Estimating the Effect of Terrorism on Agricultural Production in Nigeria

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Abstract

Nigeria has always been affected by terrorism but since the late 2000s, there has been a sharp increase in terrorism perpetrated by Boko Haram and Fulani Herdsmen terror groups. The rise in terrorism and insurgency has decimated communities and farmers have fled to protected camps. In view of that background, this paper estimates the effect of terrorism on agricultural output in Nigeria over the period 1971 to 2019. Our empirical results provide evidence which indicates that terrorism (as measured by the number of fatalities) has a negative and significant effect on agricultural output. Furthermore, this negative impact was larger over the period 2011 to 2019. This period corresponds with the onset of escalated violence from Boko Haram and Fulani Herdsmen terror groups. The following policy implications were deduced. First, government should pursue credible policies in reducing the violent attacks on farmers. Second, nomadic cattle herders should be trained and encouraged to adopt modern techniques in animal husbandry. Third, government should equip forest rangers and guards to help safeguard rural and farming communities.

Key Words: Agricultural Output, Nigeria, Terrorism, Boko Haram, Fulani Herdsmen.

JEL Classification: D74, H56, O13, Q18 and Q54

1. Introduction and Study Background

Over the last two decades, the share of employment in agriculture for Nigeria has averaged 42% (World Development Indicators, 2019). Thus, it is a country that is heavily reliant on agriculture and for which the sector accounts for the largest share of employment. More so, the agricultural sector can play an important role in a country's pursuit socio-economic development (Mkwambisi at al. 2011). The government in Nigeria, in collaboration with international agencies, such as the World Bank and African Development Bank, has pursued policies aimed at boosting the agricultural sector. Nevertheless, the efficiency of these policies may be hampered by terrorism. Between 1971 and 2010, Nigeria recorded a total of 401 terrorist incidents and 1403 fatalities from terrorism. Ever since then, and until 2019, the total number of terrorist incidents and fatalities is 4,661 and 25,570, respectively (Global Terrorism Database, 2021).

Terrorism in Nigeria is mostly in the form of killing, destruction of infrastructures, assault and kidnapping. Some of the major causes of terrorism in Nigeria rest on state failure, religious intolerance, and ethnic fragmentation (Anyanwu, 2014; Cook, 2011; Kah, 2017). Just like terrorism, Nigeria is faced with the challenges of food production and the country is heavily reliant on food imports (Ibukun & Adebayo, 2021; Olaoye, 2014). Some existing studies have identified climate change, lack of investment, credit constraints, small scale farming practices, etc., as some of the factors affecting food production in Nigeria (Obasi et al., 2013). Therefore, this study is motivated by the fact that Nigeria suffers from food shortages and is currently regarded as one of the riskiest countries in Africa due to its growing security challenges (Okafor, 2017; Olaoye, 2014).

To achieve the goal of this study, we used country-level data on terrorism and agricultural production (cereal, fisheries, and livestock) in Nigeria. The data coverage for the analysis was from the period 1971 to 2019. The results confirmed a negative and significant effect of terrorism on agricultural production. Furthermore, terrorism had a more amplified negative impact on agricultural output between 2011 and 2019. This study is important and significantly extends the

existing literature on the relationship between terrorism and agricultural production. First, unlike the study by Adelaja & George (2019), our analysis includes periods before intense terrorism in Nigeria. In addition, their study used only terror incidents from the Boko Haram terrorist organisation. This may not present a holistic picture of terrorism because there are different terrorist organisations in Nigeria. Second, the few existing studies on terrorism and agricultural output make use of micro-level household data. However, our type of data will provide us with richer analysis because it is greater than the sum of any individual sampled observations. Furthermore, the findings from our macro-level analysis will enrich the understanding of terrorism and agricultural production because different types of data sources tend to generate complementary findings (Andreasch & Lindner, 2016). Third, the intensity of terrorism has changed over the years. Thus, we considered the possibility of a structural break in our analysis. This is another departure from existing studies.

The rest of the paper is structured as follows. Section 2 will present a brief contextual background of the agricultural sector in Nigeria. Section 3 will present a review of the literature on the relationship between conflict and agricultural production. The motivating strategy and estimating strategy will be presented in section 4. Section 5 will present the data description and sources. The empirical results will be discussed in section 6. Finally, section 7 will conclude the paper and present some policy implications.

2. Brief Contextual Background of The Agricultural Sector in Nigeria

The agricultural sector in Nigeria is very important (Iorember et al., 2018). The sector is mainly driven by small-scale farmers with usually less than 2 hectares under farm cropping or general farming activities (National Bureau of Statistics(a), 2010). With respect to output, the sector has recorded steady growth over the past few years, but it continues to face numerous challenges, including policy inconsistencies from the different governments over the years. Table 1 presents comparable descriptive statistics of arable land and agricultural production. As can be briefly seen from the table, Nigeria has more arable land relative to an average SSA country and the rest of the world but still lags behind in agricultural production.

