Journal of Agriculture and Environmental Sciences
December 2019, Vol. 8, No. 2, pp. 148-158
ISSN: 2334-2404 (Print), 2334-2412 (Online)

Published by American Research Institute for Policy Development
DOI: 10.15640/jaes.v8n2a17
URL: https://doi.org/10.15640/jaes.v8n2a17

# Improving Village Poultry Performance through Community-Based Management: Evidence from Benin, West Africa

**Epiphane SODJINOU**[1]

**Abstract**

The community-based management is an approach developed in Benin, over last two decades, in order to facilitate the dissemination of village poultry improvement technologies, e.g. poultry vaccination, henhouse construction, additional feeds for birds, etc. It involves the installment of "poultry interest group" as well as the training of village poultry vaccinators. Based on a stochastic frontier trans log production function, this study shows that community-based management has a positive effect on breeders' efficiency, not only for participants, but also for non-participants of experimental villages. For the participants in community-based management, women have a marginal product which is almost equivalent to that of men, and in some cases (e.g. vet and labor) the productivity is actually higher for women than for men. Educated farmers and those living far from markets seem to be more efficient in village poultry production than non-educated farmers and those living near markets.

**Keywords**: Benin, Monotonicity condition, Productivity, Village poultry, Technical Efficiency.

## 1. Introduction

Family poultry (also named village poultry or traditional poultry) is an important source of meat and income for the rural poor in many developing countries where poultry, especially in West Africa where income from the sale of poultry products is used to finance children's schooling and begin the process of asset accumulation (Alders & Pym, 2009; Sodjinou et al., 2013; Hailemichael et al., 2017)). Family poultry production may be used as a starting point to help the poor to diversify their activities as a pathway out of poverty (Islam & Jabbar, 2005). Village poultry farming in West Africa is, however, characterized by the predominance of small-scale breeders, with low productivity due mainly to their limited access to good quality inputs and technologies. Indeed, the productivity of village poultry is very low compared with high-input systems: e.g., in Benin, scavenging hens lay 30 to 50 eggs per year against 220 eggs per year for industrialized battery hens (DE/MAEP; FAO, 2015). The improvement of family poultry production can have a significant effect on the wellbeing of rural farm households (Ahlers et al., 2009). Recognizing this importance of village poultry, various institutions (e.g. Village Poultry Improvement Support Program (PADAV), International Livestock Research Institute) have introduced in Benin Community-based poultry Management (CBM) in order to improve the productivity of these birds. CBM relies on the village community with the installment of village poultry producers associations in intervention villages. This allows the community members to develop management strategies with higher probability of meeting their needs and conditions because they better knowledge of their own problems, needs and opportunities than outsiders do (Dey & Kanagaratnam, 2007). The purpose of installing this village association is to facilitate the dissemination of innovations and technologies relevant for the improvement of smallholder poultry productivity. Indeed, the technique of traditional poultry farming (mainly scavenging system) requires coming up with initiatives at community level. Accordingly, intervention (such as CBM) that target all dwellers of the same village may have a larger impact on the family poultry's performance than actions that target individual producers (Sodjinou, 2011, Sodjinou et al., 2013). The main question that it is legitimate to ask, after several years of implementation, is whether this approach has a significant effect on productivity and performance of traditional poultry.

[1] Department of Economics and Rural Sociology, Faculty of Agronomy, University of Parakou, 01 BP 123, Parakou, Republic of Benin, Tel.: +229 95 40 15 56. Email: sodjinoue@gmail.com

Indeed, no information is available on the effect of the CBM and the various associated technologies on the performance of traditional poultry farming. Quantification of the performance status of village poultry farms is useful in many ways. First, it facilitates comparisons across similar economic units, and can help to determine the under utilization or over utilization of factor inputs. Second, in an economy where technologies are lacking, performance study can help to identify the possibility of raising productivity by improving performance without increasing the resource base or developing new technology (see also, Habiyaremye et al. 2019). Thus, the objective of this study is to assess the effect of CBM – including technologies disseminated through this approach – on the performance of village poultry (chicken, duck and guinea fowls) production in Benin as well as the factors which influence this performance.

