Technical Efficiency of Improved Indigenous Chicken Producers in Kenya: A Stochastic Frontier Approach.

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Abstract

Indigenous chicken (IC) is kept by 80% of the rural population for both meat and egg production in Kenya. However, IC has been dogged by numerous challenges leading to low productivity. These challenges include low growth rate, low egg production and high incidences of pests and diseases. In order to overcome these problems KARI (Kenya Agricultural Research Institute) now KALRO (Kenya Agricultural and Livestock Research organization) improved the local indigenous chicken and called it the KARI improved indigenous chicken which matures at four and half months (starts laying and ready for meat), lays 180 to 250 eggs per year compared to 60 to 100 of the IC in the same period. Results from the study indicated that efficiency level was low (58%) though there was room for improvement. All input variables considered were positive and significant had a direct effect on the output (eggs produced per month). Some of the socio-economic factors that influenced a farmer's technical efficiency included household size, access to extension services, distance to input and output markets and the tarmac. The result indicate that farmers are not utilizing available resources effectively and therefore there is need for capacity building on management practices.
Key words: Stochastic frontier, improved indigenous, efficiency, variables, resources, Kenya.

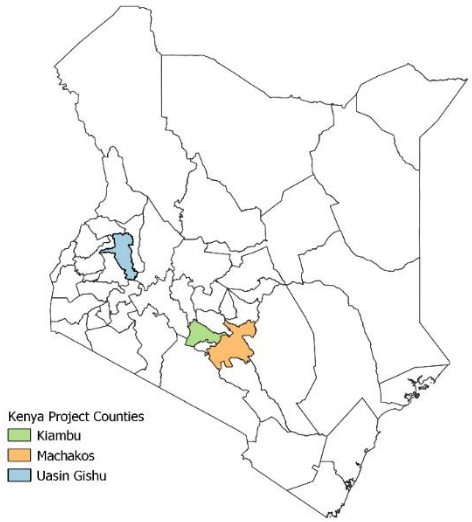
1.0: Introduction

Agriculture contributes 25% to Kenya's GDP of which 30% is from the poultry sector [1. Most rural families in Kenya (an estimated 75%) keep chicken. The most common is the indigenous chicken (IC) which contribute 71% of the total egg and poultry meat produced in Kenya and therefore impact significantly on the rural trade, welfare and food security of smallholder farmers [2]. Kenya has an estimated 43.8 million chicken contributing 5.1 % of the total livestock value added [3]. The poultry sector is highly heterogeneous and produces more than 35 000 tonnes of meat and 1.6 billion eggs [4]. Majority of indigenous chicken are found in rural areas while broilers and layers are kept in urban areas. Kenya is anticipated to face an unprecedented growth in demand for food in the next 30-40 years. The growing, increasingly affluent and urbanized Kenyan population will consume more high value food, such as meat, milk and eggs. Currently, per capita consumption of meat is low, averaging no more than 10kg for any type of meat. Supply projections for poultry show a rise from 26,000 tonnes in 2010 to 48,000 tonnes in 2030 and 71,000 tonnes in 2050, representing a 174% rise. However, this is dwarfed compared to the projected egg rise – from 87,000 tonnes in 2010 to 537,000 tonnes in 2050 [4]. The country has recorded substantial growth in commercial chicken production in the past decade, especially in urban and Peri-urban areas within and around Nairobi, Kiambu, Thika, Nakuru, Nyeri and Mombasa. This has been prompted by increased demand for chicken products in urban areas as a result of changing consumer perceptions in favour of white meat as an alternative to red meats besides the low retail prices and ease of preparation. However, the global and regional poultry sector has become very competitive due to improved technologies and innovations, product differentiation and cost management. Kenyan poultry farmers and entrepreneurs have been protesting over the influx of eggs from Uganda and China, complaining they are struggling to break even due to the high cost of production and low returns on investment. Given the scarce resources farmers must be efficient in order to improve productivity and avoid wastage. According to Bielik, technical efficiency is the ability of a farm to produce maximum output from a given set of inputs [5]. There has been no study carried out to assess the technical efficiency of the improved indigenous chicken in Kenya. Assessing the efficiency levels of farmers is very vital in assessing profitability, because it demonstrates how a farmer distributes his/her resources to achieve maximum returns from the enterprise. In a study in Nigeria technical inefficiency caused 69% deviation in the output of poultry egg production [6]. Results from a study carried out in Uganda indicated that the technical efficiency of layer poultry farmers was 81% with over 90% operating at TE levels above 50% [7]. Despite there being an increasing demand for indigenous chicken (IC) products by local consumers, their low productivity attributed to high disease incidences, inadequate nutrition, low genetic ability and poor marketing channels, reduce their contribution to rural development [8]. The chicken are kept under scavenging production systems with limited application of management interventions to improve flock productivity. With constraints such as diseases, lack of proper housing and insufficient feed, the productivity of these chicken is usually low, concluded a study carried out in Swaziland [9]. To counter some of the problems like low productivity and slow maturity, Kenya Agricultural and Research Organization (KALRO) bred a fast growing chicken with higher egg productivity popularly known as KARI Kienyeji chicken. Breeding, selection, upgrading and multiplication geared towards improving productivity of indigenous chicken in Kenya to meet changing market demands took place at KALRO Naivasha in early 2000s. The improved indigenous chicken is high performing and produces 180-250 eggs compared to 80-100 of the local ones per year. It attains market weight at 4 to 5 months. Little or nothing is known about the level of technical efficiency of improved indigenous chicken producers in Kenya hence the reason for carrying out this study. The specific objective was therefore to determine the technical efficiency of these producers.

