Economic Impact of Cocoa Farmers' Compliance to EU Pesticide Regulations in Osun State, Nigeria

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Summary

This study investigated the economic impact of cocoa farmers' compliance to EU pesticide regulations in Osun State, Nigeria. The multistage sampling procedure was used to select 255 respondents for the study. The data collected were analysed using probit regression, propensity score matching, and endogenous switching regression models. The results showed that the majority of the sampled cocoa farmers were male (88.24%), married (95.38%) and within 41-60 years age bracket (78.5%) with a mean age of 50 years. Probit regression model revealed that years of formal education, access to extension services, access to credit, insecticide price, fungicide price, total farm size, and availability of pesticides were the significant determinants of compliance with EU regulations. The propensity score matching result showed that there were significant differences in income and assets acquired by the farmers that complied and those that did not comply with estimated differences of $446.91 and $714.19, respectively. The estimated value using ESM for the productive asset, non-productive asset, and cocoa income are $258.79, $325.37, and $488.14. The study concluded that compliance with EU pesticide regulations had a positive and significant impact on the income and assets of cocoa farmers.

Key words

endogenous switching regression model, propensity score matching, EU, pesticide regulations, income, asset

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Introduction

Cocoa (*Theobroma cacao*) is a vital cash crop cultivated in the humid regions of Africa, South America, Asia, and the Caribbean (ICCO, 2018), but it is mostly consumed in developed countries in form of chocolate, butter, liquor, cake, powder, etc. For instance, more than 85% of the cocoa beans consumed by European countries are imported from Africa, including Nigeria. The cocoa product contains proteins, carbohydrates, vitamins, fats, and some minerals that exhibit health benefits (Kehinde and Adeyemo, 2017). This is ascribed to the fact that copious users of cocoa have low rates of cancer and heart disease. Also, cocoa has a unique colour, taste, and appealing aroma, which makes it a choice raw material to many food processing industries in terms of adding extra colour and flavour to many food products (ICCO, 2005; CBI, 2016). The distribution of cocoa beans from the producers, especially smallholder farmers to food processing industries, especially in Europe generates substantial income for more than five million different actors (such as cocoa exporters, marketers, warehouse agents, transporters, and farmers) along the cocoa supply chain (ICCO, 2018).

However, smallholder cocoa farmers play important roles in cocoa production in Nigeria, accounting for close to 95% of total cocoa production in the country while cultivating 1-3 hectares of farmland on average in different cocoa-producing states in Nigeria (ICCO, 2018). Cocoa in Nigeria is mostly grown in eighteen states of the country namely: Ondo, Osun, Cross River, Oyo, Edo, Ekiti, Ogun, Kwara, Delta, Abia, Kogi, Akwa Ibom, Taraba, Rivers, Lagos, Bayelsa, Imo, and Adamawa as shown in Table 1. According to the National Analysis on agricultural exportable commodities carried out by the National Bureau of Statistics (NBS), Central Bank of Nigeria (CBN), Federal Ministry of Agriculture and Rural Development (FMARD), and Federal Ministry of Trade and Investment (FMTI), (2013) Osun State alone harvested 74.10 metric tonnes of cocoa from 251.3 hectares of land, while the country as a whole harvested 370,010.00 metrics tonnes of cocoa from 1,363,600 hectares of land. As shown in Table 1, Osun State is the second leading producer of cocoa in Nigeria.

Table 1. Cocoa output and areas cultivated by cocoa-producing states in Nigeria

S/N	States	Area ('000 hectares)	% Area	Production ('000 metric tonnes)	Production (%)
1	Ondo	321.97	23.61	92.22	24.92
2	Osun	251.3	18.43	74.1	20.03
3	Cross River	327.91	24.05	69.42	18.76
4	Ekiti	98.15	7.20	36.46	9.85
5	Oyo	109.03	8.00	36.06	9.75
6	Edo	104.77	7.68	23.68	6.40
7	Ogun	92.76	6.80	19.9	5.38
8	Taraba	10.53	0.77	4.89	1.32
9	Delta	11.52	0.85	3.93	1.06
10	Abia	14.49	1.06	3.34	0.90
11	Adamawa	5.34	0.39	1.65	0.45
12	Kwara	5.14	0.38	1.43	0.39
13	Akwa-Ibom	5.35	0.39	1.25	0.34
14	Kogi	3.84	0.28	1.06	0.29
15	Rivers	0.18	0.01	0.3	0.08
16	Lagos	0.97	0.07	0.2	0.05
17	Bayelsa	0.32	0.02	0.09	0.02
18	Imo	0.04	0.00	0.01	0.03
	National	1,363.60	100%	370.01	100%

Source: Author's compilation and calculation from NBS/CBN/FMARD and FMTI (2013)

The cocoa production process in Osun State can be characterized into planting, harvesting, pod-breaking, fermentation, drying, bagging, storage/warehousing, and fumigation. However, each of these production processes, if not properly or carefully carried out, can contaminate cocoa beans that get to the final consumers. For instance, during production, cocoa beans can be contaminated through the practice of barred pesticides to prevent pests and diseases resulting in excess pesticide residues and heavy metals like cadmium, mercury, and lead far beyond the stipulated limit; while during pod-breaking, bruises or injuries to cocoa beans resulting from the use of machete or any sharp object can predispose cocoa beans to mycotoxin attack. Also, the issue of polycyclic aromatic hydrocarbon (PAH) which has to do with food safety risks can either upshot when cocoa beans are fermented and transported with contaminated bags or when they are dried along the roadside (COCOBOD, 2013; CBI, 2016, Tijani and Masuku, 2019).

End users of cocoa and its products across the globe are becoming food safety conscious, as interrelated to the usage of pesticides in the processing and production of cocoa that may be hazardous to their health. According to Mokwunye et al. (2012), Ugwu et al. (2015), and Kehinde and Tijani (2021), close to 20,000 deaths and 735,000 severe illness occurred as a result of cocoa contaminations resulting from inappropriate pesticide application and handling. In a bid to safeguard the health of people in European union member states, the European Union implemented a policy on pesticide regulations to measure and monitor the safety and quality of food consumed in the region (Aikpokpodion et al., 2012; Agritrade, 2013), most especially food products imported from other parts of the world including cocoa beans. In January 2008, the EU issued a new European Union Legislation on Maximum Residue Levels (MRLs) for pesticides (Regulation 149/2008/ EEC) permissible in food products, including cocoa, before it enters the markets of European countries. Following this, Nigeria saw a decline of 36% in its cocoa export to the EU (Tijani and Masuku, 2019). Nigeria's average cocoa beans export to the EU before the year 2008 was 202,000 metric tonnes and currently, the average export to the region is about 196,000 metric tonnes (FAOSTAT, 2019). This could be attributed partly to new import regulations concerning the European Union's level of pesticides (CBI, 2016).

