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ECONOMIC ANALYSIS OF ARTIFICIAL INSEMINATION IN BROILER PRODUCTION IN OYO STATE, NIGERIA

Grace Oluwabukunmi Akinsola[1✉], Matthew Adewumi[1], Abraham Falola[1], Ezekiel Ojediran[1], Abiodun Jimoh[1]

[1]University of Ilorin, Nigeria

Abstract. Artificial insemination (AI) in poultry production is a veritable technique in solving the problem of breeding and meeting the increasing demand. This study assesses the economics of artificial insemination in broiler production among sixty randomly selected broiler farmers in Oyo State, Nigeria. Primary data were used for this study. They were collected using a well-structured questionnaire. The analytical techniques applied include descriptive statistics, gross margin analysis and stochastic frontier analysis (SFA). The results have shown that most of the farmers are male and are at their prime age. The majority of the livestock farmers have some form of formal education and a minimum of five-year experience in poultry farming. The capital was mostly sourced from the bank. The majority of the farmers have a stock size of more than 25,000 birds. They have a gross margin of N341, 933,406. Only 20% of gross income was used for operating expenses with a return on invested capital of 4.3. The mean technical efficiency was 80.70%. Feed, vaccines and stock size were statistically significant in determining efficiency while education and extension visits are the statistically significant variable influencing technical inefficiency. It is therefore recommended that affordable and accessible input, as well as training, be made available to farmers to achieve self-sufficiency and sustainability.

Keywords: artificial insemination, gross margin, poultry, technical efficiency

INTRODUCTION

Poultry (including turkeys, ducks, geese, guinea fowls, quails and chickens) are increasingly gaining popularity in Nigeria due to their role in increasing nutrition security (especially in alleviating protein malnutrition) and their contribution to agricultural GDP (approximately 25%). They also economically empower the resource-poor settings – approximately 20 million people are employed, directly or indirectly, in poultry farming (FMARD, 2017; Omolayo, 2018). The reports have shown that poultry business is one of the highest investments in agriculture with a net worth of over 300 billion naira. Its products (meat and eggs) have become the most consumed animal protein that is unrestricted by any religion or culture in Nigeria (FMARD, 2017). About 10% of Nigerians go into poultry production, and over 70% of this production is chicken-based (Ekunwe and Akahomen, 2015; FMARD, 2017). The Nigerian poultry sector offers various possibilities for potential investors (Heise et al., 2015; Makun, 2018).

The production of commercial chicken began in Nigeria in the late 1950s, when egg farms were established in the western part of the country (Akinwumi et al., 2010). At that time, the local breeds and old layers (spent layers) were the most consumed types of chicken meat. Thus far, the industry only has two government-owned hatcheries (set up in 1970), thereby limiting its scale in

✉Grace Oluwabukunmi Akinsola, Faculty of Agriculture, University of Ilorin, P.M.B. 1515 Ilorin, Kwara, Nigeria, e-mail: graceakinsola@gmail.com; https://orcid.org/0000-0002-5278-2281

size and production. However, as demand started growing, there was also a need to increase supply that could only be met through importation of poultry inputs (like day-old-chicks, feed, vaccines and equipment). This primarily led to the fast growth of the industry (FMARD, 2017). By 1983, over 40 million commercial birds, supported by 874 feed mills, were reported (PIND, 2013). However, the devaluation of naira brought about by the World Bank's Structural Adjustment Programme subscribed by Nigeria in 1986 led to a collapse in the commercial poultry sector. A cost-push demand was created, thereby making poultry inputs (which were largely imported) unaffordable and, by extension, less competitive (Odeh, 2010). This problem was further exacerbated by the ban placed on the importation of those inputs, which greatly reduced the sustainability of commercial poultry production. That ban, however, had also a positive side – the room for domestic production of commercial poultry was created in the country (Akinwumi et al., 2010).

