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Asymmetric Effects of Economic Policy Uncertainty on Food Security in Nigeria

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Abstract: This study investigates the asymmetric effects of economic policy uncertainty (EPU) on food security in Nigeria, utilizing annual time series data from 1970 to 2021. The study used descriptive statistics, unit root tests, the nonlinear autoregressive distributed lag (NARDL) model and its associated Bounds tests to analyze the data. The analysis reveals that adult population, environmental degradation, exchange rate uncertainty (EXRU), financial deepening, food security (FS), government expenditure in agriculture uncertainty (GEAU), inflation, and interest rate uncertainty (INRU) exhibit positive mean values over the period, with varying degrees of volatility. Cointegration tests indicate a long-term relationship between EPU variables (GEAU, INRU, and EXRU) and food security. The study finds that cumulative positive and negative EPU variables have significant effects on food security in the short run. Specifically, negative GEAU, positive INRU, positive and negative EXRU have significant effects in the short run. In the long run, negative GEAU, positive and negative EXRU have significant effects on food security. Additionally, the research highlights asymmetric effects, showing that the influence of GEAU and EXRU on food security differs in the short- and long-run. The study underscores the importance of increased government expenditure on agriculture, control of exchange rate and interest rate uncertainty, and the reduction in economic policy uncertainty to mitigate risks in the agricultural sector and enhance food security. Recommendations include strategies to stabilize exchange rates to safeguard food supply and overall food security.

Keywords: economic; policy; uncertainty; policy uncertainty; economic policy uncertainty; food security; asymmetric; effect and asymmetric effect

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1. Introduction

The Nigerian agricultural sector has been a resilient sustainer of the economy in terms of food supply, employment, and national income generation. However, declining agricultural output and the overall contribution of the sector to the economy are changing Nigeria's perception of the place and role of agriculture in national development (Oluwaseyi 2017).

The agricultural sector has the potential to be the industrial and economic platform from which the speedy development of a country can take off as Nigeria faces huge food security challenges (Olarinde and Abdullahi 2014). According to Sadati et al. (2021), the poor performance of the agricultural sector and associated food insecurity could be due to a myriad of factors including economic policy and its uncertainty (Olarinde and Abdullahi 2014). Economic policy uncertainty occurs when an economic body cannot predict exactly whether, when, and how the government will change its current economic policy (Guo et al. 2020).

Protection motivation theory (PMT) is a widely used framework to understand responses to triggers that appraise individuals of a potential threat such as insecurity. Economic policy uncertainty could trigger fear messages on food security which encourage individuals to take protective measures (Shillair 2020). The theory attempts to explain and predict what motivates people to change their behavior (Soon et al. 2022; Rad et al. 2021).

Agricultural sector performance in terms of output has been disappointing and investment in the sector has been discouraging. According to Ojo and Adebayo (2012), Nigeria is far from being completely food secure coupled with global warming beset by uncertainty and confusion. Nigeria is one of the food-deficit countries in Sub-saharan Africa; thus, food security has become a first-order priority of the Nigerian government (Ministry of Budget and National Planning 2016). In response to the complex and changing global economic situation and the macro environment in which growth momentum is gradually slowing, governments in various countries are playing an active role in macro control (Guo et al. 2020; World Bank Group 2017).

The literature on the effect of economic policy and its uncertainty on general economic activities is rapidly growing. For instance, Aye (2018) investigated whether economic policy uncertainty causes real housing returns in eight emerging economies and found an adverse effect of the former on the latter. Kotur et al. (2020) found a negative effect of economic policy uncertainty on poverty in Nigeria using the ARDL model. Aye (2021) examined the short- and long-run asymmetric effects of monetary and fiscal policy uncertainty on economic activity in the U.S. and established an existence of asymmetric effects.

Regarding the focus of this study, which is on the link between economic policy uncertainty and food security, few studies have also been identified. For instance, Marmash et al. (2022) studied the association between diet quality and health status in mobile food pantry users in Northeastern Connecticut. Johnston and Walls (2019) examined economic policy and food security in Ethiopia which focused on the interrelationship between economic policy and nutrition policy. Wen et al. (2021) explored the symmetric and asymmetric impact of economic policy uncertainty on food prices in China.

Several existing empirical studies have examined the nexus between economic policy and/or its uncertainty on different macroeconomic variables for several countries. However, the few available studies on agriculture and food-related variables largely ignore the asymmetric effects of economic policy uncertainty. More so, the few asymmetric studies focused mainly on food or agricultural commodity prices while other agriculture-related variables, such as food security, among others, have not been considered. Therefore, this study intends to fill these gaps by examining the asymmetric effects of economic policy uncertainty on food security in Nigeria. This study also innovates by considering disaggregate economic policy uncertainty including monetary policy uncertainty, fiscal policy uncertainty, and trade policy uncertainty simultaneously. The research question is what is the asymmetric effect of economic policy uncertainty on food security in the short- and long-run? The objective, which is linked to the hypothesis, is to analyze the asymmetric effects of economic policy uncertainty on food security in the long and short run.

2. Literature Review

Food is life; hence, food has become an instrument of national power. A comprehensive review of Nigeria's agricultural policy shows that much work still needs to be carried out to prevent the crisis in the sector from escalating (Ojo and Adebayo 2012). Pangaribowo et al. (2013) highlighted that food-related problems are influenced not only by food production and agricultural activities but also by the structure and processes governing entire economies and societies (policy). The empirical literature connecting economic policy and/or its uncertainty and economic variables is growing. For instance, Olarinde and Abdullahi (2014) empirically investigated the impact of macroeconomic policies on agricultural output specifically on crop production in Nigeria.

Food security is considered the most important global challenge (Shoaib et al. 2021). In line with this, Abdulai and Kuhlgatz (2012) reviewed the concept of food security and the various approaches developing countries have used to promote food security. Zhang et al. (2022) evaluated the effects of uncertainty resulting from global and domestic economic policy changes on the stability component of food security in China.

Zhu et al. (2020) investigated the effect of economic policy uncertainty (EPU) on China's agricultural and metal commodity futures returns across quantiles. Frieden and

Hawkins (2010) presented an expression of the economic concept of asymmetric information with which it is possible to derive the dynamical laws of an economy.