In order to curb future trade barrier that can further limit access of cocoa beans from Nigeria to the EU market because of the regulations, the government put in place guidelines through appropriate agencies and bodies like NAFDAC and CRIN to ensure the safety and quality of cocoa beans production in Nigeria in line with the EU regulations. One of the outcomes was cocoa farm certification compliance for sustainable cocoa production to encourage compliance with the EU regulation on MRLs. Akinwale, Ojerinde, and Owoade (2019) researched on farm certification compliance for sustainable cocoa production. Their result shows that 27% of the respondents do not comply with the recommended fertilizer application, 21% moderately comply with regular record keeping. However, there is a dearth of information on the factors that influence cocoa farmers' compliance and the effects of farmers' compliance to regulations on cocoa farmers' income and assets in Nigeria. Consequently, this research seeks to fill the gap in knowledge on the economic impact of cocoa farmers' compliance to European Union regulations in Osun State. Specifically, the research profiled the socioeconomic characteristics of cocoa farmers, determined the factors affecting compliance with the EU pesticides regulations and determined the effect of compliance with the EU pesticide regulations on income and assets of cocoa farmers.

Materials and Methods

Study Area

The study was conducted in Osun State. The State lies between latitude 7.0° and 9.0° N and longitude 2.8° and 6.8° E in Southwestern Nigeria. It is bounded by Kwara State to the North, Ogun State to the South, and Ondo State to the East, Oyo State to the West (Fig. 1). The total population of the State is 3,416,959 persons with a landmass of 9,251 km^2 (NPC, 2006). the State covers an area of about 8,602 km^2 of land (World Bank, 2015). The State consists of three agro-ecological zones: derived savannah (Osogbo), savannah (Iwo), and rain forest (Ife/Ijesa) zone under the Osun State Agricultural Development Programme (OSSADEP). The soil in the area is classified as vastly ferruginous tropical red soils subterranean rocks. The well-drained clay soils of the hillcrest and slopes are the best soils for cocoa cultivation in the area (Sofoluwe et al., 2013).

Sampling Procedure and Sampling Size

A multistage sampling procedure was used to select respondents for the study. The first stage involved a purposive selection of three LGAs which are Atakumosa West, Ilesha East, and Ife East, based on the prevalence of cocoa production in these areas (Akinnagbe, 2015). At the second stage, five villages from each of the selected LGAs were selected using simple random sampling. The communities selected from each LGAs include Osu, Ifewara, Iloro, Ayetoro, and Agunja (Atakumosa West); Araromi, Oke sa, Ayeso, Egbeide, and Idasa (Ilesha East); Okerere, Keredolu, Yekemi, Fadaka, and Oke bode (Ife East) as shown in Fig. 1. At the third stage, 17 cocoa farmers were randomly selected from each of the selected villages. A total of two hundred and fifty-five (255) respondents were administered questionnaires for the study. A total of two hundred and fifty-five (255) copies of the questionnaire were administered to cocoa farmers in the study area. However, only two hundred and thirty-eight (238) copies of the questionnaire were retrieved and used for the analysis.

Analytical Techniques

Analytical methods employed in this study include probit regression, endogenous switching regression models and propensity score matching. Firstly, data were analysed using descriptive statistics in order to describe socio-economic characteristics of the cocoa farmers. To determine the factors affecting compliance with EU pesticide regulations, the probit regression model was carried out. Endogenous switching regression model and propensity score matching were used to analyze the impact of compliance to EU pesticides regulation on the income, and asset of cocoa farmers.

Probit Model

The probit model was used to determine the factors affecting compliances with the EU pesticides regulations.