## 2. Methodology

### 2.1. Data used

Data used in this study were collected in Donga and Mono, two of the poorest regions of Benin, where intervention on CBM were conducted since 1997. In each region, two districts were selected namely Bopa and Houéyougbé in Mono, and Djougou and Ouaké in Donga. In each district, discussions with development agents, extension agents and researchers enabled us to identify intervention villages: in total 8 to 10 in each district. Afterwards, two CBM villages and one non-CBM villages were randomly selected. In villages where the CBM has been implemented, a census of households producing poultry was made. Then, these households were grouped into two categories including households that participated in CBM and households that do not belong to CBM group. In both categories thus formed, 12 to 15 households were randomly selected. In villages where the CBM has not been implemented, 12 to 15 households producing poultry were randomly selected after a census. Thus, around 302 households where selected for this study (table 1).

**Table 1.Distribution of the sample according to the participation in CBM**

| Region | Non-participant of non-CBM village | Non-participant of CBM village | Participant of CBM village | Total |
|---|---|---|---|---|
| South | 33 | 61 | 72 | 166 |
| North | 24 | 40 | 72 | 136 |
| Total | 57 | 101 | 144 | 302 |

### 2.2. Analytical framework

In literature, various methods are available to judge the performance of a given production unit. In this study, village poultry production unit's performance has been judged using the concept of efficiency and productivity ratio. Efficiency can be defined as the degree to which a production process reflects "best practice," either in an engineering sense or in an economic sense (OECD, 2001). This comprises two components namely technical efficiency (TE) and locative efficiency (AE). TE measures the degree to which available inputs have been converted to output without any price consideration. To put it another way, technical inefficiency corresponds to failure to attain the highest possible level of output given inputs and technology (Bravo-Ureta & Pinheiro, 1993). AE reflects the ability of a farmer to use the inputs in optimal proportions, given their respective prices and the production technology (Coelli et al., 2005). In this study, only technical efficiency has been estimated. Since variations of (input) prices between farms are often mainly due to quality differences, it is usually not possible to estimate cost or profit functions with cross-sectional farm data (Quiggin & Bui-Lan, 1984). Hence, it is not possible to estimate the cost efficiency or economic efficiency with a cost function or profit function with the data collected in this research. It is worth noting that Kumbhakar & Wang (2006) show how technical and locative efficiency can be estimated using a primal system consisting of the production function (translog) and first-order conditions of cost minimization. We do not use this because our main objective was to focus on farmers' technical inefficiency. The stochastic frontier analysis (SFA), suggested independently by Aigner et al. (1977) and Meeusen & van den Broeck (1977), where used to obtain the technical efficiency. SFA is capable of capturing measurement errors and statistical noise. For a given producer $i$, the stochastic frontier of production can be defined as follow: $y_i = f(x_i, \beta)\exp(v_i - u_i)$, (1)

where $y_i$ is the output quantity; $x_i$ is a $(k \times 1)$ vector of input quantities; $\beta$ is a vector of parameters to be estimated; $f(\cdot)$ is a suitable functional form (such as the Cobb–Douglas or translog); $v_i$, is the random error that captures the effects that are not under the producer's control and is assumed to be independent and identically distributed as $N(0, \sigma_v^2)$; and $u_i \geq 0$ captures the technical inefficiency of the producer and is assumed to be distributed independently of $v_i$.

The most commonly-used output-oriented $TE_i$ for a given firm $i$ is the ratio of observed output to the corresponding stochastic frontier output (Kumbhakar & Lovell, 2003):

$$TE_i = \frac{y_i}{f(x_i;\beta)\cdot \exp\{v_i\}} = \exp(-u_i) \quad (2)$$

If $TE_i = 1$, the production of the firm $i$ falls on the stochastic frontier, which means that the producer is technically efficient. When $TE_i < 1$, the producer is inefficient.

