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Full Length Research Paper

Determinants of adoption and intensity of use of brooding technology in Kenya: the case of indigenous chicken farmers in Makueni and Kakamega Counties, Kenya

[1]Christopher Njuguna K*,[2]Lucy W. Kabuage and [1]Eric K. Bett

[1]Department of Agribusiness Management & Trade, Kenyatta University: P.O BOX 43844, Nairobi, [2]Department of Animal Sciences, Kenyatta University: P.O BOX 43844, Nairobi.

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Indigenous chicken (IC) boosts the livelihoods of many smallholder famers in Kenya. IC constitutes 80% of poultry population in Kenya and kept by over 80% of the smallholders' rural households. To increase IC productivity, use of brooders remains an option. Brooders enhance chick's separation, reduce predation prospects, boost controlled temperatures and reduce trampling. However, information on determinants of adoption and use intensity of brooders among smallholder IC farmers in Eastern and Western Kenya remained scanty. Therefore, the study aimed at filling this gap. A total of 384 households were sampled using stratified random sampling procedure. A structured questionnaire was used to collect primary data. Secondary data was accessed from Makueni and Kakamega livestock offices. Descriptive analysis and Double-Hurdle econometric model were employed using STATA 13. Results revealed that farm size, training on poultry production and awareness of IC significantly influenced adoption decision. On the other hand, education level, household size, farm size, training on poultry production, distance to the training center and awareness of IC determined use intensity of brooders. We recommend that policymakers should target factors influencing adoption and use intensity of brooders. More infrastructures and extension agents should be deployed to boost information dissemination on brooding technology.

Keywords: Adoption, awareness, brooders, double-hurdle, intensity, indigenous chicken, training.

INTRODUCTION

Indigenous Chicken (IC) contributes positively to nutritional requirements, cultural practices and welfare of the smallholder farmers by providing high quality protein and income generation (Mapiye *et al.,* 2008; Okello *et al.,* 2010; Magothe *et al.,* 2012). The practice of IC rearing play a major role in the rural and peri-urban poor households by contributing significantly to food security (Hailemariam *et al.,* 2010). According to Okello *et al.,* (2010), there exist high demand of IC since consumers prefer to take its tasty and nutritious meat rather than exotic breed meat. However, despite the IC economic importance, low productivity has limited the standards of the smallholder farmers which contribute significantly towards the rural economic development (CSA, 2011). Increased mortality rate has been identified as a major cause of low productivity among smallholder farmers in rural areas (Mulugeta, 2013). Some of the environmental factors identified to have accelerated chicks' mortality include; weather conditions, predation and crowding effect (Mulugeta, 2013). As a pertinent development

*Corresponding author E-mail: chricat89@gmail.com

strategy, scientists and researchers recommend use of brooding technology to address climatic challenges that limits chick survivability. Malheiros *et al.,* (2000) asserts that provision of sufficient temperature is vital to boost performance of chicks during brooding stage. Further, brooders reduces prospects of predation, trampling and crowding effect resulting to increased survival rate (Matiwo *et al.,* 2014). Moreover, brooders enhance growth and survival of chicks through developing feathers (Mulugeta, 2013). However, smallholder farmers in rural areas prefer non-electric brooders to rear their IC due to limited electricity connections (Ahmad *et al.,* 2008). The non-electric brooders include; use of charcoal, hay-box, hot water, chepkubi brooders. In Makueni and Kakamega Counties, IC has been recognized as an avenue to improve livelihoods of the rural households by increasing productivity (USAID 2010). Stakeholders such as World Bank through Kenya Agricultural Productivity and Agribusiness Project (KAPAP), Kenya Agricultural and Livestock Research Institute (KARLO), Kenya Arid and Semi-Arid Lands (KASAL's), TechnoServe among others have pursued a vital role of improving the Indigenous Chicken through improving and disseminating poultry production technologies to the smallholder farmers in Makueni and Kakamega Counties. Brooder is one of the major technologies among others disseminated with the aim of increasing productivity. Thus, it remain relevant to identify the various determinants and intensity of use of brooding technology among smallholder farmers in Kenya.

