

Technical Efficiency Analysis of Broiler Production in the Mampong Municipality of Ghana

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Abstract

This study adopted the stochastic frontier model to assess the technical efficiency of broiler farmers in the Mampong Municipality using cross-sectional data collected from the last production cycle 2017. By using the Cobb-Douglas functional form, inputs such as feed, flock size and water were all found to be statistically significant and had positive influence on technical efficiency of the sampled broiler farmers in the study area. Individual levels of technical efficiency ranged between 42% and 99% with a mean of 87%, suggesting that in the short run, the poultry farmers can still increase the efficiency of resources used at the farm level up by 13%. The determinants of technical inefficiency among the poultry farmers included age, education, farmers' experience and number of extension visits. Issues related to predators prevalence and competition from foreign imports were ranked high among the challenges of the broiler production sector. For improved efficiency and maximum production of broilers, there is the need for increased feed and water intake while encouraging farmers to increase their capacities of stocking. There is also the need to increase extension contact and introduction of non – formal education to farmers.

Keywords: Stochastic frontier, technical efficiency, broiler poultry, Mampong, Ghana

DOI: 10.7176/JESD/10-14-15

Publication date: July 31st 2019

1. Introduction

In Africa, agriculture is the main source of livelihood for many households. This is largely due to the greater number of people living in rural areas. The agricultural sector in Ghana holds a share of about 56% of the labour force while contributing 19% to the country's Gross Domestic Products [GDP] (Ministry of Food and Agriculture [MoFA], 2017). However, over the last decade, the share of agriculture in the national GDP has drastically decreased from about 29% in 2007 to 19% in 2016 (MoFA, 2017).

Similarly, the livestock sub-sector and poultry production in particular have also followed same declining trend. According to Randon and Ashitey (2011), commercial poultry production in Ghana grew rapidly in the 1980-1990s, becoming a vibrant industry that supplied 80% of the available poultry meat and eggs in the country. The sector further experienced exponential growth annually especially from 2000 to 2007 and within that period the sector realized an 80% increase in production (Food and Agricultural Organization [FAO], 2010). However, in recent times, poultry production in the country has experienced a decline amidst growing domestic demand for poultry products. The country, in effect, heavily relies on frozen chicken products imported annually from the U.S., the European Union and other parts of the world (Ashitey, 2017).

The domestic poultry industry currently faces stiffer competition from imported poultry products that tend to be about 30–40% cheaper than chicken from domestic producers (FAO, 2014). This has further aggravated the production challenges of the local poultry industry and has dimmed the sector's potential role in socio-economic development of the country. Farmers in the poultry sub-sector have consistently called for input subsidies and other import regulations to enable them compete fairly with imported ones. The growing concern is whether the poultry sub-sector is economically vibrant and have better returns on investment. Ashitey (2017) noted that there is no profitability in poultry production business especially broiler production. Several factors including feed cost which constitute about 60–70% of the cost of production have been cited as a major challenge facing the poultry industry. These raise questions about farmers' production efficiencies in the sub-sector. Ekunwe *et al.* (2006), argued that many poultry entrepreneurs approach poultry production with mere enthusiasm rather than the actual knowledge of basic poultry production techniques that can help maximize production with effective combination of inputs. With limited research on production efficiencies in the poultry sector in general in Ghana, this paper assesses technical efficiencies of broiler farmers using stochastic frontier modelling, and to profile the determinants of technical inefficiency. This will help inform policy strategies designed to improving productivity and enabling local producers compete favourably in the local poultry market.

