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Postharvest Practices and Economic Outcomes in the Cocoa Industry: Insights from Licensed Buying Agents in Southwest Nigeria

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ABSTRACT

Adopting Good Postharvest Handling Practices (GPHH) is critical to enhancing Nigeria's cocoa value chain's quality, sustainability, and profitability. This study investigates the determinants and economic impacts of GPHH adoption among Licensed Buying Agents (LBAs) in Southwest Nigeria, focusing on Ondo and Osun states. Using a multistage sampling procedure, 120 LBAs were surveyed, and an Endogenous Switching Regression (ESR) model was employed to analyze the data. The findings reveal that only 43.3% of LBAs adopt GPHH, with adoption driven by factors such as education, training participation, credit access, and access to modern technology information. Conversely, high operational costs and government charges were significant barriers to adoption. The study demonstrates that LBAs who adopt GPHH experience a substantial increase in income, with an Average Treatment Effect on the Treated (ATT) of ₦5,618,535.72 (13.2%), highlighting the economic benefits of improved practices. Furthermore, adopters achieve higher efficiency and reduced postharvest losses, enhancing their market competitiveness. The results also reveal gender disparities in adoption rates and the importance of capacity-building interventions, such as training programs and financial support mechanisms, to address barriers. This research underscores the need for targeted policy interventions to promote GPHH adoption, improve postharvest quality management, and enhance the livelihoods of LBAs. By addressing the persistent challenges in the cocoa sector, this study provides actionable insights for stakeholders to foster sustainability and economic growth within Nigeria's cocoa industry.

Keywords: *Adoption, cocoa value chain, economic impact, endogenous switching regression, quality management, Nigeria*

1. Introduction

Cocoa production is integral to Nigeria's agricultural economy, particularly in the Southwest region, which accounts for a significant share of the nation's output. This region benefits from favorable agroecological conditions, such as loamy soils, tropical climate, and a structured farming economy, which collectively make it conducive to high-quality cocoa cultivation [23][15]. Despite these advantages, inefficiencies in postharvest handling remain a critical impediment to maximizing the potential of Nigeria's cocoa industry. These inefficiencies manifest in quality deterioration, suboptimal income for key players, and reduced market competitiveness in the global cocoa trade. Cocoa is the primary cash crop of Nigeria's Southwest region, contributing substantially to the national economy and providing livelihoods for millions of smallholder farmers and intermediaries. The region's six states—Ondo, Osun, Oyo, Ekiti, Ogun, and Lagos—have ecological conditions that support cocoa's optimal growth. Ondo and Osun states, in particular, stand out for their high cocoa production volumes, collectively accounting for a significant proportion of Nigeria's annual exports [13].

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Globally, cocoa demand has been increasing, driven by the expansion of the chocolate industry and growing consumer interest in sustainably sourced products. In this context, quality assurance has become a key determinant of market access. However, Nigeria faces challenges in meeting international quality standards due to poor postharvest practices, including inadequate storage, improper drying, and contamination. These lapses diminish the competitiveness of Nigerian cocoa compared to exports from the Ivory Coast and Ghana, its primary competitors [19] [9] [20] [25]. Addressing these gaps is essential to ensuring Nigeria's sustained relevance in the global cocoa market.

The cocoa value chain in Nigeria is characterized by inefficiencies that disproportionately affect intermediaries like Licensed Buying Agents (LBAs). LBAs play a crucial role in the cocoa supply chain, serving as the link between smallholder farmers and larger buyers or exporters. Despite their pivotal position, they face significant operational challenges, particularly in postharvest handling. Recent studies indicate that only 43.3% of LBAs in the Southwest region adopt Good Postharvest Handling Practices (GPHH), a situation that undermines both quality and profitability [24] [2]. Key barriers to GPHH adoption include high operational costs, limited access to credit, and inadequate training. High operational costs, particularly for transportation and storage, reduce the financial viability of adopting improved practices. Meanwhile, limited access to formal credit restricts LBAs' ability to invest in infrastructure and technology necessary for implementing GPHH. Gender disparities also persist, with male LBAs being more likely to adopt GPHH than their female counterparts due to social norms and resource access inequities [19] [22]. The implications of these challenges extend beyond the economic well-being of LBAs to the broader cocoa sector. Poor postharvest handling contributes to high levels of aflatoxin contamination, leading to the rejection of Nigerian cocoa in international

markets. This issue has been flagged in multiple studies, highlighting the urgent need for interventions to enhance postharvest quality management [1] [11].