The commercial poultry production in Nigeria was estimated at USD 600 million, comprising of approximately 165 million birds that produced 650,000 MT of eggs and 290,000 MT of meat in 2013 alone (FAO, 2015). However, poultry meat consumption in Nigeria, estimated at 1.2 million MT, shows that there is still a wide gap between demand and supply for poultry meat. Also, the outbreak of avian influenza (H5N1) in 2015, which claimed approx. 1.4 million birds belonging to 437 farmers across 18 states, further exacerbates this gap (Sahel, 2015). Some factors are driving the increasing demand for poultry products. These include an increase in per capita incomes, population and urbanization. All these above-mentioned are correlated with an increase in chicken consumption, which, for health and price factors, is preferable to consumption of other meats (Anderson and Gugerty, 2010). The Food and Agricultural Organization of the United Nations (FAO, 2015) affirmed that growing populations, economies and incomes "are fueling an ongoing trend towards greater per capita consumption of animal protein in developing countries." According to FAO, Nigerians are expected to consume two thirds of animal protein more, with meat consumption rising by nearly 73%. This growth in protein consumption will drive demand, which – if not met with adequate supply – will exacerbate the food, nutritional, and livelihood problems the country is currently facing. The increased amount of poultry products is likely to be affected by i.a. the shortage of DOC (day-old chicks), poor quality feed, poor management efficiency, the problem of ineffective veterinary services (including drugs and vaccines), as well as by inadequate capital and requisite technical skills in managing the birds (PIND, 2013). Invariably, artificial insemination (AI) in poultry production solves the problem of breeding and meets the increasing demand of the ever-growing population in Nigeria. This study, therefore, determines the profitability and technical efficiency of broiler production through the use of artificial insemination.

MATERIALS AND METHODS

Study area

The study area was Oyo State, Nigeria. The state with capital situated in Ibadan was established in 1976. Oyo State comprises 33 local governments and it covers an area of 28,454 square kilometers. The state borders with Ogun State in the south, with Kwara State in the north, with Osun State in the east and with Ogun State and partly with the Republic of Benin in the west. It has a population density of 211 people/sq. km with a total population of 5, 591, 589 (NPC, 2006).

Data sources

The study applied primary and secondary data. A questionnaire and interview schedule were used to obtain the primary information from 60 randomly selected broiler farmers that use artificial insemination in their production process. The secondary information was obtained from the Project Coordinating Unit (PCU), CBN annual report, Federal Office of Statistics (FOS), Federal Department Of Agriculture (FDA), Poultry Association of Nigeria (PAN) and the internet.

Analytical techniques

Descriptive statistics and a gross margin analysis were applied to determine the socio-economic characteristics and to estimate the costs and returns of AI broiler farming, respectively. Returns with farm management and labour, operating ratio, gross ratio and returns on capital invested by farmers were calculated as well. Technical efficiency of farmers was determined through the Cobb-Douglas production function.

Gross Margin:

The gross margin function is as follows:

$$GM = GFI - TVC \tag{1}$$

where:
GM – gross margin
GFI – gross farm income
TVC – total variable cost.

The gross ratio is a profitability ratio that measures the overall success of a farm. A lower ratio indicates a higher return per naira.

$$GR = TFE/GI \tag{2}$$

where:
GR – gross ratio
TFE – total farm expenses
GI – gross income.

RETURNS WITH FARM MANAGEMENT AND LABOUR = GROSS MARGIN – IMPLICIT COSTS

The operating ratio is directly related to the farm variable input usage. The lower the ratio is, the higher is the profitability of the farm business.

$$OR = TOC / GI \tag{3}$$

TOC – total operating costs.

The returns on capital invested are defined as the gross margin divided by the total variable cost.

$$RI = GM / TVC \tag{4}$$

Stochastic Production Frontier

The explicit form of this model is written, hence:

$$Y_i = f(X_i \beta) + (V_i - U_i) \tag{5}$$

where:
Y_i – is the output of i[th] farm
X_i (k · 1) – a vector of input quantity of the i^{th} farm
β – a vector of unknown parameters to be estimated
V_i – random variables which are assumed to be normally distributed $N(0,\delta^2)$.

It is assumed that they are taken into account on the basis of a measurement error and another factor which is uncontrollable for the farmers.

