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Fuel subsidy removal, insecurity, the impact on rising food inflation in Nigeria: A comparative of time series analysis and machine learning techniques

Samuel Oweh Abang^{1*}, Kenneth Onaiwu Arasomwan², Oluwafemi Ayodele³

ABSTRACT

This study made use of a time series and machine learning techniques to examine the impact of fuel subsidy removal, insecurity on food inflation in Nigeria. The scope of the study spans between 1984–2023. A predictive model was developed in other to analyze the impact of fuel subsidy removal on food inflation, while nearing in mind the controlling effect of insecurity. The results of the study show that the removal fuel subsidy removal significantly increases food inflation, while insecurity worsens this effect. Furthermore, the result as presented by the machine learning language indicates that a 10 percent increase in fuel prices will lead to a 5.6 percent increase in food inflation, with insecurity increasing this impact by 2.3 percent. The study hence recommends that government should be concerned on the consequences of removing fuel subsidy while also finding lasting solution to insecurity so as to abate food inflation.

Keywords: Fuel subsidy, insecurity, food inflation, vector error correction model

1. INTRODUCTION

Nigeria, a country with large population and growing economy, adjourned as Africa's largest economy, has struggled with fuel subsidy removal, insecurity and its potential impact on food inflation. The country's reliance on fuel subsidies have exacerbated these challenges. In 2020, Nigeria spent approximately ₦1.4 trillion (USD 3.7 billion) on fuel subsidies. This accounted for 20% of the national budget. Fuel subsidies have been a contentious issue in Nigeria, with the government subsidizing fuel price to keep it low. Nevertheless, the country pays a huge sum of money for fuel subsidy. This has been the norm for a very long time (Akinyemi, 2017). This has been a contentious issue on the budget implication of the economy.

Nigeria's economy has struggled with fuel subsidy removal and insecurity and its potential impact on food inflation. This has been a topic of significant interest and debate in Nigeria, for a country grappling with the challenges of economic development and the need to address the rising cost of living. It is thus posing significant concerns for policymakers and citizens alike. The removal of fuel subsidies has led to a rise in fuel prices. The increase has contributed to higher production and transportation costs for farmers and food manufacturers. The country has experienced recurring food price shocks, which have negatively impacted the population, particularly the poor and vulnerable. Food inflation has remained high, averaging around 15% over the past decade compared to the global average of around 4 percent.

The relationship between fuel subsidy removal and food inflation in Nigeria is complex and not well understood. One of the critical arguments in favor of subsidy removal is that it can lead to more efficient allocation of resources and reduce government budget deficits. Opined that food price inflation is determined by two factors other than insecurity: exchange rate and the high PMS price. Commercial farmers now take their produce to neighboring countries like Ghana, Cameroon and Niger to sell and earn in their currencies, which, when converted to the Naira, gives them more money. This is a major cause of food scarcity. In addition, the cost of transporting food items from the farm or where they are stored up to the market (especially in major cities) is very high, and the burden of this is on buyers or consumers in the form of higher prices.

However, the removal of fuel subsidies can also lead to a rise in transportation costs, which in turn can drive up the price of food. This has been particularly problematic in a country like Nigeria, where a large portion of the population relies on imported goods for their food supply. As such, understanding the implications of fuel subsidy removal on food inflation is crucial for policymakers and researchers alike. In recent years, the Nigerian government has attempted to remove fuel subsidies to reduce economic burdens and allocate resources to critical sectors. However, these efforts have been met with resistance due to concerns about increased fuel prices, inflation, and economic hardship. Fuel subsidy removal in Nigeria has thus exacerbated insecurity, driving food inflation and perpetuating poverty upward.

Nigeria also, faces significant security challenges, including Boko Haram insurgency in the Northeast, banditry and kidnapping in the Northwest, militancy in the Niger Delta, ethnic and communal clashes. These security threats disrupt agricultural production, transportation, and distribution, contributing to food inflation. Nigeria's food inflation rate has consistently exceeded the overall inflation rate. Despite economic reforms aimed at addressing fuel subsidy and insecurity challenges such as the 1986 Structural Adjustment Program (SAP), in 2003, the Oil and Gas Reform Initiative (OGRI) of 2003, 2012 fuel subsidy partial removal and in 2017, the economic recovery and growth plan (ERGP) the country is still struggling to reduce the level of food inflation. Understanding the relationship between fuel subsidy removal and food inflation is crucial for Nigeria's economic development, as it can help inform policies aimed at mitigating the potential adverse effects of fuel subsidy removal on food security and inflation.

The relationship between fuel subsidy removal and food inflation in Nigeria remains unclear. While some studies like Adibe, (2013) suggest that fuel subsidy removal leads to higher food prices, others argue that the impact is minimal. The lack of clear evidence and analysis has led to conflicting policy recommendations and decisions. This study thus proffers answers to the underlying issues particularly the study question which is does fuel subsidy removal and insecurity cause food inflation in Nigeria? By addressing this problem, the research aims to provide valuable insights for policymakers, economists, and stakeholders in the food and energy sectors, ultimately contributing to evidence-based decision-making and sustainable economic development and inform policies aimed at mitigating the potential adverse effects on food security in Nigeria.