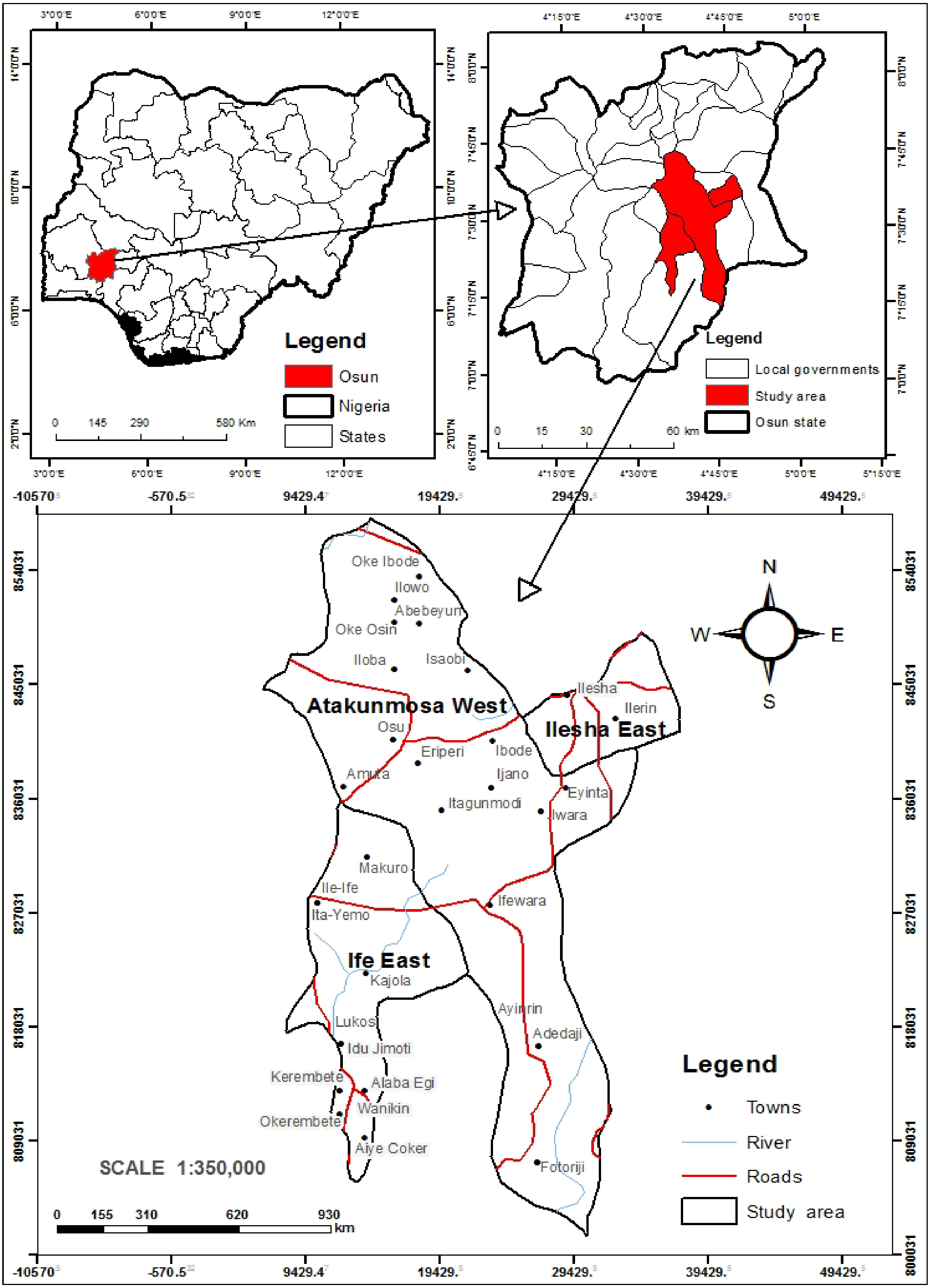

Figure 1. Map of Osun State

Source: Google Map, 2019 Accessed from https://www.researchgate.net/figure/Map-of-Osun-State-Nigeria-Source articlesapuborgsors_fig1_322661602 6/5/2019

The model is specified explicitly as follows:

$$Y = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 + b_7X_7 + b_8X_8 + b_9X_9 + b_{10}X_{10} + b_{11}X_{11} + b_{12}X_{12} + b_{13}X_{13} + u_i \quad (1)$$

where:
Y is the dependent variable which is cocoa farmers' compliance with EU regulation (Complied =1, otherwise=0).

The definition of independent variables is:

X_1 = Age (years); X_2 = Gender (male=1, otherwise=0); X_3 = Education (Years of formal education); X_4 = Household size (number); X_5 = Extension services (yes=1, no=0); X_6 = Farming experience (years); X_7 = Access to credit (yes=1, no=0); X_8 = Availability of pesticide (yes=1, no=0); X_9 = Primary Occupation (farming=1, otherwise=0); X_{10} = Membership of cocoa organization (yes=1, no=0); X_{11} = Fungicide cost/ha (N); X_{12} = Insecticide cost/ha (N); X_{13} = Farm size (ha); U_i = error term.

Additionally, marginal effects are estimated to measure instantaneous effects of changes in any explanatory variable on the predicted probability of being participated, while holding other variables constant. The marginal effects are computed as:

$$\beta_m = \Pr\left[\frac{\delta(\beta_i X_i + \varepsilon_i)}{\delta\beta X_i}\right]\beta_i \text{ for continuous independent variables} \quad (2)$$

$$\beta_m = \Pr[\gamma_i = 1] - \Pr[\gamma_i = 0] \text{ for binary variables} \quad (3)$$

Propensity Score Matching and Endogenous Switching Regression

The impact of EU pesticide regulations on cocoa farmers' income and their asset is estimated using PSM and ESRM. PSM is utilized to evaluate the factual impact of the regulations. PSM attempts to measure the change between the outcome variables of the adopters and the non-adopters with analogous inherent characteristics, but cannot detect unobservable bias, since PSM only controls the selection bias that is directly due to observable variables. When there are unobserved variables which influence both the adoption decision and the outcome variables at the same time, a "hidden bias" or "unobservable selection" bias may occur and the PSM estimator will no longer be consistent. To control bias in self-selection, and account for endogeneity neglected by PSM, endogenous switching regression model was used to fill this gap which has been neglected by many authors. Apparently, this is the first research that utilized both PSM and ESRM approaches to evaluate the impact of EU pesticide regulations on the income and assets of cocoa farmers.

Propensity Score Matching

The rationale behind the use of the matching method is to find a group of treated respondents (in our case, cocoa farmers that comply with EU pesticide regulation) that are similar to the control group (in our case, farmers that do not comply with EU pesticide regulation) in all applicable pre-treatment characteristics such that the only difference between the two groups is the one that received treatment (compliance to EU pesticide regulation) and the other did not receive treatment (non-compliance to EU pesticide regulation). Hence, PSM is a quasi-experimental method that screens self-selection which normally occurs when regulations are not distributed and self-selection into compliance occurs (Akinola and Sofoluwe, 2012; Sofoluwe et al., 2013; Kehinde and Kehinde, 2020).

Evaluating the mean impact of compliances with the EU pesticide regulation on income and asset of cocoa farmers, the propensity score was calculated using probit regression model given as follows:

$$P(X) = \Pr(D = 1 / X) = E \quad (4)$$

where D = {0, 1} is cocoa farmers' compliance with EU pesticides regulation

i.e, D = 1 if complied

D = 0, if not

X = is a set of explanatory variables.

These variables are those expected to jointly determine the probability to comply with EU regulation and its impact on income and assets. The primary parameter in the quasi-experimental context is the average treatment effect (ATT) for the treated population which is stated as follows:

$$ATT = E(\Delta Y \mid D = 1, X) \quad (5)$$

$$ATT = E(Y_1 - Y_2 \mid D = 1, X) \quad (6)$$

$$ATT = E(Y_1 \mid D = 1, X) - E(Y_0 \mid D = 1, X) \quad (7)$$

where:

Y_1 = value of the outcome (asset and income) when the respondents comply with EU pesticide regulations; Y_0 = value of the outcome (asset and income) when the respondents do not comply with EU pesticide regulations; X = is a set of conditioning variables on which the subjects were matched; D = 1 compliance (treatment), D = 0 noncompliance (control).

Following the unobserved nature of the estimation, $E(Y_1 \mid D = 1, X)$ = mean outcome when farmers comply with the regulation can be determined while $E(Y_0 \mid D = 1, X)$ = mean outcome when farmers do not comply with the regulation cannot be determined but

$$\tau = E(Y_1 \mid D = 1) - E(Y_0 \mid D = 0)$$

can be estimated through a biased estimator of τATT.

To achieve the conditional independence assumption (CIA), τ can be given as

$$Y_1 Y_0 L|D|Z \quad (8)$$

The expected effects of compliance on the outcome variables can be expressed as follows:

$$\tau ATT(z) = (Y_1 - Y_0)|z) \quad (9)$$

The mean adoption effect can be expressed as:

$$\tau = E\{\tau(z)\} \quad (10)$$

The estimation of the mean effect of the treatment through the mean difference in the outcome of the matched sets is written as follows:

$$ATT = E(Y_1 \mid D{=}1, P(X)) = E(Y_0 \mid D{=}0, P(X)) \quad (11)$$

$$ATE = E(Y_1 \mid D{=}1, P(X)) - E(Y_0 \mid D{=}0, P(X)) \quad (12)$$

Three matching methods were employed to evaluate the ATT. The matching methods were nearest neighbour matching; radius matching and kernel matching.

