Analysis of factors influencing the choice of production systems in poultry egg farming

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This study considers analysing factors influencing the choice of production systems in poultry egg farming in the southwest of Nigeria. Specifically, the study describes the socio-economic characteristics of the respondents and also identifies the factors affecting farmers' decisions to select production system in poultry egg farming. The data for the study were collected from 360 egg farmers using a purposive and snowball sampling techniques. Information on socio-economic characteristics of the farmers and poultry-specific attributes was collected through a well-structured questionnaire. Statistical tools employed in this study were both descriptive and inferential statistics. The descriptive statistics used were mean and standard deviations, while the multinomial logit model was used to determine the probability of selecting a choice reference to a base category. Results show that the mean age is 44 years with 98% male respondents. The study shows that 52% of the farmers use battery cage system only, 37% use deep litter system only and 11% use both systems. The marginal effects estimated from the multinomial logit model show that the probability of choosing deep litter system only, increases with gender, price per crate of egg, farming experience and flock size. The results also reveal that distance to the market, price per crate of egg, poultry farming experience and farm location, *ceteris paribus*, increase the probability of using both systems compared with the battery cage system. This study concludes that education of the poultry egg farmer, price of egg, flock size and experience of the farmer are key factors influencing the choice of layer production system. Based on these findings, it is suggested that all the significant variables identified in this study should be given more attention in policy making.

Keywords: Multinomial logit model, choice, poultry system, egg farming

In Africa, the average per capita egg consumption is generally low compared with the global average. For instance, Nigeria's annual average per capita consumption of egg was 2.49 kg per person compared with China's 22.72 kg per person in 2017 (FAO 2017). Unfortunately, none of the African countries is among the ten leading egg producing countries in the world. Africa produced less than 5% of the total world egg production in 2012. Low consumption of meat and eggs leads to stunting and wasting in children less than 5 years of age, and also slows mental development particularly in the rural areas of Sub-Sahara Africa (FAO 2013). Egg is a valuable source of protein and contains almost all the essential nutrients. The Net Protein Utilization (NPU) estimated for egg is 87 compared with other grains whose NPU is less than 40. Chicken meat and eggs are the cheapest among all livestock food products and their consumption has no cultural limitations (FAO 2013).

In the rural areas of developing countries, poultry provides foods, employment and income to the resource-poor households. In Sub-Sahara Africa (SSA), only 8% of dietary energy is derived from animal protein compared with 28% in China (FAO 2013). The minimum requirement of 70gm per capita per day with 35g of animal origin which is recommended by Food and Agriculture Organization (FAO) has not been fully achieved in Nigeria. The reasons for falling short of FAO's recommendation can be alluded to economic, social, political and technical constraints.

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To overcome this challenge in SSA, including Nigeria, the use of appropriate technologies in the poultry layer subsector is essential. Production of any product partly depends on the level of good technology deployed to the farm. Egg can be produced under three management systems: extensive/free range, semi-intensive and intensive. The intensive system is where birds are kept in-door for proper intensive care. It includes battery cage and deep litter system. The choice between the two of them depends on many factors.

Appropriate technologies, among other things, go a long way to measure performance in egg production. In Nigeria, Ladele, (2002) reported that absence of innovations poses a great deal of challenge in the poultry industry. The importance of using good technology has been empirically supported by previous studies. For example, Aboki et al. (2013) found that the adoption of innovation index had a negative relationship with the inefficiency of family poultry production in Nigeria. Ovwigho et al. (2009) reported a positive and significant relationship between chicken management system and egg production.

Some of the studies carried out on poultry layers housing systems showed that a good housing system aids performance of layer birds. For instance, Gerzilov et al. (2012) in Bulgaria, found that layers kept under three production systems (conventional, enriched cage, and slated/floor litter system) performed better, on the average, than birds kept in two other systems (extensive and semi-intensive) in term of egg yield per hen. However, conventional cage had the lowest mortality rate with the highest feed conversion ratio. Similar studies carried out by Ojedapo (2013); Ogbu et al. (2015) reported that housing system and the rearing environment were important management inputs in poultry production that affect the performance of birds.

