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FOOD SCIENCE & TECHNOLOGY | RESEARCH ARTICLE

The impact of the presidential cassava initiative on cassava productivity in Nigeria: Implication for sustainable food supply and food security

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Abstract: Agricultural programmes are implemented in sub-Saharan African countries to stimulate rural economic development. One such programme is the Presidential Cassava Initiative (PCI) in Nigeria aimed at reducing poverty and food insecurity, but there is a limited study on contribution of the programme to cassava output and food security. This study estimated the effects of the PCI on cassava output and food security in Nigeria. A three-stage multivariate linear regression model was applied in the empirical analysis. The results showed that the PCI has increased cassava output; promoted food supply; and enhanced national food security. The study concludes that agricultural development interventions are required to achieve a sustainable food supply and food security in sub-Saharan Africa. It is recommended that exit strategy should be incorporated in designing agricultural interventions to enable beneficiaries to enjoy sustainable effects.

Subjects: Environment & Agriculture; Agriculture & Environmental Sciences; Rural Development

Keywords: Presidential cassava initiative; productivity; food security; sustainable; Nigeria; agricultural development

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PUBLIC INTEREST STATEMENT

Most sub-Saharan African countries are faced with low agricultural productivity, and therefore, achieving a sustainable food supply and food security has become a challenge. Consequently, rural poverty, food insecurity, and unemployment are prevalent in most SSA countries. One of the contributing factors is low investment towards agricultural development. These problems became a concern to governments and donor agencies to design and implement agricultural interventions to transform rural economies in the SSA including Nigeria. One of such interventions is the Presidential Cassava Initiative (PCI) in Nigeria and other West African countries. The present study therefore estimates the effect of the PCI on cassava output, food supply and food security in Nigeria. Our findings show that the implementation of the PCI contributed to improving cassava output, national food supply, and food security.

1. Introduction

Agriculture continues to play an important role in the economic growth and development in sub-Saharan Africa (SSA). It employs the majority of the labour force and provides a valuable source of raw materials and food commodities. Evidence shows that the agricultural sector employs about 70% of the total labour force in SSA, with the majority of these people located in the rural areas (Fiszbein, Kanbur, & Yemtsov, 2014). Agriculture in SSA is characterized by low productivity emanating from the over-reliance on traditional farm technologies. Another factor contributing to the poor performance of the agricultural sector is low investment. Christiaensen, Demery, and Kuhl (2011) point out that most SSA countries allocate a low percentage of their national budgets to the agricultural sector. This issue has become a concern for the African Union (AU), which has compelled its member states to allocate not less than 10% of their national budgets to the agricultural sector. Only a few countries have enforced this regulation in their national agenda. It is not surprising that most SSA economies are not yet as transformed as Asian countries, for example, where the agricultural sector is a priority.

Most SSA countries are still struggling to achieve a sustainable supply of food commodities such as roots and tubers, cereal, and grain crops. Consequently, rural poverty, food insecurity, and unemployment rates are high in these countries. For instance, the Food and Agricultural Organization, the International Fund for Agricultural Development & the World Food Programme (2015) report reveal that about 759 million people in the world are undernourished, twenty percent (20%) are located in Africa, 14.2% in Oceania, 12.1% in Asia and 5.5% in Latin America/the Caribbean. Furthermore, 23.2% of the population in SSA is food insecure (Karfakis, Rapsomanikis, & Scambelloni, 2015). Forty-eight percent (48%) of people in SSA live on \$1.90 a day, suggesting that poverty is prevalent (World Bank, 2013). These statistics clearly indicate that Africa is lagging behind in achieving a sustainable food security and alleviating poverty. These economic problems have drawn the attention of policy makers and donor agencies to design and implement agricultural programmes to help transform rural economies in SSA, and more importantly in Nigeria, where most people depend on agriculture for their livelihoods.

One of these interventions is the Presidential Cassava Initiative (PCI), which was launched in cassava-producing countries in West Africa in 2001. The beneficiary countries include Nigeria, Ghana, and the Democratic Republic of Congo. The programme lasted for six years (2001–2007). The PCI focused on cassava because the majority of farmers in the beneficiary countries cultivate cassava as their staple food. Cassava has the ability to transform rural economies in these countries because it can survive on marginal soils, has diverse uses and requires low inputs when compared to other crops such as maize and rice. Nigeria's PCI aimed at: (1) enhancing the productivity and production of cassava by increasing the area cultivated to 5 million ha, with the hope of harvesting 150 million tonnes of fresh cassava tubers annually; (2) producing 37.5 million tonnes of processed cassava products for the local and export markets; (3) organising the export of cassava and processed cassava products as a revenue-generating project; and (4) generating about 5 billion dollars annually from exporting value-added cassava products (Sanogo & Adetunji, 2008).