Endogenous Switching Regression

ESRM is expected to correct for unobserved bias. Using the ESRM, it is possible to estimate the impact of non-random selection of farmers who complied and the selection biases that are hidden in Ordinary Least Square (OLS) estimates of compliance effects. It can also be used to predict how cocoa farmers would fare if they were put in another condition. The model is adapted from Lokshin and Sajaia, (2004). "The binary decision choice of cocoa farmers' compliance conditional on observed covariates was first specified

$I_i = 1 \quad \text{if} \quad \gamma Z_i + u_i > 0$

$I_i = 0 \quad \text{if} \quad \gamma Z_i + u_i \leq 0$

$$\text{Regime1: } y_{1i} = \beta_1 X_{1i} + \epsilon_{1i} \quad \text{if } I_i = 1 \tag{13}$$

$$\text{Regime2: } y_{2i} = \beta_1 X_{2i} + \epsilon_{2i} \quad \text{if } I_i = 0 \tag{14}$$

Here,

y_{ji} = dependent variables;

X_{1i} and X_{2i} = vectors of weakly exogenous variables;

β_1, β_2, and γ = vectors of parameters.

We assume that U_i, ϵ_{1i}, and ϵ_{2i} have a trivariate normal distribution with mean vector zero and covariance

$$\Omega = \begin{bmatrix} \sigma_u^2 & \sigma_{1u} & \sigma_{2u} \\ \sigma_{1u} & \sigma_1^2 & . \\ \sigma_{2u} & . & \sigma_2^2 \end{bmatrix}$$

where,

σ_u^2 = selection equation error term

σ_1^2 and σ_2^2 =continuous equations error terms

σ_{1u} = covariance of ui and ϵ_{1i}

σ_u^2 = covariance of ui and ϵ_{2i}

The covariance between ϵ_{1i} and ϵ_{2i} is not defined, as y_{1i} and y_{2i} are never observed simultaneously. We can assume that $\sigma_u^2 = 1$ (γ is estimable only up to a scalar factor). The estimation is done by the Full Specification of the Maximum Likelihood Model. This model also estimated the treatment effect on treated and untreated. The log-likelihood function is written as follows:

$$InL = \sum_i \left(\mathrm{I}_i \mathrm{W}_i \left[In\{F(\eta_{1i})\} + Ln \left\{ \frac{f\left(\frac{\epsilon_{1i}}{\sigma_1}\right)}{\sigma_1} \right\} \right] \right) + (1 - \mathrm{Ii})\mathrm{W}_i \left[Ln\{f(\eta_{2i})\} + In \left\{ \frac{f\left(\frac{\epsilon_{1i}}{\sigma_2}\right)}{\sigma_2} \right\} \right]) \tag{15}$$

where $F(.)$ and $f(.)$ are respectively the density and cumulative density functions. W_i is optional. Also, we have that:

$$\eta_{ji} = \frac{\gamma Z_i + \rho_j \epsilon_{ji} / \sigma_j}{\sqrt{1 - \rho_j^2}} \qquad j = 1,2$$

where ρ_j is the coefficient of correlation between ϵ_j and u.

The results of ESRM can also be used to generate conditional expectations which will provide a concise measure of any differences among cocoa farmers based on the compliance to EU pesticide (Araar, 2015). The following expressions are considered:

$$E(y_{1k} \mid I_k = 1, X_k) = X_{1k} B_1 + \rho_1 \sigma_1 f(Z_k\gamma)/F(\gamma Z_k) \tag{16}$$

$$E(y_{1k} \mid I_k = 0, X_k) = X_{2k} B_1 - \rho_1 \sigma_1 f(Z_k\gamma)/\{1-F(Z_k\gamma)\} \tag{17}$$

$$E(y_{2k} \mid I_k = 1, X_k) = X_{2k} B_2 + \rho_2 \sigma_2 f(Z_k\gamma)/F(Z\_k\ \gamma\ ) \tag{18}$$

$$E(y_{2k} \mid I_k = 0, X_k) = X_{2k} B_2 - \rho_2 \sigma_2 f(Z_k\gamma)/\{1-F(Z_k\gamma)\} \tag{19}$$

Results and Discussion

Socioeconomic Characteristics of Respondents

The socioeconomic characteristics of sampled cocoa farmers are presented in Table 2. It shows that the majority of the respondents (88.24%) are male as expected, as cocoa production is subjugated by male farmers in the study area. This is so probably because women do not usually have access to land based on cultural settings and their role mostly in cocoa production is confined to fermentation and drying of cocoa beans. This result is also in accordance with Osarenren et al. (2016). Most (41.60%) of the cocoa farmers are within the age range of 41-50 with a mean age of 50 years. This suggests that most of the sampled farmers are still in their economic active age and this could have a positive impact on cocoa production. Household size refers to the number of people living together under one roof and sharing and eating from the same pot. The majority (68.49%) of the respondents have a household size of 5-8 members and the mean household size is 7. Education is the very key to farmers' compliance with EU regulation. The Table also revealed that about 38% have secondary education. This infers that the literate farmers are involved in cocoa production. The Table further divulges that the majority (46%) of the cocoa farmers are smallholder farmers with less than 6 hectares. This implies that the farmers are resource-poor, which may affect the level of compliance with the EU pesticide regulation. About 51% of the respondents are members of farmers' association which could help in the diffusion of information and implementation of innovations. However, about 87% of the respondents did not have access to credit, which could also pose a threat to compliance of the respondents with the EU pesticide regulation. Also, the majority (61%) of the respondents had no access to extension agents. However, an NGO called "Olakoko" was responsible for the training of the farmers in collaboration with Sucden-Starlink. They met with some of the sampled farmers fortnightly, intending to comply with the EU pesticide regulations.

Factors Affecting Compliance with the EU Pesticide Regulations

The result of the factors affecting compliance with the EU pesticide regulations is shown in Table 3. The Chi-square estimate (124.23) with a value of 0.0000 shows that the model is statistically significant at 1% level. Out of the thirteen independent variables used in the model, seven variables are significant in determining compliance with the EU pesticide regulations. The variables are years of formal education, extension services, access to credit, insecticide price, fungicide price, farm size and availability of pesticides. As expected, years of education, extension service, access to credit, availability of approved pesticides and farm size have a positive and significant effect on compliance with the EU pesticide regulations. Years of formal education have a significant effect on the probability of a farmer complying with the regulation. The marginal effect was 0.01 meaning that a unit increase in years of formal education will increase the probability of farmers complying with the regulations by 0.01unit. This is expected because education enables farmers to understand what the regulation entails thus increasing the probability of compliance. This result is also inconsonant with Abankwah et al, (2010). Farmers' access to extension services has a positive effect on compliance with the EU pesticide regulations.