Table 1 comparable descriptive statistics of arable land and agricultural production

	Arable Land hectares (000)	Livestock Production index	Cereal Production metric tons (000,000)	Fisheries Production metric tons (000,000)
	2000-2019	2000-2019	2000-2019	2000-2019
Nigeria	34,490	92.937	24.210	0.785
SSA	3,275	88.985	119.902	6.787
World	6,889	91.138	2492.872	161.873

Sources: World Development Indicators (2021)

The agricultural sector in developing countries is characterised by three quite different systems – agriculture-based countries, transforming countries, and urbanised countries. In the agriculture-based countries, agriculture still contributes a reasonable amount to GDP and more than 65% of the poor live in rural areas. The transforming countries have most of the world's rural people and the proportion of the poor who are rural is on average, 80%. However, the share of agriculture to GDP is small. Finally, for urbanised countries, at least half of the poor people reside in urban areas and cities, and agriculture contributes very little to economic growth (Byerlee at al., 2008; Todaro & Smith, 2015). Nigeria, like most of the countries in Sub-Saharan Africa, is characterised by the agriculture-based system. In SSA countries, the percentage of the poor living in rural areas is about 85% (Sabina et al., 2014) and the contribution of agriculture to economic growth is around 16%.

Although, in Nigeria, agriculture contributes slightly higher to GDP at 24% (World Development Indicators, 2021) and the latest data show that poverty is high 66% (National Bureau of Statistics(b), 2010; Ozughalu & Ogwumike, 2013).

Table 2 shows brief descriptive statistics of food security and agricultural productivity in Nigeria, SSA, and the World. Food security is still not achievable and, as mentioned earlier, numerous challenges exist (Adetiloye, 2012). Technical factors[i] (Olaoye, 2014) and political instability (Awodola & Oboshi, 2015) have mainly been identified in the literature as some of the challenges facing the agricultural sector in Nigeria.

Table 2 Comparable descriptive statistics of food security and agricultural productivity

	Food security (score 0-100 where 100 is the best)	Agricultural productivity ($ per worker)	Share of Agriculture to GDP %
	2018-2019	2000-2019	2000-2020
Nigeria	48.1	4074.063	24.277
SSA	47.4	1215.018	16.419
World	62.9	2675.639	3.895

Sources: Global Food Security Index (2021) and World Development Indicators (2021)

3. Terrorism, Conflict and Agricultural Production

3a. An Overview

Instability has serious economic consequences (Beall, 2006) which can affect the agricultural sector (Rockmore, 2020). During instability, agricultural production is disrupted including any available support mechanisms and programmes that have been designed for the growth of the sector (Adelaja & George, 2019). Arias et al. (2018) proposed two main channels through which instability can affect economic production. First, terrorism cause destruction and impede on the smooth operations of market transactions. Second, individuals modify their productive behaviours in the presence of instability. Relating to the first channel, terrorism is often associated with the

destruction and degradation of capital and assets. On the second channel, the uncertainty generated by consistent instability can influence the investment decisions of households, as they rationally attempt to minimise potential losses (Arias et al., 2018; Rockmore, 2020).

Relating these arguments to agricultural production, terrorism can have a direct impact on agricultural output through the disruption of farm production and the carting away of farm produce by terrorist groups. If there is an increased probability of farmers losing their agricultural output to terrorist groups, they are likely to revise and reduce their planned level of agricultural investments (Adelaja & George, 2019). Human resources, physical infrastructures, and on-farm and off-farm equipment that are needed for improved and sustained efficiency of the agricultural sector have been directly attacked and destroyed by armed groups in times of conflict (Kah, 2017).

Policies and programmes are very important for the growth of the agricultural sector. However, frequent and intensive conflicts can erode their benefits or simply put a halt to their operational continuity and efficiencies. Agricultural extension personnel or government agricultural workers will not be available or accessible to provide support to farmers. For fear of their lives and safety, farm input suppliers and agricultural middlemen that provide trade links are likely to cease operating in such areas. The implication of this is market failure where the link between farming and trade is non-existent, and, thus, a subsequent reduction in overall agricultural production (Adelaja & George, 2019).

In Nigeria, these are some of the potential channels through which agriculture has likely been affected. The associated destruction of hard infrastructure, such as roads, dams, and bridges, has affected market access and disrupted agricultural supply mechanisms. Also, terrorists mainly attack the rural areas in Nigeria and those areas have the highest proportion of labour force in agriculture. The implication of these attacks is the constant decline in human capital through the loss of lives, injuries, and displacement (Amnesty International, 2018). Farmers in rural conflict zones are also known to have abandoned their farmlands as they fear for their safety. Thus, the labour force

needed on the farms is below the required capacity for an efficient and stable agricultural production (Awodola & Oboshi, 2015).

