Investigative Study on The Constraints of Adoption of Disruptive Agricultural Technologies in Poultry Production in South-West Nigeria: A Case Study of Internet of Things

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The adoption of disruptive agricultural technologies is crucial for enhancing the productivity of poultry production in Nigeria. This study investigated the constraints of adoption of disruptive agricultural technologies (Internet of Things) in poultry production in South-West (Lagos, Ogun and Oyo States), Nigeria. Questionnaire was used to collect data from two hundred and one (201) poultry farmers in the study locations. Descriptive and inferential statistics was used to analyze the data collected. Result showed that most (38.8%) of the poultry farmers had stock size of less than 2,500 birds. Majority (74.1%) of the poultry farmers operated both intensive and extensive production system. Furthermore, 84.0% of the poultry farmers were willing to adopt Internet of Things (IoT). The major constraints encountered by poultry farmers during adoption of disruptive agricultural technologies were lack of credit facility (2.16), poor housing system (2.06), and no government intervention (2.04). From the Logistic regression analysis, farm experience ($t<0.1$), stock size ($t<0.05$), educational level ($t<0.05$) and years of Internet of Things (IoT) experience ($t<0.05$) significantly positively influenced the willingness to adopt disruptive agricultural technologies. In conclusion, despite the willingness of the poultry farmers to adopt disruptive agricultural technologies, they were constraint due to lack of credit facility.

Keywords: Constraints, adoption, agricultural technologies, internet of things, poultry production

1. Introduction

Agriculture serves as the foundational pillar for fostering economic growth, development, and the alleviation of poverty in developing nations (Sertoglu, Ugural, &Bekun, 2017). It plays a crucial role in Nigeria's economy, making a substantial contribution to the nation's economic structure, comprising roughly 23% of the real Gross Domestic Product (GDP) (Thomas & Turk, 2023). This level of contribution has remained consistently stable over the past decade. Agriculture assumes the role of the most substantial source of employment, engaging approximately 70% of the nation's

workforce (United States Department of Agriculture, 2013; Adeyonu, Oyawoye, Otunaiya, &Akinlade, 2016). The rise in global demand of animal protein has made the agricultural sector one of the most developing and growing sectors in years to come (Motter, & Tempio, 2017).

In recent years, the poultry industry in Nigeria has exhibited a consistent and robust growth pattern, establishing itself a pivotal source of animal protein for the nation's population (Anoskie, Rekwot, Owoshagba, Ahmed & Atiku, 2018). This steady expansion reflects the sector's pivotal role in addressing the country's dietary needs, while also serving as a critical economic driver (Adeyonu, Oyawoye, Otunaiya, &Akinlade, 2016; Anoskie, Rekwot, Owoshagba, Ahmed & Atiku, 2018). This growth will become evident through a 60% projected increase in the demand for poultry products across the African continent by 2030, with Nigeria as its largest market (World Economic Forum, 2019).

Due to this significant growth in the poultry sector, disruptive technology can provide accurate tracking to ensure effective management and disease prevention among the flock through data collection (Monteiro, Santos, & Goncalves, 2021). These technology appliances are operated remotely and provide proper maintenance of pen-houses with ease through the movement, posture, and behaviour of diseased birds and compared with healthy birds through data analysis (Monteiro, Santos, & Goncalves, 2021). These disruptive technologies include Artificial Intelligence, Remote Sensing, the Internet of Things, and Robotics which could transform the management of poultry production on an international scale (Guanghui 2019).

The adoption of disruptive agricultural technologies in poultry production in Nigeria is crucial for enhancing the efficiency, productivity and sustainability of the sector. Disruptive technologies can transform various aspects of poultry farming, including breeding, nutrition, disease management, and data analytics (Li, Ren, Li, & Zeng, 2020; Olejinik, Popiela, & Opalinski, 2022). However, the adoption of disruptive technologies in the realm of poultry production has garnered limited attention in Nigeria. The notable challenge lies in farmers' capacity to effectively identify diseases despite the presence of available technological aids, raising substantial concerns. This study examined the constraints encountered by poultry farmers during adoption of internet of things (IoT).

2. Methodology

This study was carried out in the South-Western part of Nigeria. Southwest Nigeria encompasses six (6) states and spans a geographical range between latitude 6^0N and 4^0S, and longitude 4^0W and 6^0E. This region bordered by Edo and Delta States to the East, Kwara and Kogi States to the North, the Republic of Benin to the West, and the Gulf of Guinea to the South (Faleyimu, Agbeja, & Akinyemi,

2013). The climate in this region is predominantly equatorial, characterized by an average annual rainfall ranging between 150 and 1480 mm and the vegetation in the area includes freshwater and

mangrove swamps, lowland and woodland forests that extend inland into Ogun and Ondo States (Adesehinwa, Saka, Makanjuola, Sorunke, Boalduro, Omodele, & Ogunyemi, 2019).