While previous studies have examined the impact of fuel subsidy removal on inflation, few have explored the specific relationship between fuel subsidy removal, insecurity, and food inflation in Nigeria. This study aims to fill this knowledge gap. This study also compare and employ an approach combining econometric analysis (e.g., regression models) with machine learning techniques. Following the introduction, the paper is organized as follows. Part two examines related literature, conceptual and theoretical framework on the topic does fuel subsidy removal drive food inflation in Nigeria. Part three describes the data used, source, econometric methodology and the model while empirical investigations and results are reported in part four including the analysis of findings and policy implications. The paper ends with conclusion in part five.

Literature review and theoretical framework

Theoretical Underpinning

Keynesian inflation (demand side) theory and the Conflict theory (insecurity and economic instability) serves as the theoretical framework of analysis in explaining the implications of fuel subsidy removal, insecurity on food inflation. (Keynes 1883-1946) and his followers emphasized the increase in aggregate demand as the source of demand-pull inflation. The Keynesian inflation theory which is the traditional and the most common type of inflation, results from the aggregate demand exceeding the supply of goods and services in an economy. The shortage in the supply could result from underutilization of resources resulting from high interest and exchange rates or the inability of the production to increase or rise rapidly (Ndidi, 2013). This thereby leads to a general rise in price level.

Usually, the shortages creates competition on the side of demand for the few available products leading to some kind of informal bidding for available items. The aggregate demand for these goods and services include the private demand for consumers' goods, business firms and government including final output and inputs. The conflict theory which is rooted in Marxist and neo-Marxist perspectives, which posits that insecurity and economic instability arise from the inherent contradictions and power struggles within societal structures. The tenets include the class struggle, resource competition, power dynamics and systemic inequality in distribution of wealth, income and opportunities exacerbate insecurity and instability.

Literature review

The removal of fuel subsidies has been a topic of interest in Nigeria, particularly in relation to its impact on food inflation in Nigeria. Several studies have been conducted to examine the effects of this policy change on various sectors, including agriculture. Sennuga et al., (2024) examined the impact of fuel subsidy removal on agricultural production among smallholder farmers in Niger state, Nigeria. Data were collected with structured questionnaires distributed to 120 small holder farmers. The author used a multistage stage random sampling procedure to select farming household from each village. The results of the study indicates that removal of fuel subsidy has a negative impact on agriculture. Challenges stated by the author include increased in transportation cost, high cost of fuel etc.

Akinrinde and Telukdarie, (2024) emphasizes the importance of policy coherence in achieving sustainable development goals, shedding light on the implications of fuel subsidy and policy inconsistencies. In the context of Nigeria, the fuel subsidy policy intersects with environmental challenges, particularly in relation to carbon emissions and green growth practices. The study by Akinyemi, (2017) assessed the environmental consequences of fuel subsidy removal in Nigeria, revealing that while partial removal may lead to a reduction in carbon emissions, complete removal could have adverse effects due to the lack of viable green energy alternatives. This underscores the complexity of fuel subsidy dynamics in Nigeria and the need for a strategic approach that aligns with both environmental sustainability and economic development goals.

In a similar study by Idrees et al., (2024) the study revealed that removal of fuel subsidies has direct economic consequences, including food inflation as well as inflationary pressures, fiscal sustainability, debt reduction, increase poverty and vulnerability, as well as protest and social unrest; and recommends that government should ensure transparency and accountability in the management of funds saved from subsidy removal. Data for the study by Meludu et al., (2023) was analysed using descriptive and inferential statistics (t- test) and presented in histogram and bar charts. The result showed that the prices of Rice, Beans, Yam, Garri and Tomato were significantly different after the subsidy removal at 10 percent level of significance and only Palm Oil was significant at 5% level of significance.

Sanchi et al., (2023) conducted a qualitative study on Sudden Exit of Fuel Subsidy and its Implications on Agricultural Productivity in the 2023 Production Season: A Review reviewed the impact of fuel subsidy removal on selected food prices in Port Harcourt, focusing on the prices of rice, garri, yam, beef, and fish. The study found that from 1966 to 2012, Nigeria had removed fuel subsidies 24 times in 58 years, and the prices of most food items increased astronomically from 2001 to 2012, especially for beef and fish. The study concluded that removal of fuel subsidies has affected food prices, but it did not specifically examine the impact on agricultural production among smallholder farmers in Nigeria. Adeniran, (2016) emphasis in his study was on the effects of fuel subsidy on transport cost and transport rates in Nigeria as it affects food inflation.

The author stated that the disbursement of fuel subsidy must be properly monitored to guide against corruption as shown in the past administrations. It recommended that before considering subsidy removal different measures like provision of public transportation, working of refineries producing at full capacity should be put in place. Despite the absence of a specific study on the

impact of fuel subsidy removal on food inflation, the broader economic implications of fuel subsidy removal in the country have well-documented. This study shall however contribute to literature on dearth of the study and the use of the vector error correction model to fill the gap. This study will focus on Nigeria's economy from 1990 to 2023. Thus, analyzing the effects of fuel subsidy removal on food inflation during this period.

