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ECONOMIC IMPACT OF PURDUE IMPROVED COWPEA STORAGE TECHNOLOGY IN NORTH-EAST NIGERIA

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ABSTRACT
ATBU-PICS project had made a substantial effort in north-east Nigeria to further promote hermetic cowpea storage. To respond to the need for information on the robust economic impact of adoption of cowpea storage technology, the objectives of the study were to specifically explore the impact of the Purdue improved cowpea storage (PICS) technology on knowledge and margin of farmers in north-eastern Nigeria. Multi-stage sampling approach was used to select 3,000 respondents from the study area. Primary data were collected in 2020 using structured questionnaire. Both descriptive and inferential statistics (Propensity score matching [PSM] and Inverse probability weighted regression adjusted [IPWARA]) were used for the analyses. The result showed that age, sex, farming experience and availability of PICS bag in a locality positively drive both margin of farmers and knowledge of PICS technology at P≤0.1, P≤0.1, P≤0.05, P≤0.01, respectively, but household size negatively drive them at P≤0.01. The study also found the margin of adopters to be ₦124,006.10 higher than that of non-adopters; and the knowledge of PICS technology adopters was higher than that of non- adopters by 2.32 in a scale of 5. It was concluded that ATBU-PICS project had positive economic impact on the adopters of the technology. It was recommended that; the value chain of the PICS bags should be intensified to ensure its availability in all the localities for easy access while increase awareness of the technology should also be intensified.

Keywords: Economic impact, IPWRA, Knowledge, Margin, PICS, PSM.

INTRODUCTION
Food and Agriculture Organization of the United Nation (FAO, 2011) said "global food systems produce enough food to feed everyone, but nearly one third of food produced in the world for human consumption is lost or wasted every year. The cost of this food loss and waste amounts to roughly USD 310 billion in developing countries". In Nigeria, food test carried out on 217 different food items revealed the presence of DDT, Aldrin and Dieldrin to be above maximum allowable concentration level which ranged from 1.2-2160 µg kg-1, high pesticide residues present in Nigeria environment is due to inappropriate dosage applied of pesticides that leaves behind excess. However, its residues are found above safety levels in the air, water, and soil across the nation (Erhunmwunse *et al.*, 2012; and Mazlan *et al.*, 2017).

Interest in adopting hermetic technologies as a crop protection for stored grain has risen in recent years. The most proven effective method, Purdue Improved Crop Storage (PICS) bags, is worthy in controlling the postharvest pests of cowpea (Williams *et al.*, 2017).

The trend in adoption of PICS technology was estimated to be about 46%. Farmers use some type of hermetic storage for their cowpeas and about 44% of the quantity of cowpea

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stored on farms is in hermetic containers. Both the percentage of respondents and the percentage of stored quantity fall slightly short of the 50% benchmark hypothesized (Moussa *et al.,* 2014). The 2010 and 2012 estimates were comparable to about 30% of cowpea quantity stored in hermetic containers in 2003 and 2004. Regionally, the most commonly used hermetic storage container is the triple layer Purdue Improved Cowpea Storage (PICS) (Moussa *et al.,* 2014). The percentage adoption of PICS technology had increased profit of PICS adopters by $26.58/100 kg bag more than sale at harvest; this is because farmers no longer need to sell their farm produce at harvest because of the lack of affordable storage (Moussa *et al.,* 2014). Early studies explore the mean difference in profitability and income of treated and control.

It has been seven years since the last regional study of cowpea storage technology adoption in West Africa. Substantial investments have been additionally made in PICS technology dissemination. Such as, a pious effort of ATBU-PICS project in north-east Nigeria, other NGOs and development organizations that had promoted hermetic cowpea storage with programs of more limited scale. To respond to the need for information on the robust economic impact of adoption of cowpea storage technology the study specifically explored the impact of the PICS technology on knowledge and margin of farmers in north-eastern Nigeria. The study will add value to the literature on the economic impact of ATBU-PICS project on farmers in north-eastern Nigeria, specifically the knowledge and margin impact.