Lesame (2021) provided empirical evidence on the asymmetric impact of economic policy uncertainty on firm-level investment in South Africa. He concluded that firms' investment decisions in response to uncertainty reflect firms' heterogeneity. Zeng and Yue (2021) re-evaluated the asymmetric economic policy uncertainty, conventional energy, and renewable energy consumption nexus for BRICS for the period 1991 to 2019. Bahmani-Oskooee and Maki-Nayeri (2018) worked on the asymmetric effects of policy uncertainty on the demand for money in the United States using a nonlinear model. Aye (2018) investigated whether economic policy uncertainty causes real housing returns in eight emerging economies using quarterly data. Zahra and Ramez (2022) explored the short-run and long-run asymmetric impact of fiscal decentralization, green energy, and economic policy uncertainty on environmental sustainability proxied by ecological footprint. Aye (2021) examined the short- and long-run asymmetric effects of monetary and fiscal policy uncertainty on economic activity in the U.S. Bahmani-Oskooee and Saha (2019) conducted an asymmetric analysis of the effect of policy uncertainty on stock prices. Wen et al. (2021) explored the symmetric and asymmetric impact of economic policy uncertainty on food prices in China.

While there are numerous studies on the asymmetric effect of economic policy and its uncertainty, only very few analyzed this for agriculture and food-related variables specifically the focus has been on agricultural commodity futures returns and food prices. There is no investigation regarding food security in particular.

Agriculture is a vital determinant of the livelihoods of small-holder farmers and rural communities. The foregoing literature review shows that there have been numerous studies on the effects of economic policy and economic policy uncertainty on several economic variables such as aggregate or firm-level investment, economic growth, commodity returns, and financial asset returns. However, only very few studies have investigated the relationship between economic policy uncertainty and agriculture and food-related variables. Moreover, while there exist several studies on the asymmetric effect of economic policy uncertainty, only very few were found specifically on agriculture and food related variables and these focused on food price and agricultural commodity returns. This study, therefore intends to fill the gap by investigating the asymmetric effects of economic policy and its uncertainty on food security in Nigeria.

3. Methodology

3.1. Data

Secondary data consisting of annual time series covering a period of 51 years (1970–2021) were used for the study. Particularly, the data on interest rates, exchange rates, government expenditure on agriculture, and agricultural GDP were obtained from the Central Bank of Nigeria and World Development Indicators. Data on food security were obtained from the Food and Agricultural Organization Statistical Database. In addition, the data on the control variables such as inflation proxied by the percentage change in consumer price index, environmental degradation, financial deepening, and adult population were sourced from the World Development Indicators. The economic policy (monetary, fiscal, and trade) uncertainty was measured using the volatility in interest rate, exchange rate, and government expenditure in agriculture. Volatility was computed as a three-year moving standard deviation of each economic policy variable. Food security was measured as dietary energy supply in kcal/capita/day. Environmental degradation was measured as CO_2 emissions from manufacturing industries and construction (% of total fuel combustion). Financial deepening was measured as domestic credit to the private sector (% of GDP). The adult population was measured as total number of adults (males and females) in the country. Inflation was measured as the percentage change in the consumer price index (%).

3.2. Empirical Model

The nonlinear autoregressive distributed lag (NARDL) was used to analyze the effects of economic policy uncertainty on food security.

The NARDL representation of the economic relationship between the selected variables is specified as

$$\begin{aligned}\Delta FS_t = \alpha + \sum_{i=1}^{p_0}(\beta_0 i.\Delta FS_{t-i}) + \sum_{j=0}^{P_1^+}\left(\beta_1^{+,j.}\Delta INRU_{t-j}^+\right) + \sum_{j=0}^{P_1^-}\left(\beta_1^- j.\Delta INRU_{t-j}^-\right) \\ + \sum_{k=0}^{P_2^+}\left(\beta_2^+ k.\Delta EXRU_{t-k}^+\right) + \sum_{k=0}^{P_2^-}\left(\beta_2^- k.\Delta EXRU_{t-k}^-\right) \\ + + \sum_{m=0}^{P_3^+}(\beta_3^+ m.\Delta GEAU_{t-m}^+) + \sum_{m=0}^{P_3^-}(\beta_3^- m.\Delta GEAU_{t-m}^-) + \lambda_0.FS_{t-1} \\ + \lambda_1^+.INRU_{t-1}^+ + \lambda_1^-.INRU_{t-1}^- + \lambda_2^+.EXRU_{t-1}^+ + \lambda_2^-.EXRU_{t-1}^- \\ + \lambda_3^+.GEAU_{t-1}^+ + \lambda_3^-.GEAU_{t-1}^- + \in_t\end{aligned} \quad (1)$$

where

FS = food security.

INRU = interest rate uncertainty.

EXRU = exchange rate uncertainty.

GEAU = government expenditure uncertainty.

+ = positive cumulative sum of the relevant variables.

− = negative cumulative sum of the relevant variables.

β_s = short-run coefficients.

λ_s = long-run coefficients.

4. Results and Discussion

4.1. Preliminary Analysis

4.1.1. Summary Statistics

Table 1 presents descriptive statistics of the variables analyzed from 1970 to 2021. The mean values are 18.534 for adult population (ADULTPOP), 2.39 for environmental degradation (ENVT), 0.150 for exchange rate uncertainty (EXRU), 2.156 for financial deepening (FINDEEP), 7.643 for food security (FS), 0.319 for government expenditure uncertainty (GEAU), 18.304 for inflation (INF), and 8.010 for interest rate uncertainty (INRU). Median values, providing insights into central tendencies, closely align with means for most variables. Minimal gaps between minimum and maximum values suggest limited variability. The lowest observed values for GEAU and EXRU are 0.000, while their highest values are 1.850 and 0.860, respectively. Volatility, indicated by standard deviations, is low for ADULTPOP, ENVT, EXRU, FINDEEP, FS, GEAU, and GEU (ranging from 0.026 to 0.399) but high for INF (15.619) and INRU (8.435).

Table 1. Descriptive statistics of the variables used.