3b. Terrorism (Boko Haram, Fulani Herdsmen), Banditry, Kidnapping and Agricultural Production in Nigeria

The activities of Boko Haram[ii] and Fulani Herdsmen[iii] are those mostly argued as causing considerable damage to the agricultural sector in Nigeria. In addition, banditry and kidnapping have caused enormous disruption in agrarian areas. The attacks by Fulani herdsmen began in 2002 and has intensified since 2011. The total number of attacks as at 2019 is 711 with 4,505 fatalities and 1,004 injuries. Of these, only a small proportion (51 attacks, 74 fatalities and 24 injuries) have been carried out on government establishments and institutions. The attacks by Boko Haram also started about the same time but with far greater consequences. The corresponding figures over the same period are 3,086 attacks, 22,255 fatalities and 9,606 injuries (GTD, 2021). Figure 1 shows the trend of terrorist attacks in Nigeria between 1971 and 2019.

The attacks by Boko Haram are devastating for agricultural activities in Nigeria particularly in the Northern states. Farmers have been killed and their crops and farm animals either carted away or destroyed. Those that survived have abandoned their farmlands to relatively safer areas (Udemezue & Kanu, 2019). The abandonment of farmlands has made it impossible for individuals to carry on with their farming activities and the investments needed to grow the agricultural sector (Sidney et al., 2017). The peak of the attacks often come before the lean season and during the harvest season. Such systematic attacks can easily deter agricultural labour and the transportation network for the movement of agricultural goods (Van Den Hoek, 2017)[iv].

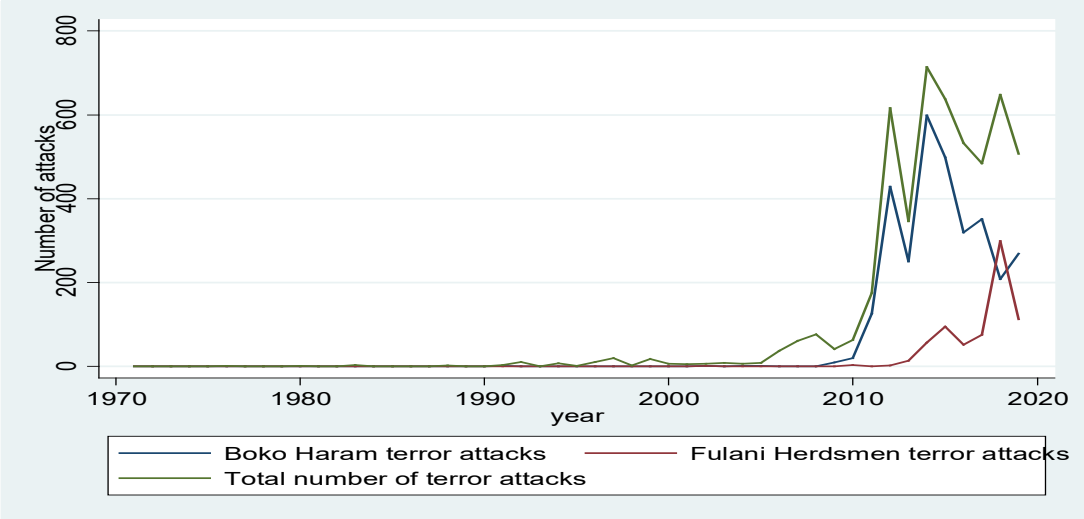

Figure 1: Plots the evolution of terrorist attacks in Nigeria from 1971 to 2019

In addition, the attacks by Fulani herdsmen have been so intense that people (mostly farmers) have been killed and those alive are forced to flee their lands (Olayiwola, 2020). Besides the loss of livelihood, the farms and crops left behind are destroyed by the herdsmen (Udemezue & Kanu, 2019). In many quarters, the attacks on farming communities are now seen as the biggest threat facing agricultural productivity and food security in Nigeria. A study conducted by Oti et al. (2017) on 210 households in the Southeastern part of Nigeria, showed that attacks by herdsmen had severe consequences on food security, agricultural productivity, and socioeconomic wellbeing. In addition, these attacks have destabilised the rural areas and scared away the labour needed in agriculture[v]. Sadly, a new source of threat has recently intensified to add to the security challenges facing the country. Criminal groups seen as an offshoot of the terrorist activities in Nigeria are now engaged in sophisticated acts of banditry and kidnapping. These groups engage in cattle rustling, theft of farm produce and kidnapping of households for ransom (Onwuzuruigbo, 2021).