Nigeria's PCI was well focused on the areas of its interventions (development of cassava production and processing, expansion of cassava, and marketing of processed cassava products), which were adequately incorporated into the cassava value chain development activities of the federal ministries. Various stakeholders, including public and government agencies, were involved in executing the various activities under the PCI. The government stakeholders include the Federal Ministry of Agriculture and Water Resources (FMAWR), the Federal Ministry of Commerce and Industries (FMCI), the Root and Tuber Project (RTEP), the Raw Materials Research and Development Council (RMRDC), the Nigerian Stored Products Research Institute (NSPRI), the National Centre for Agricultural Mechanization (NCAM), the Standards Organization of Nigeria (SON), the Central Bank of Nigeria (CBN), the National Bureau of Statistics (NBS), and the Nigerian Export Promotion Council (NEPC). The supporting institutions include the International Institute of Tropical Agriculture (IITA) and the NEPAD Pan African Cassava Initiative (NPACI) Secretariat. The private agencies involved are cassava

growers' associations, cassava processor associations, equipment fabricators, cassava traders, bread bakers and cassava transporters (Sanogo & Adetunji, 2008).

Through the PCI, the NRCRI established 60 ha of seed farm to produce 24,000 bundles of breeder stock while the RTEP set up 80 ha to generate 32,000 bundles of foundation stock; 148 ha were planted by state ADPs to produce 59,000 bundles of certified stock; release of 5 improved varieties selected from 43 varieties screened under the Pre-emptive Management of Cassava Mosaic Disease (CMD) to farmers; 500 extension agents from the south-west, south-east, and north-central were trained; 21 artisanal equipment fabricators were trained at the NCAM in the fabrication and production of processing machinery such as cassava peelers, chipping machine, and manual harvester (Ohimain, 2015; Sanogo & Adetunji, 2008).

Some studies have been conducted on cassava production in Nigeria after the implementation of the PCI. For instance, an empirical evidence demonstrates that adoption rates of improved cassava varieties are slow but some improvements are observed in Sub-Saharan African countries including Ghana (Acheampong & Owusu, 2015; Donkor, Owusu, & Owusu-Sekyere, 2014; Owusu & Donkor, 2012), Nigeria (Abdoulaye et al., 2014; Abdoulaye, Bamire, Oparinde, & Akinola, 2015; Afolami, Obayelu, & Vaughan, 2015), Zambia (Khonje, Mkandawire, Manda, & Alene, 2015), Tanzania (Kavia, Mushongi, & Sonda, 2007), Uganda (Abele et al., 2007), and Sierra Leone (Margao, Fornah, & Barrie, 2007). It is observed that the adoption rates are higher in Nigeria than the countries mentioned above. Other studies suggest that cassava productivity and efficiency levels are improving in Nigeria but access to adequate inputs such as credit, extension services, availability of improved cassava varieties still remain a challenge (Abdoulaye et al., 2015; Umunakwe, Nwakwasi, Ani, Ejiogu-Okereke, & Nnadi, 2015).

With an extensive survey of the literature, we observed that a few studies have been carried out on the effects of PCI on the Nigerian cassava outputs. A recent exploratory study by Ohimain (2015) shows that through the PCI, the Federal Government of Nigeria created a policy measure that supported the industrialisation of cassava such as 10% cassava bread, 10% bioethanol in gasoline and replacement of paraffin with ethanol gel fuel as a cooking fuel. Moreover, Ohimain (2015) reported that PCI increased investment and employment in the cassava subsector; reduced food import bills of Nigeria; and increased cassava yield from 10.8 t/ha to 20 t/ha. According to Ohimain (2015), these achievements of the PCI made Nigeria, the largest cassava producer in the world. Although the program yielded some positive results, Sanogo and Adetunji (2008) reported that there was inadequate central coordination between organisations involved in implementing the programme. The regional secretariat of the PCI indicated that there was lack of data (particularly on processing and marketing) after the implementation of the programme and this made it difficult to assess the impact of the programme on the targets (Sanogo & Adetunji, 2008).

Due to the lack of primary data pointed out by Sanogo and Adetunji (2008), there is a paucity of an empirical quantitative evidence to support these claims. This study contributes to bridging the knowledge gap by relying on macro time series data to quantify the effects of the PCI on cassava production, national food supply, and food security in Nigeria. The main research question driving the study was: What are the effects of the PCI on cassava production, food production and food security in Nigeria? The main objective of this study is to estimate the impact of the PCI on cassava production, and its implications for national food production and food security in Nigeria. The study uses a three-stage multivariate linear time series regression model.

The remainder of the paper is structured as follows. Section 2 explains the research methods employed to address the main research objective. The empirical results are presented and discussed in Section 3. The last section provides conclusions and policy implications based on the key findings of the study.

2. The cassava sector of Nigeria

Nigeria is currently the largest cassava producer in the world. It produces about three times more than production in Brazil and almost doubles that of Indonesia and Thailand. Nigerian cassava production contributed 19% to the world cassava output, 34% to that of Africa and 46% to the output of West Africa (West Africa accounts for 75% of Africa's output) (FAO, Statistics Division [FAOSTAT], 2015). Nigeria harvested over three times more than the next largest cassava-producing African countries (the Democratic Republic of Congo and Ghana).