	ADULTPOP	ENVT	EXRU	FINDEEP	FS	GEAU	INF	INRU
Mean	18.534	2.394	0.15	2.156	7.643	0.319	18.304	8.01
Median	18.535	2.499	0.076	2.104	7.63	0.199	12.775	6.163
Maximum	19.169	2.914	0.86	2.977	7.692	1.850	72.836	36.135
Minimum	17.887	1.447	0.000	1.547	7.611	0.000	3.458	0.460
Std. Dev.	0.378	0.316	0.211	0.348	0.026	0.399	15.619	8.435
Skewness	−0.015	−1.177	2.109	0.347	0.821	2.145	1.936	2.12
Kurtosis	1.836	4.229	6.811	2.359	2.175	7.665	5.949	7.316
Jarque–Bera	2.823	14.697	67.316	1.857	7.041	83.699	49.35	76.239
Probability	0.244	0.001	0.000	0.395	0.030	0.000	0.000	0.000

Source: Author's computation.

The skewness values for the variables in the analysis provide insights into the distribution symmetry. A skewness of 0 indicates a perfectly symmetrical distribution, while values close to zero suggest relative symmetry. ADULTPOP (−0.015) and ENVT (−1.177) exhibit negative skewness, indicating a left-skewed distribution with a longer tail on the left side. Conversely, FS (0.821), FINDEEP (0.347), GEAU (2.145), and INF (1.936) show positive skewness, indicating a right-skewed distribution with a longer tail on the right side. Higher positive skewness in EXRU (2.109), INRU (2.120), and GEAU (2.145) suggests highly pronounced right-skewness, implying an asymmetrical concentration of data on the left side of the distribution. Overall, these skewness values provide valuable insights into the shape and asymmetry of the distributions, aiding in understanding the underlying patterns in the data.

The kurtosis values provide insights into the concentration of data around the mean, with a normal distribution having a kurtosis of 3. ADULTPOP (1.836), FS (2.175), and FINDEEP (2.359) exhibit kurtosis suggesting a distribution less concentrated in the tails compared to normal, indicating a moderate presence of extreme values. ENVT (4.229) indicates a higher concentration in the tails, implying more extreme values. INF (5.949), EXRU (6.811), GEAU (7.665), and INRU (7.316) reveal kurtosis values indicating distributions with heavier tails or more extreme values. The Jarque–Bera test statistics for GEAU (83.699), EXRU (67.316), INF (49.350), and INRU (76.239), all with probability values of 0.000, and ENVT (14.697) with a probability value of 0.001 suggest significant deviations from a normal distribution. FS (7.041) deviates at a 0.05 significance level. ADULTPOP (2.823) and FINDEEP (1.857) with probability values of 0.244 and 0.395, respectively, indicate that their distributions are not significantly different from normal. Overall, these results highlight the varied nature of data concentration and deviations from normality in the analyzed variables.

The graphical display of the various variables used for analysis is presented in Figure 1. Except for the adult population with a clear positive trend, the rest of the variables fluctuated over the period under investigation.

4.1.2. Unit Root Tests

The Augmented Dickey–Fuller (ADF) unit root test in Table 2 revealed that the ADULTPOP test statistic is −2.490, and the *p*-value is 0.125, while the Phillips–Peron (PP) test result for ADULTPOP revealed that the t-statistic is −1.140, and the *p*-value is 0.693. With the *p*-values (0.125) and (0.693), which are greater than the commonly used significance levels (1%, 5%, or 10%), the null hypothesis of a unit root cannot be rejected at the level. However, at the first difference in both ADF and PP, there is sufficient evidence to suggest that the variable D(ADULTPOP) is stationary with t-statistics (−4.077) and (−2.595), and *p*-values of 0.003 and 0.101, respectively. Therefore, it is concluded that ADULTPOP is integrated in the order of (1) since it became stationary after first differing. The ADF and PP test statistics for FINDEEP are not significant at the level, but at first differing, the null hypothesis can be rejected for FINDEEP with a *p*-value of 0.0000. ENVT, EXRU, and FDI results revealed that the ADF test statistic is −3.234, −4. 537, −4.179 with a *p*-value of 0.024, 0.001, and 0.002, respectively. These variables fall in the rejection region at all conventional levels of significance and, therefore, exhibit stable, long-term behavior at the level. The PP results further confirmed the rejection of null hypotheses at all levels.

Food security (FS) with *p*-values of 0.984 and 0.979 for ADF and PP tests, respectively, implies that the null hypothesis at any conventional level of significance (1%, 5%, or 10%) cannot be rejected as there was not enough evidence to conclude that FS does not have a unit root. At first difference, the ADF and PP tests on FS indicate a *p*-value of 0.0000 for both tests, which is less than the commonly used significance level of 0.05. Therefore, the null hypothesis can be rejected at all conventional levels of significance (1%, 5%, and 10%) and there is sufficient evidence to conclude that FS does not have a unit root. Therefore, FS is integrated into order (1).