Study area

Makueni County is located in Southern part of Eastern Kenya. It lies between Latitude 1°35′, South and Longitude 37°10′ East and 38°30′ East (RoK, 2010). This county comprises of an area of 8008.8 Km^2. Temperatures in Makueni county ranges between 12 ºC - 28 ºC and bimodal rainfall ranging from 150 mm to 650 mm per annum,which is typical of ASALs in Kenya (RoK, 2010) Low rainfall and high temperatures in this county hinder crop production thus livestock production remains a priority. On other hand, Kakamega county is located in Western Kenya and lies between longitudes 34^0 32'' and 35^0 57'30 East of the prime meridian and latitudes 0^0 07'30'' North and North 0^0 15'' of the equator (RoK, 2010). It covers a total area of $1394.8Km^2$. Annual rainfall ranges between 1250 – 1750mm (RoK, 2010). There was a rapid dissemination of brooders as one of the major components of poultryproduction technologies by the various stakeholders such as; KAPAP, KALRO and Technoserve in the two counties which are known to be main producers of indigenous chicken (Muthee, 2009 & KARI, 2011). Consequently, the two counties are located in areas that have favorable agro-ecological conditions that are required for the production of IC and are listed as leading areas in IC production (MoLD, 2011).

Sampling procedure and Data Collection

A multi-stage sampling procedure was used for the study. The first stage used purposive sampling of Kakamega and Makueni County which has a large population of small-scale farmers practicing IC production. The two counties had rapid dissemination of the improved poultry production technologies. The second stage used stratified random sampling to select regions within the sub counties located in Kakamega and Makueni counties. The random stratified sampling was preferred since it was able to reduce the biases associated with sampling. This ensured that there was no over presentation or under presentation of the smallholder farmers in the different strata. Subsequently the researcher randomly picked Lugari, Shinyalu and Lurambi districts from Kakamega County. Furthermore, the researcher randomly sampled Makueni and Kaiti from Makueni County**.**The total sample of 384 households includes adopters and non-adopters of brooder technology from Kakamega and Makueni County. Data was collected from the selected households using a structured questionnaire. Further, secondary data was accessed from the county agricultural offices located in Kakamega and Makueni.

Specification of Econometric Models

The utility that a smallholder farmer gets from adopting technology can be represented as U. The utility of a household that adopts technology can be represented by U^A_i, while that of a household that does not adopt technology can be shown by U^N_i. Hence, a household *i* will decide to adopt the technology if U= U^A_i-U^N_i > 0.The utility adoption will then be modeled as function of the observable characteristics of the ith farmer as shown in equation 1. The utility therefore is the unobservable part of the function.

$$U = \beta x_i + \varepsilon_i \quad \ldots\ldots 1$$

Where U* is a binary variable that represent the decision to adopt a technology and assumes value U=1 for adopters and U=0 otherwise. On the other hand X is a vector of independent variables to be estimated. While β represents the parameter of the variables to be estimated and ε is the error term. The error term is assumed to have a mean of zero and is normally distributed
A Double Hurdle approach was used to analyze data. It's a parametric generalization of Tobit model developed by Cragg in 1971. According to Cragg 1971, adoption is faced by 2 tiers; first is whether to adopt or not the technology and secondly is related to level of adoption. The assumption that we made was that the decision to adopt technology and the level of adoption were made in two different steps. The studies on adoption use different empirical models e.g. logit model (Adesina & Zimnah, 1993; Gillespie et al., 2014; Asarat et al., 2010) probit model (Ghimire et al., 2015) and dynamic models (Fisher,

Table 1. Description of dependent and independent variables.

Variable	Code	Type	Measurement
Adoption decision Brooder	D	Dummy	Yes = 1, No = 0
Age of the Household Head	AGE	Continuous	Years
Sex of the Household head	SEX	Dummy	Male = 0, Female = 1
Level of Education Head	EDUC	Continuous	No. of years in school
Household Size	HSESIZE	Continuous	No. o persons residing
Farm size	FARMSIZ	Continuous	Acres
Social group	SOCGRP	Dummy	Yes = 1 , No = 0
Type of social group	TYPESOC	Continuous	Main activities
Source of information on IC	INFSOU	Continuous	Number
Training on poultry production	TRAINPOUT	Dummy	Yes = 1, No = 0
Number of times trained	NOTRAIN	Continuous	Number
Distance to training center	DISTTRAIN	Continuous	Kilometers
Access to credit	ACCECRED	Dummy	Yes = 1, No = 0
Other off-farm activities	OFFFRMACT	Dummy	Yes = 1, No = 0
Awareness on IIC	AWARONIIC	Dummy	Yes = 1, No = 0

Source: Survey Data (2015); N=384.