Cassava is gradually being transformed from a famine reserve and rural staple crop to a cash crop. Cassava plays a remarkable role in the economic development of Nigeria. The cassava sector provides numerous employment opportunities for people in the country, and cassava serves as a valuable source of dietary energy for the majority of people in Nigeria, particularly in the southern part of the country. For instance, 80% of the cassava tubers produced in Nigeria are processed into various food products that are consumed locally, and minimum quantities are exported to neighbouring African countries (Obayelu, Afolami, & Agbonlahor, 2013). This indicates that cassava plays a significant role in ensuring food security and alleviating poverty in Nigeria. Industrial raw materials, such as starch, ethanol and high-quality flour, are also derived from cassava and used by the agro-allied industries of Nigeria.

Cassava as a food crop fits well within the traditional farming systems of Nigeria. The crop can grow well with other staple crops—usually grains, cereals, and vegetable. It is well adapted to a wide range of ecological conditions and is tolerant to low soil fertility, drought, and pest infestation. The cassava production system is dominated by small- and medium-scale farmers who cultivate less than 3 and 10 ha, respectively. The small-scale farmers produce for the traditional food market, while the medium-scale farmers cultivate for both traditional food and industrial markets (FAO, 2013a).

The Nigerian cassava sector has witnessed a significant improvement over the years. However, the small- and medium-scale farmers who produce the majority of the cassava output are still producing below the potential yield of 25 tonnes per ha. The cassava farmers have achieved only 50% (12 tonnes/ha) of the potential yield (Afolami et al., 2015). For instance, the average cassava yield in the country in 2013 was 14 tonnes per ha, compared to 16.7 tonnes per ha for Ghana. Nigeria's cassava yield was above the continental average, of 11.1 tonnes, but it was very low in comparison to some Asian and Caribbean countries, where the average yield exceeds 20 tonnes per ha. In India and Thailand, for example, the average cassava yield in 2013 was 35 and 21 tonnes, respectively (FAO, 2013a). These statistics suggest that there is more potential to increase the productivity of cassava production in Nigeria.

3. Methodology

3.1. Theoretical framework

Some causal inferential approaches are employed in the empirical literature to quantify the impacts of agricultural programmes on crop yields, incomes, and other welfare indicators. Some of the popular approaches include the propensity score matching, the difference in difference, and the instrumental variable approach (Abadie & Imbens, 2006; Ho, Imai, King, & Stuart, 2007; Iacus, King, & Porro, 2011; Imai, King, & Stuart, 2008). Both PSM and difference-in-difference methods are unable to address selection bias resulting from unobservable factors. Therefore, the instrumental variable (IV) approach is suggested to be appropriate but the IV approach requires identifying an instrument, which is a challenge in an empirical estimation. None of the causal effect models is applicable to this study because the data used are macroeconomic data with 52 time periods. The study however employs a three-stage multivariate time series regression and focuses on the impacts of the PCI on three outcomes: cassava output, food production, and food security. In the first stage, cassava production is regressed on a vector of explanatory variables that include the PCI as a dummy variable, land area, fertilizer and agricultural machinery. The second stage involves the estimation of the impacts of the PCI and cassava production on national food production using the food production

index as a proxy. In the last stage, the PCI and national food production are regressed on food security. An endogeneity problem is encountered in the estimation of stages 2 and 3. Therefore, Smith and Blundell's (1986) approach is used to address the endogeneity issue. This approach is explained later in the methodology.

The theoretical foundation of this study is based on production theory, which establishes a relationship between an output and inputs. Agricultural production is regarded as a physical process of transforming different factor inputs into an output using a given technology (Barkley & Barkely, 2016). Only a single commodity, cassava, is investigated in this study, so a generalised cassava production function can be written as:

$$Y_t = f(X_{1t}, X_{2t}, \dots, X_{Nt}), t = 1, 2, 3, \dots, T \quad (1)$$

where Y_t is the quantity of cassava output; X_{1t}, \dots, X_{Nt} indicate a set of factor inputs used in the production process; f describes the relationship between the output and the factor inputs. PCI, a dummy representing 1 for the period after the implementation of the presidential cassava initiative, is introduced in Equation (1) to determine its effect on cassava production.

$$Y_t = f(X_{1t}, X_{2t}, PCI_t, \dots, X_{nt}) \quad (2)$$

Taking the natural logarithm and differentiating Equation (2) with respect to the factors including PCI gives the respective factor elasticities as expressed in (3):

$$\frac{\partial \ln Y_t}{\partial X_{it}} = \frac{\partial f(\ln X_{2t}, PCI_t, \dots, \ln X_{nt})}{\partial \ln X_{it}} = f_{x_i}, f_{pci}, \dots, f_{x_n} \quad i = 1, 2, \dots, n \quad (3)$$

Adding the error term to Equation (3) gives the econometric model for the cassava production function. Note that the cassava production in Nigeria exhibits a cyclical behaviour and therefore, a quadratic time factor is added to the model to account for this behaviour (Gujarati, 2004).