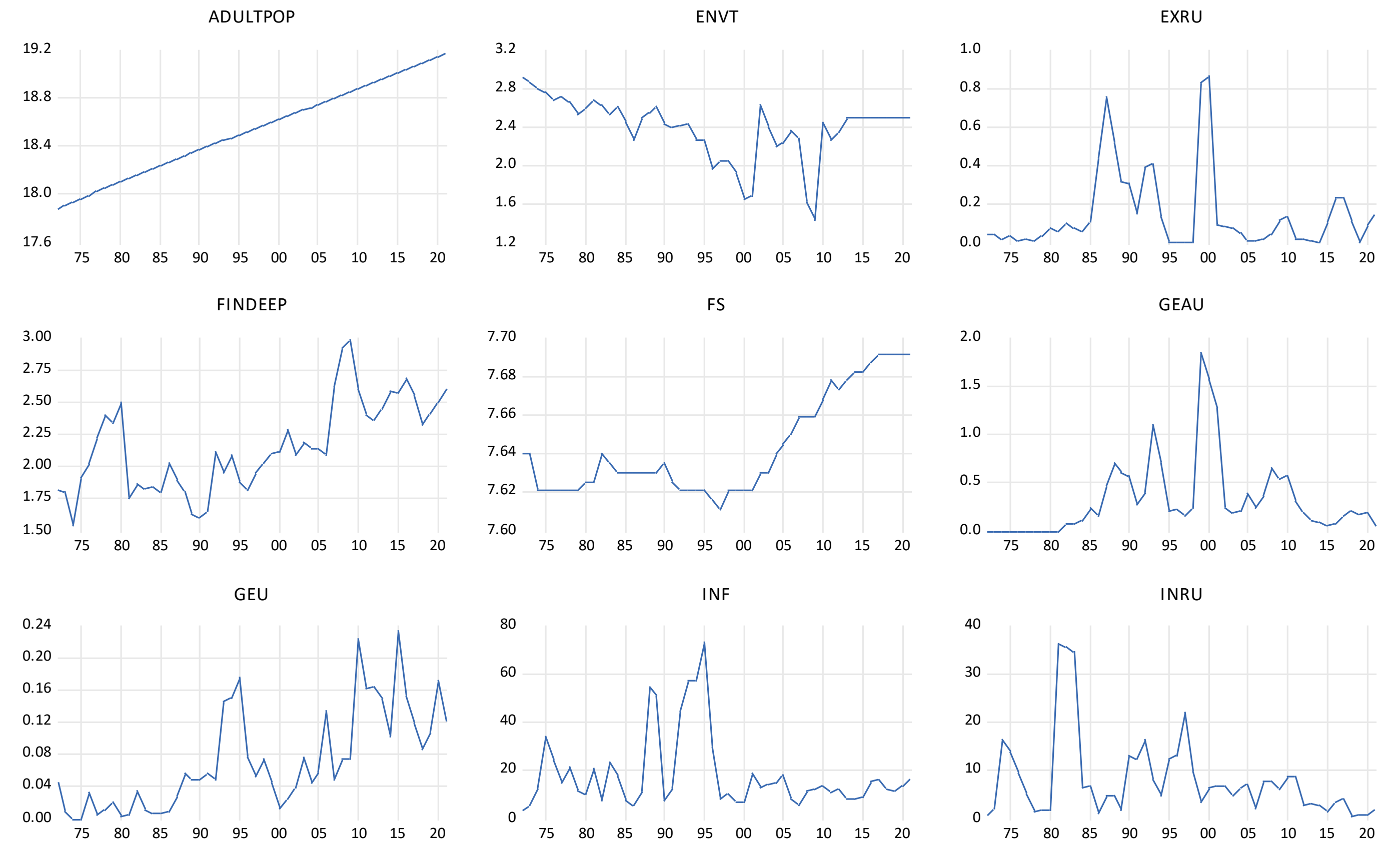

Figure 1. Graphical representation of the variables used. Source: Authors' computation.

Table 2. Unit root test.

Variables	ADF Test		PP Test		Decision
	T-Stat	*p*-Value	T-Stat	*p*-Value	
ADULTPOP	−2.490	0.125	−1.140	0.693	
D(ADULTPOP)	−4.077	0.003	−2.595	0.101	I(1)
ENVT	−3.234	0.024	−3.064	0.036	I(0)
EXRU	−4.537	0.001	−3.329	0.019	I(0)
FINDEEP	−2.061	0.261	−1.786	0.383	
D(FINDEEP)	−5.357	0.000	−9.156	0.000	I(1)
FS	0.466	0.984	0.366	0.979	
D(FS)	−6.543	0.000	−6.561	0.000	I(1)
GEAU	−3.131	0.031	−2.924	0.050	I(0)
INF	−4.106	0.002	−3.419	0.015	I(0)
INRU	−4.517	0.001	−3.285	0.021	I(0)

Source: Authors' computation.

The result for GEAU revealed the test statistic for the ADF and PP test as −3.131 and −2.924, and *p*-values of 0.031 and 0.050. The *p*-values are less than the significance level of 0.05, suggesting enough evidence to reject the null hypothesis at a 5% level of significance, suggesting that GEAU does not have a unit root and is stationary. The high test statistic and low *p*-values provide support for the conclusion that INFU and INRU do not have unit roots and are stationary based on both ADF and PP tests.

4.1.3. Diagnostic Tests

Diagnostic tests were conducted on the NARDL model, specifically focusing on the relationship between economic policy uncertainty (EPU) and food security, to ensure the reliability of the model results. The test results are presented in Appendices A.1–A.5. The Jarque–Bera test for normality yielded a high *p*-value of 0.998, suggesting no significant evidence to reject the null hypothesis that the residuals are normally distributed. The serial correlation test results presented mixed findings, with the F-statistic indicating weak evidence of serial correlation (p-value = 0.146), while the Lagrange Multiplier (LM or Obs *Chi-square) statistic suggested some evidence of serial correlation (p-value = 0.012). This implies a potential presence of serial correlation in the model, particularly considering the Chi-square statistics. The heteroskedasticity test indicated a high p-value of 0.613, implying no evidence of heteroscedasticity in the relationship between EPU and food security. The CUSUM and CUSUM of Square plots suggest that the recursive residuals did not exceed the critical lines, indicating structural stability in the relationship over time. Overall, these diagnostic tests contribute to the credibility of the NARDL model results, providing insights into the normality of residuals, potential serial correlation, heteroscedasticity, and stability of the examined relationship.

4.2. Economic Policy Uncertainty (EPU) and Food Security (FS)

4.2.1. Cointegration Relationship between Economic Policy Uncertainty and Food Security

The Bounds test was conducted to determine whether there is evidence of cointegration among EPU variables (GEAU, INRU, and EXRU) and food security. The result in Table 3 indicates that the relationship among EPU variables and food security is statistically significant suggesting that there is a long-term equilibrium relationship between the two variables. For instance, the F-statistic at 10%, 5% and 1% significance levels for the sample size of 45 are 2.327, 3.541, and 2.764 at I(0) and 4.123, 3.790, and 5.411 at I(1). The F-statistic at 10%, 5%, and 1% significance levels for the sample size of 50 are 2.309, 3.507, and 2.726 at I(0) and 4.057, 3.656, and 5.331 at I(1). The F-statistic of 4.630 exceeds the 1(0) and I (1) 10%, 5%, and 1% critical values for these sample sizes suggesting the presence of a cointegration relationship among the EPU variables and food security. For the t-statistic, the critical values provided in the table are asymptotic values, suitable for larger sample sizes. The t-statistic of −4.279 is larger than the asymptotic critical values, suggesting that there is evidence to reject the null hypothesis at conventional confidence levels. The asymptotic critical values for the F-statistic at the 10%, 5%, and 1% levels are 2.120, 3.230, and 2.450, respectively, for I(0), and 3.610, 3.150, and 4.430, respectively, for I(1). This indicates the presence of a significant cointegration relationship between EPU and food security. The results of the Bounds test suggest the presence of a cointegration relationship between EPU and food security.

