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IMPACT OF ADOPTION OF YAM MINISETT TECHNOLOGY ON PERFORMANCE OF SMALL-HOLDER FARMERS IN NIGERIA: A PROPENSITY SCORE MATCHING ANALYSIS

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ABSTRACT
There is global food insecurity which could be attributed to poor performance of the agricultural sector in the developing countries. In a bid to ensure food security, improved technologies have been developed and disseminated to farmers. These include Yam Minisett Technology. In spite of this, there is food insecurity and poverty intensification in the country. This raises the questions whether or not farmers are adopting these technologies and the efficacy of these technologies in enhancing farmer performance and alleviating poverty in the country. This research investigates the potential of YMT to improve the performance of yam farmers. The study also evaluates the use of Propensity Score Matching in assessing the impact of a technology on performance/wellbeing.

Keyword: Yam minisett technology, adoption, performance, and Propensity Score Matching

Introduction

Food situation and the conditions of Nigerian farmers are critical. Most previous studies have failed to address the problem of food insecurity in the country due to the use of inappropriate methods. The persistent food insecurity in Nigeria has raised doubts about the potential of new technology to improve farmer performance /wellbeing. There is the need to ascertain whether farmers are adopting new technologies and the efficacy of these technologies in improving farmer performance and reducing poverty. The objectives of this research are to describe the socioeconomic characteristics of Nigerian yam farmers; estimate the technical efficiency of the farmers; ascertain the determinants of adoption of YMT; investigate the role of improved technology on farmer performance enhancement for wellbeing improvement with reference to yam production and Yam Minisett Technology (YMT) in Nigeria; and evaluate the use of Propensity Score Matching (PSM) in assessing the impact of a technology on performance.

Agricultural Research and Development (R&D) is generally believed to be significant in ensuring food security and alleviating global poverty. In order to reduce food insecurity, improved technologies, believed to boost agricultural productivity, have been developed and disseminated (Sanginga, 2015; Arokoyo, 1996), including improved varieties and YMT in Nigeria. YMT is a rapid seed yam multiplication technique whereby whole-yam tubers containing periderm and cortex parenchyma are cut into small setts of 25-100g and treated for seed yam production (Aighewi et al., 2014). The main idea of YMT is to multiply seed yam for yam production. The traditional methods of yam production require the use of large quantity of yam tubers as planting material (NBS, undated). YMT was developed by NRCRI (Okoro, 2008), with the view to boost yam production by curbing the problem of scarcity of seed yam (making planting material available to farmers at a reduced cost). It reduces the excessive use of yam tubers as planting material. From five to ten percent of harvested yam is required for seed yam production using YMT while from 30 to 50% is required for yam production using indigenous yam production methods (Asiedu et al., 2009). YMT is less complicated and can generate large yams with minimal inputs (Okoro, 2008). It has been reported to produce seed yams up to 900 grams (Ogbonna et al., 2011). Despite this, there is still declining yam productivity (Amujoyegbe & Elemo, 2012). The issue is whether farmers are adopting these new technologies and the significance of the technologies on farm performance and farm family wellbeing.

Inappropriate agricultural policies based on faulty research methods worsen the pre-existing conditions. There have been many studies on adoption of agricultural technologies (e.g. Gbegeh & Akubuilo (2013); Akinola & Owombo (2011); Nchinda et al. (2010); Okoedo-Okojie & Onemolease (2009); Udoh et al. (2008); Agwu et al. (2008); Adegbola & Adekambi (2010); Eyitayo et al (2010). Previous studies on YMT in Nigeria were mainly to ascertain rate of adoption of the technology, determinants of adoption, and profitability of the technology. There are inadequate information on the performance of yam farmers in Nigeria. Few studies evaluated the impact of a technology on production performance and wellbeing (for instance, Adofu et al., 2013). However, the methods used by these previous research to evaluate the impact of technology on performance and wellbeing on production performance can give misleading results since they fail to take into consideration the counterfactual situation of the farmers (that is what the situation would be if technologies were not adopted (Wu et al., 2010, Mendola, 2007). As such, this method gave a biased estimate of the impact of such technologies on farmers' performance/wellbeing. Thus, this method has affected policies on agricultural technology advancement.

Technologies are not randomly assigned to farmers. If they were, then the effect of adopting a technology on their wellbeing would be the income difference between the adopters and non-adopters. The adoption of technology is based on self-selection which is influenced by the socioeconomic characteristics of the farmers. Before an observed change is attributed to the adoption of a particular technology, it is necessary to determine what the situation would be if the technology was not adopted. The observed change could be due to other factors rather than the adoption of the technology. One possible way of eliminating selection bias is the use of Propensity Score Matching (PSM), in which the behaviour of a given adopter is inferred by matching them with an equivalent non-adopter (Wu et al., 2010). The use of Propensity Score Matching (PSM) in assessing the impact of a technology on farmers' wellbeing eliminates the interference of other factors that could contribute to wellbeing. This current study employed Propensity Score Matching, a more appropriate method (Wu et al., 2010; Mendola, 2007), to determine the impact of YMT on yam farmer performance.

