Chapter 9

The Efficiency of Innovation Uptake among Cocoa Farmers in Ondo State

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Abstract

The study analysed the efficiency of innovation uptake among cocoa farmers in Ondo State from a sample of 120 randomly selected cocoa farmers from two Local Government Areas of Ondo State. The budgeting technique was used to estimate adopters and non-adopters net farm income. Adopters of disseminated cocoa technologies made NGN 65,180.28 profit more than non-adopters. Stochastic Frontier Production Function (SFPF) was used to analyse the technical efficiency of cocoa farmers. The estimated technical efficiency of the cocoa farmers ranged from 2.0% to 82.0%, with a mean technical efficiency of 41%, indicating that farmers operated sub-optimally, and there was a 59% allowance for improving technical efficiency. The study further observed that age, educational status, membership of farmer's organisation, household size, and adoption status were significant determinants of technical efficiency since these variables were positively and significantly associated with technical efficiency. It was therefore recommended that farmers should be encouraged to join farmer's organisations, there is a need for government and other stakeholders to invest in extension services in sensitising cocoa farmers of new innovations, and the level of literacy of the farmers should be looked into when formulating policies as it increases farmers' technical efficiency.

9.1. Introduction

The agricultural sector in Nigeria was the most important in contributions to domestic production, employment and foreign exchange earnings in the 1960s. In Nigeria, before discovering crude oil, agricultural products such as palm oil, rubber, cocoa, groundnut, and cotton played prominent roles in the nation's economy's growth, development, and stability. To this end, Nigeria was once the second leading producer of cocoa in West Africa. During this period, cocoa was ranked as the first Nigerian foreign exchange earning commodity. The situation remained sustained until the discovery, exploration and production of oil in commercial quantity (Samuel, 2017). Nigeria's dependence on oil was a disaster to the country's economic growth due to the negligence of non-oil products such as cocoa, cassava, palm oil, among others, that made Nigeria great in the First Republic (Akinwumi, 2013). Also, the International Cocoa Organization (2010) reported that Africa production of cocoa has declined from 71.8% in 2008 to 68% in 2010. Ibiremo *et al*. (2011) revealed that in Nigeria, cocoa is a significant export crop with revenue of at least 34 billion derived annually from the export of cocoa beans alone, besides revenue from cocoa by-products. The sector remained stagnant during the oil boom decade of the 1970s, which accounted mainly for the declining share of its contributions.

Agriculture is Nigeria's single most significant economic sector. In 2016, agriculture accounted for 24.4% of the Gross Domestic Product (GDP). Though agriculture makes up a sizeable portion of economic activities in Nigeria, the sector's impact on government and export revenues is relatively small, accounting for only 4.8% of total foreign earnings in 2016. For most key crops, Nigeria's share of global production has remained low over the past four decades. Specifically, the country's share of global cocoa production has declined due to the slow adoption of efficient production processes combined with rural poverty, increasing rural-urban migration and climate change. Compared to other countries that produce cocoa, the yield remains low. In 2014, yields for cocoa was lower than the global average yield of all producing countries. The low yield is possibly a reflection that, unlike Nigeria, other countries utilise improved inputs and technology to increase their yield and production levels (PWC, 2017).

Cocoa, as a critical cash crop, accounted for 21% of Nigeria's agricultural exports and generated US$ 711 million in 2015. As of 2014, Nigeria was the sixth-largest global cocoa producer, with 248,000 metric tonnes. Currently, the country is ranked fourth with the production of 255 000 metric tons during the 2017/2018 season (International Cocoa Organization, 2019). Cocoa is grown by an estimated 30,000 farmers in fourteen states across Nigeria, including Ondo, Ogun, Ekiti, Osun, Oyo, Edo and Cross River. Ondo is ranked as the largest cocoa producing state and accounted for 24% of total production in 2011. The state is commonly called the "land of cocoa farmers". Most farmers are clustered in various local government areas, including Owo, Idanre, Ile- Oluji/ Oke Igbo, Ondo West and Ondo East.