$$\ln Y_t = \psi_0 + \psi_1 t + \psi_2 t^2 + \sum_{j=3}^5 \psi_j \ln X_{jt} + \psi_6 PCI_t + \varepsilon_t \quad (4)$$

It is assumed that the PCI has spill-over effects on national food production. National food production is expressed as a function of cassava production (Y_t), fertilizer, and agricultural machinery. This is specified as:

$$\ln NFP_t = \phi_0 + \phi_1 t + \sum_{j=2}^3 \phi_j \ln X_{jt} + \Upsilon \ln Y_t + \Phi PCI_t + \gamma_t \quad (5)$$

It is observed that Y_t has become an endogenous variable in Equation (5), and so the error term (γ_t) may correlate with Y_t . We may fall into the trap of an endogeneity problem. Estimating Equation (5) without accounting for this endogeneity issue can generate biased estimates. Smith and Blundell (1986) propose a solution to such endogeneity issue. They suggest that Equation (4) should be estimated and the residuals (ResidC) be predicted. Both Y_t and the predicted residuals are included in Equation (5).

$$\ln NFP_t = \phi_0 + \phi_1 t + \sum_{j=2}^J \Gamma_j \ln X_{jt} + \Upsilon \ln Y_t + \Phi PCI_t + \lambda \text{ResidC}_t + \gamma_t \quad (6)$$

We further estimate the impact of the PCI on food security by regressing food security on the PCI and national food production. This is expressed as:

$$\ln FS_t = \delta_0 + \delta_1 t + \delta_2 PCI + \delta_3 \ln NFP_t + \zeta_t \quad (7)$$

An endogeneity problem is also recognized in Equation (7). This problem is addressed using the Smith and Blundell approach as described previously.

$$\ln FS_t = \delta_0 + \delta_1 t + \delta_2 PCI + \delta_3 \ln NFP_t + \Omega \text{ResidNFP}_t + \zeta_t \quad (8)$$

Smith and Blundell indicate that the coefficients (λ and Ω) of the predicted residuals should not be statistically different from zero. Thus, we test the hypotheses: $\lambda = 0$ and $\Omega = 0$. Accepting these hypotheses suggests that the endogeneity problem is corrected in Equations (7) and (8). Note that the Smith and Blundell approach has been applied in empirical studies to address endogeneity problem in empirical estimations (see Abdulai, Owusu, & Bakang, 2011; Kousar & Abdulai, 2015; Owusu, Abdulai, & Abdul-Rahman, 2011). ψ_5 , Φ and δ_2 represent the effects of the PCI on cassava production, national food production, and food security, respectively.

We hypothesise that the implementation of the PCI exerts significant positive effects on cassava production, national food production, and food security. Thus, $\psi_5 > 0$, $\Phi > 0$ and $\delta_2 > 0$. These hypotheses are tested with the standard t-statistic which is provided as:

$$t_{\hat{\beta}} = \frac{\hat{\beta} - \beta_0}{SE(\hat{\beta})} \quad (9)$$

where $t_{\hat{\beta}}$ represents the t-statistic; β_0 is a non-random known constant (usually zero if we would want to test the null hypothesis that the estimated parameters are significantly zero from zero); $\hat{\beta}$ is the estimated parameter; and SE denotes the standard error of the estimated parameter.

3.2. Empirical model specification

A system of equations is used to estimate the effects of the PCI on cassava output, food production and food security. The empirical models are written as:

$$\ln \text{Cassava}_t = \psi_0 + \psi_1 t_t + \psi_2 t_t^2 + \psi_3 \ln \text{Land}_t + \psi_4 \ln \text{Fertiliser}_t + \psi_5 \ln \text{AgricMac}_t + \psi_6 PCI_t + \varepsilon_t \quad (10)$$

$$\ln NFP_t = \phi_0 + \phi_1 t_t + \phi_2 \ln \text{Cassava}_t + \phi_3 \text{ResidC}_t + \phi_4 \ln \text{Fertiliser}_t + \phi_5 \ln \text{AgricMac}_t + \phi_6 PCI_t + \zeta_t \quad (11)$$

$$\ln FS_t = \delta_0 + \delta_1 t_t + \delta_2 \ln NFP_t + \delta_3 \text{ResidNFP}_t + \delta_4 PCI_t + e_t \quad (12)$$

where NFP_t denotes national food production. As already mentioned, the food production index is used as a measure of national food production. The food production index measures the changes in the production of a food commodity in a given year relative to the base year. In this study, the base year was 2004–2006 (FAO, IFAD, & WFP, 2015). Coffee and tea are excluded from the computational process. FS_t represents food security, and the dietary energy supply adequacy (ADESA) average used as a proxy. ADESA is an availability dimension of food security indicators. It compares the food supply with food energy requirement. t denotes time period. Cassava represents the quantity of cassava produced (tonnes), land is the harvested area of cassava (ha). Fertilizer is the quantity of chemical fertilizer used in agricultural production (tonnes). AgricMac_t indicates the number of items of agricultural machinery used in agricultural production. PCI denotes 1 for the period after the implementation of the PCI (from 2001 to 2013) and 0 otherwise. ResidC_t and ResidNFP_t are the predicted residuals of Equations (10) and (11), respectively. \ln is the natural logarithm. ε_t , ζ_t , e_t are the error terms. $\psi_0, \psi_1, \dots, \psi_6, \phi_0, \phi_1, \dots, \phi_6$, and $\delta_0, \delta_1, \dots, \delta_4$ are the parameters to be estimated. The parameters are estimated using the ordinary least squares (OLS). The models and descriptive statistics such mean and standard deviation are estimated with Stata 13 econometric software.