3c. Some Empirical Studies

There are some empirical studies to justify the arguments, so far, of the negative impact of instability on agricultural production. For example, Ijirshar, et al. (2015) showed empirical evidence of the significant negative effect of terrorism on crop yield and the positive effect of terrorism on

farmer displacement. The study was based on the survey data of farmers in one of the farming communities in North Central Nigeria. According to the study, terrorism reduced the level of investment on farms and reduced the pool of farm labour. Using household level panel data from Nigeria, Adelaja & George (2019) empirically concluded that agricultural production was adversely affected by terrorism. Several factors were outlined by the study in justifying this finding. First, farmers might have grown less of certain crops in anticipation of terrorists raiding and carting away their produce. Second, agricultural inputs were significantly affected as a result of terrorism. Third, the increased probability of terror attacks would have prompted farmers to utilise less productive farmlands.

Rockmore (2020) showed that households in Uganda adjusted their preferences by reducing their level of investments in livestock holdings due to the risk of conflict. Further estimates from their analysis also show that households reduced their cultivation of prevalent crops because such crops require constant weeding, intensive labour, and a long duration to harvest, which may not be feasibly possible in the face of conflict. The impact of conflict on crop yield and agricultural productivity in the conflict-ridden Orontes Basin region of Syria was investigated by Jaafar et al. (2015). Agriculture in the region was badly affected due to conflict. The study argued that farmers were temporarily abandoning their farmlands and agricultural activities in the face of the conflict, and this has been partly responsible for the drop in agricultural production. A similar empirical conclusion was reached by Eklund et al. (2017) in their study of the adverse effect of conflict on agricultural activity. Frequent conflicts reduced farming activities from high-intensity to low-intensity. Long-term investments in agriculture were also significantly reduced due to terrorism in the Punjab region of India. This was from an empirical conclusion by Singh (2013). The study showed that investment was reduced by approximately 17% and resulted in farmers losing around 4% of their annual income. Thus, in accordance with the theoretical arguments and the reviews of

the relationship between terrorism and agricultural production and productivity, we hypothesise the following.

H_{1a}: There is a negative relationship between terrorism and cereal production

H_{1b}: There is a negative relationship between terrorism and fisheries production

H_{1c}: There is a negative relationship between terrorism and livestock production

4. Motivating Theory and Estimating Strategy

The underlying premise is that agricultural output, at any given time, is influenced by several factors. This is due to the fact that factors that influence agricultural output are not constant over a given period of time. In view of that, this study investigates the effect of terrorism on agricultural output at the macro-level by exploiting a neoclassical (Solow) model. In a neoclassical (Solow) model, labour and land are supplied inelastically. Thus, economy i (i.e., Nigeria) has the constant return to scale aggregate production function

$$Y_{i,t} = \left[A_{i,t}H_{i,t}\right]^{\alpha} K_{i,t}^{\beta} L_{i,t}^{1-\alpha-\beta} \quad (1)$$

Where $\alpha + \beta \leq 1$, $Y_{i,t}$ symbolise the level of aggregated output produced in time t, $K_{i,t}$ signify capital, $L_{i,t}$ depicts the supply of land, $A_{i,t}$ is the labour-augmenting technology or knowledge, and $H_{i,t}$ is the effective unit of labour given by $H_{i,t} = h_{i,t}N_t$ where $N_{i,t}$ is total population and h_t is human capital per person. For simplicity and without loss of generality, normalise $L_{it} = L_i = 1$ for all t. Specifically, equation (1) can be re-parameterised in order to estimate the aggregate agricultural output, and this can be shown as

$$Ay_t = \boldsymbol{F}\left[\sum_{j=1}^{N} FtAAP_{j,t}, K_t, Al_t\right] \quad (2)$$

Where Ay_t symbolises the level of Nigerian aggregated agricultural output in time t, K_t signifies capital, Al_t is agricultural land, which is $L_t - \varphi$ and φ is the share of non-agricultural land, and $FtAAP_t$ are **f**actors **t**hat **a**ffect **a**gricultural **p**roduction, which are (i) population in agriculture, (ii) terrorism fatalities, (iii) rainfall (average precipitation), and (iv) fertiliser consumption. Building onto equation (2), the estimating specification for this study is of the form

$$Ay_t = \alpha + \sum_{j=1}^{N} \phi' FtAAP_{j,t} + \gamma' K_t + \lambda' Al_t + \epsilon_t \qquad (3)$$

Where, ϵ_t is the error term that is independent and identically distributed (*i.i.d*). Equation (3) is estimated using lagged regressor. This is advantageous in identifying the sources of endogeneity. There are two important points to note in equation (3). First, the total capital stock K_t is used against the capital in agriculture; this is due to the fact that in the long-run, capital is mobile (move freely) between the service, agriculture and manufacturing sectors. Second, equation (3), simultaneously, estimates the effect of terrorism on agricultural output together with other factors that influence agricultural output.