While there is substantial literature on cocoa production and its economic importance, studies focusing specifically on the role and challenges of LBAs in the value chain are sparse. Most existing research emphasizes production-side challenges, such as farm-level productivity and pest management, with limited attention to postharvest handling and its economic implications. Moreover, the determinants of GPHH adoption among LBAs remain underexplored, particularly in the context of socioeconomic variables such as education, training participation, and credit access [27]. Another significant gap lies in the lack of robust econometric analysis to quantify the impact of GPHH adoption on the incomes of LBAs. While descriptive studies provide valuable insights, they often fail to capture the nuanced interplay of observed and unobserved factors influencing adoption decisions and their subsequent economic outcomes. Advanced modeling approaches, such as the Endogenous Switching Regression (ESR) model, are needed to address these complexities and provide actionable insights for stakeholders [15].

Therefore, the present study aims to fill these gaps by investigating the adoption dynamics of GPHH among LBAs in Ondo and Osun states and assessing their impact on economic outcomes. By employing the ESR model, this research provides a comprehensive analysis of both the determinants of adoption and its effects on income, offering a nuanced understanding of the challenges and opportunities within the cocoa value chain. The rationale for focusing on LBAs stems from their unique position in the cocoa value chain. As intermediaries, LBAs influence the quality of cocoa that reaches international markets and, by extension, the price and reputation of Nigerian cocoa. Improving their practices has the potential to create a ripple effect, benefiting farmers, exporters, and the broader economy. Furthermore, addressing the barriers faced by LBAs, such as training gaps and financial constraints, aligns with global sustainability goals, including those outlined in the United Nations Sustainable Development Goals (SDGs), particularly SDG 1 (No Poverty) and SDG 8 (Decent Work and Economic Growth). This study also contributes to policy discourse by providing evidence-based recommendations for enhancing the adoption of GPHH. The findings are expected to inform the design of targeted interventions, such as capacity-building programs, credit schemes, and policy reforms, to address the specific needs of LBAs. For instance, the study highlights the importance of training programs in equipping LBAs with the skills needed to implement GPHH effectively. It also underscores the role of financial inclusion in facilitating access to the resources required for postharvest improvements [10] [12].

Objectives

The specific objectives of this study are threefold: (1) to disaggregate adopters and non-adopters of GPHH, (2) to estimate the costs and returns of the LBAs, (3) to identify the factors influencing GPHH adoption among LBAs, and (4) to quantify the economic benefits of adoption using robust econometric modeling.

2. Materials and Methods

The study was conducted in the Southwest region of Nigeria. The population of this region was estimated at 27,511,992 [14]. The region consists predominantly of the Yoruba ethnic group who make up approximately 21% of the national population [13]. The Southwest States are Ondo, Ekiti, Osun, Oyo, Lagos, and Ogun, all located in tropical forest areas. The area lies between latitudes 4^0 and 9^0 North and longitudes 7^0 and 30^0 East with a total land area of 191,843 square kilometers[22]. The region has an average annual rainfall and temperature of 1486mm and 26^0 Celsius, respectively [28]. The Southwest region of Nigeria is suitable for agricultural production due to its favorable climatic conditions, soil type, and topography. The soil in the region is mostly loamy and sandy, which is good for cocoa cultivation. However, the soil needs to be well-drained to prevent water logging, which can lead to disease outbreaks. The region has undulating hills and valleys that provide good drainage and prevent soil erosion. The major agricultural practices in the Southwest region of Nigeria include farming of cocoa, oil palm, plantain, cassava, rice, vegetable, poultry, tomato, and fishery. These agricultural practices contribute significantly to the economy of the region and the country. The region's climate is characterized by two distinct seasons: the rainy season and the dry season. The rainy season lasts from April to October, while the dry season lasts from November to March. The region's temperature ranges from 25°C to 35°C, which is suitable for cocoa growth [28].

Ondo State is situated entirely in the tropics. It is made up of 18 local government areas with a population of 3,441,034 [14], which was projected to be about 5,247,562 in 2021 at an annual growth rate of 3.5% [13]. Its approximate latitude is between 6^0 5' and $7^0$5' degrees North, and its approximate longitude is between $4^0$5' and $5^0$5' degrees East. The State has a land mass of 14,793 sq km and it shares state boundaries with Ekiti to the northeast, Edo to the east, Delta to the southeast, Ogun to the southwest, Osun to the northwest, and the Atlantic Ocean to the south. The economy of Ondo State is dominated by oil and crop production which jointly accounts for 90% of its gross domestic product. The environmental conditions are favorable for the production of crops such as cassava, cocoa, cocoyam, and maize [4] [25].