2. Related Studies

Varied levels and determinants of technical efficiency in broiler poultry production have been reported in the literature. For instance Ezech *et al.* (2012) reported that flock size, feed intake and labour were significant determinants of output whereas a mean technical efficiency of 75% was recorded among broiler farmers in

efficiency scores that ranged between 8% and 97% in Umuahia capital territory of Abia State, Nigeria. They also indicated that extension contact, household size, farmers' age and educational level were the socioeconomic factors that influenced technical efficiency. Olorunwa (2016) estimated technical efficiency scores of 57% and 97% as the minimum and maximum scores respectively with an average efficiency score of 74% among broiler farmers in Lagos. In that study, quantity of feed and flock size influenced output levels whilst education and farmer experience significantly explained technical efficiency. Another study conducted by Pakage *et al.* (2014) found that day-old chick feed and medicines were the inputs that determined broiler output. Mean technical efficiency of 93% was recorded in a range of 73% and 99% technical efficiencies scores. Socio-economic factors that explained technical efficiency were business experience and number of dependents. According to Hadi *et al.* (2018), number of day old chicks, feed intake and labour positively and significantly affected broiler output. They recorded 89%, 63% and 97% as mean, minimum and maximum efficiencies respectively with age, education and experience of broiler farmers cited as having negative and significant relationship with technical efficiency. In terms of the constraints to the broiler business, Anang *et al.* (2013) cited inadequate finance and competition with imported frozen chicken as major constraints to broiler production in Ghana. Olorunwa (2016) also identified disease outbreak, inadequate finance and high cost of feed as the most serious problems confronting farmers.

3. Analytical Framework and Data Collection Methods

3.1 Stochastic Frontier Production Model

According to Battese *et al.* (2004), the stochastic frontier function is useful because it helps to measure both the technical efficiency sources and the impact of measurement errors or factors that are not inherently related to production. By using the stochastic frontier model, the error term (ε_i) is used to estimate the technical efficiency. There are two components in the error term, ε_i which includes a random error term v_i with a zero mean ($0, \sigma_v^2$) that is associated with random or statistical disturbance term which captures the effect of weather, diseases and other factors outside the control of the farmer; and u_i , the non-negative random variable associated with individual i^{th} farmer's inability to attain maximum efficiency of production. In this paper we define u_i to represent the technical inefficiency of the poultry farmer which lies between zero and one (see Coelli, 1996). The stochastic model for a cross-sectional data as originated from the models of Aigner *et al.* (1977) and Meeusen and Van den Broeck (1977) is specified as:

$$Y_i = f(X_i; \beta) \exp(\varepsilon_i) = f(X_i; \beta) \exp(v_i - u_i), \quad i = 1, \dots, N \quad (1)$$

Where Y_i is the weight of birds at sale of the i^{th} poultry farmer, $f(X_i; \beta)$ represents a production functional form (such as Cobb-Douglas or Translog functional form) and $(\varepsilon_i = v_i - u_i)$ denotes the composite error term. Normally, the v_i captures random factors which are beyond the control of the poultry farmer and is assumed to be identically and independently distributed (*iid*) with zero mean and a constant variance as $(0, \sigma_v^2)$. The two error terms are also assumed not to be correlated with each other and with the input variables (X_i). On the contrary, the inefficiency error component u_i although has similar characteristics, differs slightly by having a non-zero mean (Coelli *et al.*, 2005). The error term u_i is assumed to have a truncated normal distribution ($u_i \approx iidN^+(\mu, \sigma_u^2)$) and the technical inefficiency effects are expressed as:

$$u_i = Z_i' \delta + w_i \quad (2)$$

In this case, Z_i is a $(P \times 1)$ vector of explanatory variables meant to capture the technical inefficiency effect including socioeconomic and poultry farm management factors; δ is a $(P \times 1)$ vector of unknown parameters to be estimated and w_i represents the unobserved random variables which are assumed to be independently distributed and normally distributed with zero mean and constant variance. The technical efficiency of the i^{th} poultry farmer, denoted by TE_i , is defined to be the ratio of the mean production of the i^{th} poultry farmer, given the value of the inputs X_i , and its corresponding technical inefficiency effect u_i to the corresponding mean of production if there were no inefficiency of production (Battese and Coelli, 1995). The technical efficiency is empirically measured by decomposing the deviation into a random component (V_i) and an inefficiency component (U_i). The technical efficiency of an individual farm is defined in terms of the observed output (Y_i) to the corresponding frontier output (Y^*) given the available technology (Battese and Coelli, 1995), that is,

$$TE = \frac{Y_i}{Y_i^*} = \frac{f(X_i; \beta) \exp(v_i - u_i)}{f(X_i; \beta) \exp(v_i)} \quad ; \quad TE = \exp(-u_i) \quad (3)$$

Such that, $0 \leq TE \leq 1$. An estimated value of technical efficiency for each observation was calculated as in equation (3). A $TE = 1$, means the firm is technically efficient and its output level is on the frontier. Otherwise, a $TE < 1$, the firm is technically inefficient because it could have produced more outputs with the given level of inputs irrespective of input prices.