For the purpose of this research, Lagos, Ogun, and Oyo States were used. The population of this region primarily engaged in agriculture, with a significant majority residing in rural communities where they derive their livelihood (Food and Agriculture Organization, 2018; Mackenzie, Lee, Duns, Toromade, &Oduntan, 2020). The fertile alluvial soil in the area is conducive to the cultivation of staple crops including cassava, maize, soybean, yam, cowpea, as well as tree crops such as citrus, kolanut, coffee, cocoa, oil palm and mango. The climate in this region also supports the rearing of livestock such as sheep, pigs, goats, and poultry (Amusa, Okoye, Enete, 2015).

Multi-stage sampling technique was used for the selection of poultry (broilers and layers) farmers in this study. Firstly, purposive sampling was used to select poultry (broilers and layers) farmers that were into poultry production from Lagos, Ogun and Oyo states out of the six (6) SouthWestern States in Nigeria. This selection was driven by the substantial concentration of commercial poultry farms and hatcheries, complemented by the region's sizeable population and vast market potential (Adesehinwa, Saka, Makanjuola, Sorunke, Boalduro, Omodele, & Ogunyemi, 2019). In the second stage, two (2) Local Government Areas (LGAs) were purposefully chosen from each of the three (3) states, with the selection process guided by data provided by the Poultry Association of Nigeria (PAN). In the third stage, 40 poultry farmers who are into rearing of broilers and layers were randomly selected from each of the two (2) LGAs, totaling 80 poultry (broiler and layers) farmers per state and resulting in a cumulative sample of two hundred and forty (240) poultry (broiler and layers) farmers for the study. A well-structured questionnaire was used to collect data from the selected 240 poultry (broiler and layers) farmers. However, 201 questionnaires were retrieved back from the poultry (broiler and layers) farmers which was equivalent to 83.75% response.

Datasets were analyzed using STATA software. Descriptive analysis was used for the socioeconomic characteristics of broiler farmers, while regression analysis was used to determine the factors affecting the willingness to adopt disruptive agricultural technologies among poultry (broiler and layers) farmers using logistic regression model.

Following the functional form of logit model is specified as follows (Gujarati & Porter, 2004; Greene, 2008).

$$P(Y_i=1)=\frac{1}{1+e^{-zi}} \qquad (1)$$

Where; P (Y_i=1) is the probability that farmers are willing to adopt DAT and P (Y_i=0) is the probability that will not willing to adopt DAT, z_i is the function of a vector of the explanatory variables.

Then 1-P (Y_i=1) represents the probability that farmers willing to adopt DAT.

1-P (Y_i=1) $= \frac{1}{1+e^{-zi}}$ ……..……..(2)

$$\frac{P\,(Yi=1)}{1-P\,(Yi=1)} = e^{zi}$$

……...(3)

Equation (3) is the ratio of the probability that farmers are willing to adopt DAT to the probability farmers are not willing to adopt DAT, taking the natural logarithm of equation (3)

$L_i = Ln\frac{P\,(Yi=1)}{1-P\,(Yi=1)} = Z_i$……..……(4)

$Z_i = ä0+ä_1X_1+ä_2X_2+ä_3X_3+ä_4X_4+ä_5X_5+ä_6X_6+ä_7X_7+ä_8X_8+å_0$ ……(5)

Where;

Z= Willingness to adopt DAT (Yes=1, No=0)

X_1 = Age of Farmers (years)

X_2 = Educational Level (1= Primary, 2= Secondary, 3= Tertiary attempted, 4= Tertiary completed)

X_3 = Marital Status (1= Single, 2= Married, 3= Widowed, 4= Divorced)

X_4 = Stock Size (number of birds)

X_5 = PAN Membership (1=member, 0=non-member)

X_6 = Years of poultry farming Experience (1= <1 year, 2= 1-3 years, 3= >3 years)

X_7 = Production System (1= Intensive, 2= Extensive, 3= Both)

X_7= Mode of Land Acquisition (1= Purchase, 2= Lease, 3= Communal, 4= Family)

X_8 = Year of usage of DAT (1= <6 months, 2= 6 -12months, 3= >1 year)

ε_0 = errors term $ä_1$, $ä_2$……..$ä_7$ are the parameters to be estimated $ä_0$= Intercept

1. Results

3.1 Socio-economic characteristics of poultry farmers

3.1 Socio-economic characteristics of poultry farmers

Table 1 showed the descriptive statistics of socio-economic characteristics of the broiler farmers in the study locations. The mean age of poultry farmers was 47 years. Majority (70.1%) of the poultry farmers were males, while 29.9% were females. The result showed that 65.2% of the poultry farmers were married, 33.3% were single, 1.0% were widowed and 0.5% were divorced respectively. Larger percentage 66.7% of the poultry farmers specified that they completed tertiary education, 17.9% completed secondary education, while 15.4% attempted tertiary education. Result further showed that most (43.2%) of the poultry farmers had between 11-20 years of farming experience. Furthermore, more than half (52.2%) of the poultry farmers were members of Poultry Association of Nigeria.