Osun State on the other hand lies between the latitudes 7° 11' and 8° 21' North of the equator and between longitudes 3° 56' and 5° 47' East of Greenwich. It lies within the tropics and has two dissimilar seasons. The dry season is between November and mid-March while the rainy season begins in mid-March to October [21]. Its mean annual rainfall is 1,570mm and its temperature is between 25°C and 27.5°C [5] [6]. It covers a land area of 14,875 square meters. Its landlocked area is bounded by other states in the north by Kwara, in the east partly by Ekiti and partly by Ondo, in the south by Ogun, and in the west by Oyo [8]. The state is rich in mineral resources such as gold, clay, limestone, and granite. The people of Osun State are mostly traders, artisans, and farmers. The major ethnic group in Osun state is Yoruba with sub-ethnic groups such as Ife, Ijesha, Oyo, Ibolo, and Igbomo, besides settlers from other parts of Nigeria [24]. The state is predominantly agrarian with the inhabitants mostly engaging in the production of food crops at subsistence level. Cocoa is the major commercial (cash) crop produced for the export market. Osun ranks as the second largest cocoa-producing state in southwestern Nigeria after Ondo [13].

Primary data were used for this study. Primary data were collected with the aid of a well-structured questionnaire. A multistage sampling procedure was employed to select the respondents for this study. The first stage involved a purposive selection of two (2) states (Ondo and Osun).

The selection of the States was because they are the major cocoa-producing states in the Southwest region of Nigeria. In the second stage, four Local Government Areas (LGAs) were purposively selected in each state based on the high volume of cocoa production (Agricultural Development Programme). The third stage involved a random selection of two (2) communities in each of the eight LGAs. In the fourth stage, eight licensed buying agents (LBAs) were selected in each community using a simple random sampling technique which makes a total of one hundred and twenty-eight (128) LBAs. However, 120 copies of the questionnaire were valid and returned for the data analysis due to the busy schedule of some participants, misplacement, survey fatigue, and accessibility issues. In analyzing the data obtained for this study, the analytical tools employed include Descriptive statistics, the Sigma Scoring method, the Budgetary technique, Endogenous Switching Regression Model.

Descriptive Statistics and Sigma Scoring Method

Descriptive statistics such as mean, frequency distribution, and percentages were used to analyze the socio-economic characteristics of cocoa farmers and LBAs in the study area (objective 1) while the Sigma scoring method was used to identify adopters and non-adopters based on the recommended good post-harvest practices for cocoa farmers and LBAs. It is worth noting to mention that the list of recommended good post-harvest practices was provided in the *appendix* for both farmers and LBAs. This scoring method involves assigning scores or weight to different adoption indicators and summing them up to obtain an overall adoption score. Using a 10-point scale, any mean score (Z) less than 5 were considered as non-adopters of good cocoa postharvest practices while 5 and above were chosen as adopters.

$Z = (X - \mu) / \sigma$.....(1)

Where:

Z = the mean score

X = is the value being standardized

μ = the mean of the data set

σ = the standard deviation of the dataset

Endogenous Switching Regression Model

The first stage involved estimating the selection to determine the factors influencing the effect of good cocoa handling practices on the income of LBAs using a probit regression model as shown in the equation below:

$Pi (Y = 1) = (Fxi)$ ..... (2)

Where $Y = \beta_0 + \beta i\, Xi$

Explicitly,

$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta 3 X_3 + \beta_4 X_4 + \ldots\ldots\ldots\ldots: + \beta_{13} X_{13} + U_i$ ..... (3)

Where, Yi = Response with respect to good handling practices status. (Dichotomous variable 1 = yes; 0 = no)

βi = vector of unknown coefficients

Xi = Independent variables

In the second stage, the effect of good handling practices on the outcome variables is specified for two regimes of adopters and non-adopters:

Regime 1: LBA (adopters); $Y_{hA=} Z'_{hA}\beta_{+}\mu_{hA}$ if $P_h = 1$, ... (4)

Regime 0: LBA (non-adopters); $Y_{hN} = Z'_{hN}\beta_{+}\mu_{hN}$ if $P_h = 1$, ... (5)

Where:

Y_{hA} and Y_{hN} are the outcome variables for adopters and non-adopters respectively; Z is a vector of households' endowments and farm-level characteristics β is a vector of parameters to be estimated μ is the error term