An important step in efficiency analysis is the choice of the functional form. The most commonly used are the Cobb-Douglas and translog functional forms. The former assumes that (i) the partial production elasticities, as well as the elasticity of scale, are constant and independent of the input mix; and (ii) the elasticity of substitution between each two inputs is one, whereas it can be anywhere from zero to infinity in practice. In contrast, the translog function is a second-order flexible functional form. In this study, we used the translog functional form defined as:

$$\ln y = \beta_0 + \sum_{k=1}^{4}\beta_k \ln x_k + \frac{1}{2}\sum_{k=1}^{4}\sum_{l=1}^{4}\beta_{kl} \ln x_k \ln x_l + v - u \quad (3)$$

where we omit the subscript $i$ for the producer to simplify the notation. We impose symmetry in input cross effects by assuming $\beta_{kl} = \beta_{lk}$ to identify these parameters, $v$ and $u$ are defined as in equation 1, and:

- $x_1$ represents the annual labor spent for poultry production in man-days,
- $x_2$ is the feed cost (cost of improved feed used plus the opportunity cost of feed from the producer's own production),
- $x_3$ is the annual expenses in veterinary treatment and medicine (including traditional treatment costs, vaccination, drugs, decontamination), and
- $x_4$ measures the capital input by taking the annual depreciation of various equipment (henhouses, chick-houses, troughs, etc.) and poultry parents.
- y denotes annual poultry production measured in kilogram of chicken equivalent, i.e. $y = TR/Pc$, with $Pc$ the average chicken selling price (in FCFA/kg) and $TR$ the total revenue (in FCFA) of poultry (chicken, ducks and guinea fowls), which takes into account the changes of livestock due to sales and purchases, and through inventory at the beginning and at the end of the observation period.

### 2.3. Inefficiency variables

In addition to the measure of the level of technical efficiency, the factors that influence this efficiency have been analyzed. For this purpose, this study uses the single-stage maximum likelihood procedure to obtain consistent parameter estimates and to identify the determinants of technical inefficiency. In this approach, the parameters of the stochastic frontier and of the inefficiency model are estimated simultaneously, given appropriate assumptions associated regarding the distributions of $v$ and $u$ (Battese & Coelli, 1995). Following these authors, the mean of technical inefficiency effects, $u$ , is defined as:

$$\mu = \delta_0 + \sum \delta_m z_m \quad (4)$$

Where the inefficiency term $u$ follows a truncated normal distribution $u \sim N^+(\mu, \sigma_u^2)$, $\delta$'s is the parameter to be estimated, and $z_m$ the farm-specific characteristics. The latter include:

- the gender of the breeder (GENDER), with 1 for males and 0 for females. This variable is used to assess the effect of gender on efficiency. In the literature, the effect of gender on technical efficiency is unclear. Quisumbing (1996) indicates that most of the studies on differences in technical efficiency between male and female farmers found insignificant dummies for the sex of the farmer. That is, female farmers and male farmers have almost the same efficiency, once individual characteristics and input levels are controlled for. This is in line with Adesina & Djato (1997) who also show that the relative degree of efficiency of women is similar to that of men. Alabi & Aruna (2005), in their study of family poultry production in the Niger-Delta (Nigeria), found that inefficiency is less among females than males. They argue that this may be because women are more involved in family production than men, so that they develop superior caring techniques to men. It may also be due to the fact that they stay at home to care for the family poultry more often than men.

On the other hand, Akter et al. (2003) show that females are significantly less efficient in poultry production in North Vietnam. The main reason is that females are generally less well educated and have less access to knowledge and information, which might reduce their efficiency. Due to this lack of consensus regarding the effect of gender on efficiency, in this study, we expect the sign of this variable to be either positive or negative.