Table 1: Socio-economic Characteristics of Poultry Farmers (n = 201)

Socio-economic characteristics	Frequency	Percent
Age (years)		
<25	16	8.0
26-40	97	48.3
41-60	64	31.8
>60	24	11.9
Mean	**47**	
Sex		
Male	141	70.1
Female	60	29.9
Marital Status		
Single	67	33.3
Married	131	65.2
Widowed	2	1.0
Divorced	1	0.5
Educational level		

Primary education	0	0.0
Secondary education	36	17.9
Tertiary education attempted	31	15.4
Tertiary education completed	134	66.7
Farming Experience (years)		
1-10	54	26.9
11-20	87	43.2
>20	60	29.9
Membership of Poultry Association of Nigeria (PAN)		
Yes	105	52.2
No	96	47.8

Source: Field survey data, 2022

3.2 Farming system operation used among the Poultry Farmers (n = 201)

The farming system operation used among the poultry farmers were presented in Table 2. Result showed that most (38.8%) of the poultry farmers specified that they had stock size which was less than 2,500 birds, 31.8% had stock size of more than 5,000 birds, while 29.4% had stock size between 2501-5000 birds. More than half (56.2%) of the poultry farmers stated that they outrightly purchased the land used for their poultry farming, 24.4% stated that they made use of family land, while 19.4% specified that they leased the land used for their poultry farming. Based on the production system, 74.1% of the poultry farmers used both intensive and extensive system, 22.4% used intensive system only, while 3.5% used extensive system only.

Table 2: Farming system operation used among the Poultry Farmers

Variables	Frequency	Percent
Stock Size (Birds)		
<2500	78	38.8
2501-5000	59	29.4
>5000	64	31.8
Mode of Land Acquisition		
Outright Purchase	113	56.2
Lease	39	19.4

Family	49	24.4
Production System		
Intensive	45	22.4
Extensive	7	3.5
Both	149	74.1

Source: Field survey data, 2023

3.3 Adoption of Internet of Things (IoT) among Poultry Farmers

Table 3 revealed the adoption of Internet of Things (IoT) among poultry farmers. Majority (47.2%) of the poultry farmers stated that they had less than1 year of experience of adoption of Internet of Things, while 20.0% specified that they had more than 1 year of experience of adoption of Internet of Things in the study locations. Furthermore, it was discovered that 91.5% of the poultry farmers were willing to adopt Internet of Things (IoT) in the study locations.

Table 3: Adoption of Internet of Things (IoT) among Poultry Farmers (n = 201)

Variables	**Frequency**	**Percent**
>1	**95**	47.2
1	66	32.8
>1	40	20.0
Willingness to Adopt Internet of Things (IoT)		
Yes	184	91.5
No	17	8.5

Source: Field survey data, 2022

3.4 Constraints encountered by poultry farmers during adoption of disruptive agricultural technologies

Constraints encountered by poultry farmers during adoption of disruptive agricultural technologies was shown in Table 4. Based on the mean ranking, result showed that the major constraints encountered by the poultry farmers was lack of credit facility (2.16), followed by poor housing system (2.06), no government intervention (2.04), pest and disease (2.01), high mortality (1.97), high cost of feeds (1.96), and erratic power supply (1.95). However, the least constraints encountered by poultry farmers were waste and litter management (1.84), poor veterinary service (1.86), and biosecurity measure (1.87).