From the technical efficiencies perspective, many researchers have done a lot of work over the years, particularly in egg production (Ojo 2003; Binuomote et al, 2008; Adepoju 2008; Ashagidigbi et al. 2011; Adewuyi et al. 2013, Etim et al. 2013; Odine et al. 2015; Osinowo and Tolorunju 2019); many have also looked towards the direction of adoption of improved layers (Teklewold et al. 2006; Wachira et al. 2010; Ochieng et al. 2012., Christopher 2018); biosecurity practices in egg farming have equally been discussed in poultry management literature (Akintunde et al. 2015; Ajewole and Akinwumi 2014). Despite the bulk of studies recorded on egg production, the production curve of egg in Nigeria is not proportionally increasing with the efforts being put in. Many people in the southwestern part of Nigeria still see consumption of poultry products as a luxury good (Adene and Oguntade 2006). The choice of poultry housing system or production system has been given little attention in economic literature, thereby creating a gap to fill by this present study.

In order to change this scenario, it is an opportune time to investigate the factors influencing the choice of production systems in poultry egg farming by farmers. This is worth investigating because, no study on identification of factors that could affect the choice of production system in egg production has been conducted in the study area. Therefore, this study will provide valuable insight into what motivates a farmer to choose a particular production system.

Modelling framework

Random utility theory

The concept employed in this study is generally built on the framework of random utility theory with the assumption that every poultry farmer is a rational decision maker about the choice of input he/she employs on the farm. Utility is understood to be the benefit that a poultry farmer *i* could derive from choosing an alternative *j* from his choice set *C*. Considering a poultry egg farmer *i* making a decision that involves an exclusive alternative that constituted a choice set C of production

systems in egg production, the choice set may differ from one farmer to another depending on some constraints. The selection of production system *j* by the farmer *i* is based on perceived utility U_{ij}. of the choice. The utility maximizing behaviour of the poultry farmer *i* for choosing production system *j* among J alternatives in the choice C. can be expressed in a linear form as:

$$U_{ij} = V_{ij} + \varepsilon_{ij} \quad (1)$$

Where,

$$V_{ij} = \beta X_{ij} + \varepsilon_{ij} \quad (2)$$

From equation (2), V_{ij} is a vector of systemic utility that composes of observed variables relating to farmer *i* that depends on attributes of alternative *j*. X_{ij} are vectors of attributes of alternative *j*. ε_{ij} is the random component/unobserved variables. β is the vector of coefficient of the observed variables.

The conditional probability of his choice then becomes.

$$P(i/C_n) = P\left[\left(V_{ij} + \varepsilon_{ij}\right) > \left(V_{ik} + \varepsilon_{ik}\right)\right] =$$

$$P\left[\left(\varepsilon_{ik} - \varepsilon_{ij}\right) < \left(V_{ij} - V_{ik}\right)\right] \ , j \neq i \ \& \ j \in C_n \quad (3)$$

The choice probability of different models depends on the assumption about the distribution of error term for all i and different treatment of β. In this study, we assume that our random component for multinomial logit specification follows the Gumbel distribution (McFadden, 1973).

Methods

Data and study design

The study area was southwestern Nigeria. Data collection was conducted in three of the six states of the southwest region of Nigeria, namely Lagos, Ogun and Oyo. The region has a land area of 77,818km^2 with a total population of 28,767,752 (National Population Commission, 2006). The two distinct seasons in the study area are the rainy season that occurs between April and October while the dry season occurs between November and March. Poultry is one of the major livestock subsector in Nigeria. A multi-stage sampling procedure was employed to select egg producers in the study areas. The first stage involved a purposive selection of three prominent egg producing States from the region. In the second stage, a purposive selection of two Local Government Areas (LGAs) in each state was carried out using the lists of members of Poultry Association of Nigeria (PAN) as a guide. The LGAs selected that were prominent in the production of eggs were Shagamu and Odeda in Ogun, Alimosho and Ojo in Lagos and Afijio and Oyo West in Oyo. In the third stage, 60 egg producers per LGA were selected using a snowball sampling technique because the farms were not clustered but scattered across each LGA. The total egg farmers selected and interviewed per state was 120. The 120 respondents from each State were pooled together to give a sample size of 360 respondents used for the analysis in this study.