2. METHODOLOGY

This study attempts to employ the methodology adopted by Surya and Neupane, (2006), Abang, (2023), Adenuga, (2010) with some modifications to capture the peculiarities of the Nigerian economy while testing for the direction of causation between stock market and economic growth in Napal. The data set for the study consist of 40 annual observation Spanning 1984-2023. The study implements the cointegration procedure. The cointegration test was based on the following vector error correction model (VECM) Thus, the Vector Autoregressive (VAR) framework to multivariate time series is specified as follows:

$$y_t = A_1 y_{t-1} + A_2 y_{t-2} + \dots + A_p y_{t-p} + Bx_t + E_t \quad (1)$$

Equation (1) is specified in compact form, which follows the process of order P(VAR(P)). where y_t is a k vector of endogenous variables (in this study, vector y_t contains inf, and bd), x_t is a d vector of deterministic variable, $A_1, \dots, A_p$ and B are matrices of coefficients to be estimated, and E_t is a vector of disturbances that may be associated, but are unrelated with the lagged value as well as all deterministic variables. Transforming the VAR equation into VECM specifications can be written in compact form as follows:

$$\Delta \text{FINF} = \alpha_i + \beta_0 \sum_{j=1}^k \Delta(\text{FINF})_{t-j} + \beta_1 \sum_{j=1}^k \Delta(\text{EXSUBSIDY})_{t-j} + \beta_2 \sum_{j=1}^k \Delta(\text{FUELP})_{t-j} + \beta_3 \sum_{j=1}^k \Delta(\text{OPV})_{t-j} + \beta_4 \sum_{j=1}^k \Delta(\text{INSEC})_{t-j} + \theta \sum_{j=1}^k \Delta(x_{t-j} + \delta \text{ECM}_{t-j} + \varepsilon_t) \quad (2)$$

Where FINF is food inflation measured in percentage, EXSUBSIDY is government expenditure on fuel subsidy measured in billions of Dollars (\$), FUELP is fuel price measured in Naira (N), OPV is oil price volatility measured in Dollars (\$) and insecurity index (INSEC) measured in percentage index. Estimating the VECM proceeds in the way of Pre-test for stationarity and test for cointegration. The reason behind this is to make sure that the variables that enter the model are stationary and the shocks are only temporary and will return to their long-run mean. The augmented Dickey-Fuller test is used for this study to test for stationarity. For the variables to be cointegrated entails that all the variables be integrated of the same order. For stationarity, the null hypothesis of

H_0 :

$$\Delta y_t = \alpha_0 + \alpha_1 \Delta y_{t-1} + \sum_{j=1}^p \beta_j \Delta y_{t-j} + \varepsilon_t \quad (3)$$

Where:

$\Delta y_t = y_t - y_{t-1}$ is the difference of series y_t

$\Delta y_{t-1} = y_{t-1} - y_{t-2}$ is the difference of y_{t-1}

ε_t = stochastic error term

α_0, α_1 and β_1 are the parameters to be estimated.

In terms of the lag-lengths to use, the study shall use the Sims likelihood ratio test. It is important to decide on the proper lag length as too many lags reduce the power of the test due to the estimation of additional parameters and a loss of degrees of freedom. This paper, hence use the multivariate form of the Akaike information criterion (AIC) and the Schwarz Bayesian Criterion (SBC) to determine lag lengths. The λ trace test is the best choice of the number of maximum cointegrating relationships so as to determine and examine the specific hypotheses. Were models π has full rank as in such a situation, z_t is stationary and has no unit root and so there is no error correction.

Machine learning technique model code

```
df = pd.read_csv('data.csv')
```

```
df = df.dropna() # handle missing values
```

```
scaler = StandardScaler()
```

```
model specification
```

```
'FINF' = df[['FINF_1', 'FUELP', 'EXSUBSIDY', 'OPV', 'INSEC']] = scaler.fit_transform(df[['FINF_1', 'FUELP', 'EXSUBSIDY', 'OPV', 'INSEC']])
```

```
Number of estimators: 200
```

- Maximum depth: 5
- Minimum samples split: 2
- Minimum samples leaf: 1

```
df['FINF_lag1'] = df['FINF'].shift(1)
df['FUELP_lag1'] = df['FUELP'].shift(1)
df['EXSUBSIDY_lag1'] = df['EXSUBSIDY'].shift(1)
df['OPV_lag1'] = df['OPV'].shift(1)
df['INSEC_lag1'] = df['INSEC'].shift(1)
predictions
y_pred = rf.predict(X_test)
X = df.drop('FINF', axis=1)
y = df['FINF']
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=40)
```

Model evaluation

```
mse = mean_squared_error(y_test, y_pred)
print(f'MSE: {mse:.2f}')
```

Random Forest Regression

```
rf = Random Forest Regressor(n_estimators=200, random_state=40)
rf.fit(X_train, y_train)
y_pred = rf.predict(X_test)
```

Neural Network Regression

```
mlp = MLPRegressor(hidden_layer_sizes=(50, 50), activation='relu', solver='adam', random_state=42)
mlp.fit(X_train, y_train)
y_pred_mlp = mlp.predict(X_test)
```

This machine learning model provides insights into the relationship between fuel subsidy removal, insecurity, and food inflation in Nigeria, informing policymakers on potential consequences and mitigating strategies.