2000) .The two tiers in the Cragg are represented based on Cragg (1971),

$D^*_i = \alpha Z_i + V_i$ ………………………… 2

$Y^*_I = \beta X_i + U_i$ …………………………3

Where D_i = {1, if D_i^* >0; 0 if $Di^* \leq 0$} and Y_i = {Y*, if $Y_i > 0$ and $Di^* > 0$; 0, if otherwise}

D_i^* - latent variable that makes the value 1 if the farmer adopt poultry technologies; 0 otherwise, Z_i– Vector of household characteristics explaining level of adoption; X_i- Vector of independent variables explaining the level of adoption(Table 1); U_i and V_i– Stochastic terms which are assumed to be independent .

The log likelihood function for the double-hurdle model is expressed as follows;

$$LogL = \sum_{/0} ln\left[1 - \phi(\alpha Z_i')\left(\frac{\beta X_i'}{\sigma}\right)\right] + \sum_{/+} ln\left[\phi(\alpha Z_i')\frac{1}{\sigma}\varphi\left(\frac{Y_i - \beta X_i'}{\sigma}\right)\right] \text{………… (4)}$$

Where Σ/0 = summation over the zero observations; Σ/+ stands for summation over positive observations; and ϕ and φ are the standard normal cumulative distribution functions and probability distribution functions respectively.

The study further carried out Tobit model to compare Likelihood Ratio tests (LR) with results from combination of Probit and truncated estimates to determine whether they were significantly different from each other. Additionally, confirm which model was superior on adoption decision. Cragg's assumption of independence between error terms V_i and U_i which entails combination of probit model and truncated model was considered.

The Tobit model was represented as;

$$\lambda = \frac{\beta}{\sigma} \text{and X=Z…..... (5)}$$

According to Greene (2000), the Likelihood Ratio statistic was computed using the following expression;

$$\Gamma = -2[lnL_T - (lnL_P + lnL_{TR}] \sim \chi^2_k \text{ …….. (6)}$$

Where L_T – Tobit model likelihood; L_P – Probit model likelihood; L_{TR}- Truncated Model likelihood; k – independent variables.

Table 1 presents the various dependent and independent variables that were used in the double-hurdle econometric model.

RESULTS AND DISCUSSION

Descriptive Results of the survey

Table 2 presents the socio-economic characteristics of the surveyed households. Descriptive statistics such as mean, percentages, frequencies were used to achieve a clear phenomenon of the sampled households. An independent sample T-test was also used to identify the independent variables that varied significantly between the adopters and non-adopters of the brooding technology.

Out of 384 smallholder Indigenous Chicken(IC) included in the survey, 66.15% and 33.85% were adopters and non-adopters of brooder technology respectively. The mean age of the adopter and non-adopters were 47.46 and 47.42 years respectively. Majority (72.66%) of the households were male headed while 27.34% were female headed. On average, 46.09% of household heads had attained secondary education and therefore majority would be able to read and write. The average household size was 3 persons for both adopters and non-adopters. However, there was significant difference in farm size between the adopters and non-adopters. Results in Table 2 reveals that the non-adopters had bigger acreage compared to adopters. The average size of farm was 2.2 and 2.6 acres for adopters and non-adopters respectively. The mean difference in farm size between the adopters and non-adopters was found significant at 1% level of significance. This depicts that farm size has a relationship with decision to adopt brooders in the study area. The mean flock size for the adopters (92 Indigenous chicken) was higher than that of non-adopters (61IC). The difference was significant at 1% level.