Table 2. Socio-economic characteristics of respondents

Variables	Frequency	Percentage
Gender		
Male	210	88.24
Female	28	11.76
Total	**238**	**100**
Age		
< 40	34	14.29
41-50	99	41.60
51-60	87	36.55
61-70	17	7.14
> 70	1	0.42
Total	**238**	**100**
Mean	50.15	
Household size (Actual Size)		
1-4	19	7.88
5-8	163	68.49
9-12	38	15.97
>12	18	7.56
Total	**238**	**100**
Mean	7.39	
Years of formal education		
0	45	18.91
1 – 6	61	25.63
7 – 12	91	38.24
> 12	41	17.23
Total	**238**	**100**
Mean	8.52	
Farming experience		
1-10	7	2.94
11-20	70	29.41
21 – 30	95	39.92
31 – 40	47	19.75
41 – 50	14	5.88
51 – 60	5	2.10
Total	**238**	**100**
Mean	27.62	

Continued. Table 2.

Variables	Frequency	Percentage
Farm size		
< 6	50	21.01
6 –11	92	38.66
11 – 16	42	17.65
16 – 21	43	18.07
> 21	11	4.62
Total	**238**	**100**
Mean	10.99	
Membership of association		
Yes	122	51.26
No	116	48.74
Total	238	100
Access to credit		
Yes	32	13.45
No	206	86.55
Total	**238**	**100**
Access to extension		
Yes	93	39.08
No	145	60.92
Total	**238**	**100**

The marginal effect was 0.06, which means that an increase in access to extension services will increase the likelihood of compliance by 0.06 units. This outcome is likewise in accordance with findings from Alabi et al. (2014) and Adekunle et al. (2017), that farmers who have contact with extension services or participated in agricultural activities (attending agricultural meetings, demonstration plots, and field day) are expected to have access to profitable information and practices. Therefore, they are more likely to comply than their counterparts who had no extension contact.

Farmers' access to credit also has a positive influence on compliance with the approved pesticides. The marginal effect was 0.14 meaning an increase in access to credit will increase the probability of compliance by 0.14 unit. Availability of approved pesticides has a positive influence on compliance which implies that if approved pesticides are available, the probability of compliance with the EU pesticide regulations will increase. This means that the availability of approved pesticides is key to compliance. This could be attributed to the fact that most of the farmers had access to approved pesticides through the extension agents sponsored by the "Olakoko" project.

Table 3. Probit regression result on factors affecting compliance with the approved pesticides

Variables	Coefficients	Standard Error	P-value	Marginal Effect
Age	-0.032	0.024	0.172	-0.004
Sex	0.129	0.371	0.728	0.015
Education years	0.071	0.030	0.017**	0.008
Household size	-0.091	0.068	0.183	-0.010
Extension	0.526	0.287	0.080*	0.061
Farming experience	-0.021	0.017	0.207	-0.002
Access to credit	1.178	0.347	0.001***	0.136
Availability of pesticides	0.821	0.332	0.013***	0.095
Farming primary occupation	-0.157	0.307	0.608	-0.018
Association	-0.258	0.287	0.367	-0.030
Fungicide cost/ha	2.043	0.654	0.002***	0.236
Insecticide cost/ha	2.013	0.493	0.001***	0.233
Farm size	0.087	0.026	0.001***	0.012
_Constant	15.924	3.035	0.000	
LR $chi^2(13)$	124.23			
Prob>chi^2	0.000			
Pseudo R^2	0.5023			
Log-likelihood	-60.4461			

Note: ***, **, *, significant at $P < 0.01$, $P < 0.05$ and $P < 0.10$, respectively

The availability of approved pesticides has a marginal effect of 0.09 units. This implies that with an increase in the availability of approved pesticides, the likelihood of compliance with approved pesticides will increase by 0.09 units. The coefficients of farm size are significant. Farm size has a positive significant effect on compliance, with a marginal effect of 0.01, thereby implying that if farm size should increase, the likelihood of compliance will increase by 0.01 units. This is in contrast with the findings of Akinwale et al. (2019) that as the farm size increase, observing certification rules may increase, thereby reducing the level of compliances.

Impact of Compliance to EU Pesticide Regulation on Cocoa Farmers Income and Asset

The impact of EU pesticide regulation on income and assets was estimated through three (3) different matching algorithms: Nearest neighbor, Radius, and Kernel matching. The result of covariate balancing indicators before and after matching and estimation of the average treatment effect of the treated are presented in the following sub-sections.

The Propensity Score Matching Estimates

Table 4 presents the PSM estimates result. The common support condition was enforced and the balancing property was set at a 5% level of significance in the entire estimated system. The results in the Table revealed that matching limits the control group (non-compliant) to heave the match of the subsample of non-compliant cases that are directly compared with the compliant cases. Table 4 also shows before and after matching balancing results for propensity scores for each covariate. The standardized bias change among compliant and non-compliant was used to compute the bias between treatment and control samples. It is clear that the variations between samples in the unmatched data surpass those in the samples of matched cases. The method of matching thus produces a high level of covariate balance between the treatment and control samples used in the evaluation process. Several variables such as age, farm experience, and years of formal education were statistically significant before matching, whereas the covariates and the pseudo-R^2 are statistically insignificant after matching. The probit result indicates that all estimations have a good matching quality.