The expected values of the outcome Y on adopters and non-adopters of good handling practices can be expressed as in Equations (6) and (7):

Regime 1: LBA (adopters): $E(Y_{hA} | P=1) = Z' X_{hA} - \sigma_{A\varepsilon}\lambda_A$ ..... (6)

Regime 0: LBA (non-adopters): $E(Y | P=1) = Z' X_{hN} - \sigma_{N\varepsilon}\lambda_N$ ..... (7)

A change in the outcome due to good handling practices termed the ATT, is expressed in Eq. (8) below as the difference in the expected outcomes:

$ATT = E(Y_{hA} / P=1) - E(Y_{hN} / P=1)$ ..... (8)

$Z(\beta_{hA-}\beta_{hN}) + \lambda_A(\sigma_{A\varepsilon-}\sigma_{N\varepsilon})$ ..... (9)

Where:

$E(Y_{hA}$ and $Y_{hN})$ are expected outcome variables for adopters and non-adopters of good handling practices, respectively; X_i is a vector of households' endowments and farm-level characteristics Z is a vector of parameters to be estimated λ is the inverse mills' ratios σ is the covariance of the error terms

Thus, the independent (explanatory) variables that were used for the probit and ESR model are specified below:

X_1 = Age (in years)

X_2 = Sex (Male= 1, Otherwise= 0)

X_3 = Education level (years)

X_4 = Years of experience (years)

X_5 = Training participation (Yes =1, No =0)

X_6 = Access to credit (Yes= 1 and 0, otherwise)

X_7 = No. of cocoa farmers, the agent is responsible for (numbers)

X_8 = Volume of cocoa purchased (kg)

X_9 = Operational cost (Naira)

X_{10} = Government charges (Naira)

X_{11} = Transportation cost (Naira)

X_{12} = Location (Ondo = 1 and 0, otherwise)

X_{13} = Access to modern technology information (Yes= 1 and 0, otherwise)

3. Results and Discussion

3.1. Adoption of Good Post-Harvest Practices

The distribution of adopters and non-adopters among Licensed Buying Agents (LBAs) was obtained through a sigma-scoring approach as stated in the methodology (see the *Appendix* for the items of GPHP). A benchmark value of 5 was set to classify the participants into adopters and non-adopters. The adopters were the participants with a score ≥ 5, while the non-adopters were the participants with a score < 5 for both the cocoa farmers and LBAs. The results in Table 1 revealed that a smaller percentage of LBAs (43.3%) had adopted GPHP compared to 56.7% who did not adopt it. The adoption rate among LBAs was below 50%, indicating that the majority of them were non-adopters.

Table 1: Distribution by the Adoption of Good Post-Harvest Practices (GPHP)

Adoption GPHP	Frequency	Percentage
Adopters	52	43.3
Non-Adopters	68	56.7
Total	120	100.0

3.2. Income Estimation of the Licensed Buying Agents (LBAs)

Table 2 depicts an analysis of the costs and returns associated with Licensed Buying Agents (LBAs) in the cocoa industry, detailing their financial performance. According to the Table, cocoa beans purchased were the largest variable cost,

accounting for 99.43% of the Total Cost of Production (TCP). This indicates that the primary expenditure for LBAs is the procurement of cocoa beans from farmers. Also, the costs of transportation and labor accounted for less than 0.5%. These costs highlighted the logistical and operational expenses involved in handling and processing the cocoa beans. The other variable costs such as energy, government charges, security guard, and maintenance were insignificant, reflecting relatively low operational overheads. The total variable cost amounted to N2,009,400,386, making up 99.90% of the TCP. This substantial portion indicated that the LBAs' costs were predominantly variable, influenced by market prices and operational activities. Again, among the fixed costs, Aqua-Boy and weighing balance/scale were the notable expenditures. These costs represented investments in essential equipment for quality control and measurement. The total fixed cost was relatively low at N2,100,725.43, comprising only 0.10% of the TCP. This suggests that LBAs' capital investments are very minimal compared to their variable costs as also observed by [7] [18].