3.2 Empirical Model Specification

As mentioned earlier, the stochastic frontier production model that comes with inefficiency effects was adopted for this paper (Battese and Coelli, 1992). The Cobb-Douglas stochastic frontier production function that assumes the production technology of broiler farmers is specified as follows:

$$\ln Y_i = \beta_0 + \beta_1 \ln X_{i1} + \beta_2 \ln X_{i2} + \beta_3 \ln X_{i3} + \beta_4 \ln X_{i4} + \beta_5 \ln X_{i5} + e_i, \quad (4)$$

Where \ln = natural logarithm; Y_i is output of the i^{th} farm; β_0 represents a constant term, β_s is the vector of the production function (unknown parameters to be estimated) and independent variables (X_s) are the input bundle used by the i^{th} broiler farmer and is defined as follows:

X_1 = Quantity of feed used per the production period (kg)

X_2 = Flock size (total number of birds at sales)

X_3 = Labour (total number of man-days)

X_4 = Quantity of water (total litres of water the birds were provided with throughout the production period)

X_5 = Vaccines (number of bottles of vaccines and other medications for a production cycle)

3.3 Inefficiency Model

Different output levels obtained by farmers may be explained by variations in production efficiencies of the farmers. In order to explain the technical efficiency variations among the sampled broiler producers, the factors were hypothesized as determinants of technical inefficiency and specified as:

$$U_i = \delta_0 + \delta_1 Z_{1i} + \delta_2 Z_{2i} + \delta_3 Z_{3i} + \delta_4 Z_{4i} + \delta_5 Z_{5i} \quad (5)$$

Where:

U_i is the technical inefficiency of the i^{th} farmer.

δ_0 is the constant.

δ_s are the coefficients:

Z_1 = age of farmer (years)

Z_2 = farmer educational level (years)

Z_3 = farmer experience (years spent in broiler farming)

Z_4 = veterinary service (dummy; Yes = 1, No = 0)

Z_5 = contact with extension service (number of visits)

3.4 Data Collection, Definition and Estimation of Variables

The study was conducted in the Mampong Municipality and environs, formerly the Sekyere West District of Ghana. It is one of the twenty-seven (27) districts in the Ashanti Region of Ghana, located north-east of Kumasi. Agriculture is the major economic activity of the people in the area engaging about 85-90% of the labour force. Apart from crop production, livestock including poultry, sheep, goat, cattle and pig production also take a major component of their agricultural activities (MoFA, 2012). Primary data was used for the study. The data was collected using a set of detailed and well-structured questionnaire. A multistage sampling procedure was used to purposely select five communities namely Kofiase, Kyeremfaso, Agona, Wiemoase and Mampong for the study. This was due to the higher numbers of poultry farmers located in these communities. Subsequently a list of poultry farmers obtained from the Ministry of Food and Agriculture (MoFA) was used as a sampling frame to randomly select 30 poultry farmers for the interview. The data collected on variables for this study ranged from socio-economic data to production data. The production variables included output and inputs used in the production process. Output was measured as the total weight of birds at sale. Descriptive statistics were used to describe the socio-economic characteristics of the respondents, inputs and output variables and the distribution of technical efficiency scores. The stochastic production frontier function was estimated using the FRONTIER (version 4.1) developed by Coelli (1996). The challenges facing the broiler production was ranked using the Kendal's coefficient of concordance in SPSS (version 25).