MATERIALS AND METHODS

The Study Area

This study was conducted in north-eastern Nigeria which consists of six (6) States. The States are Adamawa, Bauchi, Borno, Gombe, Taraba and Yobe. The study area is located between Latitude 9^0 08' to 14^0N and Longitude 8^0 68' to 15^0E. The area occupies a land mass of 280,419 km^2 (National Bureau of Statistics [NBS], 2017). According to National Population Census [NPC] (2020), the region has a population of 29, 470, 062 people based on 2006 annual population growth rate of 3%. The average population density is 89 persons per Km^2. The main economic activities in the area include; farming (crop and livestock), hunting, fishing, food processing, transportation and craft. The mean annual rainfall ranges from less than 250 mm in the Northern Sahel to 1500 mm in the derived savannah in line with southern part, and has a unimodal pattern (NPC, 2006). The study area is the major cowpea producing areas in Nigeria owing to its climate which favors growth of the crop. Being a largely Sahelian zone, insect pests (both field and storage) form a serious barrier to cowpea production and storage. The status of northeastern Nigeria as a major cowpea producing and the high incidence of pests formed the basis for the implementation of the PICS project in the area which started in 2009. The study area has been engulfed with high incidence of armed conflict which is a major hurdle to growth of the agricultural sector and to economic development more broadly in sub-Saharan Africa (Avuwadah *et al.,* 2020).

Sampling Procedure

A multi-stage random sampling technique was used in selecting the respondents. In the first stage simple random sampling was used to select 10 local government areas in each State of the study area. In the second stage, five (5) villages were selected randomly based on the list of villages on the map of the study area. In the final stage, the respondents for interview were randomly selected based on the list of the farmers taken during stakeholders meeting and village level demonstration. Five hundred (500) questionnaires were administered in each of the six States of the study area: Adamawa, Bauchi, Borno Gombe, Taraba, and Yobe States making a sample of 3,000 respondents.

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Data Collection

The primary data for this study were collected in 2020 using structured questionnaires. The six States of the study area were: Adamawa, Bauchi, Borno Gombe, Taraba, and Yobe States.

Method of Data Analysis

Propensity score matching (PSM) helps in matching sample households that fall into the treated communities with their proper counterfactuals (non-treatment communities but with attributes similar to the sample individuals under treatment group).

Identification of the causal effects of being trained farmers' knowledge and Margin of PICS technology is not trivial due to selection bias. Accurate measurement of impacts requires controlling for observable in a well specified manner characteristics through random assignment of individuals into treatments. In the absence of random assignments, selection bias may persist as observed characteristics of individuals may affect the likelihood of receiving treatments as well as outcome indicators.

Selection bias is the main concern when using observational data for impact evaluation. It occurs when farmers with favorable characteristics self-select by adopting a technology earlier than other farmers. Selection bias potentially exaggerates the measured impact because early adopters are likely to have a better farm performance than late adopters, even without the intervention. The study minimized the effect of selection bias through sampling strategy and the use of statistical matching methods. The study applied two matching methods: propensity score matching (PMS) and inverse probability weighting regression adjusted (IPWRA). These methods are commonly applied to evaluate the impact of agricultural interventions (e.g., Wossen *et al.,* 2017; Ochieng *et al.,* 2017; and Sanglestsawai *et al.,* 2015). Both methods start by regressing program placement (treatment versus control) on a set of independent farmer characteristics that simultaneously influence program placement and outcomes. The study included nine covariates that were conceptually related to program placement: age, sex, education level, farming experience, source of training, availability of PICS bag, household size, knowledge and margin. Parameters were estimated using a probit model and the predicted values the propensity scores were calculated from all covariates independent of their significance levels (Heckman *et al.,* 1998). Severe outliers in the data were replaced before estimating the propensity scores. Farm households were ranked according to their propensity score. Nearest neighbor matching was used as the matching algorithm, which finds for every treated farmer the nearest ranked control farmer, and for every control farmer the nearest ranked treated farmer. The difference in outcomes is calculated for each matched pair, after which these differences are averaged over the entire sample to obtain the average treatment effect. It is also possible to match each trained farmer to more than one control farmer and vice versa, this was done for the purpose of sensitivity testing. The IPWRA method does not directly match treated and control farmers, but uses the inverse of the propensity score to give a higher weight to farmers with a high predicted probability of being selected for training and a low weight to those with a low predicted probability. The average treatment effect is then calculated as the difference between the weighted averages of treated and control farmers.