3.3. Source of data and variable descriptions

Nigeria is one of the largest countries in Africa, with a total geographical area of 923,768 km² and a population of 170 million people (AfDB, OECD, & UNDP, 2016). About 71.2 million hectares of the land area are cultivable, but only 34.2 million hectares (about 48% of the cultivable area) are being cultivated, and less than 1% of the arable land is irrigated (Barungi, Ogunleye, & Zamba, 2015). Nigeria has 263 billion m³ of water, with two of the largest rivers in Africa running through the country. Nigeria lies within the tropics along the Gulf of Guinea on the western coast of Africa. The diversity of climatic conditions, the richness of the soil types and water sources, and the high population density provide great potential for crop, animal, fish and tree production in the country (Manyong et al., 2005).

Nigeria has a gross domestic product (GDP) of US\$ 1.166 trillion, with a per capita income of US\$ 6,351 (AfDB, OECD, & UNDP, 2016). Nigeria is a federal constitutional republic and shares boundary with Benin in the west, Chad and Cameroon in the east, and Niger in the North, as shown in Figure 1. Its coast in the south lies on the Gulf of Guinea in the Atlantic Ocean. For administrative purposes, the country is divided into 36 states (AfDB, OECD, & UNDP, 2016).

The time series data used for this study consist of cassava production from 1961 to 2013, land area under cassava production, fertilizer use, agricultural machinery, the food production index and the food adequacy index. The data were obtained from the World Bank database. The food adequacy index represents average dietary energy supply adequacy (ADESA), which expresses the dietary energy supply (DES) as a percentage of the average dietary energy requirement (ADER) (FAO, 2013b). Each country or region's average supply of calories for food consumption is normalized by the average dietary energy requirement estimated for its population to provide an index of adequacy of the food supply in terms of calories. The other variables, such as food production index, cassava output, fertilizer, land area and agricultural machinery, are already defined in the empirical model specification section.

Figure 1. Map of Nigeria.

Source: Google Map (2016).

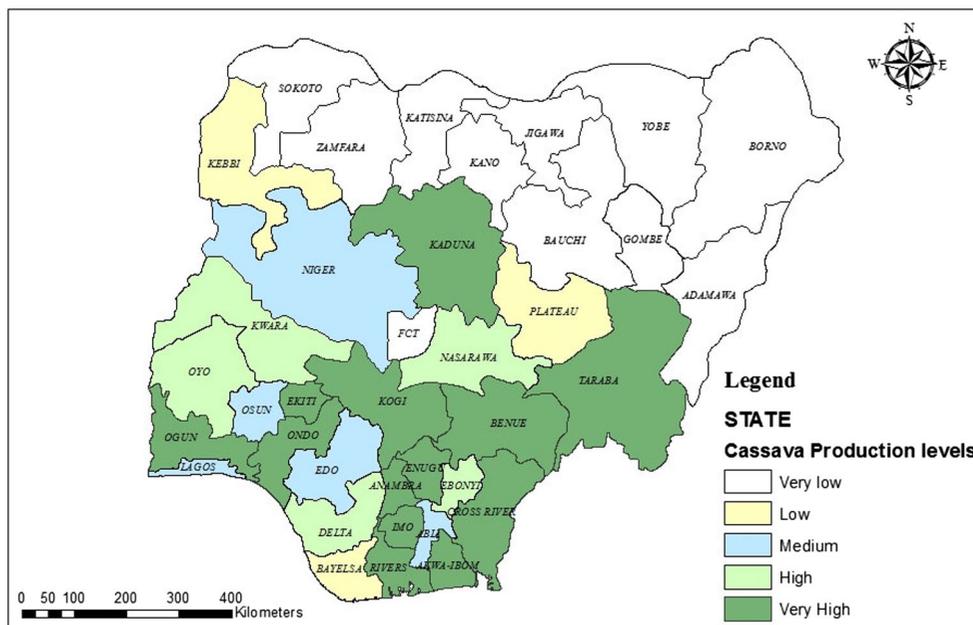


Table 1. Summary statistics of the variables included in the model

Variable	After PCI	Before PCI	Mean difference	t-value
	Mean	Mean		
Cassava output	43.700 (6.850)	16.200 (9.397)	27.500***	9.394
Land	3.648 (0.229)	1.581 (3.647)	0.207***	7.943
Agric machinery	23.883 (1.325)	9.687 (6.556)	14.197***	7.408
Fertilizer	7.979 (1.187)	0.000 (0.000)	7.9793***	12.731
Food production	99.045 (11.183)	39.679 (17.992)	59.366***	10.793
Food security	125.25 (1.138)	34.610 (54.516)	90.640***	5.720

