions, and depreciation pressures amplified rice price hikes, while government interventions through BULOG were insufficient to curb volatility. These findings highlight that food inflation in Indonesia is not merely cyclical but structurally vulnerable to both external and domestic shocks.

According to Bank Indonesia, the volatile food and administered prices groups account for approximately 40 percent of the Consumer Price Index (CPI), making them key contributors to inflation fluctuations. Increases in food prices have a more significant impact on low-income households, considering that their largest share of expenditure is allocated to food consumption (Green et al., 2013). An increase in food inflation can significantly lead to a higher poverty rate and cause a rise in non-food inflation. Therefore, controlling food inflation is not only a macroeconomic issue but also one that is closely related to social dimensions and economic inequality. Food inflation is influenced by various factors, including supply disruptions, seasonal patterns, and macroeconomic conditions such as money supply, income levels, and consumer purchasing power (Ismaya & Anugrah, 2018; Samal et al., 2022).

Several studies in Indonesia have examined the determinants of food inflation, although most employed linear approaches. Ismaya & Anugrah (2018) utilized the Generalized Method of Moments (GMM) to model Food Inflation based on variables such as food production and money supply. Nairobi & Caroline (2021) employed panel regression to analyze the CPI for food subgroups in Java and Sumatra but did not explore asymmetric responses to changes in economic variables. Meanwhile, at the international level, studies by Samal et al. (2022) in India and Malaviarachchi & Gedara (2024) in Sri Lanka, using Autoregressive Distributed Lag (ARDL) and Vector Error Correction Models (VECM), found that money supply (M2) and farmer wages, as a proxy for welfare, significantly affect food inflation. These studies, however, did not consider potential short-run and long-run asymmetries in their models. Thus, existing literature reveals two research gaps: first, the absence of asymmetric analysis in the Indonesian context, and second, the limited exploration of Farmers' Terms of Trade (FTT) as an independent variable shaping food inflation.

In other words, these studies and evidence suggest that asymmetric analysis is necessary due to complex and true dynamics between food price and its drivers, and food prices are vulnerable to volatility and varied shocks. Moreover, the absence of asymmetric analysis may generate inaccurate prediction, reducing the effectiveness of policy responses. It can be justified that indeed inflation may exhibit asymmetric characteristics, meaning that it responds differently to increases and decreases in its underlying drivers (Laxton et al., 1995; Widarjono et al., 2023; Tillmann, 2024; Kudar, 2024; Polis et al., 2025). For instance, an increase in demand or money supply tends to push inflation upwards significantly, while a decrease tends to push it downwards more slowly. Specifically, according to Polis et al. (2025), inflation risks are not always balanced, as the probability of high inflation may exceed that of deflation, or vice versa. Food Inflation, which is influenced by fluctuations in food prices that are highly sensitive to seasonal patterns, distributional factors, and dependence on strategic commodities, is also assumed to demonstrate similar asymmetric behaviour (Wen et al., 2021).

Consequently, an analytical approach that can identify asymmetric effects is essential for a more thorough understanding of inflation dynamics. This research attempts to analyze the asymmetric response dynamics among variables such as Money Supply (M2), Farmers' Term of Trade (FTT), and Food Inflation (FINF). Money Supply can be defined as total amount of money available in an economy and Farmers' Term of Trade is observed as an indicator of farmers' welfare, representing the exchange value of agricultural output against the cost of consumption and production needs. While Food Inflation can be understood as increases in food prices over time. Furthermore, both variables (M2 and FTT) have varied effects towards Food Inflation (Barnett et al., 1983; Bhattacharya & Sen Gupta, 2018; Durevall et al., 2013; Grimm, 2012; Kaur, 2023; Loening et al., 2009; Mawejje & Lwanga, 2016; Zaman et al., 2025). Basically, an increase of M2 will boost liquidity, thus improving aggregate demand and potentially resulting in higher food inflation. An increase of FTT will incentivize a higher production through improved capital and capacity of farmers in purchasing agricultural inputs such as seeds, fertilizer, and even agricultural technology, thus resulting in a lower food inflation. Meanwhile, a decrease in each of these variables will produce contrasting effects on food inflation compared to the previous explanation.