Table 3. Cointegration relationship between EPU and food security.

	Bounds Critical Values						
	10%		**5%**		**1%**		**Test Statistic**
Sample Size	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)	
			F-Statistic				4.630
45	2.327	3.541	2.764	4.123	3.790	5.411	
50	2.309	3.507	2.726	4.057	3.656	5.331	
Asymptotic	2.120	3.230	2.450	3.610	3.150	4.430	
			t-Statistic				−4.279
Asymptotic	−2.57	−4.04	−2.86	−4.38	−3.43	−4.99	

Source: Authors' computation.

A robustness check was performed by including fixed regressors (that is, ADULTPOP, FINDEEP, ENVT, and INF) as control variables in the relationship. Qualitatively, similar results were obtained (see Appendix A.6). This implies that the variables move together in the long run, despite potentially exhibiting short-term fluctuations. The presence of a cointegration relationship suggests that there may be a stable, underlying economic or statistical relationship between the variables. This implies that there is a long-run relationship or cointegration between economic policy uncertainty and food security.

4.2.2. Short-Run Asymmetric Effects of Economic Policy Uncertainty on Food Security

The results of the short-run asymmetric effects of economic policy uncertainty (EPU) related variables on food security using the NARDL conditional error correction model are shown in Table 4. The R-squared value of 0.688 indicates that the variables included in the model explain only 68.8% of the variation in food security. The model's adjusted R-squared is 0.533, which takes into account the number of variables and observations, providing a more conservative measure of the model's explanatory power. The coefficient of determination revealed that the model provides a good fit. The F-statistic of 4.419, with a very small *p*-value (0.000), indicates that all the variables included in the model are jointly statistically significant in influencing food security.

Table 4. Short-run asymmetric effects of EPU on food security.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
COINTEQ	−0.311 ***	0.049	−6.365	0.000
PD(GEAU)	−0.003	0.004	−0.732	0.470
ND(GEAU)	−0.013 ***	0.005	−2.458	0.020
PD(GEAU(−1))	−0.004	0.004	−1.016	0.318
ND(GEAU(−1))	0.012 ***	0.003	3.801	0.001
PD(GEAU(−2))	0.005	0.004	1.388	0.175
ND(GEAU(−2))	0.005	0.003	1.54	0.134
PD(INRU)	0.000	0.000	0.302	0.765
ND(INRU)	0.000	0.000	0.324	0.748
PD(INRU(−1))	0.000 ***	0.000	3.948	0.000
ND(INRU(−1))	0.000	0.000	−1.692	0.101
PD(EXRU)	0.003	0.006	0.399	0.693
ND(EXRU)	0.057 ***	0.01	5.83	0.000
PD(EXRU(−1))	−0.033 ***	0.008	−4.201	0.000
ND(EXRU(−1))	−0.006	0.007	−0.814	0.422
C	2.375 ***	0.373	6.371	0.000
R-squared				0.688
Adjusted R-squared				0.533
F-statistic				4.419
Prob(F-statistic)				0.000

*** indicate significance 1%. Source: Authors' computation.

The coefficient of the error correction term (COINTEQ), −0.311, with a t-statistic of −6.365, indicates the speed of adjustment towards the long-run equilibrium. The negative coefficient implies that there is a tendency for food security to correct any deviations from the long-run equilibrium. The statistical significance of COINTEQ suggests that the error correction mechanism is operating and that 31.1% of the deviations from the long-run equilibrium are being corrected per year. The results suggest that food security adjusts towards its long-run equilibrium, as indicated by the statistically significant coefficient of the error correction term (COINTEQ). The coefficients of the cumulative differences (i.e., cumulative positive and negative changes) of the EPU-related variables represent the short-run effects of the changes in those variables on food security. The coefficient −0.013 for cumulative negative change on government expenditure on agriculture uncertainty (ND(GEAU)) suggests that a negative change leads to, on average, a 0.013-unit decrease in FS. This coefficient is statistically significant at the 1% level, as indicated by a *p*-value of 0.005. Similar results were obtained at the first lag of the negative cumulative change in government expenditure uncertainty (ND(GEAU(−1)) with a *p*-value of 0.012. This agreed with the finding of Wen et al. (2021) that negative shocks of uncertainty have a deeper effect than positive shocks on food prices. This implies that higher levels of cumulative negative EPU can adversely affect food security. Reduced uncertainty in government spending on agriculture could lead to more consistent support for the agricultural sector, potentially resulting in increased food production and availability. This improved stability might positively impact food security.

The cumulative negative exchange rate uncertainty (ND(EXRU)) has a positive coefficient of 0.057 and a *p*-value of 0.001, which indicates that the effect is statistically significant at 1%. It implies that a unit change in the cumulative negative exchange rate uncertainty is associated with, on average, a 0.057-unit increase in FS. This suggests that decreasing exchange rate uncertainty can potentially improve food security. However, the first lag of cumulative positive exchange rate uncertainty (PD(EXRU(−1))) decreases food security significantly by 0.033 units. The negative sum of government expenditure on agriculture uncertainty and the positive sum of exchange rate uncertainty has a significant negative effect on food security, implying that when there is uncertainty in government spending in agriculture, it might lead to inconsistent support for farmers, infrastructure, and other aspects of the agricultural sector, which can impact food production and availability. This inconsistency could potentially contribute to food insecurity. This is in line with Keji and Efuntade (2020), who found that disruption in government spending in the agricultural sector would have an adverse effect on agricultural output growth. If exchange rates are highly uncertain, it can affect the cost of imported goods, including food (Oluyemi and Essi 2017). When a country heavily relies on food imports, exchange rate fluctuations could lead to price volatility and reduced access to affordable food, contributing to food insecurity (Kummu et al. 2020).