- the age of the breeder (AGE) in years. In this study, age is supposed to have either a positive or negative effect on efficiency. Indeed, the effect of this variable on efficiency is debated in the literature. Thus, Akter et al. (2003) show that age has no significant effect in North Vietnam, but in the South, farms with older household heads have significantly lower inefficiency. Note that, the square of the breeder's age (AGE2) is also included in the inefficiency model in order to account for a non-linear relationship between age and efficiency.
- the education of the breeder (EDUC), with 1 for educated farmers and 0 otherwise. This variable represents formal schooling. In general in the literature, the effect of education on technical efficiency is often positive. Akter et al. (2003) show that better education of the farmer significantly reduced inefficiency in poultry production in North Vietnam, perhaps because education facilitates better information gathering and application. Also, Coelli & Battese (1996) found that education had a significant positive effect on the technical efficiency of Indian farmers. Moreover, in a review of various studies carried out on efficiency analysis of developing country agriculture, Bravo-Ureta & Pinheiro (1993) report that farmers' education tends to have a positive and statistically significant impact on technical efficiency. In short, for poultry production, we suppose that a high level of formal education will increase efficiency.
- the access to poultry-based credit (CREDIT), with 1 for farmers who have accessed this type of credit and 0 otherwise. Measuring access to credit is not an easy task. Doss (2006) argues that one solution is to include a measure of whether the farmer has ever received credit. This is the method used in this study and we assume that access to poultry-based credit will have a positive effect on technical efficiency in village poultry production. In fact, access to credit for poultry production may increase the ability to use better quality inputs and services, and may, therefore, increase efficiency. Bravo-Ureta & Pinheiro (1993) show that access to credit tends to increase farmers' technical efficiency in many circumstances. In contrast, Akter et al. (2003) find that access to credit significantly reduced the efficiency of poultry production in North Vietnam. They argue that, normally, access to credit is expected to have a positive effect on farmers' efficiency; the opposite result may be due to the purpose for which the credit was used.
- the community-based management (CBM), with 1 for participants and 0 otherwise; the status of the village (EXPVILL), 1 for experimental village and 0 otherwise. As stated above, the community-based management (CBM) serves as a channel for the dissemination of various village poultry improvement technologies, such as village poultry vaccination, chick-house and henhouse building, and improved feed using locally available inputs. We expect that the implementation of CBM in a village will have a positive effect not only on the efficiency of the participating farmers, but also on the efficiency of other breeders living in the experimental villages. Also, participation in CBM is expected to have positive effect on the technical efficiency.
- the distance (DMARKET) to the nearest market (in km).There is a State or private veterinarian installed near the largest rural market in each district. This could be a source of supply for vaccines and other veterinary products for farmers and VPVs in particular. To account for this, the distance between the breeders' houses and the nearest market is used as a proxy for accessibility to veterinary agents as well as access to market. Thus, producers who are close to the market have greater access to information related to good poultry farming management practices. Indeed, farmers often socialize at the market place and at other similar occasions, allowing them to exchange information about their poultry farming. The information gathered through these informal sources can be used by farmers to improve their farming decisions (Boahene et al., 1999). We expect the distance to market to have a positive sign, meaning that breeders who are located far from market will be less efficient.

### 2.4. Production elasticity and marginal physical products

Based on the translog production function used, we calculate the partial production elasticities and the marginal physical products ($MP$) of the input factors. The partial production elasticity of input $x_k$ is the ratio of the proportionate change in output to the proportionate change in input $x_k$, assuming that all other inputs are fixed. It is defined as:

$$\frac{\partial y}{\partial x_k} \cdot \frac{x_k}{y} = \frac{\partial \ln y}{\partial \ln x_k} = \beta_k + \sum_{l=1}^{4} \beta_{kl} \ln x_l \ , \qquad (5)$$

and we evaluate it at the sample means. The sum of the partial production elasticities represents the elasticity of scale.