Moreover, it can also be observed that FTT's effect on inflation is more implicit or indirect, requiring further elaboration or discussion. Money supply is clearly associated with food inflation, whereas many studies observe FTT as an outcome or indicator of food inflation, rather than as an independent variable that may increase or decrease it (Chand, 2010; Durevall et al., 2013; Ivanic & Martin, 2008; Kaur, 2023; Pratomo et al., 2023). This implicit or indirect relationship makes FTT a novel explanatory variable, offering a new perspective on the supply-side determinants of food inflation in Indonesia. Considering FTT as an independent variable will provide a nuanced understanding of the logical operations and dynamics within FTT, particularly regarding how changes in farmers' income and agricultural production affect food inflation (Bhattacharya & Gupta, 2018; FAO, 2024). While several studies have also identified the determinants of food prices, there remains limited research that specifically investigates the asymmetric effects of money supply and farmers' welfare on Food Inflation in Indonesia. A comprehensive analysis of the relationship between macro and micro-level factors and food inflation therefore requires a methodological approach that can capture both short-run and long-run dynamics, as well as potential asymmetries. Building on these empirical and conceptual gaps, this study pursues a clear research objective: to examine whether Food Inflation in Indonesia responds asymmetrically to positive and negative changes in Money Supply (M2) and Farmers' Terms of Trade (FTT) using monthly data from 2011 to 2023. This objective addresses the lack of asymmetric analysis in the existing literature and extends the discussion by introducing FTT as a supply-side determinant of food inflation, a variable that remains underexplored in Indonesia.

This study provides two key academic contributions. First, it offers the first empirical evidence on asymmetric food inflation dynamics driven by monetary conditions and farmers' welfare in Indonesia. Second, it enriches the theoretical discourse by positioning FTT as a novel explanatory variable capable of capturing supply-side pressures within an asymmetric inflation framework. In addition to its academic relevance, the study contributes to policy formulation by providing evidence-based insights for designing more targeted monetary and agricultural policies aimed at stabilizing food prices and strengthening farmers' welfare.

B. METHODS

This section outlines the data, analytical procedures, and modelling strategy applied in this study. The methodological framework is designed to capture both short-run and long-run asymmetric dynamics between Money Supply (M2), Farmers' Terms of Trade (FTT), and Food Inflation. Given the monthly structure of the dataset and the possibility of mixed integration orders, an econometric approach capable of handling such conditions is required.

1. Data

This study utilizes secondary data in the form of monthly time series from January 2011 to December 2023, comprising a total of 156 observations. The variables employed in this research include food inflation, money supply (M2), and Farmers' Terms of Trade (FTT). The data were obtained from Statistics Indonesia (BPS) through its official website at https://www.bps.go.id/id. Food inflation is selected as the dependent variable due to its dominant contribution to general inflation and its high volatility (USDA, 2023). Meanwhile, M2 serves as a proxy for monetary conditions and liquidity in the economy (Balafas et al., 2018), and FTT is used as an indicator of farmers' welfare, reflecting its influence on food prices from the supply side (BPS, 2023). All variables were tested for stationarity using the Augmented Dickey-Fuller (ADF) test. If a variable was found to be non-stationary at level, first differencing was applied until stationarity at I(0) or I(1) was achieved. The NARDL framework permits the combination of I(0) and I(1) variables as long as none are integrated of order two. The analysis was conducted using EViews 12, and lag selection for the models was determined using the Akaike Information Criterion (AIC).

2. Methodology

The Nonlinear Autoregressive Distributed Lag (NARDL) model is an extension of the ARDL model that is designed to accommodate potential asymmetries in the relationship between independent and dependent variables (Shin et al., 2014). The ARDL model developed by Pesaran et al. (2001) assumes a linear and symmetric relationship, in which both positive and negative changes in the independent variables exert similar effects on the dependent variable. The Nonlinear Autoregressive Distributed Lag (NARDL) model is selected because it accommodates asymmetric effects and is suitable for datasets with moderate sample sizes such as monthly macroeconomic series. Unlike other nonlinear models such as Threshold Cointegration or Markov-Switching models, NARDL remains robust with mixed integration orders and can separately identify the long-run and short-run impacts of positive and negative shocks. This makes it particularly appropriate for analyzing the asymmetric behaviour of Food Inflation.