4.0 Results and Discussion

The descriptive statistics of socio-economic characteristics and production parameters of the farmers in relation to technical efficiency are presented in Table 1. The mean age of the farmers was 40 years which falls within the most active working group of the country. The farmers on average have acquired 13 years of formal education. This implies that at least a farmer had attained Senior High School (SHS) education. Similar results were reported in Ayerh (2015) who indicated that higher number of respondents had 12–17 years of education. The current results contradict Ezech, *et al.* (2012) who reported a mean years of education of poultry farmers as 7.5 in Nigeria. The mean years of experience is 7.7. Experience in a business is a key element in business planning and forecasting and farmers with more experience are usually expected to do better than those with less experience (Ezech, *et al.*, 2012). Average number of extension visits was 2 visits per production period, which is similar to the one reported

in Ayerh (2015). Extension helps to communicate innovations to farmers and in poultry farming regular extension visits can help farmers put appropriate measures in place especially during periods of disease outbreaks.

The output component revealed that the mean maturity weight of birds at sale was 742.23kg. This was the weight of the birds after 8–10 weeks and is the weight at which the birds are sold. The mean total weight of feed used by the farmers throughout the production period was 5274.37kg. The mean flock size of the sampled farmers was 436 birds with a minimum and maximum of 150 and 1200 birds respectively. This means that there were small, medium and large scale poultry farms in the study area as classified by Omotosho and Ladele (1998). The mean labour in man-days as presented in Table 1 is about 193 for the broiler producers. Table 1 also shows that the mean water provided in litres is 111.97. Average number of bottles of medication provided to the birds was 5 bottles. This included vaccines, immune boosters and other medication.

Table 1: Descriptive statistics of variables

Variable	N	Minimum	Maximum	Mean	Std. Deviation
Age of respondent	30	27	54	40.43	7.80
Education in years	30	6	16	12.67	2.92
Experience of farmers	30	2	13	7.70	2.93
Access to veterinary services	30	0	1	0.83	0.38
Number of extension visits	30	0	5	2.43	1.57
Total weight of birds at Maturity	30	266.20	2781.00	742.23	587.96
Total feed used	30	1890	13104	5274.37	2692.35
Number of birds at stock	30	150	1200	436.33	243.84
Labour in Man-days	30	45	348	193.40	73.81
Total water used	30	3780	40320	10111.97	7413.69
Bottles of vaccines and other medications	30	3	7	5.00	1.58

(Source: Field Survey, 2018)

4.2 Estimates of the Production Functions

The Maximum Likelihood Estimation (MLE) results of the Cobb-Douglas stochastic frontier production function for broiler farmers are displayed in Table 2. The coefficients of quantity of feed, flock size, labour, water and vaccines have positive signs showing a direct contribution to the output. Quantity of feed has a coefficient of 0.2671 and significant at 1% level of probability. Flock size has a coefficient of 0.1496 and at significance level of 1% probability. The coefficient of quantity of water is 0.2712, also significant at 1%. This implies that a 1% increase each in flock size, quantity of feed and water, keeping other factors constant will increase output by 0.15%, 0.27% and 0.27% respectively. The positive and significance levels of feed, flock size and labour have also been reported by Ezech *et al.* (2012); Olorunwa (2016); Pakage *et al.* (2014).

The computed variance ($\delta^2=0.0812$) is statistically significant at 1% level of probability. This indicates a good fit of the model to the data and the correctness of the specified distributional assumption for the composite error term. Gamma (γ) in this study is also estimated to be 0.8315 and is statistically significant at 1% level of probability indicating that 83.2% of the total variation in broiler output in the study area is due to technical inefficiencies among the poultry farmers.