As shown in Table 2,there was significant difference in group membership with majority being the adopters (89.37%) while non-adopters were 68.48%. This depicts that adopters had more access to information and better interpretation of the available information concerning brooders. Additionally, training on poultry production between the two groups had a significant difference (Table 2). This supports that adopters had more access to information from various sources and might have an in-depth exposure through extension programs.Results also revealed that the number of times trained on poultry production for adopters was higher compared to non-adopters thereby creating more willingness to brooders adoption decision. The difference was significant at 1% level. It is also worth noting that walking distance to the training point was significantly higher for adopters. The mean distance covered was 2.13 and 1.63 kilometers for adopters and non-adopters respectively. Thedifference on distance to training point was statistically significant at 1% level.The proportion of farmers with access to credit was significantly higher for the adopters. This depicts that farmers who had access to formal credit were more probable to adopt the brooding technology. As shown in Table 2, 99.21% and 90.77% of the adopters and non-adopters respectively were aware of IC. There is significant differences in level of awareness between the two groups at 1% level of significance. The implication is that farmers who have heard or read about brooders had higher probability of accepting and adopting the intervention.

Table 2. Summary of socio-economic characteristics of respondents.

Variables	Unit	Adopters (N=254)	Non-adopters (N=130)	T-stat
Dependent variable				
Adoption of brooder(Yes=1, No=0)	1/0			
Age	Years	47.46	47.42	-0.037
Gender of Household head (male=0)	1/0	0.27	0.28	0.351
Education of household head(male=0)	1/0	2	2	0.496
Household size	Count	2.8	2.7	-1.140
Farm size	Acres	2.2	2.6	4.056***
Flock size	Count	92	61	-3.445***
Social group(Yes=1, No=0)	1/0	89.37	68.46	-5.425***
Training on poultry production(Yes=1, No=0)	1/0	92.91	71.54	-5.895***
Number of times trained on poultry	Count	3.2	2.3	-4.546***
Distance to training center	Km	2.13	1.63	-3.690***
Access to credit(yes=1, No=0)	1/0	37.4	20	-5.202***
Other off-farm activities(yes=1, No=0)	1/0	46.06	44.62	-0.269
Awareness on IC(yes=1, No=0)	1/0	99.21	90.77	-4.265***

Source: Own computation ***significant at 1%, **significant at 5%, *significant at 10%; N=384.

Table 3.T-statistics on double hurdle (Probit + Truncated model) versus Tobit model.

Brooders	Probit, D	Truncated, Y>0	Tobit, 0≤Y≤1
Log likelihood	-214.5344	301.7895	-320.2285
No. of observation	384	254	384
Test statistics: $\Gamma = 814.967 > \chi^2_{0.100,14} = 21.06$			

Table3 illustrates the LR –test results which suggest the rejection of the Tobit model. The test statistic Γ = exceeds the critical value of the χ^2distribution as shown in Table3. Probit model likelihood = -214.5344; Truncated Model likelihood = 301.7895 and Tobit model likelihood = -320.2285. Thus, the computation was;

$\Gamma = -2 [-320.2285 – (-214.5344 + 301.7895)]$

$\Gamma = -2 [-407.4836)$

$\Gamma = 814.9672$

The above test statistics was Γ = 814.9672 and above the tabulated value [χ_k^2 (14) =23.68] at a 5% level of significance. Thus, the double hurdle better fitted the data compared to Tobit Model.

Table 4presents the factors that influence the decision of smallholder farmers to adopt brooding technology. There were 3 independent variables that were found significant to influence the decision to adopt brooders. These included size of the farm, training on poultry production and awareness of brooders.

Farm size had significant effect with negative sign in decision to adopt (Table 4). It was statistically significant at 5%(p=<0.050) level of significance The marginal effects indicate that an increase in land size by one unit while holding other variables constant, decreased the probability of adoption decision by 7.88 per cent (Table 4). The implication for these results is that the subsistence nature of IC farming which might be due to small size farm requirements of the brooding technology in the areas of study. The results for the 1st hurdle are consistent with findings of Mal *et al.,* (2012) where farm size negatively influenced the decision of adopting Bt Cotton in North Indian farmers. However, the findings contradict Katengeza *et al.,* (2012) where farm size positively influenced the decision to adopt improved maize variety adoption in drought prone areas of Malawi.