2.0: Materials and Methods

2.1. Study Sites

The study was carried out in Machakos, Uasin Gishu and Kiambu counties in Kenya. Machakos County is situated in the eastern part of the country with an average rainfall of between 500 mm and 1300 mm which is usually unevenly distributed and unreliable. The County had 862,592,000 indigenous chicken in 2019 [10]. Uasin Gishu is located north of the rift valley. The County has 93,611 sheep, 27,216 goats, 140,703 exotic birds, 400,000 local birds and 7,292 pigs. Kiambu County is one of the richest and 2nd most populated County (with 2.4 M people) in the Republic of Kenya. Agriculture is the predominant economic activity and had 2.6 M poultry in 2019 [10].



2.2. Research and sampling Design

A situation analysis was conducted to map out the targeted population within the respective target counties. The result from the situation analysis will be used to prepare a sampling frame to guide the study. Chicken farmers rearing indigenous and improved indigenous breeds were the target population. Purposive sampling was used to select the study areas in this case, counties. They were selected according to population size of birds (improved indigenous) which were obtained from secondary sources like County Livestock reports and sales reports from KALRO Naivasha (which is the source). For a farmer to qualify as respondent s/he must have been keeping 20 birds or more at the time of the study. Thereafter stratified sampling technique will was used to select the different sub groups. After stratification, simple random sampling was used to select respondents.

2.3. **Sample Size**

The population of chicken producers was unknown therefore the Cochran formula for infinite population was used.

$n_o=z^2pq/e^2$
where, n_o = sample size
z = selected critical value of desired confidence level
p = estimated proportion of an attribute that is present in the population
$q = 1- p$ and e is the desired level of precision
The assumption is that the maximum variability is equal to 50% (p=0.5) at 95% confidence level with ±5% precision. The calculation will be as follows:
P=0.5 and hence q=1-0.5, e=0.05 and z=1.9
n_o= $(1.96)^2 (0.5) (0.5)/(0.05)^2$ =**384.16** (Cochran 1977)
2.4. **Data types**

Both primary and secondary data were collected during this study. Quantitative data was collected using structured questionnaires which were administered through face to face and telephone interviews. The questionnaires were uploaded into android cell phones via computer assisted personal interviewing

(CAPI) method. This aided in reduction of errors by enumerators by ensuring that all questions in the questionnaire were answered. Location of farmer homes was also recorded through GPS data. Secondary data was collected through desktop reviews and statistics from the ministries of Agriculture and Livestock and Trade and Industrialization.