Prior to constructing the NARDL model, the ARDL model is estimated to identify short-run and long-run relationships among the variables. Nonetheless, since the ARDL model only captures symmetric effects, it is not sufficient to distinguish the differing impacts of increases and decreases in M2 and FTT. Therefore, the model is extended into NARDL through the decomposition of M2 and FTT into two components: the partial sum of positive and negative changes. The decomposition of M2 and FTT is expressed in the following equations:

$$M2_t^+ = \sum_{j=1}^{t} \Delta\, M2_j^+ = \sum_{j=1}^{t} \max(\Delta M2_j, 0) \tag{1}$$

$$M2_t^- = \sum_{j=1}^{t} \Delta\, M2_j^- = \sum_{j=1}^{t} \min(\Delta M2_j, 0) \tag{2}$$

$$FTT_t^+ = \sum_{j=1}^{t} \Delta\, FTT_j^+ = \sum_{j=1}^{t} \max(\Delta FTT_j, 0) \tag{3}$$

$$FTT_t^- = \sum_{j=1}^{t} \Delta\, FTT_j^- = \sum_{j=1}^{t} \min(\Delta FTT_j, 0) \tag{4}$$

These components are then separately included in the model to estimate their respective effects on FINF. This specification allows the model to detect differences in the response of FINF to increases and decreases in both M2 and FTT. Subsequently, the NARDL model is evaluated through the bounds testing approach of Pesaran et al. (2001) to determine the existence of long-run relationships among FINF, M2, and FTT. The test compares the F-statistic against the critical values of I(0) and I(1) based on the number of variables in the model. If the F-statistic exceeds the upper bound, cointegration is confirmed. If the F-statistic is below the lower bound, there is no cointegration. If it falls between the two bounds, the result is inconclusive (Fadillah et al., 2022). If cointegration is found, an Error Correction Model (ECM) is formulated to represent the adjustment toward long-run equilibrium. In this model, the Error Correction Term (ECT) reflects the deviation between actual and long-run estimated values. The ECT coefficient measures the speed of adjustment toward equilibrium and is formulated as follows:

$$ECT_{t-1} = FINF_{t-1} - (\theta_1^+ M2_{t-1}^+ + \theta_2^- M2_{t-1}^- + \theta_3^+ FTT_{t-1}^+ + \theta_4^- FTT_{t-1}^-) \tag{5}$$

Here, ${\theta_1}^+$ and ${\theta_2}^-$are long-run coefficients for $M2^+$ and $M2^-$, respectively, and ${\theta_2}^+$ and θ_3^- are long-run coefficients for FTT^+ and FTT^- with respect to FINF. The NARDL estimation in ECM form also includes the differenced components (Δ) of each variable and the appropriate lags to control for time dynamics. According to Shin et al. (2014), the ECM specification with two independent variables is as follows:

$$\begin{aligned} \Delta FINF_t = \quad & \gamma + \lambda ECT_{t-1} + \textstyle\sum_{i=1}^{p-1} \phi_i \Delta FINF_{t-i} + \sum_{j=0}^{q_1-1} \beta_{1j}^+ \Delta M2_{t-j}^+ + \\ & + \textstyle\sum_{j=0}^{q_2-1} \beta_{1j}^- \Delta M2_{t-j}^- + \sum_{k=0}^{q_3-1} \beta_{2k}^+ \Delta FTT_{t-k}^+ + \sum_{k=0}^{q_4-1} \beta_{2k}^- \Delta FTT_{t-k}^- + \varepsilon_t \end{aligned} \tag{6}$$

In this equation, λ is the coefficient of the ECT, p is the lag length for $FINF$, and q_1, q_2, q_3, and q_4 represent the lags for $M2^+$, $M2^-$, FTT^+, and FTT^-, respectively. To examine the presence of asymmetric effects, the Wald test is employed to test for asymmetry in both the short run and long run for M2 and FTT. The test evaluates the null hypothesis of equality between the positive and negative effects. In the long run, the null hypothesis is $H_0: \theta^+ = \theta^-$ against the alternative $H_1: \theta^+ \neq \theta^-$. In the short run, the hypothesis is $H_0: \beta^+ = \beta^-$ against $H_0: \beta^+ = \beta^-$ dan $H_1: \beta^+ \neq \beta^-$. If the null hypothesis is rejected, it indicates the presence of asymmetry. Finally, the stability of the model is assessed using the CUSUM and CUSUM of Squares (CUSUMSQ) tests, as suggested by Sriyana & Ge (2019). The model is considered stable if the CUSUM and CUSUMSQ plots lie within the 5 percent significance level boundaries.