***Denote significance at the 1% levels.

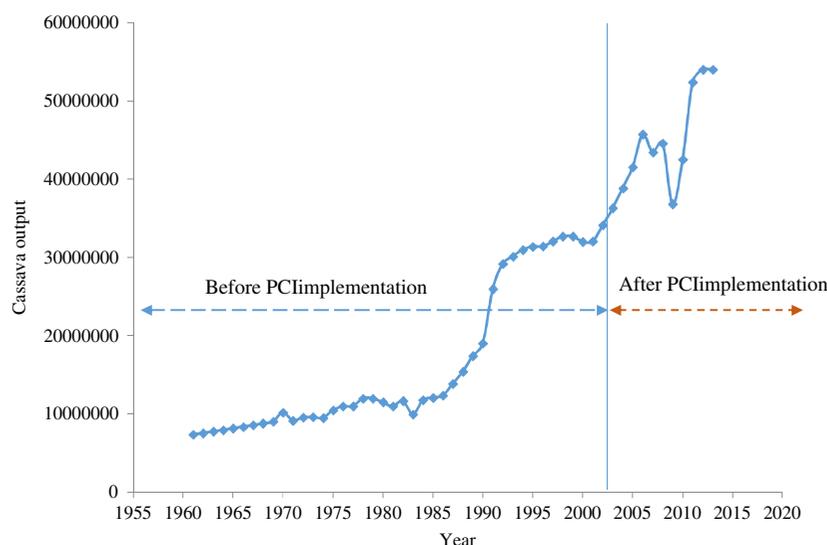
4. Empirical results

The summary statistics of the variables included in the model are presented in Table 1. Table 1 demonstrates that there are significant differences between cassava output, land area, agricultural machinery, food production and food security before and after the implementation of the PCI. For instance, the mean difference in cassava output before and after the PCI was 27.500 million tonnes and was statistically significant at the 1% level. This implies that the implementation of the PCI contributed significantly to the development of the cassava sector in Nigeria. Table 1 shows that more agricultural land area was put under cultivation for cassava after the PCI. The number of items of agricultural machinery and the application of chemical fertilizers increased after implementing the PCI. The mean differences in the food production index and the ADESA index were significantly different from zero at the 1% level before and after the PCI. The implication of this is that the PCI did not promote only cassava production, but had spillover effects on both national food production and food security.

Figure 2 shows the trend of cassava output before and after the implementation of the PCI. Figure 2 indicates that there is a general upward trend in the cassava production in Nigeria. However, it is observed that there has been a sharp and steep increase in the trend of cassava production after the implementation of the PCI relative to before the programme was implemented. This graph gives an indication that the implementation of the PCI has resulted in a significant increase in cassava output in Nigeria.

Figure 2. The trend of cassava output before and after the implementation of PCI.

Source: Authors' design.



One of the assumptions of OLS is that the explanatory variables do not correlate with each other. The violation of this assumption suggests the presence of multicollinearity in the model. Multicollinearity may cause lack of significance of individual explanatory variables, while the overall model may be strongly significant. It may also result in incorrect signs and magnitudes of regression coefficient estimates, and consequently in inaccurate conclusions about the relationship between explanatory variables (Gujarati, 2004). This study employed the variance inflation factor (VIF) to test this assumption. The results are shown in Table 2. The mean VIF for all the factors is less than 10. The overall mean VIF is also less than 10. According to Gujarati (2004), if a variable has a VIF of less than 10 it is not collinear. In addition, if the tolerance (TOL) is closer to 1, it implies that no multicollinearity is present. Another assumption is that the model should be devoid of serial autocorrelation. The Durbin-Watson d test was used to validate this assumption. The test shows that serial autocorrelation was absent in all the models. Therefore, the empirical estimates are unbiased and consistent.

Table 3 shows the results for the cassava production model. The diagnostic results indicate that the variables included in the model jointly explained the variation in cassava output. This is confirmed by the R^2 of 0.9903, which suggests that about 99.03% of variation in cassava output is explained by the covariates.

Table 2. Tests of multicollinearity and serial autocorrelation

Variable	Variance inflation factor (VIF)	Tolerance (1/VIF)
Land	3.89	0.257
Fertilizer	4.18	0.239
Agric machinery	2.73	0.366
PCI	4.99	0.200
Mean VIF	3.95	
<i>Durbin-Watson d-statistic</i>		
Model 1	1.072	
Model 2	0.979	
Model 3	0.827	

Table 3. Estimates of the cassava production model

Variable	Parameter	Coefficient	Standard error	t-value	Probability
Constant	ψ_0	4.680***	0.798	5.87	0.000
Time	ψ_1	0.001	0.005	0.23	0.820
Time square	ψ_2	0.0002*	0.0001	2.00	0.071
lnLand	ψ_3	0.812***	0.058	13.96	0.000
lnFertilizer	ψ_4	0.087**	0.040	2.15	0.037
lnAgricMachinery	ψ_5	0.019*	0.011	1.77	0.077
PCI	ψ_6	0.191***	0.058	23.26	0.002
<i>Diagnostic statistic</i>					
F-Statistic (6, 46)		1,266.23***			
R-square	R^2	0.9905			
Durbin-Watson d-statistic (6, 52)	DW	1.072			
Observation	N	53			

*Denote significance at the 10% levels.