Table 4: Constraints encountered by poultry farmers during adoption of disruptive agricultural technologies

Constraints	Very Severe		Severe		Don't know		Not Severe		Mean	Rank	S.D.
	Freq.	%	Freq	%	Freq	%	Freq	%			
Institutional											
Erratic power supply	108	53.73	75	37.31	18	8.96	-	-	1.95	7th	0.65
No government intervention	55	27.36	97	48.26	36	17.91	13	6.47	2.04	3rd	0.69
Management											
Biosecurity measure	66	32.84	104	51.74	26	12.94	5	2.44	1.87	8th	0.80
Waste and litter management	64	31.84	115	57.21	17	8.46	5	2.44	1.84	10th	0.76
Poor veterinary service	76	37.81	90	44.78	26	12.94	9	4.48	1.86	9th	0.86
High mortality	76	37.81	79	39.30	27	13.43	19	9.56	1.97	5th	1.01
Pest & disease infestation	81	40.30	91	45.27	19	9.45	10	5.98	2.01	4th	0.89
Poor Housing	61	30.35	84	41.79	43	21.39	13	6.47	2.06	2nd	0.94
Social											
Theft and pilfering	61	30.35	96	47.76	33	16.42	11	5.47	1.97	5th	0.83
High cost of feeds	101	50.25	81	40.30	17	8.46	2	1.00	1.96	6th	0.77
Financial											

No credit facility	114	56.72	57	28.36	26	12.94	4	1.99	2.16	1st	0.79

Source: Field survey data, 2022

3.5 Logistic Regression Estimates of Willingness to Adopt Disruptive Agricultural Technologies among Poultry Farmers

The logistic regression estimates of willingness to adopt disruptive agricultural technologies among poultry farmers in the study locations was presented in Table 5. The diagnostic tests (LR chi^2 and Prob>chi^2) showed that the model is well specified and fit. The Pseudo R squared showed that 34.9% variation in the willingness to adopt disruptive agricultural technologies was explained by the variables. The result showed that farm experience (t<0.1), stock size (t<0.05), educational level (t<0.05) and years of IOT experience (t<0.05) significantly positively influenced the willingness to adopt disruptive agricultural technologies among poultry farmers in the study area.

Table 5: Logisti c Regression Estimates of Willingness to Adopt Disruptive Agricultural Technologies

Variables	Coefficient	Std Error	T	P>t
Age	0.2800208	0.467025	0.60	0.549
Education	0.8383044**	0.384208	2.18	0.029
Marital	-1.763185	0.645383	-2.73	0.006
Experience	1.070705*	0.5610089	1.91	0.056
Stock size	1.778097**	0.7145914	2.49	0.013
Production system	-0.0017965	0.3612013	-0.00	0.996
Land acquisition	0.3481212	0.2903658	1.20	0.231
PAN membership	-.420487	.6708913	-0.63	0.531
IOT Experience	1.718704**	.8044362	2.14	0.003
Constant	-5.23224	3.014863	-1.74	0.083
Diagnostic Test				
Pseudo R squared	**0.349**			
LR chi^2	**40.74**			
Prob > chi^2	**0.000**			

Log likelihood	**37.882214**

Source: Field Survey Data, 2022

* Significant at 10%

**Significant at 5%

Discussion of Findings

The implementation of agricultural technology facilitates the seamless integration of information with production-oriented farming methods, resulting in enhanced productivity and a reduction in environmental impact (Griffith, 2017). The mean age of poultry farmers was 47 years which indicated that most of the poultry farmers were still within their productive age, young, energetic and vibrant which may have a positive influence on their level of adoption to agricultural technologies. This was in agreement with a study conducted in Imo State, Nigeria who testified that majority of the poultry farmers in the area were within the age bracket of 41-50 years (Olaniyi, 2013; Nwozuzu, Nwozuzu, & Onyejiuwa, 2021). Result showed that males dominated the poultry industry which was in line with another study conducted in Owerri (71.2%). This may be attributed to the tedious activities involved, and also, it requires a lot of energy which the female might not be able to cope (Olaniyi, 2013; Nwozuzu, Nwozuzu, & Onyejiuwa, 2021).

Larger percentage (66.7%) of the poultry farmers stated that they completed their tertiary education. This supported another study who specified that poultry farmers spent mean years of 14.2 which denoted that they can read and write (Nwozuzu, Nwozuzu, & Onyejiuwa, 2021). Previous literatures have revealed that positive correlation existed between level of education and adoption rate of new technologies (Olaniyi, 2013; Nwozuzu, Nwozuzu, &Onyejiuwa, 2021). In respect to farming experience, finding showed that 43.2% of the poultry farmers have between 11-20 years. This was in support with another study in Owerri who reported that 48.3% of the poultry farmers have farming experience between 11-20 years (Nwozuzu, Nwozuzu, & Onyejiuwa, 2021). Another study specified that reasonable farming experience enable poultry farmers to set goals that are realistic (Tanko & Opara, 2010). As farming increases, so does the accumulation of knowledge and technological insights that empower farmers to effectively address production challenges (Olaniyi, 2013). Consequently, their output and income tend to rise proportionally.