Econometrically, identifying instruments for macro-level studies is often difficult. Noticeably, the instrument in question is one that is strongly associated with terrorism, yet not correlated with agricultural output. Having a theoretically plausible instrumental variable ensures that the estimates are not spurious. We could have used the data that pertains to the rise of propaganda ideologies by organisations such as Al-Qaeda and Islamic State. We posit that, the rise in the dissemination of propaganda ideologies by those organisations significantly influenced the terrorists in Nigeria. Unfortunately, we are unaware that such datasets exist. In the absence of an instrumental variable, we use the lagged regressor as instruments, a common approach in a growing number of empirical studies (Afonso & Jalles, 2013; Roodman, 2009).

5. Data Description and Sources

We utilise the annual data for the period covering 1971 to 2019. There are no available data after 2019 for our main variables of interest. The data on (i) agricultural yields, which are cereal, fisheries and livestock production;[vi] (ii) employment in agriculture; (iii) agricultural land; and (iv) fertiliser consumption were obtained from the World Bank Development Indicators (WDI). The data on terrorism fatalities was collected from the Global Terrorism Database. We used the number of fatalities and not attacks because it captures better the scale or severity of terrorism. For example, a small number of terror incidents with no fatalities will have less impact in comparison to just one attack with a significant number of fatalities. Data on average rainfall (precipitation) in depth (mm per year) are obtained from the WDI and complimented by data from Knoema and a study by Ukhurebor & Abiodun (2018). The data on employment in agriculture, fertiliser consumption and average annual rainfalls had missing observations. To fill the gaps, we applied the Bayesian Backfitting and Backcasting techniques. Finally, the capital component (K_{it}) is calculated using the Perpetual Inventory Method (PIM); this follows the methodology outlined in Chikalipah (2019a) that carries the form

$$K_{t+1} = (1 - \delta)K_t + I_t \qquad (4)$$

The gross fixed capital formation I_t data is obtained from the WDI database. The depreciation rates (δ) and the initial capital stock are taken from the Penn World Tables (PWT) version 10.

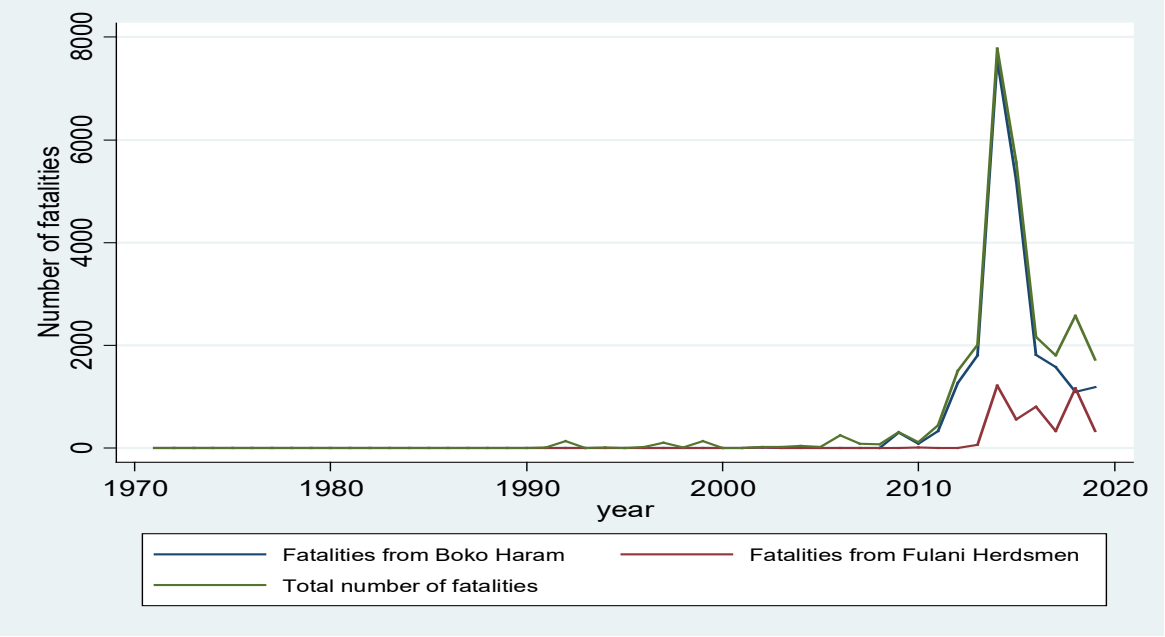

Figure 2: Plots the evolution of terrorism fatalities in Nigeria from 1971 to 2019

From figure 2, it can be observed that terrorism fatalities in Nigeria vastly increased from 2010. Moreover, terrorism fatalities reached an all-time high in 2014, mainly perpetrated by Boko Haram and Fulani herdsmen. table 3 provides the descriptive statistics of variables used in this study.