RESULTS AND DISCUSSION

Respondents' Sex, Level of Education, Marital Status and Primary Occupation

The results in Table 1 show that most (87.45%) of the respondents on Purdue Improved Cowpea Storage (PICS) were males in north-east, Nigeria. This indicates that most of the respondents contacted during the survey were males which may probably be due to the culture of the area that discourages female's activities outside their marital houses. The results also

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show that 21.88%, 21.58%, 19.61% and 18.75% of the surveyed farmers had primary education, secondary education, diploma/NCE and Islamic education, respectively. This implies that most of the respondents can read and write. The *a priori* expectation was that the respondents in the study area will understand the importance of PICS. Thus, education brings about behavioral changes to individuals and therefore enhances efficient utilization of the technology.

The findings from Table 1 reveals that most (89%) of the interviewed farmers were married in the study area. This shows that nearly all the respondents were married and saddled with the responsibilities to actively participate in economic activities in order to meet the challenges of their family need. The results in Table 1 also describe the primary occupation of PICS users. The results reveal that 52.5% of respondents were crop farmers and 28.89% of them practice mixed farming i.e. both crop and livestock farming. The result also shows that 10.78%, 3.8% and 1.60% were civil servants, livestock farmers and traders, respectively.

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Table 1: Distribution of Respondents based on Sex, Level of Education, Marital Status and Primary Occupation

Variable		Adamawa		Bauchi		Borno		Gombe		Taraba		Yobe		Pooled	
		Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Sex	Female	81	16.1	13	2.59	62	12.50	35	7.10	130	26.10	53	10.91	62	12.55
	Male	422	83.90	488	97.41	433	87.50	459	92.91	368	73.90	433	89.09	434	87.45
	Total	503	100	501	100	495	100	494	100	498	100	486	100	496	100
Highest Education Level	Adult Education	33	6.56	31	6.20	40	8.03	30	6.00	49	10.14	31	6.25	36	7.20
	Islamic/Qur'anic Education	57	11.33	65	12.97	37	7.40	127	25.30	85	17.60	188	37.90	93	18.75
	Primary Education	74	14.71	119	23.75	259	52.01	40	7.97	107	22.15	53	10.69	109	21.88
	Secondary Education	161	32.01	136	27.15	56	11.24	113	22.51	122	25.26	56	11.29	107	21.58
	Diploma/NCE	140	27.83	111	22.16	60	12.05	105	20.92	82	16.98	88	17.74	98	19.61
	Degree	30	5.96	32	6.39	34	6.83	75	14.94	33	6.83	71	14.31	46	9.21
	Post graduate	8	1.59	7	1.40	10	2.01	12	2.39	5	1.04	9	1.81	9	1.71
	Total	503	100	501	100	496	100	502	100	483	100	496	100	497	100
Marital Status	Single	27	5.40	34	6.79	22	4.40	39	7.80	71	14.17	47	9.49	40	8.01
	Widowed	11	2.19	7	1.40	20	4.03	5	0.99	11	2.20	0	0.00	9	1.80
	Divorced	6	1.19	5	1.00	9	1.81	1	0.20	12	2.40	1	0.20	6	1.13
	Married	459	91.25	455	90.82	445	89.72	458	91.05	405	80.84	447	90.30	445	89.00
	Total	503	100	501	100	496	100	503	100	499	100	495	100	500	100

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Respondents' Age, Household Size, Years of Education and Cowpea Farming Experience

According to the results, the average age of the respondents was 46.2 years in the study area with maximum and minimum years of 75 and 20 years (Table 2).

Table 2: Respondents' Age, Household Size, Years of Education, Cowpea Farming Experience and farm size

Variable		Age	Household size	Year of education	Cowpea farming experience	Total farm size
	Mean	46.2	7.6	10.6	12.6	3.6
	Std. Deviation	9.4	4.6	5.1	8.7	1.7
	Min.	20	1	0	0	0.1
Adamawa	Max.	75	30	39	60	12
	Mean	42	8.8	14.4	11.9	3.6
	Std. Deviation	9.9	6.4	89.6	8	1.96765
	Min.	20	1	1	0	0
Bauchi	Max.	70	55	20	40	10
	Mean	41.809	7.743	8.357	14.202	2.24
	Std. Deviation	11	4.6	8.7	9.4	1.3
	Min.	18	1	0	0	0
Borno	Max.	72	40	50	50	7
	Mean	43.7	9.6	10.9	16.5	6.8
	Std. Deviation	11.5	5.6	5.7	11.9	6.7
	Min.	20	1	0	0	0.3
Gombe	Max.	73	32	35	60	65
	Mean	40.5	7.9	9	10.5	5.4
	Std. Deviation	12.5	5.3	5.3	8.3	4.4
	Min.	18	1	0	0	0
Taraba	Max.	78	45	30	50	35
	Mean	41.4	6.6	9.5	9.9	5.5
	Std. Deviation	11.6	5.7	6.4	7.8	4.7
	Min.	18	1	0	0	0
Yobe	Max.	75	30	28	50	50
	Mean	42.6	8	10.5	12.6	4.5
	Std. Deviation	11	5.4	20.2	9	3.5
	Min	19	0.83	0.17	0	0.05
Pooled	Max	73.8	38.7	33.7	51.7	29.8