Model specification

This research focuses on the intensive method of raising layers. The dependent variable is categorical such as battery cage system only, deep litter system only, and both systems (battery and deep litter). The explanatory variables were selected as socio-economic characteristics of egg producers and poultry-specific attributes. The first option (battery cage) was set as the base category because it has the highest frequency.

Following Schmidt and Strauss (1975) and Greene (2012), suppose we have k categorical outcome, without loss of generality and with a base outcome of 1. The probability that the

response for the j^{th} observation equals to the i^{th} outcome is

$$Prob\left(Y_i = \frac{j}{x_i}\right) = \frac{exp(X_i^{'}\beta_j)}{1+\sum_{k=2}^{J} exp(X^{'}{}_i\beta_j)}, \quad j = 0,1,\ldots,J \tag{4}$$

Where, Y_{ji} is the probability that a poultry egg farmer i chooses a given j outcome and thus represents the choice of one of three production systems.

β_j represents unknown parameters to be estimated.

X_{ij} represents vectors of explanatory variables for i^{th} poultry egg farmer with j level of choice, and the parameters of these equations are estimated using the method of maximum likelihood (Greene 2012). The independent variables for the multinomial logit regression are shown in Table 1.

Data analysis

Descriptive statistics and a multinomial logit model were used to analyse the study specific objectives. The socioeconomic characteristics of respondents were summarised using mean and standard deviation while multinomial logit regression model was used to identify factors influencing the choice of production system in poultry egg production. Analysis of data was carried out in STATA version 14 (Statacorp 2015)

Descriptive statistics

Table 1 displays the socioeconomic characteristics of egg farmers in the study area. Results of this study showed that the mean age of egg farmers in the study area was 44 years which signifies that the farmers are no longer young but they still fall within the productive age. The average age of 44 years obtained from the field survey is similar to previous findings in Nigeria (Adeyonu et al. 2016; Akintunde et al. 2015; Osinowo and Tolorunju 2019). The respondents were mostly male (98%). This affirms the finding of earlier work (Osinowo and Tolorunju 2019) that male households are more involved in poultry egg production in Nigeria. Most of the farmers are operating at a distance of less than 2 km away from the market. The mean poultry farming experience in the study area was 12 years. With such years of experience that the farmers have spent in the poultry business, farmers are expected to have better knowledge about the inputs employed on their poultry farms and the ability to perceive and process information relating to the attributes of each type of production system to adopt for production.

The mean household size in the study area was five persons and the egg producers spent an average of 13 years in schooling. 71% of the farmers had access to extension services suggesting that poultry egg farmers will be able to have access to information and other government programmes in the study area. The average market price per crate of egg was ₦772.0 (US$2.14) but it ranged between ₦600 – ₦900. The mean income per month of egg producers stood at ₦30,985.88 (US$86.07).

Table 1: Summary statistics of the variables and poultry production systems

Variable	Description & measurement of variables	Expected sign	Mean	Std. dev.
Dependent variable				
Production systems	Battery cage = 1		0.522	0.500
	Deep litter = 2		0.369	0.483
	Battery cage/Deep litter = 3		0.108	0.211
Explanatory variable				
D_GENDER	Gender of respondents: dummy measured as male = 1, 0 otherwise	-/+	1.983	0.128
D_MAR STATUS	Marital Status of respondents: dummy measured as married = 1, 0 otherwise	-/+	1.853	0.370
DIST_T0_MARKET	Distance to poultry market: continuous measured in km	-	1.592	0.872
COOP_MEMB	Cooperative membership: dummy if respondent belongs to a cooperative = 1, 0 otherwise	+	0.744	0.437
D_EXTENSION	Access to extension service: dummy if has access to extension agent = 1, 0 otherwise	+	0.714	0.453
AGE	Age of poultry farmer, continuous (in years)	-	44.325	12.225
LAGE_SQUARED	Age squared: continuous	-		
EDUC	Level of education: continuous in years	+	12.811	5.008
EDUC_SQUARED	Education squared: continuous	+		
PRICE	Price per crate of egg: continuous in Nigerian currency ₦	+	772.444	60.024
INCOME	Level of income: continuous per month in Nigeria currency ₦	+	30985.880	57380.860
HHSIZE	Household size: continuous number of household members	+	4.572	1.760
EXPEZ	Poultry farming experience: continuous number of years so far spent in poultry egg farming	+	11.686	9.628
FLKSIZE	Flock size per farm number of layers	+	3174.150	5674.237
AGE*EXPZ	Age and Experience interaction: continuous	+		
D_OGUN STATE	Dummy for Ogun state (1/0)	-/+	0.333	0.472
D_OYO STATE	Dummy for Oyo state (1/0)	-/+	0.167	0.373
D_LAGOS STATE	Base category	-	-	-

