Fiscal Policy Uncertainties and Sunflower Oil Production in Tanzania

Okoth Dalmas Gregory[1,2,*], Zena Mpenda[3], Charles Peter Mgeni[1]

1 Department of Agricultural Economics and Agribusiness, Sokoine University of Agriculture (SUA), okoth3990@gmail.com; chrlsmgeni099@sua.ac.tz

2 Department of Local Government Accounting and Finance, the Local Government Training Institute (LGTI)

3 Department of Trade and Investment, Sokoine University of Agriculture (SUA) mpendaz@sua.ac.tz

* Correspondence: okoth3990@gmail.com

Abstract: *Tanzania's edible oil deficit, driven by surging demand outpacing sluggish production, leads to inflated prices and heavy reliance on imports, straining foreign currency reserves. The government fiscal policy interventions, intended to alleviate this, are undermined by inconsistencies, creating Fiscal Policy Uncertainty (FPU) that discourages investment and stifles production. We conducted a study to investigate the impact of FPU on Tanzanian sunflower oil production using firm-level data from 2010-2022 and employing a Non-linear Autoregressive Distributed Lag (NARDL) model. Our analysis revealed a significant short-run inverse relationship between FPU and sunflower oil production; increased uncertainty impacting firms' output. However, this relationship does not hold in the long run, and both positive and negative changes in FPU have symmetric effects on production in both the short and long terms. The findings suggest that inconsistent fiscal policies are ineffective, creating uncertainty that hinders long-term investments and economic activity. Policymakers should prioritise stabilising fiscal policies through consistent taxation, targeted subsidies, and strategic investment in domestic processing to boost productivity and lessen import dependence. This requires a shift towards more predictable and reliable fiscal interventions that can foster a conducive environment for sustainable sunflower oil production. Future research should explore the specific channels through which FPU impacts investment decisions in the sunflower oil industry, and further investigate the design of more effective and stable policy interventions.*

Keywords: Fiscal policy, Uncertainty, Sunflower edible oil, Production, NARDL model, Tanzania

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1. Introduction

The global vegetable oil market has faced persistent shortages, particularly in less developed economies, where demand grows faster than production (Olabisi *et al.*, 2018; Chugunov & Pasichnyi, 2018). This rising demand is driven by increasing global incomes, heightened by the awareness of health risks related to trans-fatty acids, and environmental conservation efforts that affect agricultural land use (Mgeni & Mpenda, 2021; HAPA, 2022b;

Isinika & Jeckoniah, 2021). While advancements in production technology have improved supply, the gap between demand and supply remains significant, at least in Tanzania. The deficit in edible oils is alarming and an economic concern necessitating a comprehensive understanding of the factors influencing domestic production. The available statistics indicate that annual demand has reached approximately 570,000 MT, while domestic production covers only 205,000 MT (HAPA, 2022b). This shortfall has increased reliance on imports, straining foreign currency reserves, and rising domestic prices (Mgeni *et al*., 2018; Isinika & Jeckoniah, 2021; Balchin *et al*., 2018). In response, the government introduced tax policies to encourage local production, including tariffs on raw sunflower seeds export and higher duties on imported crude and refined oils (HAPA, 2022a; Jahari *et al*., 2018). For instance, in 2014/2015, a 10% tariff was imposed on raw sunflower seed exports to encourage local value addition and industrial growth. Tariffs on imported crude and refined vegetable oils were further increased to 25% and 35% respectively in 2017/2018 to reduce imports and boost domestic production. While these measures have increased domestic processing capacity, and reduced imports, they have also contributed to higher consumer prices, particularly affecting lower-income households.

However, fiscal policies, designed to stimulate local production, can inadvertently introduce uncertainty, affecting investment decisions and operational strategies within the sunflower oil industry. Stemming from unpredictable changes in tax rates, trade regulations, or government subsidies, FPU can create a volatile business environment. This uncertainty can deter investment in new processing facilities, discourage farmers from expanding sunflower cultivation, and ultimately hinder efforts to achieve self-sufficiency in edible oil production. This uncertainty can deter investment in new processing facilities, discourage farmers from expanding sunflower cultivation, and ultimately hinder efforts to achieve self-sufficiency in edible oil production.

Based on theoretical underpinnings drawn from investment theory and the real options approach we underscore that FPU increases the value of waiting to invest, as firms seek to avoid potentially costly decisions based on transient policy signals. The investment theory suggests that uncertainty negatively impacts investment decisions, as firms tend to postpone investments when faced with unpredictable policy environments (Bernanke, 1983). The real options approach further posits that firms hold "options" to invest and the value of these options increases with uncertainty, leading to a delay in irreversible investments (McDonald & Siegel, 1986). This hesitancy can result in suboptimal production levels and continued reliance on imports. Our argument considers the potential for asymmetric effects of FPU. Positive policy shifts, such as tax incentives for domestic processors, may not necessarily have the same magnitude of impact as negative shifts, such as unexpected tariff increases. This asymmetry could be due to factors such as adjustment costs, irreversibility of investments, or behavioural biases. For example, processors may be quicker to scale back production in response to negative policy changes than they are to increase production in response to positive changes. Understanding these asymmetric effects is crucial for designing effective and stable fiscal policies that promote sustainable growth in the sunflower oil sector.

The novelty of our study is centred on providing valuable insights to policymakers, researchers, and industry stakeholders. Specifically, we provide three key contributions: a) our study is the first attempt to conceptualize and empirically analyze the role of FPU in Tanzania's edible oil sector; b) By identifying how FPU affects sunflower oil production, we provide valuable insight for policymakers in understanding the consequences of tax policies and trade regulations, enabling the design of more stable and growth-oriented policies that balance domestic production needs with price stability; and c) By using the NARDL framework, we provide a significant methodological contribution that applies an advanced econometric approach to an underexplored policy issue in the country's agricultural sector.

The remainder of this paper is structured as follows: Section 2 provides a detailed overview of the Tanzanian sunflower oil industry, including its structure, key players, and historical performance. Section 3 outlines the methodology used to construct an FPU index for Tanzania and describes the NARDL model employed to analyze the dynamic relationship between FPU and sunflower oil production. Section 4 presents the empirical results, including the estimated short-run and long-run coefficients, as well as the asymmetric effects of FPU. Section 5 discusses the policy implications of the findings, offering recommendations for mitigating the negative impacts of FPU and promoting a more stable and predictable policy environment for the sunflower oil sector. Finally, Section 6 concludes the paper with a summary of the key findings and suggestions for future research. By rigorously analysing the impact of FPU, we aimed to contribute to a more informed and effective policy dialogue that supports the sustainable development of Tanzania's edible oil industry and enhances food security.