Despite the country's high agricultural potential, different administrations focused on agriculture to diversify the economy. Several policies have been designed in this regard; in 2012, the Agricultural Transformation Agenda (ATA) was introduced, which was reported to have increased agriculture output by 11% to

202.9 million tonnes between 2011 and 2014. The current administration recently launched the Agriculture Promotion Policy (APP) to resolve food production shortages and improve output quality. According to Fuglie and Rada (2013), growth in yield per hectare and land expansion are the sources of agriculture growth. Yield growth can be achieved by increasing inputs and improving input productivity through the use of technology. Over the last four decades, the yield of most key crops has declined, particularly cocoa beans, due to the low utilisation of improved seedlings, agrochemicals, and poor technology adoption. The utilisation of poor inputs has resulted in declining yields across essential crops.

In contrast to agriculture yield, agricultural land usage in Nigeria has increased across key crops like cocoa and rice, although production still remains at the subsistence level. Technology and better inputs are expected to play an increasing role in raising agriculture productivity in the long run. The performance of Nigerian agriculture so far indicates that the farmers have neither used nor absorbed most of the technologies being introduced to them (Akande, 1999). First of all, innovation uptake depends on the user's capacity to access innovation and later use it. This capacity is dependent on certain cultural, socio-economic, personal, political and geographical variables. It also includes the appropriateness of the information, the credibility of the information channel, and the information provider's characteristics. The mere provision of agricultural information to farmers does not guarantee its use. This is because a host of social, economic, and psychological factors influence the rate of agricultural information use (Akande, 1999). Therefore, the need to study the efficiency of innovation uptake among respondents in the study area has become impending. This study examines how the uptake of innovation has translated into an increase in the technical efficiency of cocoa farmers in Ondo State, Nigeria. The objectives are to estimate the cost and returns of cocoa production among adopters and non-adopters of disseminated improved cocoa technologies and determine the technical efficiency of cocoa farmers in the study area.

9.2. Methodology

The study was carried out in Ondo State. The data was collected using a multi-stage random sampling technique. Two Local Government Areas (LGAs), Idanre and Ondo East were randomly selected in the first stage. The second stage involved a random selection of three villages from each LGA, giving six villages. In the last stage, two sets of farmers: adopters and non-adopters, with each set comprising of 10 farmers, were randomly selected from each village, making a total of 120 cocoa farmers that were sampled. Data collection was done using a structured questionnaire using an interview schedule with the aid of trained enumerators. Descriptive statistics (mean, frequency and percentages), budgeting technique and stochastic frontier production function were used to analyse the socio-economic characteristics, net farm income and technical efficiency, respectively. Farm budgeting technique was used to estimate the cost and returns of cocoa production, while the technical efficiency of cocoa farmers was determined by estimating a production function and efficiency scores of cocoa farmers, using a stochastic frontier model.

The Theoretical Model

Net Farm Income is defined by

$$NFI = GR - TC \tag{1}$$

Where:

NFI	=	Net Farm Income
TC	=	Total Cost, i.e. the sum of total fixed and total variable costs (TVC + TFC)
GR	=	Product of the unit price of output (P_y) and the quantity of output (Y).

A Stochastic Frontier Production Function is defined by

$$Y_i = f(Xa_i \ ; \ \beta) + \ \varepsilon_i \tag{2}$$

Where:

Y_i	=	Cocoa output of the i^{th} farmer
X_{ai}	=	Vector of input quantities used by the i^{th} farmer
B	=	Vector of unknown parameters to be estimated
f	=	represents an appropriate function (e.g., Cobb-Douglas, Translog).

The parameters of the stochastic production frontier function are estimated using the Maximum Likelihood Method (MLE).

The Empirical Model

The model of the stochastic frontier production for the estimation of the technical efficiency is specified as:

$$\ln Y_i = \ \beta_0 + \ \beta_1 lnX_1 + \ \beta_2 lnX_2 + \ \beta_3 lnX_3 + \ \beta_4 lnX_4 + \beta_5 lnX + \beta_6 lnX_6 + V_i - U_i \tag{3}$$

Where:

Y	=	Cocoa output of i^{th} farmer (kg)
β_0	=	the intercept
X_1	=	Agrochemicals in litre
X_2	=	Fertiliser in kg
X_3	=	Farm size in hectares

X_4 = Depreciation in Naira;
X_5 = Labour input in man-days
X_6 = Seedling in number
b_i = Unknown scalar parameters to be estimated
ln = Natural logarithms
V_i = Two-sided, normally distributed random error
U_i = One-sided inefficiency component with a half-normal distribution.