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These results (Table 2) indicate that most of the PICS beneficiaries were in their active age, hence have more tendencies to utilize any technology. As shown in Table 2, the average years of education in the study area was 11 with 39 as the maximum years of education. These results support that of Table 1, where all the respondents had one form of education or the other. On the other hand, the average years of farming experience was 13 with a maximum of 52. It is evident from the results in Table 2 that farmers in the study area cultivate an average of 3.6 hectares with a maximum of 12. This indicates that most of the PICS beneficiaries are small scale farmers that cultivate less than five hectares of land in the study area.

Respondents' Means of Transportation before and after ATBU PICS Project

The finding from Table 3 depicts that, the number of respondents using bicycle as means of transportation in the study area decreases from 46.24% before to 33.96% after ATBU-PICS project. The finding further reveals that, the number of respondents using motorcycle as means of transportation in the study area increases from 33.44% before the project to 50.31% after the project. In addition, the result also shows that, the respondents in the study area using tricycle as a means of transportation in the study area changed from 7.62% before the PICS to 26.09% after ATBU PICS project. The results also showed the decrease in respondents using donkey from 11.87% before to 6.69 % after the ATBU-PICS project. This implies that, the ATBU-PICS project has boosted the income of the respondents as they are changing their means of transport from one local to more sophisticated one.

Table 3: Respondents' Means of Transportation before and after ATBU PICS Project

Means of Transport			**Bicycle**	**Motorcycle**	**Tricycle**	**Car**	**Donkey**	**Horse**	**Canoe**
Adamawa	Freq.	Before ATBU PICS	173	89	18	14	14	10	17
	%		35.5	21.7	4.4	3.5	3.5	2.5	4.2
	Freq.	After ATBU PICS	222	210	36	26	9	9	18
	%		45.5	44.2	8.4	6.1	2.2	2.2	4.5
Bauchi	Freq.	Before ATBU PICS	205	235	18	42	60	4	9
	%		51.4	61.7	5.6	12.9	18.3	1.3	2.8
	Freq.	After ATBU PICS	223	308	21	103	66	15	4
	%		59.9	73.3	6.3	28.2	20.2	4.7	1.3
Borno	Freq.	Before ATBU PICS	177	25	28	31	66	6	0
	%		37.1	6.3	6.9	7.8	14.5	1.5	0.0
	Freq.	After ATBU PICS	150	103	86	80	45	7	0

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Table 3: Respondents' Means of Transportation before and after ATBU PICS Project **Cont'd.**

Means of Transport			**Bicycle**	**Motorcycle**	**Tricycle**	**Car**	**Donkey**	**Horse**	**Canoe**
Gombe	Freq.	Before ATBU PICS	185	165	18	30	31	6	2
	%		52.0	41.9	6.0	9.7	10.5	2.1	0.7
	Freq.	After ATBU PICS	71	263	30	96	9	7	2
	%		21.8	63.3	10.0	27.0	3.1	2.5	0.7
Taraba	Freq.	Before ATBU PICS	203	137	13	47	0	7	10
	%		65.3	43.2	6.0	19.1	0.0	3.4	5.0
	Freq.	After ATBU PICS	51	262	25	140	5	2	11
	%		20.6	68.9	11.5	47.0	2.5	1.0	5.4
Yobe	Freq.	Before ATBU PICS	170	103	67	41	96	10	4
	%		36.2	25.9	16.8	10.4	24.4	2.5	1.0
	Freq.	After ATBU PICS	112	121	80	112	7	2	4
	%		24.0	29.7	20.1	28.3	1.8	.5	1.0
Pooled	Freq.	Before ATBU PICS	185.5	125.67	27	34.17	44.5	7.17	7
	%		46.24	33.44	7.63	10.56	11.88	2.23	2.28
	Freq.	After ATBU PICS	138.17	211.17	46.33	92.83	23.5	7	6.5
	%		33.96	50.31	12.87	26.10	6.70	2.10	2.16