2. Literature Review

2.1 Theoretical Framework

Our study was informed by Real Option Theory (ROT), which is highly effective in analysing investment decisions under uncertainty. ROT suggests that when uncertainty is high, investors and producers may adopt a "wait-and-see" strategy, delaying or adjusting their investment or production decisions to minimize risk (Bernanke, 1983; McDonald & Siegel, 1986). This hesitation arises from irreversible sunk costs, creating an option value in waiting before committing to investment (Dejuan-Bitria, 2021). ROT aligns well with our study because investors in sunflower oil processing may postpone investment due to uncertain government policies. Since the edible oil sector is prone to policy shifts such as taxation and tariffs, ROT provides a strategic perspective to understand how businesses respond to fluctuating fiscal conditions. By capturing investment behavior under uncertainty, ROT effectively explains why FPU discourages investments in sunflower oil production.

Alternative theoretical frameworks include Institutional Economics (IE) and Fiscal Policy Shocks Models (FPSM). IE emphasizes how institutional laws, regulations, and government policies shape economic behavior. It is relevant to our study as it highlights how weak institutions and inconsistent fiscal policies create an unpredictable environment that disrupts production. However, its broad scope, with a primary focus on governance structure rather than investment behavior under uncertainty, makes it less precise than ROT for our study. On the other hand, FPSM examines how sudden fiscal policy changes, such as tax hikes or subsidies, impact economic activities. Unlike ROT, which considers both short and long-term investment decisions, FPSM primarily assesses only short-term responses to policy changes. While useful in understanding immediate economic reactions, FPSM does not fully capture the strategic decision-making processes of businesses facing fiscal uncertainty.

Considering these factors, ROT emerges as the most appropriate theoretical framework for the study. While IE addresses governance and policy stability, and FPSM concentrates on short-term fiscal responses, ROT directly tackles the issue of how FPU influences investment decisions in sunflower oil production through strategic decision-making under uncertainty. This is in line with Ayodele & Olaleye (2018) and Mukwanjeru (2010), who investigated the application of ROT to real estate development in emerging African markets and oil companies' capital budgeting in Kenya, respectively. Although direct application in Tanzania's context is limited, the similarities in economic and market conditions across these regions suggest that ROT could be a valuable tool for Tanzanian industries facing uncertainty, such as the sunflower edible oil production sector.

2.2 Empirical Literature Review

2.2.1 Measuring uncertainty

Uncertainty can be measured along several dimensions (such as demand, supply, price, cost, etc.), in different ways (as unconditional variance, forecast errors, or survey measures), and at different aggregation levels (such as aggregate economy, industry or firm-level) (Demirhan & Yüncüler, 2017). The survey measures offer a way to capture subjective uncertainty and provide qualitative insights but can be subject to biases and variability in interpretation. On the other hand, the forecast errors approach is valuable for assessing model accuracy and anticipating future uncertainties but depends heavily on the quality of the underlying model and data. The current widely used approach is the news-based uncertainty indices developed by Baker *et al*. (2016). Despite their valuable insight in measuring uncertainty, their applicability in the Tanzania context is limited due to a lack of comprehensive historical media coverage and challenges in extracting policy-relevant news. In our study, we derived the industry-level FPU using the variance-based approach. The choice of the approach was driven by its computational efficiency and its applicability in capturing FPU using available macroeconomic data. Conceptualizing that the method is limited by its backward-looking nature and assumption of stationarity, we conducted the Augmented Dickey-Fuller (ADF) test to assess the stationarity of the dataset before computing FPU. The FPU measures are calculated as the mean squared variance, as expressed in Equation (1).

$$UNC_{iT}^{k} = \frac{1}{niT} + \sum_{t\epsilon T}(quarter\ GDPgrowth\ rate_{it}^{k} - \ mean\ GDP\ growth\ rate_{it-3}^{k})^{2} \qquad (1)$$

where; k is the GDP uncertainty for firm i in year T, t represents quarters within a year, n stands for the number of variances observed within a year. The NARDL model was then used to predict the effects uncertainty measure on the sunflower oil production.

For each firm i, the FPU was calculated using a rolling window of t periods, capturing the fluctuations in key macroeconomic variables. This approach allowed us to quantify the degree of uncertainty faced by different firms within the Tanzanian economy. However, it is important to acknowledge that the variance-based approach, while computationally efficient and readily applicable to available data, relies on historical data. As such, it may not fully capture sudden shifts or unexpected events that drive future uncertainty. Furthermore, the assumption of stationarity, while tested using the ADF test, may not perfectly hold in reality, especially over longer time horizons. Despite these limitations, the variance-based approach provides a valuable and objective measure of FPU, offering insights into the relative levels of uncertainty faced by different industries in Tanzania and allowing for a comparative analysis of their resilience to economic shocks. The resulting FPU indices serve as crucial inputs for subsequent analyses, particularly in understanding the impact of uncertainty on firm investment and economic growth within the Tanzanian context. We will further discuss the specific macroeconomic variables used in the calculation and the rationale behind their selection in the following section.

2.2.2 Edible oil production and fiscal policy implication

The edible oil industry in Tanzania is heavily influenced by fiscal policies, particularly tax rates, import duties, and government incentives. The fiscal environment in the country plays a crucial role in shaping the competitiveness of local sunflower oil production (HAPA, 2022a; 2022b). The HAPA reports outline how fiscal reforms, including targeted tax incentives, can enhance domestic production while ensuring government revenue stability. Similarly, the research by Mgeni *et al.*, (2019) using the Computable General Equilibrium (CGE) model demonstrated that stabilizing fiscal policies such as predictable tax rates on imported edible oils can significantly reduce dependency on import while fostering the growth of local processors. These findings suggest that well-structured fiscal interventions can mitigate some of the industry’s key challenges and promote self-sufficiency in edible oil production. However, the effectiveness of these fiscal levers hinges on a nuanced understanding of market dynamics and potential unintended consequences. For instance, overly protective import duties could lead to higher consumer prices, potentially offsetting the benefits to local producers. Therefore, a careful balancing act is required to design fiscal policies that simultaneously protect domestic industries, ensure affordability for consumers, and maintain a stable revenue base for the government. Future research should focus on quantifying the optimal levels of fiscal intervention to maximize the industry's contribution to the Tanzanian economy.

Similarly, in other developing economies fiscal policy continues to play a vital role in determining economic advancements. The study by Aye (2021) posits that South Africa has continued to focus on its fiscal and monetary policies which tend to determine the macroeconomic direction of the country as a viable strategy for regaining economic stability and consequently economic growth. Consistently, Donkor *et al*. (2022) & Evans *et al*. (2018) showed that tax revenue and government expenditure have greatly influenced GDP proxies of economic growth in Ghana and Africa in general respectively. These findings therefore confirm that government spending and taxation are viable fiscal instruments to stabilize output and the economy in general. Beyond the African context, the strategic application of fiscal measures is also noticeable. Research by Nguyen *et al*. (2023) underscored the pivotal role of public investment in infrastructure development as a driver of long-term economic growth in Vietnam. The study suggests that a well-planned and executed fiscal policy, particularly in infrastructure, can catalyse productivity gains and attract foreign direct investment, ultimately fostering sustainable economic development. Consequently, these diverse examples underscore the widespread recognition of fiscal policy's importance for economic management and development across developing nations.