Determinants of Technical Efficiency

In this study, the technical inefficiency (U_i) was measured by the mode of the truncated normal distribution as a function of socio-economic factors (Yao and Liu, 1998). The technical inefficiency effects of U_i is defined by:

$$U_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5 + \delta_6 Z_6 + \delta_7 Z_7 + \delta_8 Z_8 + \delta_9 Z_9 + \delta_{10} Z_{10} + \delta_{11} Z_{11} + \delta_{12} Z_{12} + \delta_{13} Z_{13} + \delta_{14} Z_{14} + \delta_{15} Z_{15} + \delta_{16} Z_{16} + \delta_{17} Z_{17} \quad (4)$$

Where:

Ui = Technical inefficiency of the i^{th} farmer
δs = Unknown scalar parameter to be estimated
Z_1- Z_8 = Farmer's age, gender, marital status, education status, membership in farmer organisation, access to credit, a distance of farm to homestead, household size respectively
Z_9-Z17 = A method of land acquisition, nature of access road, amount of rent, average distance to home, average distance to market, average time taken from home, adoption status, number of years in formal education, and number of children respectively.

These are included in the model to indicate their possible influence on the technical efficiencies of the cocoa farmers.

9.3. Results and Discussion

9.3.1. Socio-Economic Characteristics of Cocoa Farmers

The socio-economic characteristics of the sampled cocoa farmers revealed that cocoa farms are predominantly operated by males (65%) with a mean age of approximately 51years, married, with six years of education, 21 years of farming experience, household size of 6 people, and farm size of 6 hectares. These results suggest that a typical cocoa farmer in the study area is a small scale farmer, literate, old, highly experienced in cocoa farming, uses more personal funds, and knows new cocoa technologies but rarely adopts innovations.

9.3.2. The Costs and Returns of the Cocoa Farmers

The cost and return analysis of the respondents are presented in table 9.1. The average variable cost per hectare for cocoa innovation adopters was NGN55, 577.23, and total revenue was NGN293, 567.91 with a net farm income NGN180, 930.80 per hectare. On the other hand, the average variable cost for non-adopters was NGN40, 159.80 with total revenue of NGN192, 036.22 and net farm income of NGN115, 750.52 per hectare. Among variable costs, the cost of fertiliser and agrochemicals of adopters accounted for more than 50% of the total cost of production, while the cost of fertiliser and labour cost were the major constituents of the total costs of non-adopters. Moreover, the total cost of production per hectare for adopters was NGN112, 637.11, while the total cost of production for non-adopters was NGN76, 285.70. Although adopters incurred a higher total cost of NGN 36,351.41 more than non-adopters, the profit made by adopters was NGN 65,180.28 higher than profit made by non-adopters. This suggests that adopting disseminated cocoa technologies is highly profitable in the study area.

Table 9.1: Estimated Cost and Returns Analysis for Adopters and Non-Adopters of the Disseminated Cocoa Technologies in the Study Area

Cost items and revenue (NGN/Ha)	Adopters	%	Non-adopters	%
Variable cost				
Labour cost	6,122.97	11.02	14,585.88	36.32
Seedling	4,901.42	8.82	1,773.84	4.42
Agrochemicals	12,884.17	23.18	8,223.95	20.48
Fertilizer	31,668.67	56.98	15,576.13	38.79
Total variable cost	55,577.23		40,159.80	
Fixed Cost				
Farm tools (depreciation)	7,380.80	12.94	2,170.70	6.00
Interest on loan	16,847.75	29.53	10,673.60	29.55
Land	32,831.33	57.54	23,281.60	64.45
Total fixed cost	57,059.88		36,125.90	
Total Cost	112,637.11		76,285.70	
Returns				
Total revenue	293,567.91		192,036.22	
Net farm income	180,930.80		115,750.52	
Gross ratio	0.38		0.40	
Operating ratio	0.19		0.21	

Source: Computed From Field Survey Data, 2013.