The positive sum of interest rate uncertainty at lag 1 has a positive significant effect on food security. A positive relationship suggests that interest rate uncertainty could impact borrowing costs for farmers and businesses in the agricultural sector (Oluyemi and Essi 2017). If interest rates become uncertain, this might lead to less investment in agriculture and potentially affect food production and supply (Ikuemonisan et al. 2018).

The robustness check result with fixed control variables such as ADULTPOP, FINDEEP, ENVT, and INF (Appendix A.7) yielded qualitatively similar results as, in general, economic policy uncertainty has adverse short-run effects on food security. The effects are, in general, qualitatively larger for increasing (positive) uncertainty relative to declining (negative) uncertainty in the short run, indicating potential asymmetric impacts on food security.

4.2.3. Long-Run Asymmetric Effects of Economic Policy Uncertainty on Food Security

The estimates of the NARDL model on the long-run asymmetric effects of EPU on food security are shown in Table 5. The cumulative negative change in government expenditure uncertainty (GEAU(−1)) is statistically significant at the 1% level, as indicated by a *p*-value of 0.007. It implies that a unit increase in the cumulative negative EPU leads to a 0.061-unit decrease in food security in the long run. It suggests that for every unit increase in the cumulative negative EPUs related to government expenditure on agriculture uncertainty, food security decreases by an average of 0.061 units in the long run. This quantifies the relationship between uncertainty in government expenditure on agriculture and its potential impact on food security, specifically through the reduction in the available food supply. In the long run, ongoing uncertainty about government support for the agricultural sector has negative effects on food production, agricultural investments, and overall agricultural stability (Osabohien et al. 2020). These effects lead to decreased food production, which affects food security. This result is consistent with the findings of Umar and Umar (2022).

Table 5. Long-run asymmetric effects of EPU on dietary energy supply.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
PD(GEAU)	−0.008	0.023	−0.357	0.723
ND(GEAU)	−0.061 ***	0.021	−2.869	0.007
PD(INRU)	0.000	0.000	−0.199	0.844
ND(INRU	0.000	0.001	0.253	0.802
PD(EXRU)	0.126 ***	0.044	2.861	0.007
ND(EXRU)	0.181 ***	0.049	3.692	0.001

*** indicate significance at 1%. Source: Author's computation.

The results of the cumulative negative and positive exchange rate uncertainty (EXRU) have coefficients of 0.126 and 0.181 with low *p*-values of 0.007 and 0.001, respectively. This typically suggests that these relationships are statistically significant at a 1% level. When there is a cumulative negative change in exchange rate uncertainty, it is associated with a positive increase in food security. That is, during periods of decreasing exchange rate uncertainty, there tends to be an increase in food security. When there is a cumulative positive change in exchange rate uncertainty, it is associated with an even stronger positive increase in food security consistent with the findings of Çitçi and Kaya (2023) and Chang et al. (2022). In essence, during periods of increasing exchange rate uncertainty, there is a more pronounced increase in food security. In the context of food security, this may imply that changes in exchange rate uncertainty can have an impact on the availability of food and this is in agreement with the findings of Oluyemi and Essi (2017), who further found that exchange rates responded positively to imports and negatively to exports. This could be due to decreased costs of imported goods, including food, which could lead to better access and affordability, as noted by Chidinma et al. (2022). The findings highlight the importance of considering exchange rate dynamics when assessing and addressing food security challenges. The findings are robust when fixed control variables are included (Appendix A.8).

4.2.4. Test of Asymmetric Effects of Economic Policy Uncertainty on Food Security in the Long and Short Run

The results in Table 6 are presented to further ascertain the hypothesis which assumes that the economic policy uncertainty (EPU) has no asymmetric effect on food security in the long and short run implying that positive and negative changes in EPU have the same effect on food security. In the long run, The F-statistic of 11.525 with a *p*-value of 0.002, indicates a significant asymmetric effect at a 1% level for GEAU. The associated chi-square statistic is 11.525, with a probability of 0.001. The result suggests that the coefficient of government expenditure on agricultural uncertainty (GEAU) exhibits significant asymmetry in its impact on food security in the long run. This result suggests that the impact of GEAU on food security is not linear and implies that increasing government expenditure on agricultural uncertainty has a disproportionate effect on food security when compared to decreasing government expenditure uncertainty. It implies there is a significant difference in the effect of a positive GEAU compared to a negative GEAU (Abdul Manap and Ismail 2019; Edeh et al. 2020).

In the short run, the F-statistic is 4.352 for exchange rate uncertainty (EXRU), suggesting a significant asymmetric effect at a 5% level. The chi-square statistic is 4.352, with a probability of 0.037. This implies that the coefficient of EXRU exhibits significant asymmetry in its impact on food security in the short run. This finding is similar to that of Umar and Umar (2022). It suggests that there is a notable difference between how increasing and decreasing exchange rate fluctuations affect food security. The result also agreed with the findings of Olowoyo (2023) that the response of the exchange rate to shocks to economic policy uncertainty is asymmetry.

In the joint tests which considered both the long-run and short-run effects, the exchange rate uncertainty (EXRU) has an F-statistic of 2.658, with a *p*-value of 0.091. The chi-square statistic is 5.315, with a *p*-value of 0.070, which suggests a potential asymmetric effect of EXRU on food security when considering both the long-run and short-run dynamics. This agrees with the results of Umar and Umar (2022) that there is a significant and asymmetric positive relationship between exchange rate and food inflation in the long and short run. Government expenditure on agriculture uncertainty (GEAU) has an F-statistic of 6.054, indicating a significant asymmetric effect at the 1% level. The chi-square statistic is 12.108, with a probability of 0.002. This indicates that the coefficient of GEAU exhibits significant asymmetry in its impact on food security when considering both the long-run and short-run effects, suggesting a strong relationship between "GEAU" and food security and that its impact is not the same across different time frames (long-run and short-run) or in both directions of change (increases and decreases). Changes in GEAU have a lasting and persistent effect on food security consistent with the findings of Anthony and Tijjani (2022). This could mean that changes in "GEAU" might lead to structural shifts in the factors affecting food security, such as agricultural production, supply chains, market dynamics, or government policies (Osuma and Ofure 2019). The robustness check with fixed control variables such as ADULTPOP, FINDEEP, ENVT, and INF (Appendix A.9) further confirmed this result which shows that the null hypothesis of symmetric effect can only be rejected for GEAU and EXRU in the long and short run.