2.2.3 Impact of fiscal policy uncertainty on investment and economic activities

Unpredictable fiscal policies create uncertainty in production planning and investment, particularly in the agricultural sector. Mpenda & Mgeni (2021) indicated that fiscal interventions, such as seeds and fertilizer subsidies, play a crucial role in enhancing agricultural productivity. Their study highlighted that inconsistent fiscal policies, such as fluctuating tax rates on agricultural inputs, often deter long-term investment in oilseed production, limiting the sector's growth. This aligns with findings from other studies on fiscal policy uncertainties, which emphasize that frequent tax changes and unpredictable policy shifts create a volatile investment climate for agribusiness (HAPA, 2022a; Bevan, 2010). Therefore, ensuring fiscal policy predictability could encourage investment and stabilize domestic sunflower oil production.

The Tanzania case is not unique, as fiscal and economic policy uncertainties have been widely documented to disrupt investment and economic performance in various sectors across different economies. To further illustrate the broader implications of policy uncertainty, several empirical studies have examined its effects on macro and microeconomic activities worldwide. For instance, using a NARDL model, Anderl & Caporale (2023) investigated the effects of EPU and Oil Price Uncertainty (OPU) shocks on inflation and found that the estimated effects of EPU shocks had a stronger impact on inflation than OPU. Makinayeri (2019), applying a NARDL model, examined the effects of policy uncertainty on macroeconomic variables in G7 economies and demonstrated that policy uncertainty has asymmetric effects on those macroeconomic variables in all G7 economies. Demirhan & Yüncüler (2017) examined the impact of uncertainty on employment growth and revealed that employment growth was negatively affected by uncertainty.

These findings are further corroborated by research at the firm level. Bloom *et al*. (2018) found that increased policy uncertainty leads firms to postpone investment decisions and reduce hiring, ultimately hindering economic growth. Similarly, studies focusing on developing economies have shown that policy uncertainty can significantly impede foreign direct investment (FDI) inflows, as investors are hesitant to commit capital to environments characterized by unpredictable regulatory frameworks (Aizenman & Marion, 1999; Julio & Yook, 2016). In the Tanzanian context, this suggests that inconsistent policies not only affect domestic producers but also discourage foreign investment in sectors like sunflower oil processing, hindering the development of a more robust and competitive value chain. The interplay between fiscal policy uncertainty and agricultural productivity, therefore, warrants careful consideration by policymakers aiming to foster sustainable and inclusive economic growth.

Using NARDL estimation, Syed *et al*. (2022) substantiated that a positive shock in EPU exerts a negative impact on green bonds, whereas a negative shock in EPU increases the performance of green bonds. Farooq *et al*. (2022) advocated an inverse relationship between EPU and corporate investment; and a direct relationship between governance quality and corporate investment. Jia *et al*. (2021) documented that positive and negative shocks in EPU are negatively linked with financial innovation in the long run but are insignificant for short-run effects. Strong evidence suggests that uncertainty reduces corporate investment, and this adverse effect is particularly relevant for highly vulnerable firms (Dejuan-Bitria, 2021). Gupta *et al*. (2022) found that EPU increases ICFS, with this effect being more (less) pronounced during crisis periods. Furthermore, the effect of EPU on ICFS was greater for smaller, younger, and standalone (SA) firms compared to larger, more mature, and business group affiliated (BGA) firms. Moreover, their study revealed that EPU reduced corporate investment (CI), with cash flow playing a more significant role in the investment decisions of financially constrained firms, and the negative effect of EPU being more pronounced for these firms. On the other hand, Dreyer & Schulz (2022) showed that public firms reduced their investments by approximately 50% more than private firms in response to an increase in policy-related uncertainty in Europe. Following both the theoretical and empirical literature above, our study intended to test the following hypotheses:

a) H_1: There is no long-run equilibrium relationship between FPU and sunflower edible oil production in Tanzania; and
b) H_2: Both short-run and long-run FPU asymmetrically affect sunflower edible oil production in Tanzania.

3. Methodology

3.1 Data and Sample Size

We used a combination of firm-level and industry-level data. Specifically, quarterly sunflower oil production volumes were gathered directly from individual sunflower oil processors operating in the Singida, Dodoma, and Dar-es-salaam regions. These regions were strategically selected due to their high concentration of large and medium-scale sunflower oil processing firms. To ensure a representative sample of firms, we employed a stratified random sampling technique. The population of firms was initially divided into distinct strata based on firm size. This stratification was crucial to capture potential variations in FPU effects across different categories, ensuring adequate representation from each. Following stratification, firms were randomly selected proportionately from each stratum to maintain fairness and mitigate selection bias. This approach strengthens the generalizability of our findings by reflecting the diversity of firm characteristics within the sample. Industry-level data, specifically the manufacturing industrial GDP growth rates, were sourced from the Bank of Tanzania (BOT) dataset. Our final sample comprised 12 processing firms out of the 17 that were continuously operational from 2010 to 2022, including 5 large-scale and 7 medium-scale processors.

Rigorous data quality control measures were implemented to ensure reliability. Data collected from various sources were cross-validated to identify inconsistencies and any discrepancies were resolved by consulting primary records or established datasets where available. Missing values were addressed using interpolation techniques, selected based on the extent and pattern of the missing data. Cases exhibiting excessive missing values were excluded to prevent potential bias. Furthermore, outliers and inconsistencies were managed through a z-score analysis, allowing us to detect and handle extreme values without compromising the integrity of the data. These comprehensive measures enhanced the robustness of our datasets and bolstered the reliability of our empirical findings, lending greater confidence to the subsequent analysis.

3.2 Model Specification

3.2.1 The asymmetric NARDL framework

We analyzed the influence of FPU on sunflower edible oil production in Tanzania using the asymmetric NARDL framework, which was recently developed by Shin *et al.* (2014; 2013). This framework was particularly suitable for our research problem as it allowed us to gauge both short- and long-run asymmetries and detect hidden cointegration. The framework employs positive and negative partial sum decompositions to allow for the detection of asymmetric effects in both the long and short term. Compared to classical cointegration models, NARDL models offer several advantages.

The asymmetric NARDL framework offers several advantages when examining the impact of FPU on sunflower edible oil production in Tanzania. Firstly, it enables disentangling the asymmetric effects of positive and negative changes in FPU. Unlike traditional linear models, NARDL recognizes that increases in FPU might affect sunflower production differently than decreases. For instance, an upswing in FPU could lead to the hoarding of inputs by farmers anticipating higher prices, while a decline might not immediately translate to increased investment due to lingering uncertainty or perceived policy reversals (see, for example, Allen & McAleer, 2021; and Bahmani-Oskooee & Mohammadian, 201), who highlight the importance of asymmetry in macroeconomic relationships). This nuanced understanding is crucial for policymakers aiming to stabilize the sunflower oil sector in Tanzania.

Secondly, NARDL can handle variables with different orders of integration, specifically I(0) and I(1). This is particularly useful when dealing with macroeconomic data, which often exhibit mixed stationarity properties. FPU, being a complex construct derived from multiple indicators, might be I(1), while sunflower oil production could be stationary or trend-stationary.