Results and discussion

Marginal effects

The parameter estimates of multinomial logit regression model for the factors influencing the decision to choose production system in poultry egg farming are presented in Table 2. The coefficients of multinomial logit regression model are difficult to interpret directly (Greene 2012). It shows only the direction of the effect of the explanatory variables thus it is necessary to take the partial derivatives of the response variable with respect to the explanatory variables to be able to reflect the actual magnitude change. The study, therefore, reports the marginal effects of the factors influencing the choice of production system in egg farming. The marginal effects are reported in Table 2.

The probability of choosing deep litter system instead of battery cage increases with gender of the respondent. The variable had a positive and significant impact on the choice of deep litter at 1% level, which implies that an additional one man in the industry, the probability of choosing deep litter as a method of egg production will increase by 2.4 times compared to female poultry farmer. The result supports the earlier study carried out in Kenya

by (Ochieng et al. 2012).

Marital status of poultry egg farmer increases the probability of selecting either deep litter only or both systems by 4.4 and 1.8 times respectively, higher compared to unmarried farmer. Married farmers have access to cheap family labour than unmarried, hence the cost of running a poultry farm can be minimized. Being a membership of cooperative society shows a negative correlation with either the choice of deep litter or both systems relative to base category. The implication is that being a member of the cooperative, the probability of selecting a deep litter only or both systems, reduces by about 20% and 74%, respectively. The finding is contrary to the studies of Rashid et al. (2020), who found a positive relationship between farmer's participation in commercialization pathways in rice production in Tanzania. The farmers in the study area seem to rely on their personal savings to run poultry business.

Access to extension services by egg farmers had a negative relationship with the choice of deep litter system only but positively related to both production systems. The implication is that, as additional information is disseminated by extension agent to poultry egg farmer, farmers will be more likely to prefer both systems compared to the base category. The results show the importance of extension services cannot be over-emphasised in an agrarian institution which is saddled with the responsibility of disseminating information to the farmers. This result is similar to the finding of Dhraief et al. (2019), who found a positive relationship between extension services and adoption of innovative technologies by livestock holders in Tunisia.

The result also reveals that above the mean age of 44 years, each additional one year in the age of the respondent decreases the probability of choice of deep litter by 3.8%. Similarly, the choice of using both systems also decreases with farmers´ age above 44 years by 1.2% in the study area. This result is consistent with the earlier studies by Dossa et al. (2008) and Oscar et al. (2012), that young farmers are risk takers compared with old farmers.

The study shows that education of the poultry egg farmer, beyond an average of 13 years, all things being equal, the probability of egg production using both systems compared to the base category increases by 16%. The result is consistent with the *a priori* expectation that adoption of innovation increases with the level of education. The finding agrees with the findings of Agwu et al. (2008); Ochieng et al. (2012); and Dhraief et al. (2019), who reported that more years spent on education increase the adoption of innovations.

Results of this study also show that with an addition of one unit in the average price per crate of egg, the probability of production of egg using either deep litter system only or both systems, relative to the battery cage, increases farmers´ revenue. Consistent with our *a priori* expectation, poultry experience is positively and significantly related to the choice of all the production systems at 1% and 5% level, respectively. Dhraief et al. (2019) in Tunisia also found a positive association between innovative technology of livestock and farming experience. The results imply that with an addition of one year of poultry experience, farmers are more likely to prefer either deep litter only or both systems by 50% and 57% respectively.

Flock size as expected is positively and statistically significant at 5% level with the choice of deep litter system relative to the base category. This implies that beyond the average flock size of 3,174 spent layers, the probability that farmers will produce egg using deep litter system is likely to be increased by 52%. This is not surprising because deep litter is not as expensive as battery cage and the deep litter system is more flexible to be converted to another venture in case the business shuts down.