The Cobb-Douglas production model of the frontier is as follows:

$$lnY = \beta_0 + \beta_{1ln}X_1 + \beta_{2ln}X_2 + \beta_{3ln}X_3 + \beta_{4ln}X_4 + \beta_{5ln}X_5 + \beta_{6ln}X_6 + V_i - U_i \tag{6}$$

where:
Y_i – total value of output
X_1 – land (ha)
X_2 – feed (kg)
X_3 – vaccine (l)
X_4 – number of egg set
X_5 – labour (man-day)
X_6 – stock size.
$T_{ei} = \exp(-U_i)$

The inefficiency part of the model is represented by U_i. This is defined as follows:

$$U_i = d_0 + d_1Z_1 + d_2Z_2 + d_3Z_3 + d_4Z_4 + ... + d_nZ_n \tag{7}$$

where:
U_i – technical inefficiency
Z_1 – age (years)
Z_2 – education
Z_3 – business commitment
Z_4 – extension visit (yes = 1, no = 0)
Z_5 – poultry production experience
Z_6 – membership of association (yes = 1, no = 0)
d_0, d_1, d_2… – parameters.

As a dependent variable of the inefficiency model represents inefficiency, a positive sign of an estimated parameter indicates that the variable has a negative effect on efficiency, but a positive one on inefficiency and vice versa (Yao and Liu, 2008).

RESULTS AND DISCUSSION

In this study, most of the farmers adopting artificial insemination are males at their prime age (50–59). A majority of the farmers (51.7%) acquired a post-secondary school education. The farmers (86.7%) mostly have a minimum of five-year experience in poultry farming and they are married. A vast majority of the farmers source their capital from the bank (75%) followed by cooperative societies (21.7%). They rarely use their savings or receive money from family and friends. Considering the returns, poultry farming using artificial insemination is taken as a full-time source of livelihood for the majority (75%) of the farmers. They all use hired labour in their production process, as it is labour-intensive.

Most of the farmers have a stock size of more than 25,000 birds.

Table 1 shows a profitability analysis of the farmers. The gross value output is N421,215,250 and the total variable cost is N79,281,844, which gives a gross margin of N341,933,406. The annual depreciation on equipment was N12,960,696, giving a net farm income of N332,605,240. The returns with farm management (after deducting a fixed cost) are N328,972,710. The operating ratio was found to be 0.20, meaning that 20% of gross income was used for operating expenses. The return on capital invested is 4.3, which means that for each naira invested, the farmers gain 4.3 naira, meaning a high return which agrees with the reports of Omolayo (2018).

Table 1. Profitability analysis – per production cycle

Variables	Values (Naira)
A. Gross value of the output	421,215,250
B. Variable cost	
Cost of stock	14,400,000
Cost of feed	46,032,383
Cost of vaccine/drug	8,623,256
Cost of hatching	4,062,476
Cost of labour	6,099,825
Cost of litter	17,497
Cost of charcoal	46,407
Total variable cost	79,281,844
C. Fixed cost	
Annual depreciation on equipment	9,328,166
Implicit cost on rent	3,632,530
Total fixed cost	12,960,696
D. Total production cost	92,242,540
E. Gross margin (A-B)	341,933,406
F. Net farm income	332,605,240
G. Returns with farm mgt (E-C)	328,972,710
Gross ratio A/(B+C)	0.22
Operating ratio (A/B)	0.20
Returns on capital invested (E/B)	4.3

Source: own elaboration.

Table 2 shows the technical efficiency level of farmers using AI in the study area. The range of technical efficiency of the farmers is 18.5–99.40%. The mean technical efficiency was 80.70%. This means that if there is 19.30% increase of the rate at which input is converted to output (100 – 80.70), the farmer will be operating on the production frontier. This indicates that there is still an opportunity for the farmers to increase their productivity and income through increased efficiency in the use of existing farming technology. This agrees with the result of Oladeebo and Ambe-Lamidi (2007).