Table 6. Wald test of asymmetric effects of EPU on food security in the long and short run.

Variable	Statistic	Value	Probability
	Long-run:		
EXRU	F-statistic	2.250	0.147
	Chi-square	2.250	0.134
GEAU	F-statistic	11.525 ***	0.002
	Chi-square	11.525 ***	0.001
INRU	F-statistic	0.278	0.603
	Chi-square	0.278	0.598
	Short-run:		
EXRU	F-statistic	4.352 **	0.048
	Chi-square	4.352 ***	0.037
GEAU	F-statistic	0.059	0.809
	Chi-square	0.059	0.807
INRU	F-statistic	2.190	0.152
	Chi-square	2.190	2.190
	Joint (Long-Run and Short-Run):		
EXRU	F-statistic	2.658 *	0.091
	Chi-square	5.315 *	0.070
GEAU	F-statistic	6.054 ***	0.007
	Chi-square	12.108 ***	0.002
INRU	F-statistic	1.096	0.350
	Chi-square	2.193	0.224

*, **, *** indicate significance at 10%, 5% and 1%, respectively. Source: Authors' computation.

5. Conclusions and Policy Implications

The nonlinear autoregressive distributed lag (NARDL) model and its associated Bounds tests provide evidence of asymmetric effects of economic policy uncertainty (EPU) variables on food security in the long and short run. The exchange rate uncertainty (EXRU) suggests a potential asymmetric effect of EXRU on food security when considering both the long-run and short-run dynamics. Government expenditure on agriculture uncertainty (GEAU) exhibits significant asymmetry in its impact on food security when considering both the long-run and short-run effects, suggesting a strong relationship between "GEAU" and food security and that its impact is not the same across different time frames (long-run and short-run) or in both directions of change (increases and decreases). Changes in GEAU have a lasting and persistent effect on food security.

Based on the findings, this study recommends that to lower potential risks in the agricultural industry and ensure food security, the government should reduce uncertainty about economic policies. The government should set up strategies to stabilize exchange rates or mitigate the negative effects on the food supply, which might be necessary to ensure food security. This study was limited by the unavailability of an existing database on economic policy uncertainty variables for Nigeria. However, this was overcome by constructing a three-year moving standard deviation of each policy variable (monetary, fiscal, and trade policies) that represents the volatility in the respective series.

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L.N.K.; resources, G.C.A., L.N.K. and J.B.A.; data curation, L.N.K.; writing—original draft preparation, L.N.K. writing—review and editing, G.C.A. and J.B.A.; visualization, G.C.A. and L.N.K.; supervision, G.C.A. and J.B.A.; project administration, G.C.A. and J.B.A.; funding acquisition, L.N.K. All authors have read and agreed to the published version of the manuscript.

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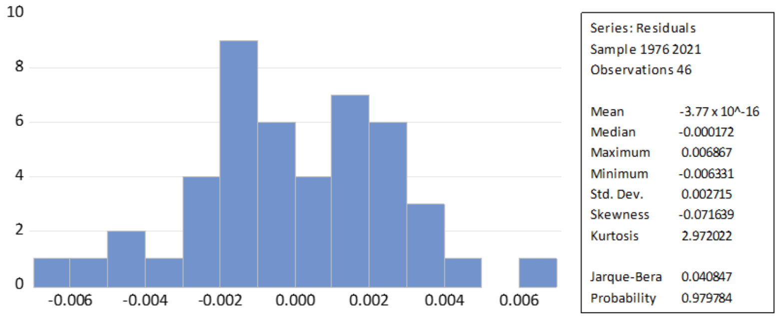
Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Appendix A.1. Normality Test for EPU and Food Security



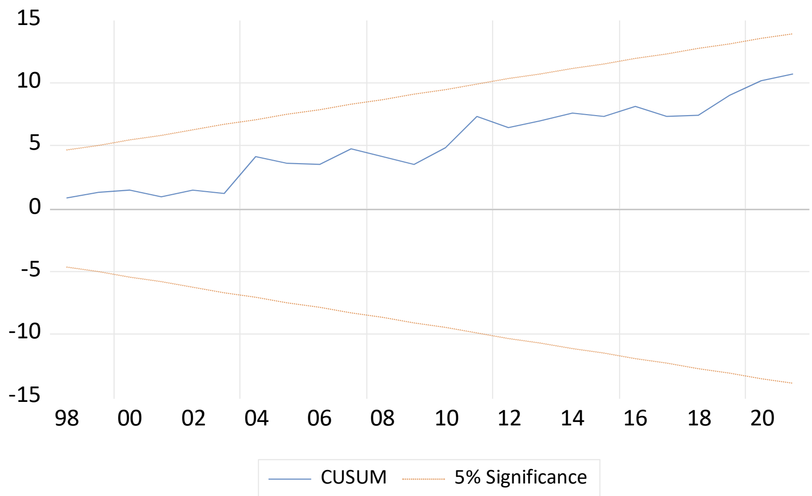
Appendix A.2. Serial Correlation LM Test for EPU and Food Security

Breusch–Godfrey serial correlation LM test:			
Null hypothesis: No serial correlation at up to 4 lags			
F-statistic	1.922	Prob. F(4,20)	0.146
Obs*R-squared	12.773	Prob. Chi-Square(4)	0.012