Table 2: Maximum Likelihood Estimation (MLE) of Broiler Farmers

Variables	Coefficients	Standard Error	t-ratio
Constant	0.9504**	0.3681	2.5819
Qty of feed	0.2671***	0.0891	2.9977
Flock size	0.1496***	0.0336	4.4531
Labour	0.1045	0.2553	0.4093
Water	0.2712***	0.0203	13.3596
Vaccine	0.1776	0.1095	1.6219
Sigma-squared	0.0812***	0.0243	3.3432
Gamma	0.8315***	0.0543	15.3123

Log likelihood function = - 34.0780

*** Significant at 1%; ** Significant at 5%

Source: Authors' computation, 2018

4.3 Determinants of Technical Inefficiency in Broiler Production

The factors that influence the technical inefficiency of broiler farmers in the Mampong Municipality and environs were estimated from the Cobb-Douglas stochastic frontier production function and the results are presented in Table 3. As can be seen in Table 3, farmer education, farmer experience and number of extension visits have significant effects on the level of technical inefficiency with their coefficients of -1.472, -2.265 and -9.313 being significant at 10%, 1% and 5% level of probabilities respectively. The negative signs imply that an increase in

these variables will decrease the inefficiency level of the farmer. Age is also significant at 5% level of probability but has a positive relationship to technical inefficiency implying that as the farmer gets older, technical inefficiency tends to increase. The result does not support that of Chavanapoonphol *et al.* (2005) who found that technical efficiency and profit efficiency increase with increasing age. However this finding does agree with the findings of Mbanasor and Kalu (2008) who reported that the older the household head becomes, the more he or she is unable to combine the available technology.

The coefficient of educational level has a negative sign and is statistically significant at 10% as shown in Table 3. This suggests that as the level of education of the farmer increases, his/her level of technical inefficiency reduces. This finding is consistent with that of Ezeh *et al.* (2012) who reported negative coefficient of education at 1% significant level. The findings however contradict that of Onyenweaku and Nwaru (2005), and Onyenweaku *et al.* (2004) whose results showed a positive coefficient of educational level.

Table 3: Determinants of technical inefficiency

Variables	Coefficients	Standard Error	t-ratio
Constant	-9.954	- 8.315	1.197
Age	0.375**	0.146	2.568
Educational level	-1.472*	- 0.767	1.919
Farm experience	-2.265***	-0.449	5.044
Veterinary service	-0.722	-1.600	0.451
Extension visits	-9.313**	-4.528	2.057

*** Significant at 1%; ** Significant at 5%; * Significant at 10%.

Source: Authors' Computation, 2018

4.4 Technical Efficiency Distribution of Broiler Farmers

The technical efficiency of the sampled broiler farmers is less than 1 (or 100%), indicating that all the farmers are producing below the maximum efficiency frontier. In Table 4, a range of technical efficiency is observed across the sampled broiler farmers with the best broiler farmer having a technical efficiency of 99%, while the worst farmer had a technical efficiency score of 42%. The mean technical efficiency was 87%. This means that on average, the respondents obtained about 87% of optimal output from the given set of inputs selected for this study. The implication being that the farmers could still achieve 23% more output with the same set of inputs.

Table 4: Frequency Distribution of Technical Efficiency among Broiler Farmers

Technical Efficiency Range %	Frequency	Percentage
≤50	1	3.30
51-60	0	0.00
61-70	2	6.70
71-80	4	13.33
81-90	8	26.70
91-100	15	50.00
Total	30	100
Mean technical efficiency	87%	
Minimum technical efficiency	42%	
Maximum technical efficiency	99%	

(Source: Authors' Computation, 2018)

4.5 Challenges Confronting Broiler Production

Based on the literature and the nature of the broiler business in Ghana, some challenges were proposed for the farmers to rank from the most serious challenge to the least serious challenge. The Kendal's coefficient of concordance value of 0.137 implies that there was about 14% agreement among the broiler farmers with respect to the ranking of challenges facing their broiler business. Among the eight challenges, high incidence of predators was ranked first, with stiff competition from foreign imports being the second most serious challenge to the farmers. High feed cost and issues of theft were ranked third and fourth respectively.