Table 2. Distribution by technical efficiency estimates

Efficiency level (%)	Frequency	Percentages	Minimum	Maximum
1–20	1	1.7	18.50	20.0
21–40	3	5.0	24.00	29.08
41–60	2	3.3	55.35	57.03
61–80	18	30.0	66.94	80.47
81–100	36	60.0	82.62	99.40
Total	60	100		

Source: own elaboration.

The maximum likelihood estimates (MLEs) of the parameters in the stochastic production frontier model and technical inefficiency effect model are presented in Tables 3 and 4. The results obtained indicate that the effects are significant for the AI users with σ2 being significantly different from zero. Hence, indicating that the Cobb-Douglas production function is a representative model and that the majority of error variations are due to the inefficiency error *us* (not due to the random error *vi*). The significance and magnitude of the estimate for the variance parameter – γ (0.807) – supported the results from the likelihood-ratio tests as well. The maximum-likelihood estimate for the parameter γ is 0.807. This indicates that 81% of the variations in output are due to their technical inefficiency. Feed, vaccines and stock size were statistically significant in determining efficiency. As the Cobb-Douglas production function was applied, an estimator directly represents elasticity of independent variables. An increase in feed, vaccines and stock size by a unit will lead to an increase in output by 0.681, 0.009 and 0.032, respectively. Feed has been

Table 3. Stochastic production frontier of farmers using AI method

Variables	Coefficients	S.E.	t-value
Constant	6.532	1.050	6.218
Land	0.016	0.062	0.188
Feed	0.681*	0.093	7.315
Vaccine	0.009***	0.025	3.475
No. of egg set	0.148	0.127	1.165
Labour	0.006	0.079	–0.825
Stock size	0.032*	0.026	1.675

***Significant at 1%, **significant at 5%, *significant at 10%.
Source: own elaboration.

Table 4. Inefficiency parameters affecting productivity

Variables	Coefficients	S.E	t-value
Constant	–1.137	1.017	–1.118
Age	0.161	0.289	0.558
Education	–0.486**	0.231	–2.100
Business Commitment	–0.165	0.344	–0.478
Extension visits	0.929**	0.445	2.086
Poultry experience	–0.292	0.635	–0.460
Association	0.451	0.491	0.918
Sigma squared	0.297***	0.059	5.05
Gamma	0.807***	0.004	8.032

***Significant at 1%, **significant at 5%, *significant at 10%.
Source: own elaboration.

shown to improve productivity as well as vaccines to prevent diseases that would essentially cause mortality (also pointed out in Ahiale et al., 2019).

The estimated coefficients of explanatory variables in the model for technical inefficiency effects are of interest and have important implications as shown in Table 4. Given the specifications of the preferred model with an inefficiency effect, it is noted that education and extension visits are a statistically significant variable influencing technical inefficiency. Education was negatively significant at 5%, which implies that with rising levels of education there is an increase in technical efficiency, and this is true considering the level of technological sophistication. This agrees with the result of Ahiale et al., 2019. The extension was positively significant at 5%. However, past studies reported a negative relationship. This positive relationship, however, may result from the lack of trust among farmers on the potency of information received from the extension.

CONCLUSIONS AND RECOMMENDATIONS

The use of artificial insemination in broiler production is profitable, and production can increase given the technical efficiency estimates. Feed, vaccines and stock size were found to influence efficiency.

Therefore, recommendations are as follows:

- As artificial insemination is a capital-intensive, but very profitable, venture, the government should improve access to credit facilities that are affordable in order to enhance the use of this method vis-à-vis production;
- Proper education, training, and skill acquisition programme should be introduced for farmers in order to improve efficiency in the use of this method in production;
- Extension services should be overhauled, with the objective of enlisting the participants' confidence on the usefulness of information extension;
- Necessary inputs (like feed, vaccines, DOC, etc.) should be readily available for farmers that use this method of production to improve efficiency.

RESEARCH SUGGESTIONS FOR FUTURE RESEARCHERS

Another aspect to consider is the comparative analysis of artificial insemination and traditional method of breeding, comparing the cost and efficiency of each method under the same condition, even across continents.

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