The marginal product of input $x_k$ ($MP_k$) is the first partial derivative of the production function with respect to $x_k$. In other words, it is the change in output resulting from an increase in an input by one unit, holding all other inputs constant. We have:

$$MP_k = \frac{\partial y}{\partial x_k} = \frac{\partial \ln y}{\partial \ln x_k}\frac{y}{x_k} = (\beta_k + \sum_{l=1}^{4}\beta_{kl}\ln x_l)\frac{y}{x_k} \ , \qquad (6)$$

In this equation, we set $y$ equal to (average) total revenue ($TR$) so that the $MP$ is in fact marginal value products ($MVP$) and hence the change in output can be interpreted in monetary terms (FCFA).

### 2.5. Model estimation and monotonicity condition

The maximum likelihood method was used to estimate the parameters of the stochastic frontier and the inefficiency model simultaneously. It was assumed that the distribution of the efficiency component would be truncated. The maximum likelihood estimation of equations 3 and 4 yields estimators for $\beta$, $\gamma = \sigma_u^2 / \sigma^2$ (with $0 \le \gamma \le 1$) and $\sigma^2 = \sigma_u^2 + \sigma_v^2$. The value of $\gamma$ is equal to 0 if there are no technical inefficiency effects and all deviations from the frontier are due to noise (Coelli et al., 2005). If inefficiency exists, $\gamma$ will be different from zero.

It is worth noting that the transom production function, in contrary to the Cobb-Douglas, is often not globally monotonic or globally quasi-concave (see also Greene, 2008). Monotonicity of the production function requires positive marginal products with respect to all inputs and thus non-negative partial production elasticity's. Henningsen & Henning (2009) show that the efficiency estimates of the individual farmers cannot be reasonably interpreted if a production frontier is not monotonically increasing. For this purpose, we impose monotonicity on our translog frontier production function using the three-step method suggested by Henningsen & Henning (2009). In the first step, the unrestricted stochastic production function, including the inefficiency effects model defined in equations 3 and 4, is estimated. Then the parameters $\hat{\beta}$ of this production frontier are extracted, as well as their covariance matrix $\hat{\Sigma}_\beta$ from the estimation results. In the second step, the restricted $\beta$ parameters are obtained by a minimum distance estimation subject to the monotonicity constraints:

$$\hat{\beta}^0 = \arg\min(\hat{\beta}^0 - \hat{\beta})\hat{\Sigma}_\beta^{-1}(\hat{\beta}^0 - \hat{\beta}) \ ; \qquad (7)$$

$$\text{s.t. } f_i(x, \hat{\beta}^0) \ge 0 \ \ \forall i, x .$$

In the third step, the efficiency estimates of the farmers are determined as well as the effects of variables explaining technical inefficiency based on the theoretical consistent production frontier. The stochastic frontier model of this step is given by:

$$\ln y = \alpha_0 + \alpha_1 \ln \tilde{y} - u^0 + v^0 \qquad (8)$$

$$\mu = z'\delta^0$$

where the only "input variable" is the "frontier output" of each firm calculated with the parameters of the restricted model: $\tilde{y} = f(x, \hat{\beta}^0)$. Parameters $\alpha_0$ and $\alpha_1$ allow an adjustment of the restricted production frontier, which gives: $y = e^{\alpha_0} f(x, \hat{\beta}^0)^{\alpha_1}$.

It is worth noting that the stochastic frontier analysis was carried out using the package 'frontier' (Coelli & Henningsen, 2010) of R statistical software. The minimization of the distance was performed by using the R package 'quadprog' (Turlach + Weingessel, 2010). The package 'frontier' also allows us to calculate the marginal effect of a z-variable (of equation 4) on the technical efficiency. The formula used is the one suggested by Olsen & Henningsen (2011):

$$\frac{\partial TE}{\partial z_m} = (1-\hat{\gamma})\left( \frac{\phi\left(\frac{\mu_*}{\sigma_*} - \sigma_*\right) e^{-\mu_* + \frac{1}{2}\sigma_*^2}}{\sigma_*\left(\phi(\frac{\mu_*}{\sigma_*})\right)} - \frac{\phi\left(\frac{\mu_*}{\sigma_*} - \sigma_*\right)\phi\left(\frac{\mu_*}{\sigma_*}\right) e^{-\mu_* + \frac{1}{2}\sigma_*^2}}{\sigma_*\left(\phi(\frac{\mu_*}{\sigma_*})\right)^2} - \frac{\phi\left(\frac{\mu_*}{\sigma_*} - \sigma_*\right) e^{-\mu_* + \frac{1}{2}\sigma_*^2}}{\phi\left(\frac{\mu_*}{\sigma_*}\right)} \right)\delta_m \qquad (9)$$