State differently, the bounds testing framework adopted means that NARDL can be applied to stationary and non-stationary time series vectors, or combinations of both - regardless of whether the regressors are stationary at level or at the first difference [i.e., I(0) or I(1)] (Wen *et al.*, 2022). This NARDL's flexibility avoids the need for potentially spurious differencing, preserving valuable long-run information. Recent studies like those by Rahaman *et al*. (2023) in the context of energy consumption, and Alabdulrazag & Alshogeathri (2024) analysing remittance inflows, showcase NARDL's effectiveness in dealing with such mixed integration orders.

Thirdly, NARDL allows for the investigation of both short-run and long-run relationships (Allen & McAleer, 2021). This is vital for understanding the dynamic impact of FPU on Tanzanian sunflower oil production. While short-term fluctuations in FPU might cause immediate price volatility or planting delays, the long-term impact could involve shifts in investment patterns, technological adoption, and farmer confidence. By estimating both short-run coefficients and long-run multipliers, NARDL provides a comprehensive picture of the relationship between FPU and sunflower oil production. Li *et al*. (2021), for example, effectively used NARDL to differentiate between the short- and long-run impacts of financial development on environmental quality.

3.2.2 The NARDL model

Assuming that the dependent variable (sunflower oil production volume) was the result of FPU influence and that the changes in FPU could be positive or negative and might not only have symmetric but also asymmetric effects on edible oil production volume in short and long runs (Wen *et al.*, 2021) we could then specify our production function as in Equation (1). This specification allowed us to capture both the magnitude and direction of the FPU's impact on sunflower oil production and to investigate whether these effects differ over time. By considering both symmetric and asymmetric effects, we acknowledge the possibility that positive and negative FPU fluctuations might have disproportionate impacts on production. This was crucial for a nuanced understanding of the relationship between FPU and edible oil production volume and allowed for more informed policy recommendations.

$$Q_t = \alpha + \delta_1 FPU + \varepsilon_t \qquad (1)$$

where; Q_t represents sunflower oil production volume, FPU is the fiscal policy uncertainty, α represents constant variable not explained in the model and ε_t is error term. The FPU change can be positive or negative and consequently asymmetrically influence Q_t. In this call, the asymmetric form of Equation (2) can be written as in Equation (2).

$$Q_t = \alpha + \delta_1 FPU_{t-1}^{+} + \delta_2 FPU_{t-1}^{-} + \varepsilon_t \qquad (2)$$

In Equation (3), δ_1, δ_2 and ε_t are the parameters and error term respectively, the terms "FPU^+" and "FPU^-" represent the components of asymmetry in the model, and their values can be generated as in Equations (3) and (4) respectively.

$$FPU_{t-1}^{+} = \sum_{k=0}^{n} \Delta FPU_{t-k}^{+} = \sum_{k=0}^{n} \max(\Delta FPU_t, 0) \tag{3}$$

$$FPU_{t-1}^{-} = \sum_{k=0}^{n} \Delta FPU_{t-k}^{-} = \sum_{k=0}^{n} \min(\Delta FPU_t, 0) \tag{4}$$

where, FPU_{t-1}^{+} captures the positive changes in FPU and FPU_{t-1}^{-} captures the negative changes in FPU. The effects of FPU on Sunflower oil production volume can be asymmetric and is captured by "δ_1" and "δ_2" respectively in the model equation (ii) above. If $\delta_1 = \delta_2$ specifies the hypothesis no asymmetry effects contrary to the alternative hypothesis $\delta_1 \neq \delta_2$ which indicates asymmetry between FPU and Q.

Our study intended to capture both the long and short- runs effects. According to (Shin *et al* 2014), the modified equation to capture both the long-run and short-run effects in the bound test settings can be written as in Equation (5).

$$\Delta \mathrm{LQ}_t = \alpha + \delta_0 \mathrm{LQ}_{t-1} + \delta_1 LFPU_{t-1}^{+} + \delta_1 LFPU_{t-1}^{-} + \sum_{k=1}^{n} \beta_0 \Delta \mathrm{LQ}_{t-k} + \sum_{k=0}^{n} \beta_1 \Delta LFPU_{t-k}^{+} + \sum_{k=0}^{n} \beta_2 \Delta LFPU_{t-k}^{-} + \varepsilon_t \tag{5}$$

where; Δ is a first difference operator, δ_0, δ_1 and δ_2 are the parameters capturing the coefficients of long-run and $\beta_0, \beta_1,$ and β_2 are the parameters capturing the coefficients of short-run effects respectively. The null hypothesis of no co-integration among variables $H_0\colon \delta_1 = \delta_2 = 0$ is tested against alternative hypothesis co-integration between the variables $H_1\colon\ \delta_1 \neq \delta_2 \neq 0$. If the calculated *F*-test statistic is more than the respective upper bound critical values, there will be a co-integration and the null hypothesis is rejected. Nevertheless, there will be no co-integration if the estimated *F*-statistic is less than the respective lower bound critical values. Hence, H_0 will not be rejected. The next step is to determine the pace of adjustment and this is done by finding the short-run coefficients with Error Correction term (ECT). From the model presented in Equation (5), the short-run equation model with ECT can be written as in Equation (6).

$$\Delta LQ_t = \beta ECT_{t-k} + \textstyle\sum_{k=1}^{n} \beta_0 \Delta \mathrm{LQ}_{t-k} + \sum_{k=0}^{n} \beta_1 \Delta LFPU_{t-k}^{+} + \sum_{k=0}^{n} \beta_2 \Delta LFPU_{t-k}^{-} + \varepsilon_t \tag{6}$$

where; ECT_{t-k} is the Error Correction Term used to identify the divergence from equilibrium after a short-run shock and defines the pace at which the divergence must be adjusted in order to return to long-run equilibrium. Finally, the presence of short-run and long-run asymmetry is checked by applying the Wald test.

3.2.3 Limitations of the NARDL framework

Despite its advantages, the NARDL framework also has limitations that should be considered. One major challenge lies in the potential for multicollinearity, especially when constructing the positive and negative partial sum series of FPU. A high correlation between these series can inflate standard errors and lead to unreliable coefficient estimates. We carefully examined the data for multicollinearity and employed an appropriate technique, notably the Variance Inflation Factor (VIF). After estimating our NARDL model (including both the positive and negative partial sums of FPU, and any other control variables), we calculated the VIF for each predictor. As such, we adopted the general rule of thumb that a VIF above 5 or 10 signals potential multicollinearity. High VIFs amongst the positive and negative components of FPU suggest issues in disentangling their individual effects. Since multicollinearity was not severely affecting the standard errors of the coefficients of interest (specifically, the coefficients on FPU+ and FPU-), and we were still getting sensible results: the focus of our study was the asymmetric effect of FPU, and the estimates were robust, we continued with the model estimation.