Table 4. Indicators of covariate balancing before and after matching

Variables	Sample	Mean		%bias	%[bias] Reduction	t-test	
		Treated	Control			T	p>|t|
Age	Unmatched	47.392	50.904	-46.5		-2.77***	0.006
	Matched	47.392	46.961	5.7	87.7	0.32	0.752
Sex	Unmatched	0.156	0.10695	14.7		0.98	0.329
	Matched	0.156	0.117	11.5	21.4	0.57	0.569
Education years	Unmatched	11.176	7.791	70.2		4.13***	0.000
	Matched	11.176	12.431	-26.0	62.9	-1.59	0.115
Household size	Unmatched	6.941	7.513	-23.7		-1.42	0.158
	Matched	6.941	6.706	9.8	58.9	0.64	0.520
Extension	Unmatched	0.647	0.321	68.6		4.38***	0.000
	Matched	0.647	0.804	51.9	-1.79	-1.79*	0.077
Farm experience	Unmatched	25.471	28.209	-27.0		-1.69*	0.093
	Matched	25.471	19.784	56.1	-107.7	3.39***	0.001
Access to credit	Unmatched	0.372	0.069	77.8		6.01***	0.000
	Matched	0.372	0.314	15.1	80.6	0.62	0.536
Availability of pesticides	Unmatched	0.372	0.118	61.6		4.43***	0.000
	Matched	0.372	0.431	-14.2	76.9	-0.60	0.549
Farming pri. occupation	Unmatched	0.705	0.647	12.5		0.78	0.434
	Matched	0.705	0.725	-4.2	66.7	-0.22	0.828
Association	Unmatched	0.509	0.513	-0.70		-0.04	0.964
	Matched	0.509	0.588	-15.6	-2650.0	-0.79	0.431
Fungicide cost/ha	Unmatched	4.122	3.906	89.7		6.07***	0.000
	Matched	4.122	4.141	-7.6	91.5	-0.45	0.657
Insecticide cost/ha	Unmatched	3.766	3.284	136.9		8.55***	0.000
	Matched	3.766	3.792	-7.4	94.6	-0.40	0.688
Farm size	Unmatched	11.147	10.95	3.0		0.19	0.849
	Matched	11.147	6.682	68.6	-2162.6	3.94***	0.000
LR $chi^2(15)$		126.43					
Prob>chi^2		0.000					
Pseudo R^2		0.511					
Log likelihood		-60.446					

Note: ***, **, *, significant at $P < 0.01$, $P < 0.05$ and $P < 0.10$, respectively

The findings show that the matching procedure balances the characteristics in the treated (compliant) and untreated groups (non-compliant).

Impact of Compliance to EU Pesticide Regulation on Asset

The impact of compliance to EU pesticide regulations on cocoa farmers' asset was evaluated using three (3) methods; nearest neighbor, kernel, and radius matching method. The output of the three methods produced analogous results. The results are shown in Table 5. Results showed that the value of productive assets of farmers that complied with EU pesticide regulations amount to $826.29 while that of the farmers that did not comply with EU pesticide regulations was $112.09. The estimated difference in the value of productive assets acquired by the farmers that complied and did not comply with EU pesticide regulations was positive "$714.19 in favour of compliant farmers". The difference was found to be significant at 1% level. In addition, the value of non-productive assets of farmers that complied with EU pesticide regulations amounts to $327.39 while that of the farmers that did not comply with EU pesticide regulations was $137.78. The estimated difference in the value of productive assets acquired by the farmers that complied and that of those who did not comply with EU pesticide regulations was positive ($189.60 in favour of complied farmers) but the difference was found to be significant at 1% level. This suggests that compliance with the EU pesticide regulations had made compliant farmers better off than non-compliant farmers. This implies that the use of approved pesticides by sampled farmers had increased the assets of the compliant farmers.

Impact of Compliance to EU Pesticide Regulation on Income

The impact of compliance to EU pesticide regulations on cocoa farmers' income was evaluated using three (3) methods; nearest neighbor, kernel, and radius matching method. The output of the three methods produced analogous results. The results are

Table 5. Estimates of ATT and ATE: Effect of EU Pesticide Regulation on asset

Outcomes		Nearest neighbor	Kernel matching	Radius matching
Productive asset	Treated	826.293	821.453	826.293
(ATT)	Control	112.094	104.323	174.555
	Difference	714.198	717.129	651.738
	Standard error	238.865	280.955	266.262
	t-statistics	2.99***	2.55***	2.45**
Non-productive asset	Treated	327.387	329.309	327.386
(ATT)	Control	137.785	140.925	197.921
	Difference	189.601	188.385	129.465
	Standard error	69.507	73.999	68.428
	t-statistics	2.73***	2.55***	1.89**
Productive asset	Treated	783.789	871.112	841.592
(ATE)	Control	158.935	276.043	163.607
	Difference	624.855	595.069	677.985
	Standard error	238.283	283.366	319.804
	t-statistics	2.61***	2.10***	1.78**
Non-productive asset	Treated	347.456	330.544	327.386
(ATE)	Control	199.256	227.938	214.479
	Difference	148.199	102.606	112.906
	Standard error	84.317	72.465	68.428
	t-statistics	1.76**	1.42	1.65**

Note: ***, **, *, significant at $P < 0.01$, $P < 0.05$ and $P < 0.10$, respectively

shown in Table 6. Results showed that the income from cocoa by farmers that complied with EU pesticide regulations amount to $1508.01 while that of the farmers that did not comply with EU pesticide regulations was $1061.09. The estimated difference in the income from cocoa by the farmers that complied and those that did not comply with EU pesticide regulations was positive ($446.92 in favour of complied farmers). The difference was found to be significant at 5% level. This suggests that compliance with the EU pesticide regulations had made compliant farmers better off than non-compliant farmers. This implies that use of approved pesticides by sampled farmers had increased the income of the compliant farmers.

Estimating the Impact of Compliance to EU Pesticide Regulation Using ESRM

The ESRM was employed to evaluate the strength of the estimated impact obtained from the PSM model since the PSM model accounts only for the observable factors (Khonje et al., 2015a and Khonje et al., 2015b). Table 7 presents the ESRM-based average treatment effects of the impact of EU pesticide regulations for the outcome variables; productive assets, non-productive assets, and cocoa income. The evaluated coefficient on the selected terms for the productive assets was $258.79 and was statistically significant at 5%, while for non-productive assets the coefficient of the estimate was $325.37, statistically significant at 1%. Also, cocoa income was $488.14 and was significant at 1%, signifying that there was self-selection in compliance with the EU pesticide regulation. The ESRM-based average treatment effect estimates presented in Table 7 are close to the PSM-based estimates. Findings show that compliance with EU pesticide regulations increases cocoa farmers' income and assets. However, the significant level improves in the ESR model, which means that the model corrects for biased due to unobservable factors that PSM did not account for. This suggests that compliance with the EU pesticide regulations has made compliant farmers better off than non-compliant farmers. The use of approved pesticides by sampled farmers has increased the productive and non-productive assets and income of the compliant farmers.

ESRM by Full Information Maximum Likelihood for Cocoa Income

The coefficient estimates are presented in the first, second, and third columns of Table 8 of the ESRM for the impact of EU pesticide regulation on cocoa income. The first column represents the selection model, while the second and third column represent the cocoa farmers that do not comply with the EU pesticide regulations and those that comply with EU pesticide regulations respectively.