in which $\phi(\cdot)$ denotes the probability density function of the standard normal distribution, $\delta_m$ and $z_m$ are defined in equation 4, $\mu_* = (1-\hat{\gamma})\hat{\mu} - \hat{\gamma}\varepsilon$, $\sigma_* = \sqrt{\hat{\gamma}(1-\hat{\gamma})\hat{\sigma}}$, $\hat{\sigma} = \hat{\sigma}_u + \hat{\sigma}_v$, $\hat{\gamma} = \hat{\sigma}_u / \hat{\sigma}$, $\hat{\sigma}_u$ denotes the estimated variance of the inefficiency term $u$, $\hat{\sigma}_v$ represents the estimated variance of the stochastic error term $v$, $\varepsilon = u + v$ is the total residual, and $\hat{\mu}$ is calculated by equation 4 using estimated $\delta$ coefficients. Please note that we define $\mu_*$ slightly differently to Olsen & Henningsen (2011), because in our study the inefficiency term $u$ is subtracted from the production frontier, while in their output distance function the inefficiency term is added.

## 3. Results and Discussion

### 3.1. Monotonicity condition

The table 2 indicates that before the imposition of the monotonicity condition, the model was overall monotonic for 42% of the observations, and was quasiconcave for about 13% of the observations. For each input variable, the monotonicity condition was fulfilled 61% for feed, 69% for labor, 89% for vet and 100% for capital. However, after the imposition, the monotonicity condition for the exogenous variable was fulfilled at 100%, and the translog function was quasiconcave in 269 out of 302 observations (89.1%).

**Table2. Analysis of the consistency of the translog functional form: percentage of observations satisfying monotonicity and quasiconcave conditions**

| | Label | Before imposing monotonicity | After imposing monotonicity |
|---|---|---|---|
| VET | Vet | 88.7 | 100.0 |
| LABOUR | Labor | 69.2 | 100.0 |
| CAPITAL | Capital | 100.0 | 100.0 |
| FEED | Feed | 60.9 | 100.0 |
| Overall | Joint consideration of all inputs | 42.1 | 100.0 |
| Quasiconcavity | | 12.6 | 89.1 |

### 3.2. Technical efficiency

The results of the maximum likelihood estimates of the stochastic production frontier model are presented in table 3. The partial production elasticity's calculated at the mean input quantities are also presented in this table. The analysis of these elasticity's indicates that an increase in the capital by 10% will lead to a 3.1% increase in village poultry output. In the same way, a 10% increase in labor will lead to approximately 0.3% increase in poultry output. Furthermore, a 10% increase in veterinary services and feed is likely to increase poultry output by 1.4% and 1% respectively.