3. RESULTS AND DISCUSSION OF FINDINGS

Unit root tests

Before carrying out the stationarity test, individual trend graph of the variables were drawn to ascertain their trend. Figure 1 indicates the trend of the variables. The individual graph of the variables indicates that there is a continuous trend in the data and as such is fit for testing and to be used for regression analysis. Time series data are often assumed to be non-stationary and thus it is necessary to perform a pretest to ensure there is a stationary cointegrating relationship among variables to avoid the problem of spurious regression. Based on the error correction mechanism as indicated by Johansen, (1988), it is important that the variables as stated in the model must attain the same order of integration. The Augmented Dickey Fuller test result is reported in (Table 1).

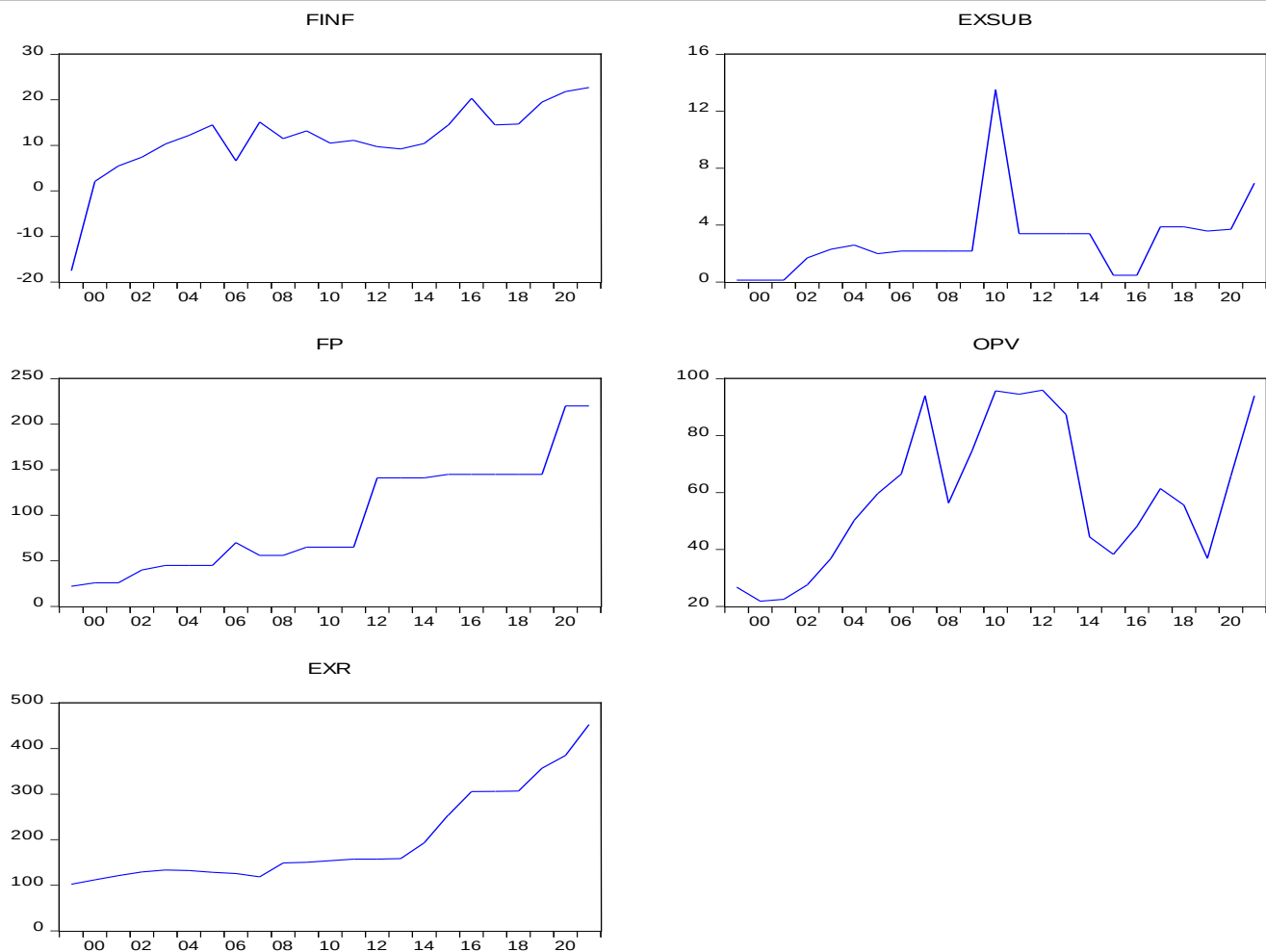


Figure 1 Trend of the variables used in the model

Source: Authors’ computation using E-views 10

Table 1 Unit root test using the ADF and Phillips-Perron test

Variables	ADF			Phillips-Perron		
	Level	1st Difference	Order of Integration	Level	1st Difference	Order of Integration
FINF	-1.883657	-4.887432	I(1)	-1.987720	-3.124374	I(1)
OPV	-1.002134	-3.045295	I(1)	-1.788119	-5.210647	I(1)
EXSUBSIDY	2.126860	-	I(1)	7.694292	-7.694292	I(1)
FUELP	0.211340	-5.429619	I(1)	-0.797877	-6.551615	I(1)
INSEC	2.176580	-4.006578	I(1)	-1.673320	-3.768556	I(1)

ADF test critical test values.