Methodology

Cross sectional data was obtained from 360 yam farmers in Benue, Enugu and Ondo. Stochastic frontier production function was used to estimate the TE of the farmers. The impact of adoption of YMT on TE was ascertained using PSM. Before estimating non-parametric propensity score, the first step is to ascertain the determinants of adoption of improved technology by using Probit analysis. Logit and Probit models are standard approaches to measuring binary dependent variables. These two approaches give similar results. Farmers are then grouped based on similarity in conditions that could influence adoption of technology and TE. Adopters and non- adopters of the technology are then regressed based on their performance. This eliminates the interference of other determinants of adoption. T-test was performed to compare the mean technical efficiencies of adopters and non-adopters of YMT before and after PSM. T-test was also conducted to test the hypothesis that adoption of YMT has a significant effect on farmer performance. The hypothesis that the socioeconomic characteristics of farmers affect the adoption of YMT was tested with Z-test generated from the Probit model.

The Probit/Logit model is expressed implicitly as:

$Y_i = b_0 + b_iX_i + E$ ………………………………1

where Y_i has the value of either 0 or 1

The effect of a technology is the difference between the performance of farmer adopting a technology (A=1) and not adopting the technology (A=0) expressed as:

$E^T = (Y_i^1 - Y_i^0)$ ……………………………………2

In reality, farmers either do or do not adopt a technology. The performance of a farmer is either Y_i^1 or Y_i^0.

The unobserved wellbeing is the counterfactual situation. This is what the situation of the farmers would have been had they not adopted the technology. The observed performance of the farmer can be written as:

$Yi = A\, Y_i^1 + (1-A)\, Y_i^0$ ………………………….. 3

According to Wu et al. (2010), the quantity of interest in the counterfactual framework is the Average Technology Effect (ATE). The ATE for the whole sample is the weighted average of the technology effect for the adopters and non-adopters (Wu et al., 2010). The ATE for the whole sample is the expected effect of the technology across all farmers expressed as:

ATE= P. [E (Y^1|A=1)-E (Y^0 |A=1)] + (1-P). [E (Y^1|A=0)-E (Y^0 |A=1)] … 4

where P is the probability of adopting improved technology (A=1), E (Y^0 |A=1) is the expected value of non- adopters adopting the technology while E (Y^1|A=0) is the expected value of adopters not adopting the technology. The counterfactual states, E (Y^0 |A=1) and E (Y^1|A=0) are unobserved. The counterfactual wellbeing of the farmers should be constructed in estimating the ATE.

The ATE for the adopters can be written as:

ATE_A = (E^T|A=1) = E [(Y^1|A=1] –E [(Y^0|A=1] … 5

The problem of self-selection bias is obvious in the above equation as the condition E [(Y^0|A=1] is unobservable. The non-adopters can be used to compare the adopters if the condition E [(Y^0|A=1] = [(Y^0|A=0] is satisfied.

The Average Technology Effect ATE−the expected effect of the technology across all farmers is expressed as:

ATE= P. [E (Y^1|A=1)-E (Y^0 |A=1)] + (1-P). [Y^1|A=0) - E (Y^0 |A=1)] …6

Where P is the probability of adopting improved YMT (A=1), the counterfactual states is E (Y^0 |A=1). The problem of self-selection bias is obvious in the above equation as the condition E [(Y^0|A=1] is unobservable. The non-adopters can be used to compare the adopters if the condition E [(Y^0|A=1] = [(Y^0|A=0] is satisfied.

Translog production function is specified as:

$$LogY_i = b_0 + \sum_{k=1}^{5} b_k \, logX_{ik} + 0.5 \sum_{k=1}^{5} \sum_{m=1}^{5} b_{km} logX_{ik} \, LogX_{im} + v_i - u_i \quad .....7$$

Y = Output of yam, X_1 =Land area in hectares, X_2 = Labour in mandays, X_3 = fertilizer used in kg, X_4= seed-yam used in kg, X_5 = depreciated cost of capital, v_i = random error not under the control of the farmer, u_i = captures technical inefficiency relative to stochastic frontier and b_0- b_{20} = parameters estimated.

Result and Discussion

Socioeconomic profile of yam farmers

The socioeconomic characteristics of yam farmers in Nigeria are presented in Table 1. Nigerian yam farmers were mostly middle-aged. An average yam farmer in Nigeria was 47 years old. Most yam farmers were in the age range of 40-59 (Table 2).