9.3.3. Estimating Stochastic Frontier Production Function

The Maximum Likelihood Estimates of the stochastic production function (equation 3) are shown in Table 9.2. The sigma-square (δ2) indicates the goodness of fit and the correctness of the specified distributional assumptions about the composite error term. The result shows that the sigma squared (δ2) estimated was

8.627 and significant at 0.01 probability level. The gamma (γ) takes care of the model's unexplained variables; the gamma (γ) value was 0.486 and significant at 0.01 probability level. This implies that 48.6% of the variations in cocoa output were due to production inefficiency. This result agreed with the findings of Onyenweaku and Nwaru (2005), who found out that total variation in food crop output was due to technical inefficiency in Imo State, Nigeria. Three out of the six explanatory variables considered were significant. Depreciation with a maximum likelihood estimated value of 0.574 is significant at the 0.01 probability level. This implies that if depreciation in capital inputs is increased by 1%, the output of cocoa will increase by 57.4%, holding other variables constant. Fertiliser and Labour inputs with MLE estimated values of 0.778 and 0.019 respectively were significant at 0.05 probability level, implying that if fertiliser and labour were increased by 5%, the output of cocoa would increase by 77.8% 19% respectively.

Technical Inefficiency Analysis

The analysis of the inefficiency model (table 9.2) shows that the signs and significance of the estimated coefficients in the inefficiency model have important implications on the technical efficiency of the cocoa farmers. Since the inefficiency function's dependent variable (cocoa output) represents the efficiency model, a negative sign of the MLE in the inefficiency function means that the associated variable has a positive effect on efficiency, and a positive sign indicates that the associated variable has a positive effect hurts efficiency.

From table 9.2, Age, educational status, membership of farmer organisation, household size, and adoption status are the significant determinants of the efficiency of cocoa farmers in the study area as they were significant and positively related to technical efficiency. This implies that households with larger family sizes are more efficient, indicating more availability of a larger labour supply. One of the significant constraints in cocoa production in Nigeria is labour availability to perform specific on-farm tasks as cocoa farmers rely on household members to perform specific labour-intensive tasks. This has a severe negative impact on the adoption of any innovation requiring intensive labour techniques.

Table 9.2: MLE of Parameters of the Cobb-Douglas Frontier Function

Variable	Parameter	Coefficient	T- value
Constant (beta)	β_0	2.696	3.904***
Agrochemicals	β_1	0.056	0.328
Fertilizer	β_2	0.778	2.653**
Size in ha	β_3	-0.050	-1.164
Depreciation	β_4	0.574	5.829***
Labour input in man days	β_5	0.019	2.159**
Seedling in number	β_6	-0.001	-1.167
Constant (delta)	δ_0	-2.619	-1.755*
Age	δ_1	-1.626	-1.863*
Sex	δ_2	1.450	1.448
Marital status	δ_3	5.973	3.548***
Educational status	δ_4	-2.370	-2.378**
Membership of farmer org.	δ_5	-1.586	-1.635*
Access to credit	δ_6	-0.699	-0.711
Dist. of farm to home stead	δ_7	0.179	2.995***
Household size	δ_8	-0.762	-1.857*
Method of land acquisition	δ_9	-1.587	-1.292
Nature of access road	δ_{10}	3.209	2.612**
Amount of rent	δ_{11}	-0.032	-0.290
Av. dist. to home in km	δ_{12}	0.296	1.159
Av. dist. to market in km	δ_{13}	-0.077	-0.612
Av. time taken from home	δ_{14}	-0.067	-1.554
Adoption status	δ_{15}	-4.608	-3.049***
Formal education in years	δ_{16}	-0.102	-0.959
No. of children	δ_{17}	0.724	1.459
Diagnosis statistics			
Sigma-square ($\delta^2 = \delta u^2 + \delta v^2$)		8.627	6.785***
Gamma ($\gamma = \delta u^2/\delta^2$)		0.486	3.499***
log likelihood function		-275.6399	
LR test of the one-sided error		38.2408***	
Average = TE		**0.4123**	

Note: ***, ** and *implies statistical significance at P<0.01, P<0.05 and P<0.10 probability levels, respectively.

Source: Computed From Field Survey Data, 2013.