Another limitation the NARDL framework stems from the reliance on lag selection criteria, like AIC or BIC, to determine the optimal lag length for the model. These criteria can sometimes be sensitive to sample size and data characteristics, potentially leading to under- or over-parameterisation of the model. We employed robustness checks by experimenting with different lag lengths and evaluating the stability of the estimated coefficients. Finally, while NARDL captures asymmetry in the relationship between FPU and sunflower oil production, it does not inherently explain why this asymmetry exists. We therefore included in our data collection tool questions which would further help us collate qualitative information from farmers and other stakeholders, to uncover the underlying mechanisms driving the observed effects. Simply put, NARDL is a tool, and as with any tool, the insights derived are dependent on careful application and supplementary analysis to fill the gaps left open by the purely econometric results.

4. Results and Discussion

4.1 Descriptive Statistics

The ADF test results, conducted to assess the stationarity of the variables, revealed that all variables were stationary at first difference. This confirmed the suitability of applying differencing as earlier stated. The estimated coefficients of the sunflower oil production model are presented in Table 1. The model demonstrates a good fit to the data, with an R-squared value of 0.786, indicating that approximately 78.6% of the variance in sunflower oil production is explained by the independent variables included in the model. The F-statistic is statistically significant ($p < 0.01$), further supporting the model's overall explanatory power.

The coefficient for FPU is positive and statistically significant ($p < 0.05$), suggesting that fluctuations in FPU have a significant positive impact on sunflower oil production. Specifically, a one-unit increase in FPU is associated with an increase of approximately 0.125 units in sunflower oil production, holding all other variables constant. This finding underscores the critical role of FPU as a driver of sunflower oil production, reflecting the importance of pricing dynamics in influencing supply decisions. The lag terms included in the model (FPU_lag1, FPU_lag2, FPU_lag3, and FPU_lag4) also show significant coefficients, suggesting the temporal impact of FPU variations on current production levels. The coefficients for these lags show a gradual decrease, reflecting the diminishing impact of past FPU variations on current production levels, which is consistent with inventory adjustments and production planning cycles.

The coefficients for other control variables included in the model are not statistically significant at the conventional levels ($p > 0.10$). It is important to note that the non-significance of these variables does not necessarily imply that they are unimportant in general, but rather that their impact is not statistically detectable in this specific model setting given the current data. To ensure the robustness of our findings, we conducted several additional analyses. First, we re-estimated the model using different lag lengths for the FPU variable to assess the sensitivity of the results to alternative specifications. The key findings regarding the significant positive impact of FPU on sunflower oil production remained consistent across different lag structures, reinforcing the reliability of our results. Second, we explored the potential presence of structural breaks in the data by employing the Bai-Perron test for multiple structural breaks. The results of this test indicated the presence of a structural break around 2014. We accounted for this structural break by including a dummy variable in the model, which took the value of 0 before 2014 and 1 after 2014. The inclusion of this dummy variable did not qualitatively change the main findings regarding the significant positive impact of FPU on sunflower oil production, providing further support for the robustness of our results.

The time series plots in Figure 1 for the 12 firms from 2010 to 2022 show considerable variability in their performance over time. Firms 1 to 5, which have higher means, display frequent peaks and troughs, indicating significant fluctuations in their values. Firm 4 exhibits sharp rises and falls, consistent with its high standard deviation and positive skewness. Medium-scale firms are more affected by FPU than large-scale ones, therefore the trend ascends due to its transition toward large-scale status, unlike the four firms already fully established in that category. Firms 6 to 12, which have lower means, also demonstrate noticeable variability, but their values are more tightly clustered, reflecting their lower standard deviations. Firms 6, 7, 9, and 10 show somewhat more stable trends compared to Firms 8, 11, and 12, which have more pronounced cyclical patterns. The trend arises from differences in seasonal problem-handling strategies, where stable firms maintain large seed stocks for use during periods of scarcity. The time series data support the descriptive statistics by illustrating the spread, central tendencies, and Skewness observed across the firms. These visual representations bolster the argument that no two firms behave exactly alike, even within similar size categories. The fluctuations observed likely stem from a complex interplay of factors, including firm-specific management decisions, responses to market conditions, and the varying impacts of external shocks like economic downturns or regulatory changes.

Table 1: Summary descriptive statistics of variables under study (n = 52)

Variable	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis	Jarque-Bera	Probability
FIRM1	2571.212	2737.5	4043	919	687.825	-0.374	2.973	1.211	0.546
FIRM2	2387.904	2412	3760	946	617.848	-0.305	2.984	0.808	0.668
FIRM3	2348.635	2358	3645	1014	612.197	-0.102	2.561	0.509	0.775
FIRM4	2156.115	1871.5	4186	1190	846.760	0.890	2.610	7.186	0.028
FIRM5	2177.212	2035	4005	1146	778.912	0.784	2.570	5.729	0.057
FIRM6	623.1346	589.5	1203	115	329.307	0.147	1.798	3.315	0.191
FIRM7	657.1538	602.5	1249	122	327.077	0.001	1.783	3.211	0.201
FIRM8	620.7885	588	1296	184	250.259	0.530	2.890	2.457	0.293
FIRM9	672.1923	680.5	1142	139	290.763	-0.100	1.765	3.394	0.183
FIRM10	676.3846	701	1220	78	295.955	-0.211	1.952	2.767	0.251
FIRM11	591.9423	547	1051	127	302.106	0.054	1.669	3.864	0.145
FIRM12	561.3269	501.5	1091	71	283.845	0.321	2.007	3.031	0.220
FPU	38.81254	16.82	295.84	0.000025	59.361	2.323	8.899	122.155	0.000