Table 5: Constraints to broiler production in the Mampong Municipality

Challenges to Broiler Business	Mean Rank	Rankings
Problems of pest/disease	6.08	8 TH
High incidence of predators	3.42	1 ST
Theft problems	4.10	4 TH
High cost feed	4.00	3 RD
lack of funds/credit facilities	4.85	6 TH
high mortality rate	4.82	5 TH
Lack of market	5.20	7 TH
Stiff competition from foreign imports	3.53	2 ND
Kendall's W ^a		0.137
Chi-Square		28.746
Asymp. Sig.		0.000

(Source: Authors' Computation, 2018)

Surprisingly, issues of pest/disease and lack of market were not serious challenges to the farmers as these were ranked least in 7th and 8th positions respectively. The continuous treatment and routine vaccination protocols may explain why issue of pest and disease was reported as being a non-serious challenge to the farmers. Market may not be a serious issue because most farmers produce broilers in festive seasons where patronage of live birds is better. The higher ranking of stiff competition from foreign imports and high cost of feed are however very common constraints to broiler production as they are widely reported in other studies (see Anang *et al.*, 2013; Olorunwa, 2016).

5.0 Conclusion

This study adopted the stochastic frontier model to analyse the technical efficiency of broiler producers in the Mampong Municipality. The results of this study revealed that broiler farmers in the Municipality were not fully technically efficient presumably as a result of high cost of production and poor management of inputs. Individual levels of technical efficiency ranged between 42% and 99% with a mean of 87%, suggesting that in the short run, the poultry farmers can still increase the efficiency of resources used at the farm level by 13%. Input variables such as flock size and water were significant in explaining technical efficiency of broiler farmers. Farmer specific factors such as age, education, farmer experience and extension visits were also found to be significant in influencing technical inefficiency. From the findings of the study, education on broiler production needs to be intensified through extension services and other non-formal education channels. Again, broiler farmers should make sure that feed and water are sufficiently provided to their birds and ensure efficient feed intake.

Reference

- Aigner, D.J., Lovell, C.A., & Schmidt, P. (1977). Formulation and Estimation of Stochastic Production Function Model. *Journal of Econometrics*, 6 (1): 21-37.
- Anang, B.T., Yeboah.C. & Agbolobu. A.A. (2013). Profitability of broiler and layer production in the Brong Ahafo Region of Ghana, *ARP Journal of Agricultural and Biological science*, vol. 8 Pp. 423-430, Retrieved: March 20 2018 from , [http:// www. Arpnjournals.com/pdf](http://www.Arpnjournals.com/pdf).
- Ashitey, E. (2017). *Poultry & Products Brief Annual: Ghana. Global Agricultural Information Network (GAIN) Report*. 10/7/2017. Retrieved: April 14, 2018, from http://gain.fas.usda.gov/Recent%20GAIN%20Publications/Poultry%20and%20Products%20Brief%20Annual_Accra_Ghana_10-7-2017.pdf.
- Ayerh, F. (2015). *Technical efficiency of tomato farmers in the Ashanti region of Ghana* Doctoral dissertation, University of Ghana, Legon.
- Battese, G. E., & Coelli, T. J. (1992). Frontier production functions, technical efficiency and panel data: with application to paddy farmers in India. *Journal of productivity analysis*, 3(1-2), 153-169.
- Battese, G. E., & Coelli, T. J. (1995). A model for technical inefficiency effects in a stochastic frontier production function for panel data. *Empirical economics*, 20(2), 325-332.
- Battese, G. E., Rao, D. P., & O'donnell, C. J. (2004). A meta frontier production function for estimation of technical efficiencies and technology gaps for firms operating under different technologies. *Journal of Productivity Analysis*, 21(1), 91-103.
- Chavanapoonphol, Y., Battese, G.E., & Chang, H.C. (2005). *The impact of rural financial services on the technical efficiency of rice farmers in the upper North of Thailand*. Paper presented at the Annual Conference of the Australian Agricultural and Resource Economics Society at Coffs Harbour.
- Coelli, T. J., Rao, D. S. P., O'Donnell, C. J., & Battese, G. E. (2005). *An introduction to efficiency and productivity analysis*. Springer Science & Business Media.