This is congruent with the findings of Baffoe-Asare *et al.* (2013), who found that experience, training, age of household head, household size, and social capital are the key variables that positively influence the decision of farmers to adopt new technology. This finding also supports the expression of Amos (2007) that age, level of education and family size were significant variables greatly influencing the technical efficiency of cocoa farmers. Positive association of membership of farmer's organisation with technical efficiency implies a decrease in technical inefficiency. This concurs with Adedeji *et al.* (2013), who found that farmers' organisations have more access to agricultural information, credit and other production inputs and a more enhanced ability to adopt innovations. Moreover, educational status and adoption status were positively related to technical efficiency and meets the a *priori* expectation that technical efficiency should increase with the increase in the educational level of farmers since education and adoption of innovation is expected to be positively correlated (Amos, 2007). This is consistent with those of Nmadu *et al.* (2015) which found that level of education was positive and significantly associated with the uptake (adoption) of disseminated cocoa technologies. Education is considered an indication that literate farmers will better understand making the best use of available technologies to increase technical efficiency (Tirkaso, 2013; Abebe, 2014). Marital status, the distance of farm to homestead, and nature of access road were negatively associated with the technical efficiency of the cocoa farmers. This indicates that production inefficiency will increase as the marital status, the distance of farm to homestead, and the nature of access road increases. However, access to credit, method of land acquisition, amount of rent, the average distance to market and number of years in formal education were not statistically significant, implying their little or no importance in improving the technical efficiency of cocoa farmers.

Distribution of Technical Efficiency

The estimated results showed a higher variation in technical efficiency scores among respondents. As presented in table 9.3, the technical efficiency among cocoa farmers ranges from a minimum score of 2 per cent to a maximum score of 82 per cent. About 15 per cent of the farmers have efficiency scores less than 10 per cent. The majority (44.6 per cent) of cocoa farmers have an efficiency score between 11 and 50 per cent. In contrast, 37.5 per cent of the farmers have an efficiency score between 51 and 80 per cent. Only 2.5 per cent of the farmers have an efficiency score greater than 80 per cent. This is probably due to the low rates of adoption of disseminated cocoa technologies. Such wide variation in efficiency scores suggests farmers' inefficiency in utilising available cocoa technologies, which further implies the existence of a broader scope for improving their efficiency.

The stochastic frontier production function results showed that the mean technical efficiency obtained was 41 per cent indicating that farmers operated sub-optimally, and there was a 59 per cent allowance for improving their technical efficiency. Thus, in the short run, there is a possibility of increasing cocoa production in the study area by an average of 59 per cent by adopting the disseminated technologies used by best practice cocoa farms.

Table 9.3: Frequency Distribution of Technical Efficiency Indices

Efficiency Class Index	Frequency	Percentage
0.00 – 0.10	18.00	15.00
0.11 – 0.20	12.00	10.00
0.21 – 0.30	16.00	13.30
0.31 – 0.40	13.00	10.80
0.41 – 0.50	13.00	10.80
0.51 – 0.60	17.00	14.20
0.61 – 0.70	13.00	10.80
0.71 – 0.80	15.00	12.50
0.81 – 0.90	3.00	2.50
Total	120.00	100.00
Mean (%)	0.41	
Minimum (%)	0.02	
Maximum (%)	0.82	

Source: Computed From Field Survey Data, 2013.

9.4. Conclusion and Recommendations

It is concluded that adopting disseminated cocoa innovations was profitable in the study area. The technical efficiency of cocoa farmers varied due to the technical inefficiency effects of not adopting new and improved cocoa technologies. The study further concludes that marital status, the distance of farm to homestead and nature of access road decrease the farmer's technical efficiency. In contrast, the age of cocoa farmers, educational status, membership of farmers' organisation and adoption status of cocoa farmers increases the farmer's technical efficiency. The study recommended that farmers be encouraged to join farmer's organisations, increasing their awareness of new cocoa technologies. There is a need for the government and other stakeholders to invest in extension services in sensitising cocoa farmers of innovations, as this can increase the adoption rate and farmers' productivity, efficiency and income. Also, the level of literacy of the farmers should be looked into when formulating policy as it increases farmers' technical efficiency.

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