Table 2: Parameter estimates and marginal effects of the factors affecting the choice of production systems in egg farming

	DL-SYSTEM	DL-SYSTEM	B&D-SYSTEM	B&D –SYSTEM
Variable	**Coef. (Std. Err.)**	**∂y/∂x**	**Coef. (Std. Err.)**	**∂y/∂x**
CONSTANT	-1425.09 (172.15)*	-	-638.55(129.12)***	-
D_GENDER	16.31 (3.51)***	2.36 (0.48)	4.75 (3.04)	0.11(0 .46)
D_MAR STATUS	33.78 (4.73)**	4.48(0 .83)	19.19(4.13)***	1.86(0.72)
LOGDIST_MARKET	0.46 (0.33)	0.06 (0.04)	0.32(0 .32)	0.04(0 .05)
COOP_MEMB	-15.58 (1.98)***	-2.09(0 .37)	-8.21 (1.65)***	-0.74(0 .29)
D_EXTENSION	-23.22 (2.75)***	-3.16(0 .52)	-11.37 (2.16)***	-0.96(0 .39)
LOGAGE	-(28.59 (7.69)***	-3.77(1.17)	-16.72(5.95)***	-1.65(0.97)
LOGAGE_SQUARED	21.59 (3.67)***	2.89(0 .62)	11.54 (3.60)***	1.06(0 .60)
LOGEDUC	48.72 (52.86)	3.16 (7.39)	102.42 (53.79)*	15.71(8.50)
LOGEDUC_SQUARED	11.32 (8.64)	0.97(1.22)	18.52 (8.81)**	2.73(1.39)
LOGPRICE	756.32 (95.58)***	101.67(17.53)	398.76(79.23)***	36.15(13.98)
LOGINCOME	0.67 (1.38)	0.08 (0.21)	0.53 (1.09)	0.06(0 .19)
LOGHHSIZE	1.13 (0.73)	0.16(0 .10)	0.36(0.64)	0.01(0 .09)
LOGEXPEZ	4.43(1.59)***	0.50(0 .23)	4.41 (1.70)**	0.57(0 .27)
LOGFLK SIZE	3.72 (1.49)**	0.52(0 .25)	1.57 (1.22)	0.11(0 .21)
LOG AGE*EXPEZ	13.52 (2.51)***	1.78(0 .41)	8.02 (2.21)***	0.80(0.37)
D_OGUN STATE	0.34 (0.73)	0.06(0 .10)	-0.20 (0.75)	-0.05(0.12)
D_OYO STATE	0.89 (0.71)	0.06(0 .10)	1.74 (0.66)***	0.27(0.10)

* Level of significance: *** 1%,** 5%, *10% Log likelihood -130.6927, LR Chi^2 354.57, pseudo R-squared 0.5756. Base category: battery cage only: DL: deep litter only, B&D = battery and deep litter

Conclusion and recommendations

The findings of this study show that the mean age of egg farmers in the study area is 44 years. Based on the mean age of 44 years, the result implies that farmers are still highly productive in their poultry businesses. Most (98.0%) of the farmers are male with an average of 13 years of education. Many of the farmers (85.0%) are married. The distribution of flock size shows that the farmers are usually medium-scale operators. Based on the statistical significance of the following variables in the multinomial logit model estimated, the study therefore concludes that the probability of choosing deep litter system only, increases with gender, price of egg, farming experience and flock size. Further scrutiny of the results reveals that distance to the market, price per crate of egg, experience and farm location, *ceteris paribus*, increase the probability of using both systems compared to the battery cage. It is suggested that government should provide a policy framework that will accommodate a market-driven economy. On the average, the educational level of poultry egg farmers in this study is reasonably high, however, educating and re-training of egg farmers are still necessary. The results suggest that extension services and youth participation in poultry egg farming should be encouraged. Farmers are the key agents in the poultry industry; they should be encouraged to adopt the spirit of financial cooperation through formation of cooperative societies so that members can get loans to expand egg farms in the country without stress. Existing policies on poultry farming should be overhauled and every grey area incompatible with research findings should be expunged.

Government should use the results of this study to design appropriate interventions for poultry egg farmers in order to boost egg production. The agricultural engineering arm of the agricultural sector will be stimulated to come up with better and affordable production

technology, that can compete favourably with the rest of the world.

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