More than half (52.2%) of the poultry farmers were members of Poultry Association of Nigeria (PAN). This was in accordance with another study who conveyed that 65% of the poultry members belonged to one social organization (Nwozuzu, Nwozuzu, & Onyejiuwa, 2021). The finding indicated that poultry farmers were able to interact with other farmers and get important information and assistance when needed. This further indicated that due to their membership, poultry farmers were able to access capital to improve their productivity level (Yusuf, Martins, &

Gabriel, 2017). Also, being a member of PAN, they would have access to extension services and information that will help their farming activities (Olaniyi, 2013).

In regards to farming system operation used, most (38.8%) of the poultry farmers had a stock size of less than 2,500 birds, 29.4% had a stock size between 2500 and 5000 birds while 31.8% had a stock size of above 5000 birds. Based on the classification of small poultry farms which was grouped between 50-500 birds, medium scale farms were 501-1000 birds and above 1000 birds as large-scale poultry farms, the finding of this study revealed that most of the poultry farmers operated mostly on medium and large-scale while some operated on a small poultry size (Ajibefun & Daramola, 1999). It was observed that 74.1% of the poultry farmers practiced both extensive and intensive production system in the study locations. This was not in line with another study conducted in Nigeria who reported that 99.2% of the poultry farmers practiced intensive system. The finding of this study denoted that poultry farmers operated majorly on a medium and large-scale operation (Ajiefun& Daramola, 1999). The choice of production system may vary due to factors such as the scale of birdkeeping, educational background, capital requirements, and specific inputs needed for each method (Olaniyi, 2013).

Larger percentage of the poultry farmers showed high willingness to adopt disruptive agricultural technologies in the study locations. This was in agreement with another study conducted in Owerri who revealed that poultry farmers were much aware and adopted highly in the use of regular vaccination programme, regular litter replacement, and improved breeds (Nwakwasi, Nwozuzu, & Okeke, 2021). Furthermore, poultry farmers exhibited a strong inclination to embrace novel precision agriculture technologies within their poultry production operations. Precision livestock farming is a rapidly emerging trend in animal agriculture, capturing the keen interest of numerous farmers (Olejnik, Popiela, & Opalinski, 2022). Precision livestock farming leverages artificial intelligence and technology to oversee and assess animal performance and health; thereby enhancing profitability and efficiency throughout the production chain (Rowe, Dawkins, &Gebnardt-Henrich, 2019; Groher, Heitkamper, &Umstatter, 2020).

The major constraints to poultry farmers adoption of disruptive agricultural technologies included lack of credit facility (2.16), poor housing system (2.06), no government intervention (2.04), and pest and disease (2.01). This was a bit in line with another study who reported that financial incapacitation as well as high cost of livestock feeds were major challenges to farmers adoption of improved technologies (Nwozuzu, Nwozuzu, &Onyejiuwa, 2021).

Based on the findings of logistic regression, for every one-point increase in the years of farming experience, 1.07-point increase in the willingness to adopt disruptive agricultural technologies among the poultry farmers was expected. This is so because the more the experience of the poultry farmer, the higher the willingness to adopt the technologies as it helps to combat pest and disease infestation on the farm. The result supports the existence of a positive relationship between farm experience and adoption of poultry technologies (Nwakwasi, Nwozuzu, & Okeke,

2021). Also, for every one-point increase in the size of the stock, the willingness to adopt disruptive agricultural technologies among the poultry farmers increases by 1.78. This is so because the larger the size of the stock, the more likely the farmers will want to adopt disruptive agricultural technologies to ease mode of operation to increase farm income.

Moreover, findings showed that 1 unit increase in the years of experience in the use of disruptive agricultural technologies would result to 1.72 increase in the willingness to adopt disruptive agricultural technologies among the poultry farmers. This indicated that the higher the years of experience in the usage of disruptive agricultural technologies, the higher their willingness to adopt the technology. The finding of this study was in accordance with another study who revealed that experience increases the intensity to adopt agricultural technologies which will invariably increase their farm production (Adetomiwa, 2020).

Conclusion

The study concluded that majority of the poultry farmers were willing to adopt agricultural technologies but their major constraints included lack of credit facility, poor housing system, no government intervention, and pest and disease.

Recommendations

Based on the findings of this study, the following recommendations were made;

1. Farmers should be encouraged to go for more training and enlightenment on the use of IoT technologies since education and farm experience reduce risk level, efficiency, farm output, and farm income.
2. Extension agents should liaise with the government and other relevant stakeholders to provide credit facilities at single digit rates to poultry farmers to increase stock size and increase production at affordable costs.
3. Poultry farmers should be sensitized on biosecurity measures and proper poultry housing structures compatible with IoT technologies.

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