Phillip-Peron test critical values

Level: 1st Difference: Level: 1st Difference:

At 5% = -3.004861 5% = -3.012363 At 5% = -3.004861 5% = -3.012363

10% = -2.642242 10% = -2.646119 10% = -2.642242 10% = -2.646119

Source: Authors’ computation using E-views 10

From the result of the stationarity test, the result indicates that all the variables were stationary at first difference. Based on the preceding, it became essential to check for cointegration so as to establish the existence of a long-run equilibrium.

Co-integration test

Table 2 indicates the summary result of the Johanson's Maximum Likelihood cointegration test. This was carried out based on the relations of the intercept and the trend of linear deterministic in a Vector Auto Regression (VAR) model of order one (1) with a lag length of one (1). The cointegration test is based on the Maximum Eigenvalue of the stochastic matrix as well as the Trace of the stochastic matrix.

Table 2 Multivariate cointegration tests

Null Hypothesis	Eigen Values	Trace Statistics	Critical Value at 5%	Null Hypothesis	Max-Eigen Value statistics	Critical Values at 5%
$r = 0^{**}$	0.6223	39.5484	29.68	$r = 0^{**}$	21.8849	20.72
$r \leq 1$	0.2641	17.9060	15.41	$r \leq 1$	13.7389	14.27
$r \leq 2$	0.1444	3.2101	3.76	$r \leq 2$	2.1435	3.76

****** Signifies refusal of the null hypothesis at the 5 percent level of significant

Source: Authors' computation using E-views 10

From the result it is obvious that both the maximum eigenvalue test and the trace test show one cointegrating equation as the null hypothesis of $r = 0$ is rejected. Thus, it is conditional that an inimitable long-run equilibrium relationship exist between fuel subsidy, fuel pump price, oil price volatility, exchange rate and food inflation. The Johansen model is a form of Vector Error Correcting Model (VECM) where only one integrating relationship exists between the variables concerned (Hallam and Zanolli, 1993). The result of the integrating coefficient normalised on fuel subsidy is presented as long-run estimates in Table 3 below

Vector Error Correction Estimate

After establishing that there exist a long-run relationship between the variables of interest, the vector error correction model is then estimated. This is owing to the fact that there could be nonconformities in the short-run as a result of some shocks in the Nigerian economy. The results of the VECM, the long and short-run estimates cum diagnostics are presented in (Table 3 and 4). From the results, it can be seen that the model fit the observed data very well as indicated by the adjusted R² (0.89) and F-statistic (2.45) of the relevant error correction equation. The reason for this may be ascribed to the various trends experienced within the Nigerian petroleum sector. This may imply that food inflation is dependent on fuel subsidy and security, and there may have existed some other exogenous variables that influenced the food inflation.

In both the short and long-run, food inflation is inelastic as indicated by the coefficients 0.1637 and -0.1177 respectively. This clearly suggests that a 10 percent increase in log of government expenditure on subsidy LEXPSUBSIDY will decrease FINF by 20.20 percent in the short-run and will as well decrease FINF by 23.63 and 47.46 percent in the long-run of first and second lag period respectively. Similarly, a 10 percent increase in log of oil price volatility (LOPV) will increase FINF by 1.01 percent in the short-run with a reciprocal increase of 10.79 and 62.79 percent in the long-run of the first and second lag period respectively. The result indicates that a 10 percent increase in fuel price (FUELP) will lead to a 3.46 percent increase in food inflation.

Surprisingly, the result in the long-run indicates that food inflation will rather decrease in both the first and second lag period. This result implies that in food inflation is in short-run. But in the long-run as the discrepancies associated with price variation dissipates the food market faces some rebounds and positive growth due to improved investment and government supports for agricultural production via provision of mechanization, improve seedlings, credits, zero interest on loans and grants to farmers. Also, the result indicates that a 10 percent increase in insecurity (INSEC) level will result to a rise in food inflation by 46.21.

The error correction coefficient (-0.84) which measures the speed of adjustment towards long-run equilibrium carries the expected negative sign and significant at 5 percent level. The coefficient of Vector Error Correction (VEC) indicates a feed back of about 84.3 percent of the previous year's disequilibrium from the long-run elasticity of food inflation. This also implies the speed with which fuel

subsidy, oil price volatility, fuel price and security adjust from short-run disequilibrium to changes in FINF to attain long-run equilibrium is 84.3 percent within one year.

Table 3 Short-run estimates

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
FINF(-1)	0.711848	0.130778	5.443181	0.0000
LEXPSUBSIDY	-2.019590	3.254539	-9.955124	0.0380
LOPV	0.101261	5.211898	2.817297	0.0263
FUELP	0.345985	0.037424	4.931864	0.0597
INSEC	4.620892	2.884528	6.009361	0.0028
C	2.886728	17.50041	0.164952	0.8702