Table 3 Descriptive statistics

VARIABLE	MEAN	S.D	MIN	MEDIAN	MAX
Dependent Variables					
Cereal Prod. (million metric tons)	18.200	7.570	5.810	20.100	32.100
Fisheries Prod. (million metric tons)	0.502	0.306	0.245	0.357	1.210
Livestock Production (index=100)	67.760	32.970	26.960	67.530	101.360
Explanatory Variables					
Agricultural land (sq. km in million)	0.620	0.069	0.472	0.654	0.693
Capital Stock (USD in Billions)	2,170	1,280	500.100	2,100	4,590
Fertiliser Consumption (Kg/ha)	9.740	5.440	4.210	8.570	21.060
Employment in Agriculture (%)	43.900	5.260	34.970	44.91	50.200
Average Rainfall (mm/yr. in depth)	1064.140	85.020	920	1083	1295
Terrorism Fatalities	**550.500**	**1450**	**0.000**	**134**	**7781**

NOTES: The monetary data is dollarised.

6. Empirical Results

a. The baseline results

In this section, we present the results of the effect of terrorism on agriculture in Nigeria. The results are obtained after estimating Equation (3) using the OLS and lagged regressor estimators. Theoretically, given that our OLS specification does not control for endogeneity of terrorism fatalities, the model estimates are most likely to be understated. However, in all the specifications, the coefficients have consistent signs and this possibly indicates that our estimates do not suffer from endogeneity bias. Furthermore, the Kleibergen–Paap rk Wald *F* statistic in all the lagged regressor specifications, is above 10, which infers the absence of a weak instrument problem (Stock & Yogo, 2015).

Table 4 Estimation results of the effect of terrorism fatalities on agricultural yields in Nigeria over the period 1971 - 2019

	DEPENDENT VARIABLES					
	Cereal Production		Fisheries Production		Livestock Production	
	OLS	OLS (lagged regressor)	OLS	OLS (lagged regressor)	OLS	OLS (lagged regressor)
Agricultural land	0.006[a]	0.009[a]	2.170[a]	2.192[a]	1.226[a]	1.362[a]
	(0.001)	(0.003)	(0.350)	(0.301)	(0.119)	(0.200)
Capital Stock	0.820[a]	0.316[a]	0.232[a]	0.234[a]	0.186[a]	0.184[a]
	(0.194)	(0.097)	(0.043[a]	(0.037)	(0.021)	(0.025)
Fertiliser Consumption	-0.029[a]	-0.038[a]				
	(0.009)	(0.016)				
Employment in Agriculture	0.221[a]	0.112[a]	0.002[b]	0.003[a]	0.336[a]	0.315[a]
	(0.059)	(0.030)	(0.001)	(0.001)	(0.024)	(0.022)
Average Rainfall	0.006[b]	0.007[c]	0.004[b]	0.006[b]	0.002	0.003
	(0.003)	(0.004)	(0.002)	(0.003)	(0.003)	(0.002)
Terrorism Fatalities	**-0.007[a]**	**-0.008[a]**	**-0.006[a]**	**-0.004[b]**	**-0.005[a]**	**-0.004[b]**
	(0.002)	**(0.003)**	**(0.002)**	**(0.002)**	**(0.002)**	**(0.002)**
Observations	49	49	32	32	49	49
R - Squared	0.310	0.180	0.570	0.270	0.370	0.410

NOTES: The figures in parentheses represent standard errors (SEs). The letter **c** expresses significance at the 10 percent level, **b** at 5 percent and **a** at 1 percent level.

The OLS and lagged regressor estimates, as presented in table 4, show that the coefficient of terrorism fatalities is negative and statistically significant at 1 or 5 percent for all the dependent variables. An increase in terrorism fatalities by 100, lowers cereal production and fisheries production by about 0.4 to 0.8 million metric tons. Although, the impact of terrorism on cereal production is slightly higher. The plausible explanation could be that as a community gets decimated due to terrorism, they abandon their farms and flee to protected shelters. Thus, we can empirically confirm the hypotheses and expectations of our study. Furthermore, the results are consistent with some existing studies on terrorism and various measures of agricultural productivity and outputs (see: Adelaja & George, 2019; Noubissi & Njangang, 2020).

The coefficients of the Solow regressors (capital stock, agricultural land, and population in agriculture), in all specifications, are statistically significant. The coefficients of average rainfall are positive and significant, indicating that an increase in rainfall has a positive effect on cereal and fisheries production. Unexpectedly, we found that rainfall has an insignificant effect on livestock production. The rational explanation for this finding is that the forage used to feed livestock can still grow and be sufficient even in seasons of low rainfall patterns. Thus, rainfall variations have a minimal effect on livestock production, yet this conclusion is likely to change during the period of severe droughts[vii]. Fertiliser consumption is negative and robustly significant at 1 percent in all specifications. Some studies have shown that excessive use of artificial fertilisers reduces the microbial function critical to crop health (see: Burke et al., 2019; Kotschi, 2015). When estimating the determinants of fisheries and livestock productions, fertiliser consumption was not included as a regressor. The underlying reason is that, in Nigeria, fertiliser is rarely used in fisheries and livestock productions.

b. Assessing the effect of terrorism on agricultural yields by considering the structural break point

In this sub-section, we evaluate the possible effect of a structural break (break point) in our dataset. Econometrically, this is not necessary, given that we have not employed a time series analysis. Yet, the rationale for considering the possible effect of a structural break, is to assess the magnitude of the impact before and after 2010 when terrorism fatalities rose by 1,723%.