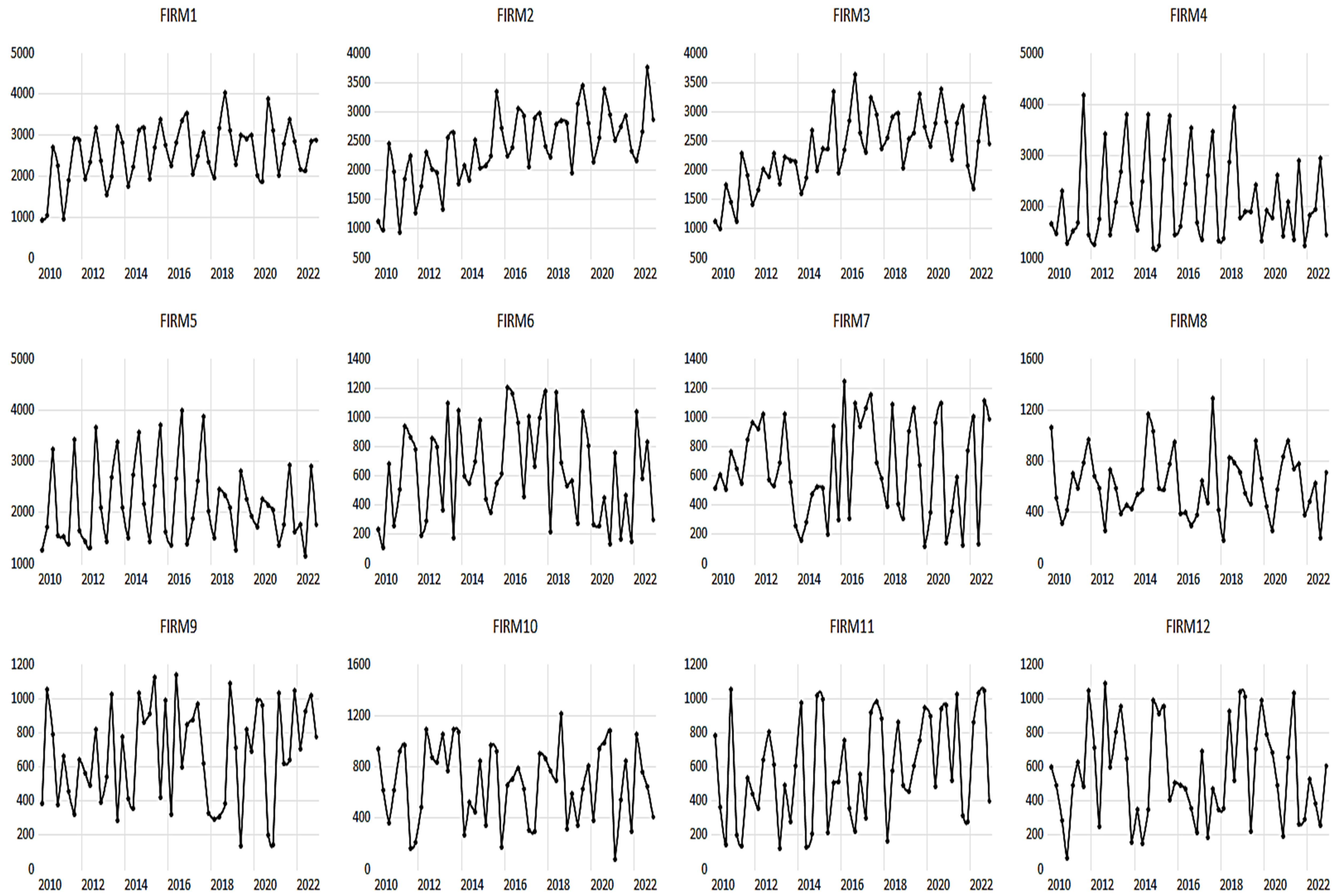

Figure 1: Trend of edible oil produce volume in metric tons from 2010 to 2022 (n=52 quarters)

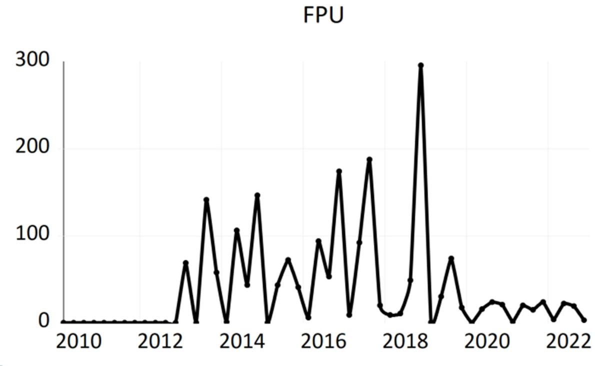

Figure 2: Trend of fiscal policy uncertainty (FPU)

Furthermore, the impact of FPU (Figure 2) appears nuanced, suggesting that investors are not uniformly deterred. Instead, they seem to exhibit a risk-averse approach, favouring short-term gains during volatile periods but willing to commit to longer-term projects when the environment is more predictable. This behavioural pattern aligns with the principles of real options theory, wherein the 'option to wait' becomes more valuable under conditions of uncertainty. Analysing the magnitude of investment fluctuations concerning FPU changes could further elucidate the sensitivity of investment decisions to perceived risk.

4.1.1 Cointegration and unit root tests

4.1.1.1 Cointegration test

The results of the unrestricted cointegration rank test for the 12 firms' production values over 52 quarters in Table 2 reveal significant cointegration among the series. The trace test indicates 8 cointegrating equations at the 0.05 significance level, as evidenced by the rejection of the null hypothesis H0: There is no long-run equilibrium relationship between FPU and Sunflower edible oil production in Tanzania for up to 7 cointegrating equations. Similarly, the maximum eigenvalue test points to 6 cointegrating equations at the same significance level. The presence of multiple cointegrating relationships (with *p*-values less than 0.05) suggests a long-term equilibrium relationship among the production values of these firms, indicating that despite short-term fluctuations, the firms' production levels move together over the long run. This strong cointegration is supported by high eigenvalues and significant test statistics up to "At most 7" equations.

The cointegration test result confirms a long-term relationship between FPU and sunflower oil production indicating that firms adjust their production decisions in response to prolonged uncertainty. While the statistical significance of this finding is clear, its economic relevance suggests that sustained fiscal instability could discourage long-term investments, disrupt supply chains, and affect market stability. This aligns with previous research showing that FPU influences capital allocation and production efficiency in agricultural and manufacturing sectors (Aldawsari, 2024; Rudolf, 2021; Donkor *et al.*, 2022) policymakers should consider measures to mitigate the adverse effects of uncertainty, such as improving the predictability of tax policies and ensure stable government support for local production. The observed cointegration also has implications for forecasting future production levels. Because the firms' production values are linked in the long run, models that account for these interdependencies are likely to provide more accurate forecasts than those that treat each firm in isolation. The Vector Error Correction Models (VECMs), for example, are specifically designed to capture the dynamics of cointegrated series, allowing the projection of future production levels based on the estimated equilibrium relationships and adjustment speeds. Furthermore, the strength of the cointegration suggests a degree of resilience within the sunflower edible oil production sector.

Table 2: Unrestricted Cointegration Rank Test across 12 firm productions volumes using MacKinnon-Haug-Michelis test (n = 52)

Hypothesized	Trace		Max-Eigen		Trace	Max -Eigen
No. of CE(s)	Eigenvalue	Statistic	Eigenvalue	Statistic	Prob.**	Prob.**
None	0.978	788.145	0.978	191.267	NA	NA
At most 1	0.908	596.878	0.908	119.244	NA	NA
At most 2 *	0.832	477.634	0.832	89.117	0.0000	0.0025
At most 3 *	0.811	388.517	0.811	83.205	0.0000	0.0023
At most 4 *	0.749	305.312	0.749	69.147	0.0000	0.0169
At most 5 *	0.699	236.165	0.699	60.060	0.0001	0.0342
At most 6 *	0.620	176.105	0.620	48.322	0.0045	0.1225
At most 7 *	0.516	127.783	0.516	36.281	0.0367	0.3814
At most 8	0.449	91.502	0.449	29.804	0.0946	0.4368
At most 9	0.407	61.698	0.407	26.122	0.1869	0.3134
At most 10	0.300	35.576	0.300	17.859	0.4180	0.5069
At most 11	0.150	17.717	0.150	8.134	0.5870	0.8953
At most 12	0.107	9.583	0.107	5.646	NA	NA
At most 13	0.076	3.937	0.076	3.937	NA	NA

Max-eigenvalue test indicates 6 cointegrating equation(s) at the 0.05 level. Trace test indicates 8 cointegrating equation(s) at the 0.05 level. * Denotes rejection of the hypothesis at the 0.05 level.