2.5. **Empirical Model Specification**

The stochastic frontier production function approach (SFA) was used for measuring technical efficiency in this study. There are two basic empirical approaches used to measure production efficiency i.e: mathematical programming techniques of estimating a frontier relationship usually referred to Data Envelopment Analysis (DEA) and econometric techniques that are either deterministic or stochastic. Following the pioneering work of Farrell [11], the theoretical and applied research in this area has become rich [12, 13]. The stochastic frontier approach incorporates a composed error structure with a one sided inefficiency component and a two-sided symmetric random component [12]. The inefficiency component is used to obtain firm specific or average efficiency with the random component picking up the effect of uncontrolled random shocks, such as weather, measurement error, disease and other statistical noise. By contrast, the DEA and deterministic models assume any deviation from the frontier is due to inefficiency and consequently they do not allow for random shocks, which is unrealistic. Random error may not be zero even if a farm uses a best practice technique due to errors of measurement, weather and other factors.

This study uses the stochastic frontier approach in which there are many variants in model specification and distribution of the unknown variance of the efficiency component. We assume a modified Cobb-Douglas specification and specify the following frontier production and inefficiency models that are variants of Coelli and Battese [14]:

$q = f(k, l) = A\, k\, \alpha\, l\, \beta,$
Where A, α, β are constants. The production function is presented as follows:
$\ln Y_i = \alpha + \beta 1 \ln X1 + \beta 2 \ln X2 + \beta 3 \ln X3 + \beta 4 \ln X4 + \ldots\ldots\ B8 \ln X8 + \mu;$
Yi represents the output of the i^{th} farmer measured in number of eggs per month. The variables in the model include:
X1 = No. one day old chicks
X2=quantity of water used in litres
X3 = Labour (man-days)
X4 = Quantity of poultry feed in kilograms
X5 = Quantity of vaccines (mls) administered
X6 = Quantity of energy used measured in amount of cash used
X7= Flock size (No. of birds kept for eggs)
X8=Production system (1=intensive, 2=semi-intensive, 3=free range)
Factors that influenced technical inefficiency of the chicken producers were specified as follows:
$R = \beta 0 + \beta 1X1 + \beta 2X2 + \beta 3X3 + \beta 4X4 + \beta 5X5 \ldots \ldots + \beta nXn + e$
Where: R= Technical Efficiency
X1=Marital Status
X2=Sex of household head
X3=Age in years
X4= Education (No. of years of schooling)
X5=Experience in poultry production (No. of years)
X6= Main occupation of farmer
X7=Distance to the input market (Km)

X8=Distance to the output market
X9=Credit access
X10=Access to livestock extension services

3.0. Results and Discussion

3.1. Stochastic Production Frontier Estimation

Table 1 below presents the Maximum Likelihood Estimate (MLE) results of the Cobb-Douglas stochastic frontier production function. Feeds, labour, veterinary, energy, and water costs have a positive influence on technical efficiency. This implies that these factors have a direct effect on the output (number of eggs laid in a month). Quantity of purchased feeds had a coefficient of 0.215 and highly significant at 1%. Another factor which was highly significant at 1% was labour (0.173). This concurs with previous studies carried out in Ghana and Nigeria which reported similar results [15] and [16]. The implication here is that the more commercial feed used the higher the output. A unit increase in quantity of commercial feeds used caused a 21% increase the number of eggs laid. This could be attributed to the fact that commercial feeds contain a range of macro and micro nutrients for the different stages of growth. For egg production, majority of chicken are fed with layers which mostly boosts egg production. There was a positive and significant relationship between labour and the output. Majority of improved indigenous chicken are reared in semi-intensive production system which requires some amount of labour especially for feeding, cleaning, administering drugs and egg collection. One of the major challenges in chicken production as cited by farmers was diseases with some causing 100% deaths and others lowering productivity. The results here indicate that veterinary services positively affected TE of the farmers in the three counties. The implication is that as disease incidences reduced, the productivity of the chicken enterprise increased. Though not statistically significant, the breed of chicken kept affected the output in terms on quantity of eggs laid. Both local and the improved indigenous chicken had a negative effect on output. This could be attributed feeding or production systems whereby some farmers kept both breeds at free range or semi intensive system. Some farmers were not supplementing the locally available feeds due to increased prices of feeds in the country.