**Denote significance at the 5% levels.

***Denote significance at the 1% levels.

The time-square variable had a positive coefficient and was statistically significant at 10%, suggesting a cyclical trend in cassava production. The variable representing the PCI exerted a significant positive effect on cassava production. The implementation of the PCI led to a 19.10% increase in cassava output. Some improved farm technologies, including cassava varieties, were promoted and chemical fertilizers were subsidized for cassava farmers during the PCI (Ohimain, 2015). Cassava farmers also received a training on improved practices in cassava production. The training improved the managerial skills of cassava farmers, which promoted their efficiency levels and consequently increased cassava output levels. The PCI uplifted the hopes of cassava farmers due to the massive supports they received from the intervention. The finding of this study supports the assertion that the PCI promoted national cassava output (Anyanwu, Amoo, Odey, & Adebayo, 2011; Ohimain, 2015; Onwumere & Ichie, 2013). Ohimain (2015) specifically claimed that PCI increased annual cassava output from 31.7 million tonnes in 2003 to about 49 million tonnes in 2006 which represented about 35% increment. Our estimated impact is quite lower than what Ohimain (2015) asserted probably because we considered period beyond 2006.

Land area showed a significant positive effect on cassava output and was statistically different from zero at the 1% level. An expansion in land area under cassava production by 1% tended to increase cassava output by 81.20%. The result is consistent with the empirical literature, which states that, in sub-Saharan African countries, agricultural productivities are driven by expansion in land area (Donkor & Owusu, 2014; Nyuor et al., 2016; Owusu, 2016).

The coefficient of fertilizer was statistically significant at 1% and precipitated a positive significant impact on national cassava output. This result suggests that chemical fertilizer application is important to increase cassava output in Nigeria. Over the years, the cassava farmers had not been applying chemical fertilizers on their cassava farms because the soils were fertile and cassava production was not regarded as a cash crop. However, a continuous cropping has decreased the soil fertility. Therefore, farmers are advised to incorporate chemical fertilizers in their cassava production. The evidence is observed in this empirical result, which shows that increasing fertilizer application by 1% increased cassava output level by 8.7% over the years. This result is also supported by the empirical studies by Barrett, Moser, McHugh, and Barison (2004), Hedlund, Witter, Hoang, and An (2004), Abdoulaye and Sanders (2005), Dorward and Chirwa (2011), and Javdani (2012), in which it was found that fertilizer application promoted agricultural production in SSA.

Agricultural mechanization had a significant effect on cassava output and was statistically different from zero at the 10% level. This finding suggests that increasing the number of agricultural machinery enhanced the cassava output by 1.90%. Cassava production in Nigeria is gradually transforming into a cash crop and agricultural machinery is required to promote cassava commercialization. Agricultural machinery is needed to prepare farm lands for cassava cultivation, harvest and transport cassava outputs to the market.

As illustrated in the methodology, cassava output and national food production are regarded as endogenous variables in the national food production and food security models, respectively. The coefficients of the residuals (ResidC and ResidNFP) were not significantly different from zero, suggesting that any endogeneity problem that might have been caused by cassava output and national food production in the national food production and food security models has been addressed adequately.

Three main factors, namely: the PCI, cassava output, and agricultural machinery, significantly influenced the food supply of Nigeria. The coefficient of the PCI showed a significant positive effect on national food production and was statistically significant at the 5% level. The result indicates that the PCI increased food supply by 15.10%. During the implementation of the PCI, the cassava farmers received a subsidy for chemical fertilizers. The smallholder cassava farmers, who constitute the majority, mostly cultivate other crops besides cassava. Therefore, there are high chances that most farmers may have channelled some of the fertilizer input designated for cassava to other crops.

Also, farmers could apply knowledge and skill acquired from the programme to other crops. The implication is that the PCI had a positive externality on the production of other crops.

Cassava production exerted a positive impact on food production, pointing to the fact that cassava production has significant implications for national food supply. A 1% increase in cassava output increased the national food supply by 68.50%. The literature demonstrates that cassava is one of the major food staples for many people in Nigeria especially in the South-west, South-east and North-central (Afolami et al., 2015). About 80% of the cassava produced in Nigeria is consumed locally in various forms, suggesting that cassava plays a major role in achieving sustainable national food security in Nigeria (Onwumere & Ichie, 2013) (Table 4).