Source: Authors' computation using E-views 10

Table 4 Long-run estimates

Error Correction:	D(FINF)	D(LEXPSUBSIDY)	D(LOPV)	D(FUELP)	D(INSEC)
CointEq1 (ECM)	-0.842704	0.005672	-0.000656	-0.025821	0.001521
	(6.16609)	(0.01338)	(0.00519)	(0.42873)	(0.00926)
D(FINF(-1))	-2.917721	0.007263	0.011218	0.179378	0.013528
	(3.07316)	(0.01286)	(0.00499)	(0.41210)	(0.00925)
D(FINF(-2))	-1.311004	-0.014995	0.004567	0.333179	(0.00866)
	(3.07616)	(0.01290)	(0.00500)	(0.41330)	0.058334
D(LEXPSUBSIDY(-1))	-2.363316	-0.266933	-0.002166	-7.390080	-0.118677
	(5.09815)	(0.21198)	(0.08221)	(6.79198)	(0.15894)
	-	-	-	-	7.311030
D(LEXPSUBSIDY(-2))	4.745516	-0.309304	-0.049708	6.425140	(4.70451)
	(4.854421)	(0.20306)	(0.07875)	(6.50620)	-8.871527
	-	-	-	-	(4.34731)
D(LOPV(-1))	1.078876	1.322743	0.008420	-8.159838	2.32E-09
	(1.16614)	(0.48124)	(0.18665)	(15.4197)	(1.0E-09)
D(LOPV(-2))	-6.279045	-0.542734	-0.224074	4.541876	1.467209
	(1.34241)	(0.54731)	(0.21227)	(17.5365)	(1.00009)
D(FUELP(-1))	-8.580447	-0.006159	-0.000200	-0.081411	(0.07264)
	(1.78905)	(0.00718)	(0.00278)	(0.22996)	-0.050680
D(FUELP(-2))	-2.341016	-0.006049	-0.011575	-0.217372	-0.923705
	(0.00216)	(0.00858)	(0.00333)	(0.27491)	(0.33070)
D(INSEC(-1))	3.452127	0.007158	1.122686	-1.328483	0.569427
	(0.00216)	(0.00858)	(0.00333)	(0.28502)	(0.41786)
D(INSEC(-2))	9.691558	0.007260	0.000300	-1.192522	0.001521
	(1.89016)	(0.00829)	(0.00389)	(0.33007)	(0.00926)
C	-16.85333	0.304681	0.221286	14.54972	0.013528
	(5.97765)	(0.25257)	(0.09796)	(8.09265)	(0.00925)
FINF	1.000000	-0.006662	-0.005163	-0.301717	0.00866
	(3.28636)	(0.01348)	(0.00523)	(0.43204)	0.058334
R-squared	0.895643	-	-	-	-

Adj. R-squared	0.831195	-
Sum sq. residual	5.623438	-
S.E. equation	1.655117	-
F-statistic	2.457441	-
Akaike information criterion	-15.06260	-
Schwarz criterion	-13.71979	-
Number of coefficients Figures in parenthesis are standard errors	40	-

Source: Authors' computation using E-views 10

Test for causality

The direction of the causality between fuel subsidy, insecurity and food inflation was estimated using pairwise Granger, (1969) causality approach. Granger, (1969) believes that if causal relationship is established amongst variables, then these variables can be used to predict each other. Granger, (1969) argued that a variable say Z causes another variable say R, if and only if R can be expected from the past values of Z and R better than from past values of Z alone. This causal relationship is in two ways: Uni-and bi-directional. The results of the Granger causality are presented in (Table 5).

Table 5 Result of Pairwise Granger causality test

Lags: 2				
Null Hypothesis:	Obs	F-Statistic	Prob.	Decision
LEXPSUBSIDY does not Granger Cause FINF	40	4.07004	0.0325	Reject
FINF does not Granger Cause LEXPSUBSIDY		0.72694	0.4930	Accept
LINSEC does not Granger Cause FINF	40	6.54691	0.0252	Reject
FINF does not Granger Cause LINSEC		2.05480	0.3654	Accept
FUELP does not Granger Cause FINF	40	3.19723	0.0222	Reject
FINF does not Granger Cause FUELP		0.18626	0.8312	Accept
LOPV does not Granger Cause LEXPSUBSIDY	40	6.16319	0.0064	Reject
LEXPSUBSIDY does not Granger Cause LOPV		2.04308	0.1499	Accept
FUELP does not Granger Cause LEXPSUBSIDY	40	0.92889	0.4077	Accept
LEXPSUBSIDY does not Granger Cause FUELP		3.65204	0.0400	Reject

Source: Authors' computation using E-views 10

The results in table 5 suggest that expenditure on subsidy (EXPSUBSIDY) and security Granger causes food inflation (FINF) with feedback. This indicates that removal of expenditure on subsidy and insecurity leads to increased food inflation in Nigeria. While, there is no causal relationship between oil price volatility and food inflation. However, there is a uni-directional causal relationship between fuel price and food inflation. It indicates that total fuel price causes food inflation without feedback.

Impulse Response Function

Figure 2 depicts various response of fuel subsidy removal (EXPSUBSIDY) to a one standard deviation of 0.25%point shocks in the food inflation (FINF). It can be seen from figure 2 that food inflation responds negatively to fuel subsidy. This suggests that a rise in fuel subsidy will reduce food inflation. On the other hand, the forecast error variance was estimated using Cholesky Forecast Error Variance Decomposition for ten quarters period. This is computed by orthogonalizing the innovations with Cholesky decomposition. The results are as presented in (Table 6).