C. RESULT AND DISCUSSION

1. Overview of the data

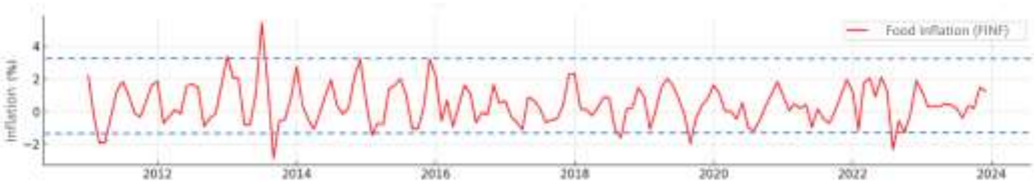
Descriptive statistics are the initial step in the analysis, aiming to provide a general overview of the data characteristics and facilitate understanding of patterns within each variable. Table 1 presents the descriptive statistics, including the mean, median, standard deviation, minimum, and maximum values. Meanwhile, the time series plots in Figure 2 illustrate the dynamic behaviour of each variable throughout the study period. Images are numbered using Arabic numerals. The caption must be in an ordinary font size of 11 pt.

Table 1. Descriptive Statistics

Variable	Mean	Median	Standard Deviation	Minimum	Maximum
M2	5,282,359	5,198,863	1,801,139	2,420,191	8,826,531
FTT	104.058	103.165	3.256	99.47	117.76
INFF	0.437	0.315	1.228	-2.88	5.46

(a)

(b)



(c)

Figure 1. Time Series Plots of (a) M2, (b) FTT, and (c) Food Inflation

Table 1 and Figure 2 display the descriptive statistics for M2, FTT, and Food Inflation from February 2011 to December 2023. M2 showed an upward trend throughout the study period, with the lowest value occurring in February 2011 and the highest in December 2023. This increase reflects the implementation of expansionary monetary policy, particularly during the 2020 pandemic. The largest increase in M2 was recorded in December 2022, amounting to 2.78 percent compared to the previous month. This was driven by a rise in net foreign assets and increased credit distribution (Bank Indonesia, 2022) FTT ranged from 99.47 to 117.76, with an average of 104.06. A value above 100 indicates that farmers achieved a surplus in income. Between 2011 and 2020, FTT occasionally fell below 100, indicating downward pressure on farmers' welfare. Since 2020, FTT has increased, peaking in December 2023 due to higher prices in the food crops and plantation sub-sectors. Food inflation averaged 0.437 percent per month and remained within the national inflation target of 2.5 percent ±1 percent annually. The highest food inflation occurred in July 2013 at 5.46 percent, caused by increases in fuel and food commodity prices. The lowest food inflation was recorded in September 2013 at -2.88 percent, which was primarily attributed to import policies and market operations implemented by the Coordinating Ministry for Economic Affairs of the Republic of Indonesia.

2. Stationarity Test (unit Root Test)

The stationarity or unit root test is a preliminary step in NARDL analysis to ensure that the variables are either stationary at level or at first difference. The Augmented Dickey-Fuller (ADF) test was employed for this purpose. In the initial testing stage, the results showed that M2 and FTT were non-stationary at level, while food inflation (FINF) was already stationary. Since the NARDL model requires that variables be stationary at level (I(0)) or at first difference (I(1)), the M2 and FTT variables were transformed through first differencing. The ADF test results after first differencing confirmed that all variables (ΔM2,ΔFTT, and ΔFINF) were stationary, with p-values less than 0.05. Therefore, the data satisfy the requirements for applying the NARDL model, as shown in Table 2.

Table 2. Unit Root Test

Variable	Level (I(0))		First Difference (I(1))		Stationarity Level
	ADF	P-value	ADF	P-value	
M2	1.35	0.999	-16.928	0.0001	I(I)
FTT	0.707	0.992	-8.601	0.0001	I(I)
FINF	-10.455	0.001	-12.786	0.0001	I(0)

3. Optimal Lag Selection

The selection of optimal lag in the NARDL model aims to determine the best lag combination based on the Akaike Information Criterion (AIC). With two independent variables, the lag structure in this model is represented as $(p, q_1, q_2, q_3$, and $q_4)$,, where each component corresponds to the lag length of the dependent variable $(FINF)$, (FINF), $M2^+$, $M2^-$, FTT^+, and FTT^- respectively. All possible combinations of lags from 0 to 4 were evaluated, resulting in 3,125 model combinations. The ten combinations with the lowest AIC values are summarized in Table 3. The model with the lowest AIC value was selected as the optimal lag specification. Based on the estimation results, the best lag combination is (4, 0, 3, 1, 2) with an AIC value of