The results of profitability measures indicated that the Total Revenue (TR) generated by LBAs was significantly high at N2,100,000,000. This indicates a robust revenue stream from their operations. The Gross Margin, calculated as TR minus TVC, was N90,559,614. This large margin highlighted the efficiency of LBAs in converting their variable costs into substantial revenue. The Net Income, derived from subtracting TCP from TR, stands at N88,498,889. This significant net income underscores the profitability of LBAs after accounting for all costs. The Return on Investment (ROI) was 1.04, indicating that for every Naira invested, LBAs earn back N1.04 kobo. This shows a solid return on investment, albeit lower than that of cocoa farmers. It can be deduced from the results that LBAs in the cocoa industry operate with high revenue and profitability. The dominance of variable costs, particularly the cost of purchasing cocoa beans, underscores the importance of efficient procurement strategies and cost management. The relatively low fixed costs suggest that capital investments are not a major financial burden for LBAs, allowing them to focus on variable cost optimization. The substantial gross margin and net income figures indicate that LBAs effectively manage their costs relative to their revenue generation. The ROI of 1.04, while lower than that of cocoa farmers, still represents a significant return on investment, highlighting the financial viability of LBA operations. The result was consistent with the findings by [24] [17] [16] [3] who recorded huge net income from cocoa marketing in Southwest, Nigeria.

Table 2: Distribution by Costs and Returns of the LBAs

Indicator	Cost Items	Mean Value (₦)	Percent (%) of TCP
	Variable Inputs		
	cocoa beans purchased	2000000000	99.43
	Labour	3800000	
	Rentage	100000	
	Transportation	2207521	
	Energy	332865	
	Government charges	2100000	
	Security guard	360000	
	Maintenance	500000	
A	Total Variable Cost (TVC)	2009400386	99.90
	Depreciation Cost of Fixed Inputs		
	Pallet	16608.33	
	Wheelbarrow	5904.17	
	Shovel, rake, and spade	4698.21	
	Aqua-Boy	1287002.17	
	Weighing balance/Scale	711893.95	
	Basket and bucket	525.83	
	Jute bags, rope, knife, and needle	8921.01	
	Scoop	6091.65	
	Tarpaulin/Nylon	7058.33	
	Counterbalance	52021.78	
B	Total Fixed Cost (TFC)	2100725.43	0.10
C	Total Cost of Production (TCP)	2011501111	100.00
D	Total Revenue (TR)	2100000000	
	Gross Margin (D – A)	90559614	
	Net Income (D – C)	88498889	
	Return on Investment (D/C)	1.04	

Source: Computed by Author, 2024

3.3.Estimation of ESR for LBAs

The diagnostic results of the ESR model indicated that the model was robust and the variables included were jointly significant in explaining the income variation among Licensed Buying Agents (LBAs) as presented in Table 3. The significant sigma values (0.574 and 0.416) suggested variability in income between both adopters and non-adopters, with greater variability observed among adopters.

The rho values highlighted the correlation between unobserved factors influencing adoption and income, with a negative correlation for adopters (-0.217) and a positive correlation for non-adopters (0.031). The high Wald chi-square (113.54) value and significant Wald test of independent equations confirmed the appropriateness of the ESR model in capturing the endogenous relationship between the adoption of Good Postharvest Handling and the income of LBAs.

These diagnostics reinforced the validity of the model's findings and the importance of considering both observed and unobserved factors in analyzing the impact of GPHH adoption on income.

3.3.1 Selection Model for Licensed Buying Agents (LBAs)

The selection equation of the Endogenous Switching Regression (ESR) model for Licensed Buying Agents (LBAs) identified the factors influencing the adoption of Good Postharvest Handling (GPHH) as presented in the second column (Selection Equation) of Table 3. The coefficient for sex was positive and significant at the 10% level, indicating that male LBAs were more likely to adopt GPHH by 22.5% compared to their female counterparts. This result suggests a gender disparity in the adoption of improved practices, possibly due to differences in access to resources, information, or social norms that favor male LBAs in adopting new technologies. Education had a positive and significant coefficient (0.583) with a p-value of 0.046. This indicated that higher educational levels significantly increased the likelihood of LBAs adopting GPHH by 58.3%. Education equips LBAs with the knowledge and skills needed to understand and implement better postharvest practices, highlighting the importance of educational programs and awareness campaigns in promoting GPHH adoption. Education is assumed to have a positive influence on the adoption of improved technologies because of its ability to process, understand, and interpret the agricultural information coming to farmers from any direction [10] [11] [27].