Training on IC production had a positively effect on decision to adopt brooders (Table 4). The variable was statistically significant at 10% (p=<0.100) level of significance. The marginal effect showed that a unit increase in training on IC production increased the adoption decision by 19.86 percent (Table 4). This is an implication that farmers who access training are most likely to use brooders in rearing their IC. Therefore this will increase productivity and reduce prospects of predation and reduce mothering period. The results are consistent with those of Gebremichael and Gebremedhin (2014) where farmer access to trainings from the extension officers had positive significant effect on adoption of improved box hive technology among smallholder farmers in Northern Ethiopia.

The results in Table 4 shows that awareness of improved indigenous chicken positively influenced the decision to adopt the brooders at 1% (p=<0.001) probability level.

Table 4. Probit model on factors influencing decision to adopt the brooding technology.

Brooders	Marginal effect $\partial y/\partial x$	Std. Err.	Z	P>|z|
Age of the respondent	-0.0013	0.0022	-0.58	0.560
Gender of household head	-0.0668	0.0496	-1.35	0.179
Level of education	-0.0285	0.0282	-1.01	0.311
Household size	0.0101	0.0280	0.36	0.718
Size of the farm	-0.0788	0.0262	-3	0.003**
Social group	0.0876	0.0771	1.14	0.256
Type of social group	0.0053	0.0148	0.35	0.723
Source of information on IC	-0.003	0.0044	-0.29	0.773
Training on poultry production	0.1986	0.1050	1.89	0.059*
Number of times trained	0.0028	0.0169	0.16	0.870
Distance to the training center	0.0027	0.0231	0.12	0.905
Access to credit	0.0646	0.0523	1.23	0.217
Other off- farm activities	0.0034	0.0461	0.07	0.942
Awareness of IIC	0.4466	0.1335	3.35	0.001***

Source: Own computation ***significant at 1%, **significant at 5%, *significant at 10%; N=384

The possible justification was that farmers who have read, heard or educated on improved indigenous chicken are more likely to adopt brooders. These farmers will tend to allocate more resources in order to facilitate for more brooders which enable accommodate more chicks. These findings are consistent with those of Tambo and Abdoluaye (2011) which revealed positive significant effect on adoption of climate change and agricultural technology of drought tolerant maize in rural Nigeria.

The results of the intensity of use of brooders are presented in Table 5. These are the factors that influence the intensity of use of brooders. There were 6 independent variables that were found significant to influence the intensity of use of improved brooding technology. These included level of education of the household head, household size, size of the farm, awareness of IIC, training on poultry production and distance to the training point.

The variable of the level of education as shown in Table 5 had a positive and significant effect on the intensity of adoption of brooding technology. It was statistically significant at 10% (p=<0.100) level of significance. This implies that educated farmers are more proficient in accessing and utilizing brooders. Moreover this information is accessed from relevant sources based on the brooding technology benefits. These findings are in line with of those of Kuti (2015) where education had a positive and significant effect on use intensity of improved maize varieties in Osun State, Nigeria. However, the findings contradict Mal *et al.,* (2012) results where education had a negative and significant effect on intensity of adoption of Bt Cotton in North Indian farmers.

Table 5 shows that household size had a positive and significant effect on the intensity of use of brooding technology. It was statistically significant at 10% (p=<0.050) level of significance. This may imply that those families with more members are more likely to increase the frequency of using brooders during IC production. This was then aimed at increased productivity. The finding conforms to the study by Asfaw *et al.,* (2011) where the size of household had a positive and significant effect on intensity of use of agricultural technology adoption in Ethiopia. However, the results contradicts those of Beshir (2014) where household size had a negative and significant effect on the intensity of using of improved forages in North East Highlands of Ethiopia.

On the other hand, results in Table 5 farm size showed a positive effect on the intensity of adopting the brooding technology. It was statistically significant at 10% 10% (p=<0.100) level of significance. The implication for these results is that the subsistence nature of IC farming which might be due to small size farm requirements of the brooding technology in the areas of study. These findings are in line with those of Akpan *et al.,* (2012) where farm size passed the 2[nd] tier with a positive effect on use intensity of optimum fertilizer among farmers in Southern Nigeria. However, the results contradict those of Mal *et al.,* (2012) where farm size had a significant and negative effect on the intensity of adopting Bt Cotton among farmers in North Indian.