3.2. Technical Efficiency level scores

Table 1: Stochastic Frontier Analysis

Technical efficiency refers to the ability of the farms to achieve maximum outputs given a set of inputs. The results presented in table 2 indicate that the mean TE of the sampled and interviewed chicken producers was 58% with Machakos County having the highest (60%) and Kiambu the lowest. These results imply that on average, the farmers could only achieve 58% of the maximum output from a given mix of production inputs. To attain maximum productivity levels within a given set of inputs, they need to improve their efficiency by 42%. Majority of the farmers (69%) attained 41% to 50% technical efficiency levels, while a negligible number attained TE levels of between 61% and 80%. This could be attributed the small flock size per household (64) and number of laying hens (25) which utilized similar resources as of

Production factors (TE)	Coefficients (TE)	Std Error
Constant	1.802 (0.000)	0.466
Total quantity of purchased feeds per month	0.215 (0.000)***	0.036
Total Quantity of un-purchased feeds per month	0.009 (0.745)	0.032
Labour days spent in production	0.173 (0.000)***	0.039
Veterinary cost	0.119 (0.002)***	0.040
Cost of transport	-.061 (0.125)	0.039
Energy and water cost	0.088 (0.018)**	0.037
Poultry Housing	0.065(0.021)**	0.028
KARI improved Chicken	-0.017 (0.528)	0.028
Local Chicken	-0.022 (0.471)	0.029
Machakos County	0.244 (0.441)	0.316
Kiambu County	0.339 (0.274)	0.310
Uasin Gishu County	0.281 (0.372)	0.314
The asterisks represent t statistics at different confidence levels *, ** and * i.e 1%, 5% and 10% respectively**		

100 birds for example vaccines and labour. Studies elsewhere recorded similar results; for instance, a study carried out in Cross River State, Nigeria to analyze the TE of poultry farmers recorded a mean TE score of 58% [17]. Another study in the same country on TE of family poultry production recorded a mean TE score of 63%, [18].

Table 2: Distribution of Technical efficiency scores for improved indigenous chicken farmers.

Efficiency levels	Frequency	Percentage	Cumulative
0 - 0.40	7	1.83	1.83
0.41 - 0.50	262	68.59	70.42
0.51- 0.60	104	27.23	97.64
0.61 - .70	8	2.09	99.74
0.71 - .80	1	0.26	100
TOTAL	384	100	

3.3. Socio-economic and institutional factors influencing technical efficiency of improved indigenous chicken in Kenya.

Several socio-economic factors affected the technical efficiency of chicken farmers in the sampled areas. They included education of the household, age of household head, access to extension services, farming experience of household head, total land owned and distance to the tarmac road. These factors were statistically significant at different confidence levels (1%, 5% and 10%). Education level of the household had a negative coefficient and significant at 5%. This implies that an extra year in school increased the farmers' technical efficiency by 4.9%. This outcome concurs with several studies carried elsewhere where education level of farmers reduced technical inefficiency of poultry farms [20], [7] and [15]. The reason could be that more educated farmers tend to get information on new technologies and innovations faster than the less educated. They are also able to access social and digital space where a lot of information is shared. When it comes to training, they grasp topics faster and might have capital to invest in trials of different techniques of farming. Some areas in poultry farming that require some knowledge include breed selection, artificial incubation, vaccination, disease management and marketing (digital). However, there was a contradicting result in a similar study carried out in Indonesia where higher education level contributed to increased technical inefficiency [21]. Farming experience (in years) had a negative coefficient and was significant at 1% implying that an extra year in farming decreased technical inefficiency. The more time one spends in an activity, the better they become in carrying out the same. Farmers with more years of rearing chicken are able to detect diseases faster, administer drugs easily and have wider market networks compared to the less experienced ones. They are also able to avoid mistakes and apply cost minimizing strategies to increase their profits. This concurs with similar studies carried out in different countries whereby farmer years of experience had a positive influence on technical efficiency [19], [20] and [15]. However, other studies found out that more experienced farmers were less efficient maybe due to routine which became boring while other farmers were rigid and did not want to try new technologies [22]. In other studies, farmer experience did not influence their technical efficiency [7] and [19]. Another factor which influenced TE of chicken farmers in the three counties was total land owned which was significant at 1%. This is consistent with a study carried in Nigeria, Tanzania and Tanzania [23] but contradicts a study carried out in Uganda which found out that total land owned did not influence the technical efficiency of farmers [7]. Land is key in production of crops which are used as raw materials for chicken feed. Some crops which are key in formulation of chicken feed include maize, sunflower, cotton, soya beans, sorghum and vegetables. Majority of the farmers in the sampled areas indicated that they were formulating their own feed with some mixing some ingredients with the commercial feeds. As much as land is key for crop and livestock production it might not be necessarily true for chicken production with new innovations on construction of vertical/storeyed chicken houses in place. Intensive and semi-intensive production systems don't require large sizes of land to establish. Age of household had positive coefficient and was significant at 10% implying an extra year of the household head increased technical inefficiency in improved indigenous chicken production. Aged farmers tend to ignore new technologies and innovations and majority do not access digital farming platforms. This agrees with previous studies which reported that age increased technical inefficiency and that younger farmers were likely to be more efficient that the older ones [20], [15], [8] and [7]. However, it contradicts studies which indicated that the older the farmer the technically efficient s/he is [15], [25], [26] and [27]. Another institutional factor affecting technical efficiency of chicken farmers in the sampled areas was distance to tarmacked road which was significant at 5%. Farmers need to transport both inputs and outputs and the nearer the tarmac road the faster one can access the market. A kilometer less from the tarmac road increased the farmers' technical efficiency and vice versa. This concurs with previous studies carried out in Bangladesh and Honduras which recorded a similar finding [28, 30]. Access to extension services had a negative coefficient and significant at 10% implying that the more a farmer accessed extension services, the more efficient s/he was. Extension services include training, introduction of new technologies and innovations, pest and disease management and market linkages. Chicken production is faced with many technical challenges hence the need for support from the extension staff. Some of the extension services required by farmers include feed formulation, vaccination, artificial incubation, disease management and market information. This result concurs with others obtained in previous studies which found out that extension contact increased the efficiency of farmers [24, 28, 20, 29, 15]. Studies elsewhere did not find any significant effect of access to extension services on TE of farmers [7] and [31].