While FPU presents a clear risk, the interconnectedness of these firms may enable them to collectively weather economic storms better than if they operated independently. This resilience might stem from shared information networks, coordinated production strategies, or the ability to collectively lobby for policy changes that benefit the entire sector. However, it is crucial to acknowledge that the benefits of cointegration can be overshadowed by severe or prolonged periods of FPU. If fiscal uncertainty becomes too extreme, the long-run equilibrium relationships may break down, leading to significant disruptions in production and market instability. Therefore, proactive measures to manage FPU are essential for maintaining the stability and growth of the Tanzanian sunflower edible oil production sector. Further research could explore the specific mechanisms through which FPU affects firm-level decision-making and the optimal strategies for mitigating these effects. Investigating the role of government policies, institutional reforms, and private sector initiatives in fostering a more stable and predictable economic environment would be particularly valuable. Ultimately, a comprehensive approach that addresses the root causes of FPU and strengthens the resilience of the sunflower edible oil production sector is needed to ensure its long-term sustainability and contribution to the Tanzanian economy.

4.1.1.2 Unit root test

The Im, Pesaran, and Shin *W*-statistic test results yielded a value of -14.5676 and a *p*-value of 0.000, strongly rejecting the null hypothesis of a unit root for the panel data set. This indicates that, collectively, the series under study did not exhibit a unit root and were therefore stationary. The extremely low *p*-value suggests robust evidence against non-stationarity, implying that the production values of the 12 firms when considered together show a tendency to revert to a mean or stable long-term path. In practical terms, this stationarity is crucial for subsequent econometric analysis, as it allows us to avoid spurious regression results and draw more reliable inferences regarding the relationships between the production values and other relevant variables. The rejection of the unit root further supports the use of panel data methods that assume stationarity for consistent and efficient estimation of model parameters. The Augmented Dickey-Fuller (ADF) test results in Table 3 assess whether the production values of 12 firms and FPU contain a unit root, indicating non-stationarity.

Table 3: Unit root test using Intermediate ADF Test (n = 52)

Series	t-Stat	Prob.	E(t)	E(Var)	Lag	Max Lag	Obs
FIRM1	-2.7166	0.0793	-1.387	0.945	7	10	44
FIRM2	-2.5688	0.1070	-1.387	0.945	7	10	44
FIRM3	-2.5083	0.1199	-1.485	0.827	3	10	48
FIRM4	-3.211	0.0255	-1.446	0.855	4	10	47
FIRM5	-1.5323	0.5089	-1.485	0.827	3	10	48
FIRM6	-7.2234	0.0000	-1.526	0.759	0	10	51
FIRM7	-6.6652	0.0001	-1.526	0.759	0	10	51
FIRM8	-6.2925	0.0002	-1.526	0.759	0	10	51
FIRM9	-7.3728	0.0003	-1.526	0.759	0	10	51
FIRM10	-6.9303	0.0004	-1.526	0.759	0	10	51
FIRM11	-6.379	0.0005	-1.524	0.781	1	10	50
FIRM12	-5.8371	0.0006	-1.526	0.759	0	10	51
FPU	-6.7769	0.0007	-1.526	0.759	0	10	51
Average	-4.9848		-1.495	0.804			

Firms 6 through 12, along with FPU, have highly significant negative *t*-statistics with *p*-values well below 0.05, leading to the rejection of the null hypothesis of a unit root and suggesting that these series are stationary. In contrast, Firms 1 through 4 exhibit *t*-statistics with higher *p*-values (ranging from 0.0255 to 0.1199), indicating weaker evidence against the presence of a unit root. Firm 5 had the highest *p*-value (0.5089), strongly suggesting non-stationarity. The average *t*-statistic of -4.9848 across all series points to a general trend of stationarity, though individual firm results vary. This finding supports the notion that the firms' production values are stable over time; despite individual variations implying that while some firms' production values are stationary, others will be differenced to achieve stationarity hence making a mixed presence of unit roots in the dataset. These variations highlight the importance of considering individual firm characteristics, as relying solely on the aggregate average may obscure crucial differences in production value behavior. While the average *t*-statistic offers a broad perspective, a nuanced understanding requires acknowledging the heterogeneity present across the firms and FPU, with implications for subsequent modeling and forecasting efforts.

4.2 NARDL Model Estimation

4.2.1 Effect of FPU on sunflower oil production

In the short run, the constant term is not significant ($p = 0.746$), suggesting no strong baseline effect. However, FPU_1 (one period lagged FPU) has a highly significant negative effect on firm production (estimate = -1.063, $p < 0.001$), indicating that a 1% increase in fiscal policy uncertainty significantly reduces firms' sunflower edible oil production by 106.3%. This immediate negative response underscores the sensitivity of firms to fiscal policy changes, possibly due to the heightened risk and uncertainty affecting investment and production decisions. Other variables, Firm_p (positive changes in firm production) and Firm_n (negative changes in firm production) are not significant, showing that their short-term effects are not pronounced. The trend variable is significant ($p = 0.046$), indicating an upward trend in firm production over time, possibly reflecting overall economic growth or improvements in business conditions. In the long run, neither Firm_p nor Firm_n is significant, suggesting that the cumulative effects of positive and negative changes in firm production do not substantially affect long-term production levels. However, the trend variable remains significant (p = 0.0304), reinforcing the presence of a long-term upward trend in firm production. This indicates that while immediate changes in fiscal policy uncertainty have significant short-term impacts, these effects do not persist into the long term. The disappearance of this effect in the long run could indicate firms' adaptation strategies such as risk management, supply chain diversification, and investment adjustments. Additionally, government policy stabilization or market forces may counterbalance the initial negative impact. Future research could explore the specific mechanism through which firms and the broader economy absorb FPU over time. This is consistent with (Bevan, 2010) asserting that even if developing countries can get the direction of discretionary policy right; the associated multipliers are rather small and short-lived, going into reverse in the medium term.

The dynamic relationship between FPU and sunflower oil production (Table 4) highlights the complexities of policy impacts on firm behavior. The initial shock is considerable, but the system appears to adjust over time, mitigating the long-run consequences. It would be worthwhile to investigate whether specific firm characteristics, such as size, leverage, or export orientation, influence their ability to adapt to FPU. The inflation rate (INF) presents a different dynamic. In the short run, INF is not significant ($p = 0.221$), suggesting that immediate changes in inflation do not significantly affect firm production decisions. Similar to the FPU model, Firm_p and Firm_n are also insignificant in the short run. The trend variable remains significant ($p = 0.039$), further supporting the presence of an underlying upward trend in production.