Again, experience was positively associated with GPHH adoption, with a positive coefficient, significant at the 10% level. This finding suggests that more experienced LBAs were more likely to adopt GPHH. Experienced LBAs likely have better farming and business skills, making them more capable of adopting and benefiting from improved practices. The positive relationship was also stated in the studies of [20] [11]. Participation in training had a highly significant positive coefficient. This indicates that participation in training programs greatly increased the likelihood of adoption by 5.8% more than those who did not participate. Training provides LBAs with the necessary skills and knowledge to implement improved practices effectively, underscoring the need for regular and accessible training programs to promote GPHH adoption. These programs can offer practical insights, best practices, and updates on new technologies, making them essential for successful implementation. The coefficient for access to credit was positive and significant at a 5% probability level. Access to credit significantly enhanced the likelihood of adopting GPHH by 63.1%, as it provided LBAs with the financial resources needed to invest in postharvest improvements. This finding highlighted the importance of financial support mechanisms and credit facilities in promoting the adoption of improved practices. Credit access allows LBAs to purchase better storage facilities, equipment, and other resources that contribute to effective postharvest management.

The number of farmers responsible for an LBA had a positive coefficient and was significant at the 10% level. This suggests that LBAs who were responsible for more farmers were more likely to adopt GPHH by 42.1%, possibly because managing a larger size of cocoa farmers creates economies of scale and provides greater incentives to improve postharvest practices to maintain quality and efficiency. A larger network of farmers also implies greater volumes of produce, which necessitates the adoption of efficient postharvest practices to handle the increased workload.

The operational cost had a negative and highly significant coefficient. This indicated that higher operational costs decreased the likelihood of adopting GPHH by 0.8%. High operational costs can act as a financial burden, making it difficult for LBAs to invest in and adopt improved practices.

Government charges also had a negative and significant impact on GPHH adoption. This suggests that higher government charges reduced the likelihood of adopting GPHH by 0.1%. Excessive regulatory costs could discourage LBAs from adopting new practices, indicating a need for policy reforms to reduce these charges and support adoption. Access to modern technology information used as an instrumental variable, had a highly significant positive coefficient relationship with the adoption. This strong relationship indicated that access to information about modern technologies greatly increased the likelihood of adopting GPHH by 92.9%. Information access is crucial for understanding and implementing new practices, highlighting the role of information dissemination in promoting GPHH adoption. Providing LBAs with up-to-date information on the latest postharvest technologies, through workshops, digital platforms, and extension services, can significantly boost adoption rates.

In a nutshell, the positive impact of training, education, and credit access emphasized the need for capacity-building and financial support to promote adoption. Conversely, the negative effect of high operational costs and government charges suggested areas where policy interventions can reduce barriers.

3.3.2. Outcome Equation for Licensed Buying Agents (LBAs)

The outcome equation results of the Endogenous Switching Regression (ESR) model for Licensed Buying Agents (LBAs) were presented in the third (Adopter) and fifth (Non-adopter) columns of Table 3. This provided insights into the factors influencing the income of LBAs based on their adoption status of Good Postharvest Handling (GPHH).

Age of LBAs: Age had a non-significant positive coefficient (0.009, p-value = 0.167) for adopters, indicating no strong effect on income. For non-adopters, age had a negative coefficient (-0.006) and was marginally significant (p-value = 0.078), suggesting that older non-adopters tend to have slightly lower incomes. This may reflect the challenges older LBAs face in adapting to market changes or leveraging new opportunities such as the GPHH. [14] [10] reported that cocoa yield would decline even after farmers reach a specific age barrier, which is likely to be old age. Also, [16] reported a negative relationship between age and output of cocoa.

Sex: For adopters, the coefficient for sex was positive and highly significant at a 1% level, indicating that male LBAs who adopt GPHH had higher incomes by 26.9% compared to female adopters. For non-adopters, the coefficient was negative and highly significant (p-value = 0.001), indicating that male non-adopters have lower incomes by 14.4% compared to female non-adopters. This reversal suggests that while male adopters benefited more from GPHH, female non-adopters may perform relatively better within their context.

Education: Education had a positive and significant effect on the income of adopters (coefficient of 0.005, p-value = 0.045), indicating that higher educational levels contributed to higher incomes for LBAs who adopted GPHH by 0.5% more than those who were not educated.

Experience: Experience significantly increased income for both adopters (coefficient of 0.500, p-value = 0.023) and non-adopters (coefficient of 0.419, p-value = 0.088). Experienced LBAs benefited from higher incomes, with a slightly stronger effect observed among adopters. This underscored the value of accumulated knowledge and skills in enhancing productivity and income. According to [10], the significant positive relationship could be ascribed to the fact that farming experience gives farmers access to unlimited information about the general benefits of increased productivity.