Table 5 presents the results on the impact of the PCI on food security. The R-square of 0.979 shows that 97.90% of the variation in food security is explained by the PCI and national food supply. The coefficient of national food supply showed a positive effect on food security and was statistically significant at the 1% level. A 1% increase in food supply led to a 31.20% increase in national food security. This result shows that an adequate and sustainable food supply is required to promote food

Table 4. Estimates of the food production index model

Variable	Parameter	Coefficient	Standard error	t-value	Probability
Constant	ϕ_0	-7.382***	1.6111	-4.58	0.000
Time	ϕ_1	0.006	0.007	0.94	0.353
lnCassava	ϕ_2	0.685***	0.090	7.60	0.000
ResidC	ϕ_3	-0.134	0.180	-0.75	0.458
Infertilizer	ϕ_4	0.003	0.004	0.97	0.339
lnAgricMachinery	ϕ_5	0.049	0.042	1.17	0.247
PCI	ϕ_6	0.151**	0.058	2.59	0.013
<i>Diagnostic statistic</i>					
F statistic (6, 46)		1,514.86***			
R-square	R^2	0.979			
Durbin-Watson d-statistic (6, 52)	DW	1.066			
Observation	N	53			

**Denote significance at the 5% levels.

***Denote significance at the 1% levels.

Table 5. Estimates of the food adequacy model

Variable	Parameter	Coefficient	Standard error	t-value	Probability
Constant	δ_0	3.729***	0.146	25.55	0.000
Time	δ_1	0.007***	0.002	4.08	0.001
lnFoodPI	δ_2	0.312***	0.050	6.30	0.000
ResidFPI	δ_3	0.011	0.064	0.17	0.864
PIIC	δ_4	0.019***	0.006	3.05	0.006
<i>Diagnostic statistic</i>					
F-statistic (4, 19)		62.51***			
R-square	R^2	0.9294			
Durbin-Watson d-statistic	DW	0.827			
Observation	N	24			

***Denote significance at the 1% levels.

security in Nigeria. This finding supports that of the FAO, IFAD, & WFP (2015), indicating that food insecurity is declining gradually in the SSA, despite a significant population growth. The PCI was found to increase food security by 1.90%. The impact of PCI on food security was smaller because cassava is mostly consumed in different forms in the South-west, South-east, and North-central part of Nigeria which constitutes the minority of the Nigerian population. The implication is that PCI had some impact on food security of cassava growing areas in Nigeria.

5. Conclusion and policy implications

Most SSA countries are struggling to achieve a sustainable food supply due to low agricultural productivity. One of the contributing factors is low investment in the agricultural sector. National budgets allocated to the agricultural sector have been declining over the years. Rural poverty, food insecurity and unemployment are prevalent in the SSA countries. This has prompted policy makers and donor agencies to design and implement agricultural interventions to assist in transforming rural economies in the region. One of these interventions was the presidential cassava initiative (PCI) implemented in Nigeria from 2001 to 2007. The aim of this study, therefore, was to estimate the impact of the PCI on cassava production, national food supply and food security in Nigeria, using a three-stage multivariate linear time series model in the empirical analysis. An endogeneity problem was encountered in the empirical estimation, and Smith and Blundell's approach was employed to address this problem.

The empirical results revealed that the PCI made some contributions to enhancing cassava output, food supply and food security. The results suggest that cassava production was promoted by increasing land area, fertilizer application and agricultural machinery, which were resulted from the implementation of the PCI. Furthermore, cassava output was found to be one of the major contributors to the food supply particularly in the South-east, South-west and North-central Nigeria. The implication is that cassava plays a major role in the nutrition of Nigerians, as 80% of the cassava output is consumed locally in different processed forms (Obayelu et al., 2013). Therefore, interventions that target the cassava sector has a broader effect on food supply, food security, and economic livelihoods of many people in Nigeria since most smallholder farmers rely on the cassava sector as a source of livelihoods.

The main conclusion drawn from the study is that government interventions that empower smallholder farmers and other stakeholders in the agricultural sector have broader positive impacts on agricultural development and food security in Nigeria. Therefore, scaling up such intervention could enhance rural development through provision of inputs, introduction of improved farm technologies, and mechanisation. Despite the potential of agricultural development interventions on rural livelihoods, it is often noted that the social programmes do not institute any exit strategy for beneficiaries to continue implement the initiatives introduced. After the execution of the programme, some beneficiaries find it difficult to implement the interventions and are left stranded. Therefore, agricultural programme designers are entreated to incorporate exit strategies in programmes to enable beneficiaries to operate independently without seeking for external support after the programme has ended. Such exit strategies require cooperation and involvement of the private sector particularly financial institutions, non-governmental agencies, food companies, and other corporate entities. Also, good governance, rigorous monitoring and evaluation are keen factors to ensure successful executing of agricultural development, and this guarantees an effective impact assessment of the programme. Lastly, we suggest that in the future, a rigorous micro-survey is required to investigate the effects of the PIC on livelihoods of different actors and stakeholders in the cassava value chain in Nigeria. It is however acknowledged that it may be challenging to obtain quantitative data but an in-depth qualitative study would be instrumental. Such study would reveal perceptions of beneficiaries on how the programme affected their lives and how they are thriving after its completion.

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Competing Interests

The authors declare no competing interest.

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