2.6699. This combination was used in the construction of the NARDL model for subsequent analysis.

Table 3. Lag Combinations with the Lowest AIC Values

Lag	AIC
(4, 0, 3, 1, 2)	**2.6699**
(4, 4, 0, 1, 2)	2.6736
(4, 1, 3, 1, 2)	2.6754
(4, 0, 4, 1, 2)	2.6771
(4, 0, 3, 1, 3)	2.6815
(4, 0, 3, 2, 2)	2.6820
(4, 1, 4, 1, 2)	2.6832
(4, 4, 0, 1, 3)	2.6847
(4, 4, 0, 2, 2)	2.6870
(4, 1, 1, 1, 2)	2.6869

4. Cointegration Test

The cointegration test is conducted to examine the presence of a long-run relationship among M2, FTT, and food inflation (FINF). The test is based on the bounds testing approach developed by Pesaran et al. (2001), which involves comparing the F-statistic with the lower and upper critical bounds at the 5 percent significance level, as shown in Table 4.

Table 4. Cointegration Test Result

F-Statistic	α	Bound Testing Score		Decision
		Lower Bound	Upper Bound	
23.170	5%	2.56	3.49	Cointegration exists

5. Long-Run Coefficient Estimation

Table 5. Wald Test Results for Long-Run Asymmetry

Variable	Coefficient	t-statistic	P-value
$M2^{+}$	6.85×10^{-7}	2.2730	0.0246**
$M2^{-}$	1.33×10^{-6}	2.2024	0.0293**
FTT^{+}	0.054606	1.5623	0.1205
FTT^{-}	0.156925	4.0083	0.0001***

In this table, ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

The Wald test results indicate the presence of long-run asymmetry in the effect of money supply (M2) on food inflation. Both components, $M2^{+}$ and $M2^{-}$, are statistically significant at the 5 percent level. The coefficient of $M2^{+}$, which is 6.85 $\times 10^{-7}$with a p-value of 0.0246, suggests that an increase in $M2$ in the long run contributes to higher food inflation. This finding aligns with Yoga & Pratiwi (2023), who argue that an increase in money supply enhances purchasing power, exerts pressure on the supply side, and consequently drives food inflation. Similar findings were reported by Samal et al. (2022). The negative component, $M2^{-}$,is also statistically significant with a coefficient of 1.33×10^{-6} and a p-value of 0.0293. Although economic theory suggests that a decrease in M2 should reduce inflation, the result here indicates otherwise. This can be explained by the large proportion of quasi-money in M2, which is relatively illiquid. A decline in M2 driven by a reduction in non-liquid funds does not immediately affect consumption levels, as explained by Manuhuttu (2023); Laksono et al. (2024).

Meanwhile, the positive component of the Farmers' Terms of Trade FTT^+, has a positive coefficient of 0.0546 but is not statistically significant (p-value 0.1205). This suggests that an increase in farmers' purchasing power does not significantly affect food inflation in the long run. In contrast, FTT^- is statistically significant with a coefficient of 0.1569 and a p-value of 0.0001. A decrease in FTT reflects a decline in farmers' purchasing power, which weakens their access to agricultural inputs and lowers food production. This result is consistent with Yasin & Amin (2021), who found that declining production due to weakened purchasing power among farmers can trigger price increases and drive inflation.

6. Test for Short-Run Asymmetry and Estimation of the Error Correction Model (ECM)

Table 6. Wald Test Result for Short-Run Asymmetry

Short-Run Wald Test		
Variable	**F-statistic**	**P-value**
$M2^+$	4.2363	0.0414**
$M2^-$	3.6006	0.0151**
FTT^+	0.3698	0.8478
FTT^-	0.0552	0.9464

In this table, ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively

Table 7. Error Correction Model Estimation

Error Corection Model Estimation			
Variable	**Coefficient**	**t-Statistic**	**P-value**
C	0.5431	2.2674	0.0249**
$D(FINF(-1))$	0.8196	8.6229	0.0001***
$D(FINF(-2))$	0.4267	5.3089	0.0001***
$D(FINF(-3))$	0.2562	3.4658	0.0007***
$D(M2^-)$	1.03×10^{-6}	0.5532	0.5810
$D(M2^-(-1))$	3.91×10^{-6}	2.1201	0.0358**
$D(M2^-(-2))$	-4.59×10^{-6}	-2.4973	0.0137**
$D(FTT^+)$	-0.6088	-3.9289	0.0001***
$D(FTT^-)$	-0.0724	-0.4589	0.6470
$D(FTT^-(-1))$	-0.3593	-2.2985	0.0230**
$ECT(-1)$	-0.4903	-6.8035	0.0001***
R^2	0.5221		
Adj R^2	0.4733		