Training participation: Participating in training had a significant positive effect on income for both adopters (coefficient of 0.078, p-value = 0.010) and non-adopters (coefficient of 0.003, p-value = 0.028). The stronger effect for adopters highlighted the importance of continuous training in maximizing the benefits of GPHH. Training equips LBAs with the latest techniques and best practices, directly contributing to improved income [11].

Access to credit: Access to credit had a significant positive effect on the income of adopters, indicating that financial support enhances the ability to implement GPHH and improves income by 8.1% more than those who did not have access. [10] [14] also reported a positive and significant relationship in their studies.

Numbers of Farmers Responsible for an LBA: The number of farmers an LBA was responsible for positively influenced income for both adopters and non-adopters. It means that the more the farmers the LBA was responsible for, the more the income accrued by the adopters and non-adopters by 39.6% and 3.7%, respectively. Managing more farmers allows LBAs to achieve economies of scale, enhancing their income through more efficient operations and higher volumes of transactions. This effect is slightly stronger for adopters, indicating that when combined with GPHH, managing a larger network of farmers can significantly boost income by improving the overall efficiency and quality of operations.

Volume of Cocoa Beans Purchased: For adopters, the volume of cocoa beans purchased had a positive and significant effect on income, indicating that larger volumes correlate with higher incomes. This suggests that LBAs who adopt GPHH benefit from purchasing larger quantities of cocoa beans, possibly due to improved handling and reduced postharvest losses. For non-adopters, the effect was positive but not significant, suggesting that without GPHH, the volume of purchases alone does not significantly impact income. This highlights the additional benefits that GPHH provides in enhancing the efficiency and profitability of operations.

Operational Cost: Operational cost had a negative and significant impact on income for both adopters and non-adopters. This implies that higher operational costs reduced profitability, underscoring the importance of managing expenses to enhance income. The stronger negative effect for non-adopters suggests that operational efficiency is particularly critical when not adopting GPHH, as these LBAs do not benefit from the efficiencies and cost savings that GPHH can provide.

Transportation: Transportation costs had a significant negative impact on income for both adopters and non-adopters. This implies that high transportation costs reduce net income, emphasizing the need for efficient logistics and transportation solutions to maximize profitability. Addressing transportation inefficiencies can significantly enhance income by reducing costs and improving market access for both groups.

Location (Ondo): Location had a positive and significant effect on the income of adopters. It means that geographical factors played a role in the income of Ondo LBAs who adopted GPHH by 34.9% compared with their counterpart in Osun State. This could be due to differences in infrastructure, market access, or climatic conditions that favor the adoption of improved practices.

Table 3: Full Information Maximum Likelihood Estimates of Endogenous Switching Regression Model for Adoption and Impact of Adoption of GPHH on LBAs' Income.

Variable	Selection Equation		Adopters		Non-Adopters	
	Coefficient	p-value	Coefficient	p-value	Coefficient	p-value
Constant	-3.886	0.594	1.809	0.042	4.935	0.002
Age	-0.041	0.383	0.009	0.167	-0.006*	0.078
Sex	0.225*	0.073	0.269***	0.000	-0.143***	0.001
Education	0.583**	0.046	0.005**	0.045	0.235	0.100
Experience	0.311*	0.052	0.500**	0.023	0.419*	0.088
Training	0.058***	0.000	0.078**	0.010	0.003**	0.028
Credit	0.631**	0.036	0.081***	0.001	-0.291	0.119
Number of Farms responsible for	0.421*	0.092	0.396**	0.037	0.317**	0.029
Volume of cocoa beans purchased	0.001	0.108	6.37e-07**	0.034	2.49e-07	0.741
Operational cost	-0.008***	0.002	-8.25e-07**	0.017	-2.87e-07***	0.000
Government charges	-0.001**	0.011	0.021	0.421	-0.531	0.367
Transportation	-1.56e-06	0.622	-1.24e-06**	0.025	-1.23e-06**	0.011
Location	0.464	0.302	0.349**	0.041	0.489	0.116
Access to modern technology information	0.929***	0.000	-	-	-	-
Diagnostic						
sigma_1			0.574***			
rho_1			-0.217**			

sigma_2					0.416***	
rho_2					0.031***	
Wald chi2(12)	113.54***					
Log-likelihood	-58.48					
Wald test of Indep. eqns.:χ^2(1)	35.91***					