Table 5 Decadal variability of terrorism incidents in Nigeria

DECADE	DEATHS (μ)	NOTES
1971 - 1980	0.3	
1981 - 1990	0.5	
1991 - 2000	44	
2001 - 2010	96	Breakpoint: 2010
2011 – 2019	2841	

NOTES: Table 5 reports the decadal variation of terrorism fatalities (deaths), and the decadal mean (average from 1971 to 2019). The break point for the series of terrorism fatalities is 2010. The symbol μ denotes mean (average).

In table 5, we applied the Zivot–Andrews break tests (Zivot & Andrews, 2002), and the test showed 2010 as the break point. Therefore, we re-estimated equation (3) on subsamples covering the following periods: (i) 1971 to 2010, and (ii) 2011 to 2019. Given that the subsample covering the period 2011 to 2019 is small, with fewer degrees of freedom, we rely on the OLS estimator, as the estimation with the lagged regressor will be inconsistent. This approach is widely applied in empirical studies – for the related literature see Chikalipah (2019b, p402).

Table 6 Estimation result of the effect of terrorism fatalities on agricultural outputs using a sub-sample (OLS estimates)

	DEPENDENT VARIABLES		
	Cereal Production	**Fisheries Production**	**Livestock Production**
PERIOD A (1971 - 2010)			
Agricultural land	0.008[a] (0.003)	2.040[a] (0.280)	0.922[a] (0.228)
Capital Stock	1.009[a] (0.230)	0.326[a] (0.066)	0.142[a] (0.028)
Fertiliser Consumption	-0.018[a] (0.005)		
Population in Agriculture	0.0287[a] (0.072)	0.002[b] (0.001)	0.201[a] (0.043)
Average Rainfall	0.013[c] (0.007)	0.006[b] (0.003)	0.002 (0.002)
Terrorism Fatalities	**-0.004[b] (0.002)**	**-0.003[a] (0.001)**	**-0.002[b] (0.001)**
Observations	40	40	40
R - Squared	0.240	0.190	0.300
PERIOD B (2011- 2019)			
Agricultural land	0.312[a] (0.881)	0.059[a] (0.018)	0.010[a] (0.003)
Capital Stock	0.115[a] (0.028)	0.116[a] (0.038)	0.011[b] (0.005)
Fertiliser Consumption	0.009[a] (0.002)		
Population in Agriculture	0.006[b] (0.003)	0.005[a] (0.001)	0.047[b] (0.011)
Average Rainfall	0.027[a] (0.008)	0.013[c] (0.007)	0.039 (0.027)
Terrorism Fatalities	**-0.168[a] (0.034)**	**-0.094[a] (0.011)**	**-0.101[a] (0.002)**
Observations	9	9	9
R - Squared	0.890	0.980	0.770

NOTES: The figures in parentheses represent the standard errors (SEs). The letter **c** expresses significance at the 10 percent level, **b** at 5 percent and **a** at 1 percent level.

From table 6, the magnitude and significance of some coefficients are somewhat different from the baseline results reported in Table 4. The lack of consistency is mainly due to the Simpson-Yule (Simpson Paradox) effect, which often occurs when the results of full samples differ from their sub-samples (Wagner, 1982). The variable of interest is terrorism fatalities, and when methodically matched with the results reported in Periods A and B, the magnitude of the coefficients for terrorism fatalities in Period B is larger. This implies that between 2011 and 2019, terrorism has

had an amplified negative effect on agricultural production. This period has seen Nigeria suffer greatly from terrorism and largely perpetuated by Boko Haram and Fulani herdsmen. An increase in terrorism fatalities by 100, lowers cereal production and fisheries production by about 10.1 to 16.8 million metric tons. This is far greater than the preceding period of 1971 to 2010.

c. Evaluating the Strength of the Regressors using the Bayesian Model Averaging (BMA) framework

In this section, we evaluate the strength of the regressors. The possible objection to the estimating framework, specified in equation (3), is that it may suffer from a potential variable selection bias. Thus, we exploit a Bayesian Model Averaging (BMA) as our estimation technique. The BMA approach addresses the potential model's uncertainty problems (Moral-Benito, 2015). As a result, we apply the BMA technique based on Hoeting et al. (1999).