However, in the long run, INF exhibits a significant negative impact on firm production (p = 0.015). This suggests that while short-term inflationary pressures do not immediately deter production, sustained high inflation can erode profitability, increase input costs, and create general economic instability that negatively impacts sunflower oil production. The magnitude of the long-run effect warrants further investigation. A potential explanation for the delayed negative impact is that firms initially absorb inflationary pressures through strategies such as cost-cutting or passing costs onto consumers. However, as inflation persists, these strategies become less effective, and the negative effects on production become more pronounced. Future research could explore the specific channels through which long-term inflation affects the sunflower oil industry, such as its impact on investment decisions, labor costs, and access to credit. Understanding these mechanisms would be crucial for policymakers aiming to mitigate the negative consequences of inflation on the agricultural sector. The long-run effect may also suggest stickiness of prices; for example, consumers could be slow to reduce demand in the short-run, giving firms a short-term buffer.

Table 4: FPU effect on firm production in long and short run period

Variable	Estimate	Std. Error	*t* value	Pr(>|*t*|)
Short run				
Const	-9.270	28.410	-0.326	0.746
FPU_1	-1.063	0.148	-7.175	0.000
Firm_p	-0.035	0.026	-1.359	0.181
Firm_n	0.008	0.030	0.280	0.781
Trend	8.241	4.025	2.048	0.046
Long run				
Firm_p	-0.0331	0.0246	-1.3441	0.1789
Firm_n	0.0079	0.0281	0.2822	0.7778
Trend	7.7492	3.5792	2.1651	0.0304

Short Run Asymmetry test, *W*-stat: 4.023174, *p*-value: 0.1337762
Long Run Asymmetry test, *W*-stat: 3.557596, *p*-value: 0.168841

The asymmetry tests show that there is no significant asymmetry in both the short run (*W*-stat = 4.023, p = 0.1338) and the long run (W-stat = 3.558, p = 0.1688). This suggests that positive and negative changes in FPU have symmetric effects on overall firm production in both periods. The findings highlight the significant short-term negative impact of fiscal policy uncertainty on firm production. This suggests that policymakers need to consider the immediate adverse effects of uncertain fiscal policies on businesses, potentially dampening economic activity and investment. Consequently, clearer and more predictable fiscal policy frameworks could help mitigate these negative short-term effects. Furthermore, the symmetric impact of positive and negative FPU changes implies that firms react similarly regardless of whether the uncertainty stems from potentially beneficial or detrimental policy shifts. This underscores the importance of transparency and communication in fiscal policy implementation to manage firm expectations and minimize disruptions to production.

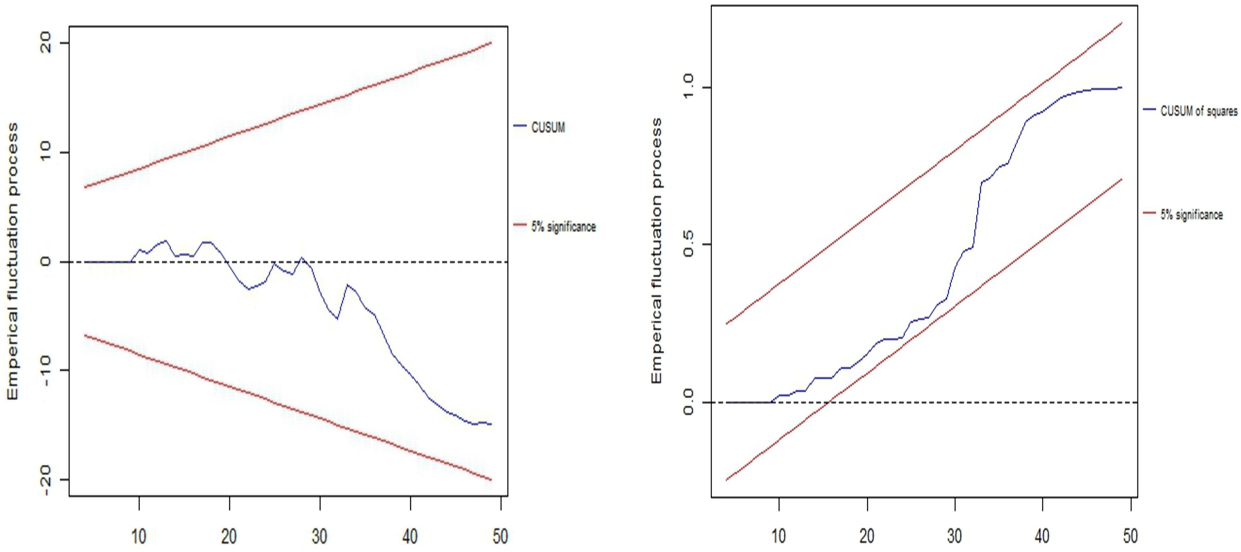

Figure 4: CUSUM and CUSUM of square test on FPU to Firm production

5. Conclusion and Recommendations

5.1 Conclusion

While several empirical studies indulge in factors such as inadequate raw materials, poor processing technologies and power outages as being the sources of edible oil deficit in Tanzania, much less consideration has been paid to FPU despite its relevance in determining firms' decisions. Our study attempted to fill the existing gap by analysing the effects of FPU on Sunflower edible oil production in Tanzania. The study findings highlight the significant short-term impact of FPU on sunflower oil production. However, these relationships do not persist in the long run. The findings further indicate that positive and negative changes in FPU have symmetric effects on overall firm production in both periods. This outcome reinforces the need for stable and predictable fiscal policies to ensure sustainable sunflower oil production and broader industrial growth. These insights contribute to the ongoing fiscal policy discussions by emphasizing the need for long-term strategies that support resilience in the edible sector. From policy perspectives, we provide empirical evidence that policymakers should focus on minimizing short-term fiscal disruptions while ensuring long-term stability to support the sector. This is particularly relevant for tax regimes, subsidies, and trade policies affecting edible oil production. Furthermore, the result suggests that sunflower oil producers may adapt over time through diversification, cost management, market adjustment, and macroeconomic Offsetting factors. This underscores the importance of equipping edible oil processors and agribusinesses with risk-mitigating strategies such as access to financial instruments and supply chain resilience measures to cushion against fiscal uncertainty.

5.2 Recommendations

Based on the findings, we recommend that to reduce uncertainty, the government should ensure consistency in tax rates on agricultural inputs and processing equipment by minimizing abrupt changes in VAT and import duties that directly affect sunflower oil production cost. To encourage domestic sunflower oil production and processing we suggest the introduction of targeted tax incentives such as reduced corporate tax rates or temporary tax exemptions, for local sunflower oil processors investing in new technology and capacity expansion. Additionally, we suggest the implementation of structured subsidy programs for sunflower seed production to enhance productivity and ensure a stable supply of raw materials. The government should also maintain a stable and transparent trade policy regarding edible oil import and export tariffs to minimize supply chain disruption ensuring that domestic producers compete effectively without sudden policy shifts. For further study, it will be beneficial to probe the effects of FPU on Sunflower seed production (farm-level production) and other sunflower value chain nodes to provide a more comprehensive picture of the overall value chain.

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