Table 7. Estimates of ATT and ATE: impact of Compliance to EU Pesticide Regulation on an asset using ESM

Outcomes		ATT	ATE
Cocoa income	Estimate	488.144	1985.240
	Standard error	132.449	131.581
	t-statistics	3.69***	15.1***
Productive asset	Estimate	258.791	1060.14
	Standard error	112.457	335.428
	t-statistics	2.30**	3.16***
Non-productive asset	Estimate	325.371	472.179
	Standard error	34.206	25.376
	t-statistics	9.51***	18.6***

Note: ***, **, *, significant at $P < 0.01$, $P < 0.05$ and $P < 0.10$, respectively

Table 6. An estimate of ATT and ATE: Effect of EU Pesticide Regulation on income

Outcome		Nearest neighbor	Kernel matching	Radius matching
Cocoa income	Treated	1508.013	6382.002	1407.179
(ATT)	Control	1061.097	4294.232	808.287
	Difference	446.916	2087.771	598.893
	Standard error	231.049	1367.317	182.253
	t-statistics	1.93**	1.58	3.29***
Cocoa income	Treated	1432.454	1527.888	1455.812
(ATE)	Control	1022.279	1100.809	1076.519
	Difference	410.175	427.079	379.293
	Standard error	197.199	221.284	210.996
	t-statistics	2.08**	1.93**	1.80***

Note: ***, **, *, significant at $P < 0.01$, $P < 0.05$ and $P < 0.10$, respectively

Age, sex, and primary occupation are statistically significant but have a negative coefficient in explaining the differences in the cocoa income amid the cocoa farmers that do not comply with EU pesticide regulations. A decrease in age will lead to non-compliances and also those that farming is not their main occupation are likely not going to comply and in return reduce their income from cocoa. Likewise, male farmers are not likely to comply. Furthermore, education, household size, farm size, and insecticide cost/ha have positive coefficients and are significant. This implies that an increase in education will increase compliance while increasing their income from cocoa farming. Also, a large household size will increase compliance likewise an increase in the price of insecticides will also increase compliance with the EU pesticide regulations and in return increase their income from cocoa. In addition, sex and farming experience are statistically significant but have negative coefficients in explaining the differences in the cocoa income amidst the cocoa farmers that do comply with EU pesticide regulations. This implies that female farmers are more likely to comply with the regulation, a decrease in the level of farming experience will likewise increase the level of compliance and in return increase their income from cocoa. On the other hand, education, household size, farming primary occupation, and farm size have a positive coefficient and are statistically significant. This infers that farmers with higher educational level and large farm sizes will comply with the regulations and also increase their income from cocoa.

Table 8. ESRM by Full information maximum likelihood for cocoa income

Variables	Selection	Non-compliances	Compliances
Age	-0.027 (0.020)	-0.011 (0.002) ***	-0.001 (0.003)
Sex	0.145 (0.393)	-0.152 (0.086) *	-0.134 (0.048) ***
Education years	0.063 (0.032) **	0.013 (0.003) ***	0.012 (0.004) ***
Household size	0.066 (0.007) ***	0.057 (0.007) ***	0.066 (0.007) ***
Extension	0.518 (0.303) *	0.066 (0.050)	-0.031 (0.035)
Farming experience	-0.011 (0.017)	0.001 (0.002)	-0.004 (0.002) *
Access to credit	0.986 (0.356)	0.157 (0.091)	-0.061 (0.069)
Farming primary occupation	-0.208 (0.275)	-0.068 (0.042) *	0.084 (0.038) **
Association	0.001 (0.278)	-0.015 (0.038)	-0.013 (0.039)
Fungicide cost/ha	0.406 (0.261)	-0.013 (0.040)	-0.014 (0.025)
Insecticide cost/ha	0.903 (0.262) ***	0.111 (0.051) ***	-0.028 (0.036)
Farm size	0.079 (0.021) ***	0.006 (0.003) **	0.012 (0.004) ***
Available	0.729 (0.440) *		
_Constant	-12.080 (3.129) ***	11.781 (0.472) ***	12.82 (0.430) ***
/Ins 0	-1.439 (0.067) ***		
/Ins1	-2.167 (0.175) ***		
/r0	-0.726 (0.285) ***		
/r1	-0.259 (0.724)		
Sigma_0	0.236 (0.016) ***		
Sigma_1	0.114 (0.020) ***		
Rho_0	-0.621 (0.175) ***		
Rho_1	-0.254 (0.678)		
LR test of indep. Eqns	$Chi^2(12)$ =138.500	Prob > Chi^2 = 0.000	

Note: ***, **, *, significant at $P < 0.01$, $P < 0.05$ and $P < 0.10$, respectively

The rho_0 and rho_1 correlation coefficient are both negative but are statistically significant only for the compliance equation and the cocoa income of those cocoa farmers who do not comply. Meanwhile, rho_0 is negative and statistically significantly changed from zero, the model recommends that farmers who decide not to comply with the EU pesticide regulations have higher cocoa income than random farmer from the sample would have achieved. Those cocoa farmers who complied are not worse or better than a random farmer. The probability ratio assessment for mutual independence of the three equations is statistically significant at 1%, which infers that these three models are not mutually independent and ought not to be disjointed.

ESRM by Full Information Maximum Likelihood for Non-Productive Asset

The coefficient estimates are presented in the first, second, and third columns of Table 9 of the endogenous switching regression model for the impact of EU pesticide regulation on the non-productive assets. The first column represents the selection model, while the second and third column represent the cocoa farmers that do not comply with the EU pesticide regulations and those that comply with EU pesticide regulations respectively. Farming as a primary occupation has a negative coefficient and is statistically significant in explaining the differences in non-productive assets amid the farmers that do not comply with EU

Table 9. ESRM by Full information maximum likelihood for non-productive asset

Variables	Selection	Non-compliances_0	Compliances_1
Age	-0.025 (0.021)	0.011 (0.009)	0.021 (0.023)
Sex	0.145 (0.364)	0.090 (0.216)	-0.414 (0.327)
Education years	0.063 (0.031) **	0.041 (0.014) ***	0.056 (0.027) **
Household size	-0.073 (0.056)	0.040 (0.028)	0.126 (0.052) ***
Extension	0.518 (0.250) **	-0.143 (0.191)	-0.036 (0.201)
Farming experience	-0.011 (0.014)	-0.004 (0.008)	-0.021 (0.015)
Access to credit	0.986 (0.467) **	-0.183 (0.533)	-0.079 (0.265)
Farming primary occupation	-0.207 (0.271)	-0.598 (0.133) ***	0.447 (0.290)
Association	0.001 (0.326)	-0.013 (0.129)	-0.177 (0.204)
Fungicide cost/ha	0.406 (0.248) *	-0.072 (0.138)	-0.092 (0.188)
Insecticide cost/ha	0.903 (0.224) ***	-0.030 (0.209)	-0.062 (0.161)
Farm size	0.079 (0.023)	0.020 (0.014)	-0.006 (0.018)
Available	0.729 (0.338) **		
_Constant	-12.080 (2.734) ***	11.009 (2.127) ***	11.791 (2.469) ***
/Ins 0	-0.129 (0.50) ***		
/Ins1	-0.261 (0.119) **		
/r0	-0.219 (0.750)		
/r1	-0.603 (0.306) **		
Sigma_0	0.878 (0.044) ***		
Sigma_1	0.770 (0.091) ***		
Rho_0	-0.215 (0.715)		
Rho_1	-0.539 (0.217) ***		
LR test of indep. eqns	Chi^2 (12) = 61.160	Prob > Chi^2 = 0.000	