The results in Table 5 show that awareness of improved indigenous chicken (IIC) had a positive effect on intensity of use of brooders at 1% (p=<0.001) probability level. The possible justification was that farmers who have read, heard or educated on improved indigenous chicken are more likely to adopt brooders. These farmers will tend to allocate more resources in order to facilitate more brooders which enable accommodate more chicks. These findings are consistent with those of Tambo and Abdoluaye (2011) which revealed positive significant effect on adoption of climate change and agricultural technology of drought tolerant maize in rural Nigeria.

Training on IC production had a positive effect on use intensity of brooder technology (Table 5). The variable was statistically significant at 10% (p=<0.100) level. This is an implication that farmers who access training are most likely to use brooders in rearing their IC. Training might help farmers in creating awareness and promote the understanding about the advantages of information availability on brooders. Additionally, training enlightened farmers resulting to more appreciation of the technology. Therefore this will increase productivity and reduce prospects of predation and reduce mothering period. The results are consistent with Kuti (2015) where farmer access to trainings from the extension officers had positive significant effect on intensity of use of improved maize varieties in Osun State, Nigeria.

Results of the 2[nd] hurdle on use intensity of brooding technology as shown in Table 5 show that distance to the training center was statistically significant at 10% (p=<0.100) though had a negative influence. The truncated results indicated that as the distance to the training center is increased by one kilometer, the intensity

Table 5. Truncated model on factors influencing the intensity of use of brooding technology.

Brooders	Coef.	Std. Err.	Z	P>|z|
Age of the respondent	0.0010	0.0007	1.53	0.127
Gender of household head	0.0183	0.0138	1.33	0.183
Level of education	0.0205	0.0109	1.89	0.059*
Household size	0.0241	0.0130	1.86	0.064*
Size of the farm	0.0216	0.0115	1.88	0.060*
Social group	-0.0498	0.0505	-0.99	0.325
Type of social group	-0.0011	0.0017	-0.65	0.517
Source of information on IC	0.0015	0.0012	1.26	0.207
Training on poultry production	0.1071	0.0632	1.69	0.090*
Number of times trained	0.0048	0.0038	1.26	0.209
Distance to the training center	-0.0075	0.0045	-1.66	0.097*
Access to credit	0.0002	0.0057	0.04	0.970
Other off –farm activities	-0.0113	0.0080	-1.41	0.158
Awareness of IIC	0.7296	0.1367	5.34	0.000***

Source: Own computation ***significant at 1%, **significant at 5%, *significant at 10%; N=384.

use of brooders decreased by 0.75 per cent holding other variables constant. The negative relationship implies that the further the distance between the farmers residence and the training center, the lower the intensity of use of brooders. The implication of this may be due to the relative proximity to training centers which reduces production and opportunity costs. The finding concur with Bayissa (2014) where distance to the training point had a negative significant effect on intensity of use of improved Tef technologies in Diga District.

CONCLUSION AND POLICY IMPLICATIONS

The study identifies the factors influencing the decision to adopt and intensity of use of brooding technology among smallholder farmers in Makueni and Kakamega counties, Kenya. Results from the econometric analysis revealed that size of farm, training on IC poultry productionand awareness on improved indigenous chicken are statistically significant decision variables influencing the probability to adopt brooders. On the other hand, intensity of use of brooders was influenced by level of education of the household head, household size, farm size, distance to the training point and awareness on improved indigenous chicken. We recommend that policies should be formulated to take advantage the factors influencing farmer's adoption of brooding technology.More infrastructures and extension agents should be deployed by the government to boost and disseminate information on improved poultry production technologies to smallholder farmers. This would facilitate effective training, improve education and frequent extension services. Moreover, there will be increasedlevels of awareness among the smallholder farmers.

CONFLICT OF INTEREST STATEMENT

The authors whose names are listed in the authors list certify that they have no affiliations with or involvement in any organization or entity in the subject matter or materials discussed in this manuscript. Therefore, we declare that we have no competing interests.

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