In this table, ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively

The results of the Wald test indicate the existence of short-run asymmetry in the influence of money supply (M2) on food inflation. Both $M2^+$ and $M2^-$ are statistically significant, with p-values of 0.0414 and 0.0151 respectively. This suggests that both increases and decreases in M2 have a significant impact on food inflation in the short run. In contrast, the positive and negative components of the Farmers' Terms of Trade, FTT^+ and FTT^-, are not significant, with p-values of 0.8478 and 0.9464. These results indicate that changes in farmers' purchasing power do not have a direct short-run effect on food inflation. This finding is consistent with Mulyawan and Fakhruddin (2022), who noted that the impact of FTT tends to be limited in the short term compared to other factors such as government policy interventions.

The Error Correction Term (ECT) is negative and statistically significant, with a coefficient of -0.4267 and a p-value of 0.0001. This confirms the presence of a strong correction mechanism. It implies that when a short-run deviation from equilibrium occurs, the model adjusts quickly toward the long-run trend. These findings demonstrate that money supply has a significant influence on food inflation in both the short run and long run. Managing M2 is therefore essential in controlling food inflation. In addition, stabilizing the purchasing power of farmers through FTT is also necessary, particularly to avoid price spikes caused by disruptions in food production. The asymmetric effects between increases and decreases in economic variables further highlight the need for responsive and well-targeted monetary policy.

The findings of this study are consistent with international evidence on food inflation dynamics. Samal et al. (2022) show that monetary expansion increases food inflation in India through rising aggregate demand, and Malaviarachchi & Gedara (2024) report similar results for Sri Lanka. The asymmetric response of M2 aligns with Tillmann (2024); Widarjono et al. (2023) who document that increases in monetary aggregates have stronger inflationary effects than decreases because prices adjust more quickly upward than downward. Regarding FTT, the pattern that FTT positive is not significant while FTT negative is strongly significant is consistent with Yasin & Amin (2021); Loening et al. (2009) who find that declining farmers purchasing power reduces agricultural output and consequently raises food prices. These similarities confirm that the asymmetric effects found in this study follow global patterns while contributing new evidence for Indonesia.

The asymmetric influence of M2 can be explained by the monetary transmission mechanism. Increases in M2 expand liquidity and stimulate aggregate demand which creates demand pull pressures in food markets where supply responds slowly. Decreases in M2 do not reduce inflation proportionally because of downward price rigidity and the dominance of quasi money in Indonesia which does not affect consumption immediately. The asymmetric pattern of FTT also arises from agricultural production cycles. A decline in FTT restricts farmers access to inputs such as fertilizer and seeds which reduces output and raises food prices. In contrast, increases in FTT require one or more planting seasons before production expands which explains the weaker long run effect of FTT positive. These mechanisms are consistent with findings reported by Bhattacharya & Gupta (2018) and the FAO report in 2024.

7. Diagnostic Test, CUSUM, and CUSUMSQ

After estimating the NARDL model, the next step is to conduct a series of diagnostic tests. These tests are essential to ensure that the estimated model satisfies the classical assumptions required for reliable and valid inference. The diagnostic procedures include tests for autocorrelation, heteroskedasticity, normality, and linearity. Following the diagnostic checks, the stability of the model was assessed using the CUSUM (Cumulative Sum of Recursive Residuals) and CUSUMSQ (Cumulative Sum of Squares of Recursive Residuals) tests. These tests are used to verify whether the model’s parameters remain stable over the sample period, as shown in Table 8.