Table 7 Evaluating the strength of regressors used when estimating the effect of terrorism on agricultural yields in Nigeria – The Bayesian Model Averaging Approach

	DEPENDENT VARIABLES					
	Cereal Production		**Fisheries Production**		**Livestock Production**	
	PIPs	**Sign**	**PIPs**	**Sign**	**PIPs**	**Sign**
Agricultural land	**0.55**	(+)	0.15		**0.30**	(+)
Capital Stock	**0.24**	(+)	**0.95**	(+)	**0.53**	(+)
Fertiliser Consumption	**0.23**	(-)	0.16		0.14	
Population in Agriculture	**0.20**	(+)	**0.21**	(+)	**0.58**	(+)
Average Rainfall	0.13		**0.48**	(+)	0.18	
Terrorism Fatalities	**0.22**	(-)	**0.21**	(-)	**0.20**	(-)

NOTES: The BMA analysis yields the posterior inclusion probabilities (**PIPs**) and the (**Sign**) certainty index of a relationship. Where the **Sign** is not given, this indicates that the estimated coefficient is not significant in explaining the agricultural yield in Nigeria. Thus, the **sign** is only given where the PIPs exceed 0.2. The PIPs of greater than 0.2 are shown in **bold** text, and are considered robust in explaining agricultural yield in Nigeria. The PIPs are calculated by using the method from Raftery (1995).

Table 7 presents the BMA estimates of factors that influence agricultural yields in Nigeria over the period 1971 to 2019. The empirical results suggest that an increase in terrorism fatalities is associated with a reduction in agricultural output in a year. When the results presented in table 6

are jointly analysed, it is appropriate to conclude that our baseline estimates are not biased. In summary, our main finding indicates a statistically significant negative relationship between terrorism and agricultural yield in Nigeria.

7. Summary and Policy Implications

a. Summary and Concluding Remarks

We were motivated to undertake this empirical scrutiny by the sharp rise in terrorism and food insecurity in Nigeria. As earlier mentioned, the rise in terrorism has decimated communities and local farmers have fled to protected camps. Importantly, investigating the effect of terrorism on agriculture is critical in the formulation of optimal policies that promote food security in Nigeria. Our estimates show that terrorism (as measured by the number of fatalities) has a negative and significant effect on agricultural output.

b. Policy Implications

Based on the empirical findings of this study, we deduce the following recommendations. First, the government of Nigeria should pursue and implement credible measures that will prevent or at the least reduce terrorism to the barest minimum. Some of the root causes of terrorism have been identified in the literature and policymakers may use that as a benchmark. Second, farmers in conflict hit areas will abandon their farms in the face of insecurity and this has serious implications for agriculture. Therefore, policymakers should set up security and military posts in agricultural known hubs and provide safety nets or investment protection measures (such as insurance schemes) for farmers. In addition, forest rangers and guards should be better trained, equipped and remunerated to help patrol and safeguard rural communities from attacks. Third, conflict increases the risks and uncertainty of investments, which will certainly make it difficult for traditional creditors to provide farmers with the needed credit. Hence, in conflict prone areas, the government should set up mechanisms in place that will guarantee farmers the soft credit needed

to help cushion the impact of insecurity. Fourth, the nomadic/wandering nature of the Fulani herdsmen has contributed to instability, banditry, and terrorism. Therefore, the government should train and encourage cattle herders to adopt modern techniques in animal husbandry such as cattle ranching. This will limit the movement of cattle by pastoralists and a halt to open grazing. It will also bring forth new economic opportunities for cattle herders while at the same time, encouraging social and cultural cohesion between farmers and cattle herders.

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[i] Technical factors indude poor infrastructures, outdated farming practices, lack of extension services, and harsh environmental or dimatic conditions.

[ii] An Islamic terrorist group operating mainly in Nigeria but affiliated with Al-Qaeda and ISIS.

[iii] Traditionally, they are ethnic pastoralist groups that move across West and Central African countries in search of greener pastures for their cattle.

[iv] See, Akinola (2015); Weeraratne (2017) for an in-depth review of the Boko Haram insurgency in Nigeria.

[v] See, Abodunrin et al. (2020) and Obi & Chukwuemeka (2018) for a more detailed review on the politics and socioeconomic impact of Fulani Herdsmen terrorism.

[vi] We would have also used the food production index as an alternative dependent; however, that parameter is strongly correlated with livestock production. The pairwise correlation coefficient between the two variables is 0.95.

[vii] According to Eze (2018), between 1971 and 2016 drought occurrences in Nigeria were recorded during the following rainy seasons: (i) 1972-73, (ii) 1984-85, (iii) 2007-08, and (iv) 2010-11. Given that that there have not been so many drought occurrences over the period considered in this study, this could explain our findings.