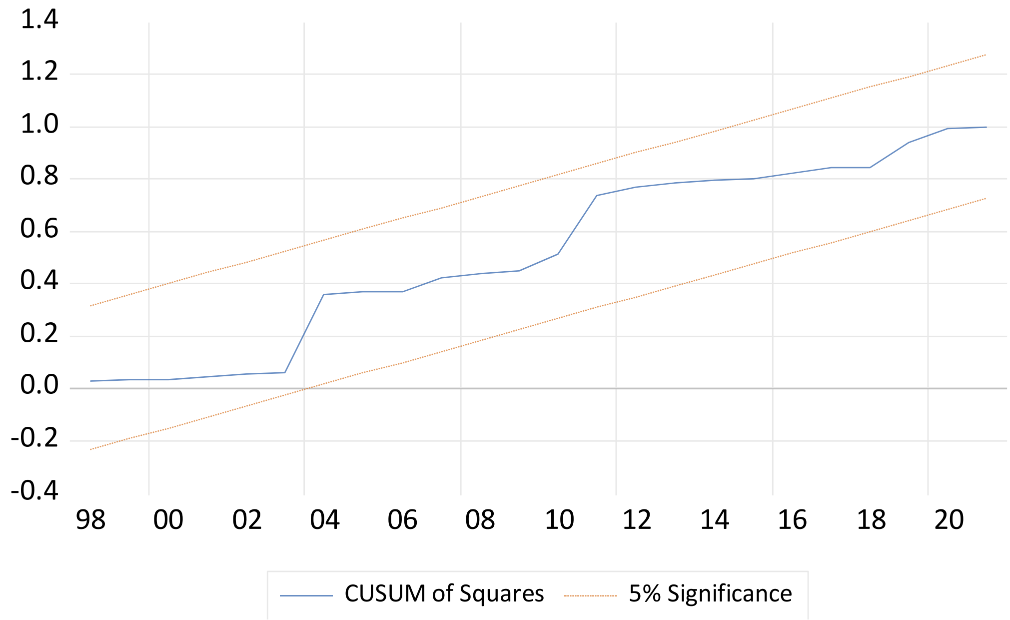
Appendix A.3. Heteroscadasticity Test for EPU and Food Security

Heteroskedasticity Test: Breusch–Pagan–Godfrey			
Null hypothesis: Homoskedasticity			
F-statistic	0.886	Prob. F(23,23)	0.613
Obs*R-squared	22.075	Prob. Chi-Square(23)	0.516
Scaled explained SS	8.193	Prob. Chi-Square(23)	0.998

Appendix A.4. CUSUM Stability Test for EPU and Dietary Energy Supply



Appendix A.5. CUSUM of Squares Stability Test for EPU and Food Security



Appendix A.6. Cointegration Bounds Test for EPU and Food Security with Fixed Regressors

	10%		5%		1%		Test Statistic
Sample Size	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)	
			F-Statistic				6.438641
45	2.327	3.541	2.764	4.123	3.790	5.411	
50	2.309	3.507	2.726	4.057	3.656	5.331	
Asymptotic	2.120	3.230	2.450	3.610	3.150	4.430	
			t-Statistic				−4.55286
Asymptotic	−2.57	−4.04	−2.86	−4.38	−3.43	−4.99	

Note: I(0) and I(1) are, respectively, the stationary and non-stationary bounds.

Appendix A.7. Short-Run Estimates for EPU and Food Security with Fixed Regressors

Variable	Coefficient	Std. Error	t-Statistic	Prob.
COINTEQ	−0.569	0.074	−7.701	0.000
D(FS_DES(−1))	0.332	0.134	2.474	0.021
DP(GEAU)	−0.009	0.004	−2.002	0.056
DN(GEAU)	0.006	0.005	1.221	0.234
DP(GEAU(−1))	−0.016	0.004	−3.834	0.001
DN(GEAU(−1))	0.014	0.003	4.394	0.000
DP(INRU)	0.000	0.000	0.719	0.479
DN(INRU)	0.000	0.000	−1.971	0.060
DP(INRU(−1))	0.001	0.000	6.070	0.000
DN(INRU(−1))	−0.001	0.000	−3.768	0.001
DP(INRU(−2))	0.000	0.000	1.686	0.104
DN(INRU(−2))	0.000	0.000	−1.814	0.082
DP(EXRU)	0.007	0.007	1.012	0.321

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DN(EXRU)	0.061	0.009	6.789	0.000
DP(EXRU(−1))	−0.030	0.007	−4.284	0.000
DN(EXRU(−1))	−0.006	0.007	−0.959	0.347
ADULTPOP	0.053	0.007	7.472	0.000
FINDEEP	0.006	0.002	2.824	0.009
ENVT	0.010	0.002	4.439	0.000
INF	0.000	0.000	1.866	0.074
C	3.348	0.439	7.629	0.000
R-squared	0.814			
Adjusted R-squared	0.666			
F-statistic	5.484			
Prob(F-statistic)	0.000			

Appendix A.8. Long-Run Estimates for EPU and Food Security with Fixed Regressors

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DP(GEAU(−1))	0.027 **	0.013	2.035	0.049
DN(GEAU(−1))	−0.004	0.012	−0.362	0.719
DP(INRU(−1))	0.000	0.001	−0.723	0.474
DN(INRU(−1))	0.000	0.001	0.148	0.883
DP(EXRU(−1))	0.055 **	0.028	1.989	0.054
DN(EXRU(−1))	0.105 ***	0.028	3.805	0.001

Note: ** and *** indicate significant at 5% and 1%, respectively.

Appendix A.9. Wald Test of Asymmetry for EPU and Food Security with Fixed Regressors

Variable	Statistic	Value	Probability
	Long-run		
EXRU	F-statistic	4.215	0.054
	Chi-square	4.215	0.040
GEAU	F-statistic	8.853	0.008
	Chi-square	8.853	0.003
INRU	F-statistic	1.169	0.293
	Chi-square	1.169	0.280
	Short-run		
EXRU	F-statistic	3.989	0.060
	Chi-square	3.989	0.046
GEAU	F-statistic	6.201	0.022
	Chi-square	6.201	0.013
INRU	F-statistic	2.879	0.106
	Chi-square	2.879	0.090
	Joint (Long-Run and Short-Run)		
EXRU	F-statistic	2.806	0.086
	Chi-square	5.613	0.060
GEAU	F-statistic	9.549	0.001
	Chi-square	19.099	0.000
INRU	F-statistic	1.901	0.177
	Chi-square	3.802	0.149

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