Table 3: Determinants of technical inefficiency

Inefficiency factors	Coefficients	Std Error
Gender of the household head	-0.025 (0.132)	0.016
Education of the household head	-0.005 (0.511)	0.008
Age of the household head	0.150(0.456)	0.201
Marital status	0.0005 (0.953)	0.008
Occupation of the household head	-0.008(0.458)	0.011
Household size	-0.005 (0.006)**	0.002
Access to extension services	-0.034 (0.008)**	0.013
Member of a chicken farmer group	-0.012 (0.332)	0.013
Experience of the household head	-0.008 (0.302)	0.008
Access to information	-0.003 (0.873)	0.018
Total land owned in acres	-0.002 (0.538)	0.003
KALRO Breed	-0.003(0.754)	0.010
Local Breed	-0.020 (0.072)*	0.012
Distance to input market	0.045 (0.010)**	0.017
Distance to output market	-0.051 (0.002)***	0.016
Distance to the tarmac road	-0.032 (0.017)**	0.013
Constant	0.288(0.241)	0.245

The asterisks represent t statistics at different confidence levels ***, ** and * i.e 1%, 5% and 10% respectively.

4.0: Conclusion and policy implications

A stochastic frontier analysis approach is used to analyze the technical efficiency of improved indigenous chicken producers in Kenya. Results from the study indicate that there is room for improvement of efficiency if available resources are allocated proficiently. Several operational factors have been positive and significant implying that they directly affected the output (number of eggs). Some these factors include feeds, labour, veterinary services, energy, water and housing. Transportation has a negative coefficient implying that the longer the distance, the less the efficiency of the farmers. The average technical efficiency score is 58% implying that there is room for improvement to attain maximum productivity. Socio-economic factors contributing to farmers' technical inefficiency include household size, access to extension services, chicken breed, distance to the input and output market and finally distance to the tarmac (all weather road). For farmers to operate optimally there is need improve their efficiency by reducing cost of feeds, improving infrastructure especially roads and engage/recruit more extension services. Cost of feed Kenya has doubled since 2020 leading to low production with some farmers abandoning the enterprise completely. The government should provide some subsidies and incentives (removal or reduction of taxes levied on poultry feeds and their raw materials). Farmers also need to increase their flock size to enjoy economies of scale and eventually make profits. County governments need to increase the number of extension officers especially in the rural areas where one officer covers a vast area leading to high incidences of diseases and mortality rate.

Recommendation for Future Research

Future research could look at technical efficiency of farmers keeping local indigenous and exotic birds for egg production.

Author contribution
Data collection and analysis, SW, manuscript preparation, SW, editing and proof reading, IM and GM.
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