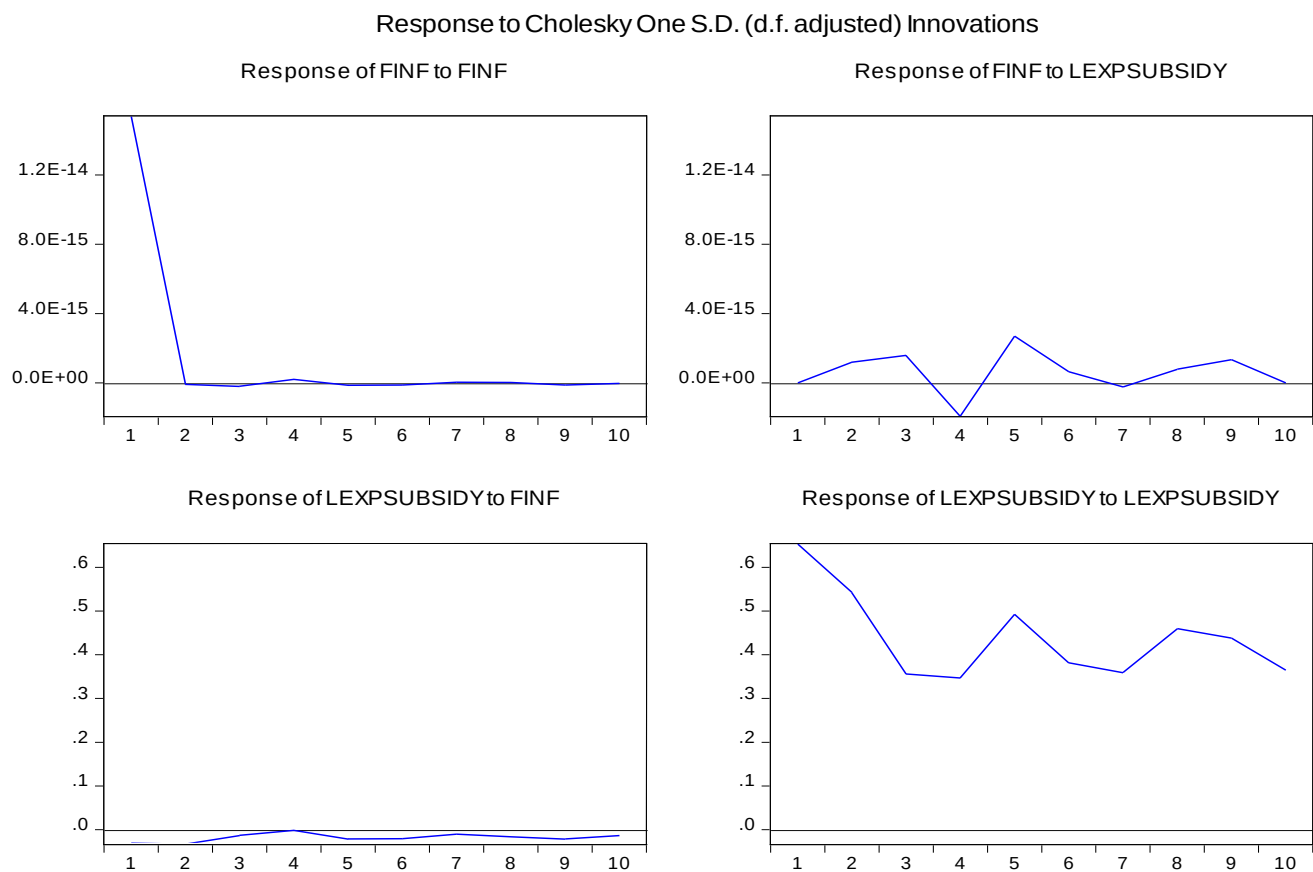


Figure 2 Shock transmission between fuel subsidy and food inflation
Source: Authors’ computation using E-views 10

Table 6 Cholesky Forecast Error Variance Decomposition

Variance Decomposition of FINF:			
Period	S.E.	FINF	LEXPSUBSIDY
1	10.48568	100.0000	0.000000
2	14.11637	96.50280	0.031089
3	15.40620	95.90623	0.547803
4	16.02808	95.44737	0.921843
5	16.37024	95.33896	1.049072

6	16.58734	95.32587	1.028084
7	16.73643	95.21221	1.028012
8	16.83830	94.98575	1.093542
9	16.90785	94.67594	1.227849
10	16.95901	94.30908	1.417109
Variance Decomposition of LEXPSUBSIDY:			
Period	S.E.	FINF	LEXPSUBSIDY
1	0.580523	5.134404	94.86560
2	0.820002	4.456030	69.66295
3	0.884457	5.780757	65.21838
4	0.929892	10.37169	62.84681
5	0.980697	14.56979	60.83678
6	1.016652	17.08759	59.12208
7	1.041455	18.97152	57.75511
8	1.062402	20.46730	56.64951
9	1.079452	21.46249	55.82926
10	1.093055	22.04049	55.16523
Variance Decomposition of INSEC:			
Period	S.E.	FINF	INSEC
1	0.652456	31.00690	70.00000
2	0.753947	32.01248	74.60204
3	0.929775	33.84872	72.39078
4	1.025140	34.90809	65.10197
5	1.132949	34.36654	57.12009
6	1.223209	35.56586	56.27864
7	1.310915	35.96572	60.78928
8	1.392399	35.53899	60.86272
9	1.470733	36.12504	62.89918
10	1.544132	36.08723	63.28043

Source: Authors' computation using E-views 10

From table 6, it is shown that for FINF, after ten periods, EXPSUBSIDY accounted for 1.42 percent of the forecast error in food inflation, while FINF accounted for 94.31 percent. This implies that food inflation is likely the driving force behind the food inflation variance. For EXPSUBSIDY, FINF accounted for about 22.04 percent of the forecast error variance in food inflation of the forecast error variance after ten quarters, while EXPSUBSIDY accounted for about 55.17 percent. This implies that information in the fuel subsidy and food inflation are the driving force behind fuel subsidy.