Respondents' Ownership of Farm Assets before and after ATBU PICS Project

The result in Table 4 reveals that, the respondents in the study area possessing pair of bulls and ox-plough increased from 21.3% to 22.1% and 17.7% to 21.2% respectively after ATBU-PICS project. The findings also show that there was slight increase in the number of respondents possessing an ox-cart and a sprayer before from 12.3% to 18% and 36.5% to 45.1% after ATBU-PICS project, respectively. In addition, the ownership of tractor and power tiller among the total respondents slightly increased from 8.8% to 12.6% and 4.1% to 5.4% after the ATBU-PICS project respectively. The findings further reveal that ownership of hoe and cutlass among the respondents in the study area decreases from 75.6% to 62.8% and 60.4% and 56.1%, respectively, after the ATBU-PICS projects. The results also reveal that, the number of respondents possessing planter decreases from 5.7% to 3.7% after the ATBU-PICS project. This implies that, respondents in the study area are changing from the use of manual labour to mechanization as a result of little boost in their income and economic activities after the ATBU-PICS project.

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Table 4: Respondents' Ownership of Farm Assets before and after ATBU PICS Project (Pooled)

Farm Asset	Before		After	
	Frequency	%	Frequency	%
Pair of bulls	80.7	21.3	84	22.1
Ox-plough	65.8	17.7	78.5	21.2
Ox-cart	44.5	12.3	66	18
Sprayer	139.3	36.5	187.8	45.1
Tractor	25.7	8.8	42.7	12.6
Power tiller	12.8	4.1	16	5.4
Harvester	56.3	15.5	44.5	12.3
Hoes	363.8	75.6	300.2	62.8
Cutlass	271.7	60.4	251	56.1
Planter	11.5	3.7	16.2	5.7

Respondents' Household Assets

The results in Table 5 described the pooled results on the types of assets owned by the respondents before and after the adoption ATBU-PICS technology. On the other hand, the Table explained the types of household assets owned by the respondents across the study area. Based on the findings more than half (56.58%) of the respondents owned radio in the study area. However, the findings show a reduction in the ownership of radio by 17.58% after the adoption of ATBU-PICS. This may likely be due to the fact that used of PICS in the storage of cowpea enhanced its value thereby improving the income of the farmers. In addition, the reduction in the ownership of radio may be as a result of 50% increase in the ownership of TV set after the adoption of PICS. Thus, the findings also reveal that substantial number (37.2%) of the respondents owned television (TV) set after PICS adoption as against 13.96%.

The results in Table 5 show that 17.38% of the respondents owned electric iron after the adoption of PICS. This indicates an increase in the ownership of electric iron after the adoption of PICS than before adoption (8.09%). However, 19.61% and 20.04% of the respondents owned fan after adoption and before adoption of PICS. This shows little decrease in the ownership of fan which violates the *a priori* expectation of increased in the use of the asset after adoption due to change in income of the farmers. On the other hand, 18.9% and 7.83% owned refrigerator/freezer after and before the adoption of PICS bags technology. The findings indicate more than 50% increase in the number of farmers that owned refrigerator after PICS bags adoption. The findings further reveal that 18.66% and 29.91% of the respondents owned household furniture before and after the adoption of PICS. The results also indicate an increase in the ownership of furniture after the adoption.

Result in Table 5 depicts that 7.02% and 11.01% of the respondents owned computer before and after PICS adoption. The results in Table 5 show that substantial proportion (42.01% and 49.09%) of the surveyed farmers owned mobile phone before and after PICS adoption, respectively.