- Coelli, T.J. (1996). A Guide to FRONTIER 4.1: “A Computer Programme for Stochastic Frontier Production and Cost Function Estimation”. Working Paper in Center for Efficiency and Productivity Analysis. Department of Econometrics, University of New England, Armidale. 32-36.
- Ekunwe P. A., Soniregun O. O., & Oyediji J. O. (2006). Economics of Small Scale Deep Litter System of Egg Production in Oredo Local Government Area of Edo State, Nigeria. *International Journal of Poultry Science*, 5(1): 81-83. Retrieved: November 10, 2018, from <http://www.pjbs.org/ijps/fin527.pdf>
- Ezeh, C. I., Anyiro, C. O., & Chukwu, J. A. (2012). Technical efficiency in poultry broiler production in Umuahia capital territory of Abia State, Nigeria. *Greener Journal of Agricultural Sciences*, 2(1), 001-007.
- Food and Agricultural Organisation of the United Nations (FAO), (2010). *Poultry Meat and Eggs: Agribusiness Handbook*. Director of Investment Centre Division, FAO. Rome, Italy, pp: 77. Retrieved: May 17, 2018, from <http://www.fao.org/docrep/012/.../al175e.pdf>
- Hadi, N. A., Ali, S., & Wahid, U. (2018). Estimation of Technical Efficiency of Broiler Farms in District Mardan, Khyber Pakhtunkhwa. *Sarhad Journal of Agriculture*, 34(2).
- Haligah, S. (2017). *Analyzing production challenges plaguing Ghana’s agricultural sector: A focus on poultry production in Greater Accra* (Doctoral dissertation). AIR: Retrieved: June 11, 2018 from <http://hdl.handle.net/20.500.11988/333>.
- Mbanasor, J.A & Kalu, K.C. (2008). Economic Efficiency of Commercial Vegetable Production System in AkwaIbom State, Nigeria: A Translog Stochastic Cost Function Approach. *Tropical and Subtropical Agrosystems* 8(3): 313-318.
- Meeusen, W., & van Den Broeck, J. (1977). Efficiency estimation from Cobb-Douglas production functions with composed error. *International economic review*, 435-444.
- Ministry of food and agriculture (2012). Mampong municipal assembly. Retrieved: August 5, 2018 from <http://www.MoFA.gov.gh>.
- Ministry of Food and Agriculture (2017). *Agricultural Sector Progress Report, 2016*. Ministry of Food and Agriculture, Accra, Ghana. Retrieved: August 5, 2018 from <http://www.mofa.gov.gh>.
- Olorunwa O. J. (2016). Profitability and Technical Efficiency of Broiler Production in Lagos State Poultry Estate, Nigeria. *Unpublished*. Retrieved: August 15, 2018 from <https://doi.org/10.13140/RG.2.2.18384.61447>.
- Omotosho, O. A., & Ladele, A. A. (1988). Management problems in large scale poultry business in Nigeria. *Farm Manage. Nig. J*, 3, 27-35.
- Onyenweaku, C. E. and Nwaru, J. C. (2005) “Application of the Stochastic Frontier Production Function to the Measurement of Technical Efficiency in food production in Imo State, Nigeria” *The Nigeria Agricultural Journal*, 36(2),1-12.
- Onyenweaku, C. E., Igwe, K. C., & Mbanasor, J. A. (2004). Application of the stochastic Frontier in the measurement of Technical Efficiency in Yam production in Nasarawa state, Nigeria. *Journal of sustainable Tropical Agriculture Research*, 13, 70-78.
- Pakage, S., Hartono, B., Fanani, Z., & Nugroho, B. A. (2014). Analysis of technical efficiency of poultry broiler business with pattern closed house system in Malang East Java Indonesia. *Journal of Economics and Sustainable Development*, 5(12), 16-22.
- Randon, M. E., & Ashitey, E. (2011). Poultry and products brief annual. *Global Agricultural Information Network Report, USDA Foreign Agricultural Services*. Retrieved: 5th August, 2018 from <https://apps.fas.usda.gov/gainfiles/200808/146295649.pdf>