Table 8. Diagnostic Test Results

Test Name	Test Statistic	P-value	Decision	Interpretation
Autocorrelation (Breusch-Godfrey LM Test)	0.2571	0.7495	Fail to Reject H_0	No autocorrelation, the model is free from autocorrelation issues
Heteroskedasticity (Breusch-Pagan Test)	1.1690	0.3059	Fail to Reject H_0	No heteroskedasticity, residuals have constant variance (homoskedasticity)
Normality (Anderson-Darling Test)	0.2730	0.663	Fail to Reject H_0	Residuals are normally distributed
Linearity (Ramsey RESET Test)	1.1083	0.2697	Fail to Reject H_0	No model misspecification, linear relationship among variables

The results in Table 8 show that the model satisfies all classical diagnostic criteria. There is no evidence of autocorrelation or heteroskedasticity, the residuals are normally distributed, and the model demonstrates a correct linear specification.

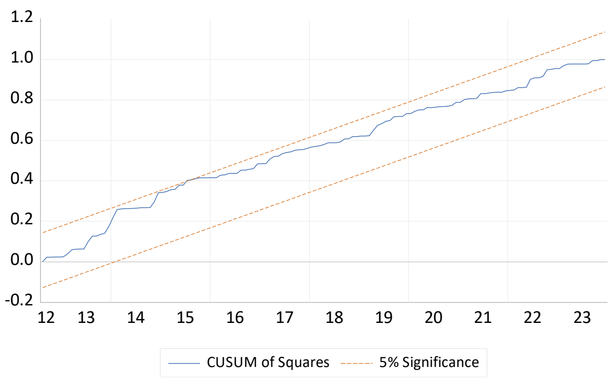


Figure 2. CUSUM Plot

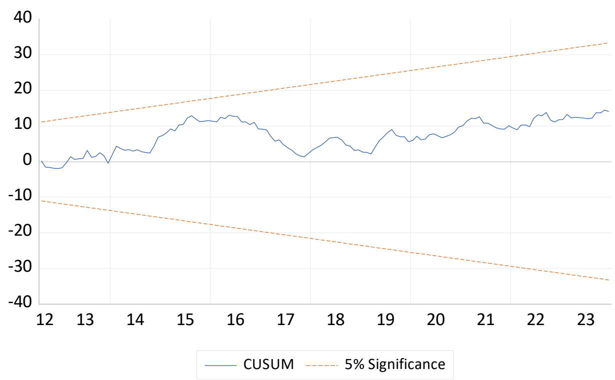


Figure 3. CUSUMSQ Plot

Figures 3 and Figures 4 show the CUSUM and CUSUMSQ plots. Both graphs confirm the stability of the model as the lines remain within the 5 percent significance boundaries. These results indicate that the estimated parameters are stable over the entire observation period, confirming the robustness of the model. The empirical results have several policy implications. The strong and asymmetric effects of M2 suggest that Bank Indonesia must manage liquidity carefully, since increases in M2 generate stronger inflationary pressure than decreases in M2 can offset. Policy tools such as open market operations, reserve requirements, and liquidity management instruments should therefore be calibrated to prevent excessive monetary expansion. The significant effect of FTT negative highlights the importance of protecting farmers purchasing power through stable input prices, improved credit access, efficient distribution of fertilizer, and fair producer price mechanisms. The findings demonstrate that monetary policy and agricultural policy must be coordinated so that demand side management of liquidity and supply side support for farmers can work together to stabilize food inflation in Indonesia.

D. CONCLUSION AND SUGGESTIONS

This study analyzes the asymmetric effects of Money Supply (M2) and Farmers Terms of Trade (FTT) on Food Inflation (FINF) in Indonesia using the NARDL approach. The findings confirm a long-run relationship among the variables. M2 shows significant long-run asymmetry, where both increases and decreases in liquidity raise food inflation. This reflects the monetary transmission mechanism in which higher liquidity stimulates aggregate demand, while reductions in M2 do not lower inflation proportionally due to price rigidity and the dominance of quasi-money. FTT also displays asymmetric effects, with only decreases in FTT significantly increasing inflation through supply-side constraints. This occurs because declining farmer purchasing power restricts access to inputs and reduces output. In the short run, M2 continues to exhibit asymmetric effects, while FTT has no immediate influence. The model explains 52.21 percent of food inflation and passes all diagnostic tests. Policy implications require more operational clarity. Bank Indonesia should enhance liquidity control through calibrated open market operations and reserve requirement adjustments. Agricultural policies should focus on stabilizing input costs, improving credit access, and ensuring efficient fertilizer distribution to protect farmers purchasing power. Future research can include variables such as exchange rates, global food prices, and climate shocks. These factors are conceptually relevant because Indonesian food prices are increasingly linked to international markets and climate variability.

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