Males were more involved in yam production in Nigeria than females. Generally, females did not participate actively in yam production in Nigeria. Only 15% of the interviewed yam farmers were female (Tables 1 and 2). Most Nigerian yam farmers have some form of education (Table 2). On average, the farmers had secondary education. Sixteen per cent of the yam farmers in Nigeria had no formal education. Farming is the primary occupation of most Nigerian yam farmers, approximately 95% (Table 2). The majority of the farmers in Nigeria were experienced in yam farming. An average Nigerian yam farmer had farming experience of above 20 years. The majority of farmers in Nigeria had farming experience between 6-15 years. The result of this investigation also shows that most Nigerian farmers are not members of any agricultural organizations (Table 1). Approximately 38% of the yam producers were members of farming associations. An average Nigerian yam farmer has a small farm. Yam producers in Nigeria had a mean farm size of 1.5 hectares. This project discloses that Nigerian yam farmers have poor interaction with extension agents. An average Nigerian has four extension visits per annum. This study also observed that most of the yam farmers in Nigeria were married (Table 2). They have large households. An average Nigerian yam farmer had a household size of eight members. Most yam farmers in Nigeria had household size of between 6-10 members. This research further reveals that most Nigerian yam farmers lack access to funds. Over 50 percent of Nigerian yam farmers lack access to credit for yam production (Table 1). Finally, the socioeconomic analysis detects that Nigerian yam farmers are faced with some health issues. Approximately twenty-two percent of the farmers had health challenges (Table 1).

Determinants of adoption of Yam Minisett Technology in Nigeria

This project indicates that YMT adoption is influenced by the socioeconomic status of yam farmers, farm specific, and geographical/ environmental factors. Table 6.3 presents determinants of adoption of YMT in Nigeria. A positive relationship means that increases in the variables would facilitate adoption while a negative sign means that the variables impede adoption. The factors influencing the adoption of YMT in Nigeria include age, education, time of planting, use of fertilizer, number of farm income, access to financial institutions, planting material, capital inputs and extension visits.

Table 3 shows that age is a determinant of the adoption of YMT in Nigeria. It had a positive relationship with adoption and was significant at 1%. This signifies that adoption of YMT increases with age. Older yam farmers in Nigeria are more inclined to adopt YMT. Level of education affects the adoption of YMT in Nigeria. It had a negative impact on YMT adoption and was significant at 1%. This indicates that adoption of YMT decreases with education. Educated yam farmers are less disposed to adopt YMT in Nigeria. Delayed yam planting reduces the probability of YMT adoption in Nigeria. Time of planting had a negative effect on YMT adoption and was significant at 1%. This shows that time of planting moves in opposite direction with YMT adoption. Early planting of yam encourages YMT adoption in Nigeria. The use of fertilizer affects the adoption of YMT in Nigeria. It had a positive coefficient and significant at 1%. The use of fertilizer increases the adoption of YMT. The users of fertilizer were more motivated to adopt YMT in Nigeria. Number of farm income determines the adoption of YMT in Nigeria. It had a negative and significant influence on adoption. Increase in number of income sources decreases the adoption of YMT. Nigerian yam farmers with diverse income generating activities were disinclined to adopt the technology. This result also establishes that access to financial institution influences the adoption of YMT in Nigeria. It had a positive coefficient and was significant at 1%. This shows that access to financial institution encourages the adoption of improved technology. Nigerian yam farmers who had access to financial institutions were more subject to adopting YMT. Quantity of planting material affects the adoption of YMT. Its coefficient was negative and significant at 1%. This shows that the use of more planting material decreases the adoption of YMT. Adopters of YMT were farmers who used less quantity of planting material. The Table also shows that capital input determines the adoption of YMT in Nigeria. It had a negative relationship with adoption. Its coefficient was significant at 1%. This supports that the use of more capital inputs reduces the propensity of yam farmers to adopt YMT. Farmers who used more input for yam production were less inclined to adopt YMT. Lastly, the result supports that extension visit encourages the adoption of YMT. It had a positive and significant effect on YMT adoption. Its coefficient was significant at 1%. This infers that contact with EAs increases the adoption of YMT. Nigerian yam farmers who had contact with EAs were predisposed to adopt YMT technology.

Technical efficiency estimates for yam farmers

The TE estimate of yam farmers in Nigeria is high. Table 4 presents the TE estimate of yam farmers in the country. The Table indicates that the majority of yam farmers in Nigeria had efficiency above 80%. The mean, maximum and minimum TE of yam farmers in Nigeria were 0.86, 0.96 and 0.49 respectively. This shows that an average Nigerian yam farmer is 86% efficient. The ideal yam farmer in Nigeria is 96% efficient. The least performing yam farmer in Nigeria 1s 49% efficient.