*Note: *,**,*** denote significance at 10%, 5%, and 1% levels, respectively.*

3.4Income Impact of LBAs

The Average Treatment Effect on the Treated (ATT) provided an estimate of the effect of adopting Good Postharvest Practices (GPHH) on the income of Licensed Buying Agents (LBAs) who had adopted these practices (Table 4). The ATT represented the difference in income between adopters and non-adopters, specifically estimating the effect of adopting GPHH on the income of those who had adopted these practices. The ATT value of N5,618,535.72 (13.2%) was statistically significant at the 1% level, indicating a strong and significant positive effect of GPHH adoption on the income of LBAs. This substantial income difference underscores the economic benefits of adopting GPHH. The results suggest that adopting GPHH can lead to an increase in income by approximately N5,618,535.72 for the LBAs who have adopted these practices. This increase can be attributed to various benefits associated with GPHH, such as reduced postharvest losses, improved quality of produce, and better market prices.

Table 3: Impact of LBA's Income using ATT

Variable	Adopters	Non-Adopters	ATT
Income (₦)	46,855,607.17 (21,392,390.43)	41,237,071.45 (33,099,121.10)	5,618,535.72*** (3,001,139.08)

*Note: Standard errors in parenthesis. ***Significant at the 1% level*

4. Conclusion and Recommendations

This study highlights the critical role of Good Postharvest Handling Practices (GPHH) in enhancing the quality, profitability, and sustainability of Nigeria's cocoa value chain, focusing on Licensed Buying Agents (LBAs) in Ondo and Osun states. The findings demonstrate that GPHH adoption remains suboptimal, with only 43.3% of LBAs meeting recommended standards. Adoption is significantly influenced by socioeconomic factors such as education, training participation, access to credit, and exposure to modern technology information, while barriers include high operational costs and government charges. The study also reveals that adopting GPHH has substantial economic benefits. The Average Treatment Effect on the Treated (ATT) indicates a 13.2% income increase for adopters compared to non-adopters, underscoring the profitability of improved postharvest practices. Additionally, adopters benefit from reduced postharvest losses and enhanced market competitiveness. These findings validate the economic and sustainability advantages of scaling GPHH adoption among LBAs and the broader cocoa value chain. Based on these findings, several policy and practical recommendations are proposed:

- → Stakeholders should prioritize regular training programs to equip LBAs with the skills needed for effective postharvest handling. Training should emphasize best practices, quality management, and innovations in postharvest technologies.
- → Governments and financial institutions should establish credit schemes tailored to the needs of LBAs. Access to affordable financing will enable LBAs to invest in infrastructure, equipment, and operational improvements.
- → Reducing regulatory charges and operational costs can create an enabling environment for GPHH adoption. Policymakers should streamline bureaucratic processes and offer subsidies for postharvest technology acquisition.
- → Extension services and digital platforms should be leveraged to provide LBAs with timely and accurate information on postharvest innovations and market opportunities.
- → Efforts should be made to address gender disparities in GPHH adoption by promoting inclusive policies and providing targeted support for female LBAs.
- → Investments in transportation and storage infrastructure are crucial to reducing operational inefficiencies and postharvest losses.

Table 1A: Distribution by Adopted Good Post-Harvest Handling by the LBAs

s/n	Good Post-Harvest Handling Adopted by Licensed Buying Agents(LBAs)	Frequency	Percentage
1.	Always ensure that cocoa beans are stored in good jute bags	51	42.5
2.	Bagged cocoa beans are stored in buildings that are neat, weatherproof, whitewashed, well-ventilated, free from dampness, free from insect pests, free from smoke, and free from contaminants	64	53.3
3.	Cocoa store has dunnages or pallets to avoid direct contact with the bare floor	85	70.8
4.	Normally store cocoa 90cm away from the building wall	77	64.2
5.	Avoid exposing stored cocoa beans to direct sunlight or near heating sources	110	91.7
6.	Always re-dry wet cocoa beans to between 6.5-8% as recommended	87	72.5
7.	Avoid storing cocoa beans with other produce as they are hygroscopic	97	80.8
8.	**Number of times do you disinfect stores for storing cocoa beans per year**		
	None	11	9.2
	1	96	80.0
	2	10	8.3
	3	3	2.5
9.	Always re-sort cocoa beans to remove extraneous matters, sieves, defective beans, and so on	69	57.5
10.	Always presenting cocoa beans for grading by authorized agents	116	96.7
11.	Always carry out standardization (as standardized cocoa bags should weigh 63.5kg) using a good weighing scale	116	96.7
12.	Bags are well stacked and crossed over for mutual support	116	96.7
13.	Sewing of cocoa bean bags (19 stitches per bag) to avoid spilling during transportation	49	40.8

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