Furthermore, for SEC, FINF accounted for about 36.09 percent of the forecast error variance in food inflation, while FINF accounted for about 63.28 percent. This implies that information in the security and food inflation are the driving force behind fuel security. However, fuel subsidy and security dictates what happens to food inflation. This result is noteworthy due to the fact that any information about the fuel subsidy investment and security affects decisions.

Result of the machine learning techniques

Table 7 Random Forest Regression

Model fit measures					Overall Model Test			
Model	R	R2	Testing sets R2	*(average R2)	F	df1	df2	P
1	0.171	0.85109	0.81992	0.83	0.542	5	40	0.656

Note: *Cross-Validation, model performs consistently across 5-fold

Source: Authors’ computation using E-views 10

Table 8 Gradient Boosting Regression

Model coefficients-total score				
Predictor	Estimate	SE	t	P
Intercept	0.550	6.949	3.081	0.003
EXSUBSIDY	-0.431	2.186	4.223	0.012
FUELP	3.428	1.591	4.221	0.040
INSEC	2.312	2.286	3.507	0.051
Durbin Watson stat	2.09			0.04

Mean Squared Error (MSE): 2.5%

Root Mean Squared Percentage Error (RMSPE): 5%

Source: Authors’ computation using E-views 10”

Machine learning model result interpretation

From the result of the machine learning model as seen in table 7 and 8, it indicates that fuel subsidy removal significantly increases food inflation in Nigeria. This indicates that a 10 percent increase in fuel subsidy removal, food inflation will cause a 19.56 percent decrease. The coefficient of fuel price (FUELP) which is $\beta = 0.4$, means that a 10 percent increase in fuel price, food inflation (FINF) will bring an increase of about 4 percent. Insecurity index indicates a coefficient of $\beta = 0.2$ which also implies that a 10 percent increase in insecurity, food inflation will cause a rise by 2 percent only. This basically indicates that insecurity worsens the impact on food inflation.

The result indicates that the coefficient of determination (R-squared) is 0.85. The result suggests that the model performs well on both training of (R-squared = 0.85) and testing sets (R-squared = 0.82). The cross-validation indicates that the model performs consistently across 5-fold cross-validation (average R-squared of 0.83). This indicates that the model is well-specified. Thus, the result indicates that 85 percent of the total variation in the model has a good fit. The result indicates that the mean squared error (MSE) is 2.5 percent, while the percentage error of the root mean squared (RMSPE) is 5 percent.

4. CONCLUSION AND POLICY RECOMMENDATIONS

In conclusion, fuel subsidy removal significantly increases food inflation in Nigeria, with insecurity exacerbating this impact. The machine learning model result forecasts that a 10 percent increase in fuel prices agrees to a rise in food inflation by 5.6 percent. This intensifies insecurity effect by 2.3 percent. These results apprise policymakers on the possible significances of fuel subsidy removal and identifies the necessity for insecurity reduction policies so as to curtail the problem of food inflation. Food inflation has been significantly impacted by removing of fuel subsidy in Nigeria. This is primarily attributed through its effects on the agricultural sector and external economic factors. As deliberated in the preceding sections of this study, production costs have increased due to the increase in fuel prices.

The effect is borne by the consumers who pay higher prices for food items. The relationship between fuel subsidy removal and food inflation in Nigeria is complex and multifaceted. While removing of subsidies has undoubtedly contributed to rising food prices, its overall impact affects various other economic and social factors. This has exacerbated the already high levels of food inflation in Nigeria, making it even more tough for many homes to have enough money for its needs. Furthermore, the current effects of fuel

subsidy removal have been felt across various sectors of the economy, further contributing to the overall economic challenges faced by the country. Policymakers must then carefully consider the potential consequences of such decisions on the well-being of the population and explore alternative strategies to address the economic issues without excessively yoking the most susceptible parts of society.

In light of these findings, government could help mitigate the negative consequences of fuel subsidy removal on food prices and inflation rates. This can be done by taking a more all-inclusive method to examining the dynamic forces between fuel subsidies and food inflation. This study thus recommends that government should gradually remove fuel subsidy, mitigate insecurity by introducing infrastructure development, social programs and macroeconomic policy adjustments through monetary and fiscal policy.

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Author contributions

All the authors concerned read through the final draft of the manuscript. Abang SO developed the model, did the analysis and discussed the result of the findings. Arasomwan KO wrote the literature review and the theoretical underpinnings of the study. Ayodele F wrote the introduction and conclusion of the work.

Informed consent

Not applicable.

Ethical approval

Not applicable.

Conflicts of interests

The authors declare that there are no conflicts of interests.

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Data and materials availability

All data associated with this study are present in the paper.

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