Impact of Yam Minisett Technology adoption on yam farmer performance

Adoption of YMT has a significant impact on the performance of Nigerian yam farmers. The T-test to compare the mean technical efficiencies of adopters and non-adopters of YMT before and after PSM (Table 5) reveals adopter of YMT outperformed non-adopters. There was no significant difference in the mean TE estimates of adopters and non-adopters before the PSM. However, this was significant after PSM. This implies that increased adoption of YMT increases farmers TE. This justifies the use of PSM to assess the impact of a technology on performance.

Conclusion

Nigerian yam farmers were mostly middle-aged males with large families. On average, the farmers had secondary education. The majority of the farmers in Nigeria were experienced in yam farming. However, they had small farms and limited contact with extension agents. The adoption of YMT is influenced by age, education, time of planting, use of fertilizer, number of farm income, access to financial institutions, planting material, capital inputs and extension visits. This research supports idea that comparing the impact of a technology on performance/wellbeing without considering the counterfactual situation of the technology gives a biased estimate of the impact the technology. The adoption of YMT has the potential to improve farmers' performance in Nigeria. It increases the TE of yam farmers in the country. Therefore, YMT should be disseminated to farmer for increased adoption of the technology and to boost yam production in the country.

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Table 1: Socioeconomic characteristics of yam farmers in Nigeria

Variables	**Nigeria**
Average age (years)	47.2
Gender (% of male farmers)	85.0
Average household size (number of household members)	8.2
Average farming experience (years)	20.7
Average farm size (hectare)	1.5
Extension visit (number of times)	4.1
Average education (years)	9.3
Member of Organization (%)	37.8
Access to credit (%)	46.9
Health issues (%)	21.9

Source: Field Survey, 2013

Table 2: Distribution of socioeconomic characteristics of yam farmers in Nigeria

Variables	Nigeria (%)
Age	
≤19	0.3
20 – 39	29.1
40 -59	46.2
≥60	24.4
Total	100
Gender	
Male	85.0
Female	15.0
Total	100
Household size	
<6	28.3
6-10	53.6
11-15	12.5
>15	5.6
Total	100
Education	
No formal education	16.4
Primary	23.9
Secondary	35.3
Tertiary	24.4
Total	100
Farming Experience	
≤5	11.1
6-15	35.3
16-25	24.7
26-35	13.3
≥36	15.6
Total	100
Primary Occupation	
Farmer	94.6
Civil Servant	0.4
Others	4.8
Total	100
Marital Status	
Single	6.6
Separated and widowed	1
Married	92.5

Source: Field Survey, 2013

Table 3: Determinants of adoption of Yam Minisett Technology in Nigeria

Parameter	coefficient	Std. Error	Z value
Intercept	-1.01	0.07	-13.72***
Gender (male=1, female =0)	-0.03	0.02	-1.30
Age (years)	0.01	0.00	9.55***
Primary occupation(farmers =1, Non farmers=2)	-0.06	0.04	-1.51
Experience in Yam farming (years)	0.00	0.00	1.15
Farm size (hectare)	0.00	0.02	-0.13
Education (years)	-0.02	0.00	-9.60***
Time of planting (months)	-0.02	0.00	-6.61***
Staking (Number)	-0.01	0.02	-0.31
Difficulty acquiring farm input (yes=1, no=0)	-0.02	0.02	-0.98
Use of fertilizer (user=1, non-user=0)	0.08	0.03	3.06***
Distance from market (km)	-0.01	0.03	-0.35
Number of farm income (number of income sources)	-0.02	0.01	-2.05**
Access to financial institution (Yes=1, No=0)	0.18	0.03	5.49***
Quantity of planting material (kg)	0.00	0.00	-11.25***
Labour (man-days)	0.00	0.00	-0.27
Capital input (₦)	0.00	0.00	-13.42***
Extension visit (number of tines)	0.00	0.00	3.43***

Source: Result of Probit analysis
*** and ** are significant at 1 and 5% respectively.

Table 4: Technical efficiency estimates of yam farmers in Nigeria

Technical efficiency	percentage
≤0. 50	0.20
0.51-0.60	1.11
0.61-0.70	3.60
0.71 – 0.80	17.50
0.81- 0.90	48.33
≥0.91	29.17
Mean technical efficiency = 0.86	
Maximum technical efficiency = 0.96	
Minimum technical efficiency = 0.49	

Source: Frontier 4.1 result

Table 5: Difference in mean technical efficiency

Technical efficiency	Mean	Bias	Standard error	Sig. (2-tailed)
Before propensity score matching				
Non-adopters	0.85	0.00	0.01	
adopters	0.86	0.00	0.01	0.51
After propensity score matching				
Non-adopters	0.82	0.00	0.01	
adopters	0.86	0.00	0.01	0.01

Source: Field Survey, 2013
Bootstrapping at 95% Confidence Interval, bootstrap results are based on 1000 bootstrap samples