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Table 5: Pooled Results of Respondents' Ownership of Assets before and after the adoption ATBU PICS in the Study Area

Household Asset	Pooled			
	Before ATBU PICS		After ATBU PICS	
	Frequency	%	Frequency	%
Radio set	244	56.58	174	39.0
TV set	47.8	13.96	146	37.2
Electric iron	28.0	8.09	60.3	17.38
Fan	61.8	20.04	67.3	19.61
Refrigerator/freezer	24.8	7.83	59.5	18.9
Furniture	68.0	18.66	111	29.91
Computer	24.8	7.02	38.2	11.01
Mobile phone	178	42.01	217	49.09
Bed	200	45.53	164	36.91
Mattress	158	35.77	170	37.71
Electric kettle	35.5	9.52	47.5	12.96
Cattle	75.0	20.11	73.7	19.93
Sheep	177	41.43	183	40.82
Goats	166	38.46	178	42.83
Poultry	159	37.01	144	32.95

Distribution of Respondents Based on Household Assets Ownership

The findings also reveal that 45.53%, 35.77% and 9.52% of the respondents owned bed, mattress and electric kettle before the adoption of ATBU-PICS. The findings further show that 36.91%, 37.71% and 19. 93% (Table 6) of the respondents owned bed, mattress and electric kettle after the adoption of ATBU PICS. The results on household livestock show that 20. 11%, 41.43%, 38.46% and 37.01% owned cattle, sheep, goat and poultry before adoption of ATBU-PICS. The findings on the other hand reveal that 19.93%, 40.82%, 42.83% and 32.95% of the respondents owned cattle, sheep, goat and poultry after adoption of ATBU-PICS. The findings indicate an increase in the ownership of sheep after the adoption of ATBU-PICS.

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Table 6: Distribution of Respondents Based on Household Assets Ownership (Pooled)

Household Asset	Pooled			
	Before ATBU PICS		After ATBU PICS	
	Frequency	%	Frequency	%
Radio set	244	56.58	174	39
TV set	47.8	13.96	146	37.2
Electric iron	28	8.086	60.3	17.38
Video set	0	0	0	0
Fan	61.8	20.04	67.3	19.61
Refrigerator/freezer	24.8	7.829	59.5	18.9
Furniture	68	18.66	111	29.91
Computer	24.8	7.016	38.2	11.01
Mobile phone	178	42.01	217	49.09
Bed	200	45.53	164	36.91
Mattress	158	35.77	170	37.71
Electric kettle	35.5	9.516	47.5	12.96
Cattle	75	20.11	73.7	19.93
Sheep	177	41.43	183	40.82
Goats	166	38.46	178	42.83
Poultry	159	37.01	144	32.95

P-score Matching Estimation of the Respondents

The below Table 7 showed the P-Score matching estimation of the program participation. Prior to non-parametrically estimate the participation impact, the study needs to ‘‘well’’ specify the propensity scores for treatment variable. The study uses a probit model to predict the probability to participate in the program and we include different ranges of household characteristics as regressors. The common support condition is imposed and the balancing property is set and satisfied in all regressions at 1% significance level. The fact that estimating the p-score allows us to make treated and controls more similar than without the p-score analysis (in other words to construct the counterfactual).

Age, Sex, Farming experience and Availability of PICS bag were found to be positively significant at P≤0.1, P≤0.1, P≤0.05, P≤0.01, respectively. Only household size was found to be negative but significant (P≤0.01). Age was positively significant (P≤0.1), this implied that as age increases by one year, the likelihood of participation into ATBU-PICS project will increase by log of odds of 0.01 when other variables were kept constant. This was probably due to the fact that old farmers tend to choose safer way of storage that had no residual effect on them and their younger counterparts. This corroborates Moussa *et al.* (2014) who found age to be affecting PICS adoption in Senegal.

Sex was found to be positively significant (P≤0.1), this depicts that male farmers were more likely to participate in ATBU-PICS project by 0.22 log of odds when other variables were kept constant. This might be due to the fact that females participate less in economic activities, they rarely participate into farming and other commercial activities in North-eastern Nigeria due to religious, capital and cultural issues. This is contrary to Moussa *et al.* (2014) who inferred that female farmers adopt more than their male counterparts in Senegal and Ghana. The differences might be due to the cultural differences in the area. Household size was found to be negative but significant (P≤0.01), this revealed that as the household reduces by one

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person, the probability of participating in ATBU-PICS project increases by 0.02 log of odds. This is contrary to *a priori* expectation. It's contrary to Moussa *et al.* (2014) who showed that larger household size adopts more PICS technology in Nigeria and Niger.