Note: ***, **, *, significant at $P < 0.01$, $P < 0.05$ and $P < 0.10$, respectively

pesticide regulations. This suggests that those farmers whose main occupation is not farming will reduce the acquisition of non-productive assets, while education has positive coefficients and is significant, implying that an increase in the level of education will lead to non-compliance with the regulations. In the same vein, education and household size also have positive coefficients and are statistically significant in elucidating the differences in non-productive assets amidst the farmers that do comply with EU pesticide regulations. This suggests that an increase in educational level and household size will lead to an increase in the acquisition of non-productive asset. The rho_0 and rho_1 correlation coefficient are both negative but are statistically significant only for the compliance equation and the non-productive asset of those cocoa farmers who do not comply. Meanwhile, rho_1 is negative and statistically significantly changed from zero, the model recommends that farmers who choose to comply with the EU pesticide regulations have higher non-productive assets than random farmer from the sample would have achieved. Those farmers who do not comply are not better or worse than a random farmer. The likelihood ratio assessment for mutual independence of the three equations is statistically significant at 1%, which infers that these three models are not mutually independent and ought not to be disjointed.

Table 10. ESRM by Full information maximum likelihood for productive asset

Variables	Selection	Non-compliances	Compliances
Age	-0.025 (0.021)	-0.003 (0.054)	0.099(0.150)
Sex	0.145 (0.354)	3.393 (1.065) ***	-0.032(2.238)
Education years	0.063 (0.029) **	0.014 (0.078)	0.422(0.243) *
Household size	-0.073 (0.054)	0.358 (0.148) ***	0.339(0.357)
Extension	0.518 (0.267) **	-0.189 (1.020)	0.433(1.748)
Farming experience	-0.011 (0.014)	0.004 (0.049)	-0.042(0.093)
Access to credit	0.986 (0.335) ***	0.960 (1.328)	3.880(2.272) *
Farming primary occupation	-0.207 (0.263)	-0.473 (0.910)	0.932(1.836)
Association	0.001 (0.298)	0.230 (0.840)	-2.681(1.925)
Fungicide cost/ha	0.406 (0.244) *	-1.633 (0.865) **	-0.057(1.399)
Insecticide cost/ha	0.903 (0.232) ***	0.560 (0.854)	1.505(1.533)
Farm size	0.079 (0.019) ***	-0.060 (0.070)	-0.011(0.162)
Available	0.729 (0.460)		
_Constant	-12.080 (2.400) ***	17.274 (8.627) ***	-17.759(19.329) ***
/Ins 0	1.685 (0.038) ***		
/Ins1	1.673 (0.208) ***		
/r0	-0.177 (0.352)		
/r1	0.870 (0.459) **		
Sigma_0	5.394 (0.209) ***		
Sigma_1	5.330 (1.108) ***		
Rho_0	-0.175 (0.341)		
Rho_1	-0.701 (0.233) ***		
LR test of indep. Eqns	Chi^2 (12) =28.15	Prob> Chi^2=0.005	

Note: ***, **, *, significant at $P < 0.01$, $P < 0.05$ and $P < 0.10$, respectively

ESRM by Full Information Maximum Likelihood for Productive Asset

The coefficient estimates are presented in the first, second and third columns of Table 10 of the ESRM for the impact of EU pesticide regulation on productive asset. The first column represents the selection model, while the second and third column represent the cocoa farmers that do not comply with the EU pesticide regulations and those that comply with EU pesticide regulations respectively. Fungicide cost/ha has negative coefficient and is statistically significant in elucidating the differences in productive assets amidst the farmers that do not comply with EU pesticide regulations. However, sex and household size have positive coefficients and are significant. On the other hand, access to credit and education also have positive coefficients and are statistically significant in elucidating the differences in non-productive assets amidst the farmers that do comply with EU pesticide regulations. The correlation coefficient rho_0 is negative while rho_1 is positive, but are statistically significant only for the correlation between the compliance equation and the productive assets of those farmers who do comply. Meanwhile, rho_1 is positive and statistically significantly changed from zero. The model recommends that farmers who decide to comply with the EU pesticide regulations have lower productive assets than a random farmer from the sample would have achieved. Those farmers who do not comply are not better or worse than random farmers. The likelihood ratio assessment for mutual independence of the three equations is statistically significant at 1%, which infers that these three models are not mutually independent and ought not to be disjointed.

Conclusion and Recommendation

This study examined the economic impact of EU pesticide regulation on cocoa farmers in Osun State, Nigeria. The results showed that the majority of cocoa farmers were male (88.24%) and married (95.38%). The results also revealed that the majority (78.15%) of the farmers were within the 41-60 years of age bracket with a mean age of 50 years. To determine the factors affecting compliance with the EU pesticide regulations, the probit regression model was used. The result revealed that the Chi-square estimate (124.23) with a value of 0.0000 shows that the model was statistically significant at a 1% level. Out of the thirteen independent variables used in the model, seven variables were found to be significant variables affecting compliance with the EU pesticide regulations. The variables are years of formal education, extension services, access to credit, insecticide price, fungicide price, farm size, and availability of pesticides. The propensity score matching result shows that there were significant differences in assets and income of the farmers that complied and those that did not comply with estimated differences of $446.92 and $714.19 in assets and income respectively. The likelihood of cocoa farmers' compliance with the EU pesticide regulations was positively influenced by access to extension agents, availability of the approved pesticides and access to credit. The study also revealed that there were significant differences in an asset acquired by the farmers that complied and those that did not comply with an estimated difference of $446.91 and $714.19, based on the results of the study. The study suggests that cocoa farmers' access to extension services needs to be improved as this will help to provide them with adequate information that can increase their level of compliance with the EU pesticide regulations. The study also suggests the implementation of policies or programmes that will increase cocoa farmers' access to credit in the study area. This credit could also be in the form of improved and approved agricultural inputs such as approved pesticides that the farmers can secure at the beginning of the farming season and then pay back after the sales of their cocoa beans.

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