Farming experience was found to be positively significant (P≤0.05), this showed that as faming experience increases by one unit, the likelihood of participating into ATBU-PICS project will increase by the log of odds of 0.01. More experienced farmers tend to participate in so many development programs to be able to draw benefit to their farming venture. Availability of PICS bag was positively significant (P≤0.001). This means that if farmers had the PICS bag at their local markets, they may participate more by log of odds of 0.25, because even if the farmers intended to use more of PICS bag, if it is not available, they cannot use it. This is in line with Moussa *et al.* (2014) who inferred that availability of the bags at farmers' locality influences adoption.

Table 7: P-score Matching Estimation

Variable	**Coeff.**	**S.E**	**. z**	**P>|z|**
Age	0.01	0.00	1.88	0.06
Sex	0.22	0.11	1.91	0.06
Household size	-0.02	0.01	-2.70	0.01
Education qualification	0.03	0.02	1.54	0.12
Farming experience	0.01	0.00	2.07	0.04
Farm size	-0.01	0.01	-0.91	0.36
Source of training	-0.04	0.07	-0.54	0.59
Availability of PICS bags	0.25	0.07	3.52	0.00
Knowledge	-0.02	0.02	-0.88	0.38
Margin	0.00	0.00	-0.68	0.50
Constant	-1.04	0.18	-5.83	0.00
LR Chi-square (10)	37.51			
Pseudo R-square	0.02			
Log pseudolikelihood	-999.55			

Impact of ATBU-PICS on PICS Technology Margin

The result in Table 8 showed that the ATBU-PICS project had an impact on the adopters, the adopters had a margin of ₦8051.99 higher than that of a non-adopter in North-eastern Nigeria.

Table 8: Impact of ATBU-PICS on PICS Technology Margin

Matching method	**Nearest neighbor**
Treatment	532
Control	377
ATT	8051.99
S.E	17073.6
T	0.472

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Impact of ATBU-PICS Technology on Margin Using IPWRA

The result in Table 9 revealed that the potential outcome mean was significant (P≤0.01), this showed that the on average, ATBU-PICS project had impacted the margin of cowpea farmers through storage by ₦124,006.10.

Table 9: IPWRA Estimate of Impact of ATBU-PICS Technology on Margin

Variable	Coef.	Robust Std. error	Z	P>|z|
ATET				
TR				
(1 vs 0)	-4693.39	13426.08	-0.35	0.727
POmean				
TR				
0	124006.1	9461.495	13.11	0

Impact of ATBU-PICS on PICS Technology Knowledge of Farmers

Table 10 depicts that the farmers' knowledge increases by the score of 0.038 (with a standard error of 0.127). This means that only 0.038 (with a standard error of 0.127) was the difference between the treated communities and the untreated communities on a scale of 1-5. This might be possible as a result of the sustained PICS project by IITA.

Table 10: Impact of ATBU-PICS on PICS Technology's Knowledge of Farmers

Matching method	Nearest neighbor
Treatment	532
Control	377
ATT	0.038
S.E	0.127
T	0.2

Test for Selection Bias

The impact of ATBU-PICS project on PICS technology's knowledge of farmers (Table 11) was found to be 2.3 score out of 5 using IPWRA as shown by the potential outcome mean (PO-mean). This proves that there was no selection bias in the model.

Table 11: Impact of ATBU-PICS on Knowledge of PICS Technology of Farmers Using IPWRA (n = 1,886)

Variable		Coef.	Robust Std. error	z	P>|z|	[95% Conf	.Interval]
ATET	Treatment						
	(1 vs 0)	-0.19	0.08	-2.31	0.02	-0.36	-0.03
PO-mean	Treatment						
	0	2.32	0.06	38.60	0.00	2.20	2.44

CONCLUSION AND RECOMMENDATIONS

The study concluded that age, sex, farming experience and availability of PICS bag in a locality positively drives both margin of farmers and knowledge of PICS technology at P≤0.1, P≤0.1, P≤0.05, P≤0.01, respectively, but household size negatively drive them (P≤0.01). The study founds the margin of adopters to be ₦124,006.10 higher than that of non-adopters while

the knowledge of PICS technology of adopters is higher than that of non- adopters by 2.32 in a scale of 5. This implies that ATBU-PICS project had positive economic impact on the adopters of the technology. It was recommended that; the value chain of the PICS bags should be intensified to ensure its availability in all the localities for easy access while increase awareness of the technology should also be intensified.

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