**Table 3. Estimates of the Stochastic Production Frontier Model**

| Variables | Label | Coefficients | Std. Error | z-stat | Coefficients | Elasticities |
|---|---|---|---|---|---|---|
| Production factors | | Unrestricted model | | | Model with monotonicity imposed | |
| LnLABOUR | Ln (labor) | -0.055 | 0.383 | -0.14 | 0.004 | 0.030 |
| LnCAPITAL | Ln (capital) | 0.596 | 0.366 | 1.63 | 0.210 | 0.309 |
| LnVET | Ln (vet) | -0.077 | 0.339 | -0.23 | -0.056 | 0.143 |
| LnFEED | Ln (feed) | -0.708* | 0.407 | -1.74 | -0.165 | 0.101 |
| LnLAB2 | Ln $(labor)^2$ | 0.080 | 0.075 | 1.07 | 0.009 | |
| LnCAP2 | Ln $(capital)^2$ | 0.047 | 0.072 | 0.65 | 0.023 | |
| LnVET2 | Ln $(vet)^2$ | 0.129*** | 0.040 | 3.25 | 0.040 | |
| LnFEED2 | Ln $(feed)^2$ | 0.199*** | 0.060 | 3.31 | 0.043 | |
| LnLABCAP | Ln (labor) x Ln (capital) | -0.021 | 0.052 | -0.41 | 0.002 | |
| LnLABVET | Ln (labor) x Ln (vet) | -0.017 | 0.043 | -0.41 | -0.009 | |
| LnLABFEED | Ln (labor) x Ln (feed) | 0.024 | 0.058 | 0.42 | 0.007 | |
| LnCAPVET | Ln (capital) x Ln (vet) | -0.029 | 0.039 | -0.76 | -0.006 | |
| LnCAPFEED | Ln (capital) x Ln (feed) | -0.057 | 0.055 | -1.04 | -0.008 | |
| LnVETFEED | Ln (vet) x Ln (feed) | -0.044 | 0.038 | -1.17 | -0.001 | |
| (constant) | | 2.098* | 1.101 | 1.91 | 1.677 | |
| Inefficiency factors obtained after imposing monotonicity condition | | | | | MGF | |
| GENDER | Gender of the breeder (1 = male) | -0.281** | 0.115 | -2.44 | 0.100 | |
| AGE | Age of the breeder (year) | -0.015 | 0.017 | -0.85 | 0.002 | |
| AGE2 | Squared of [AGE] | 0.0001 | 0.0002 | 0.51 | | |
| EDUC | Formal education (1 = yes) | -0.388** | 0.187 | -2.08 | 0.138 | |
| CREDIT | Access to poultry-based credit (1 = yes) | 0.294 | 0.244 | 1.20 | -0.105 | |
| EXPVILL | Experimental village (1 = yes) | -0.580*** | 0.200 | -2.91 | 0.207 | |
| CBM | Participation in community-based management (1 = yes) | -0.085 | 0.240 | -0.35 | 0.030 | |
| DMARKET | Distance to the nearest market (km) | -0.089*** | 0.022 | -4.06 | 0.032 | |
| (constant) | | 1.531*** | 0.460 | 3.33 | NN | |

N = 302; Wald chi-square Stat. (14) = 220.81***; Log likelihood = -254.09; $\sigma^2$= 0.329***; Elasticity of scale = 0.583;
MGF = Mean values of the marginal effects (mean values over all observations); NN = Not Need
*** Significant at 1%, ** Significant at 5%, * Significant at 10%

The calculated elasticity of scale is less than unity (i.e., 0.58), which indicates that sample breeders actually operate under decreasing returns to scale. These results are in line with the findings of other studies (e.g. Akter et al., 2003; Oladeebo & Ambe-Lamidi, 2007) carried out in village poultry farming. Indeed, using a Cobb Douglas production function, Akter et al. (2003) found that the elasticity of scale in poultry production in Vietnam was significantly less than unity (0.68 in the North and 0.876 in the South). In Osun State (Nigeria), Oladeebo & Ambe-Lamidi (2007) found that there are decreasing returns to scale (elasticity of scale was 0.76) in poultry production. The lower panel of table 3 presents the estimates of the inefficiency model. The standard errors must be interpreted with caution as they might be downward biased (Henningsen & Henning, 2009). The average technical efficiency index is 89%, which indicates that an inefficiency effect amongst village poultry breeders exists; i.e. there is room to increase village poultry output in Benin. As expected, the education has a positive and significant effect (at 5% level) on producer's efficiency.

In other words, farmers who received formal education are, on average, 14 percentage points more efficient in village poultry production than non-educated farmers. This is due to the fact that the high level of education enables farmers to access relevant information that stimulate their production (Aboki et al. 2013). Education may enhance the farmer's ability to efficiently allocate inputs across competing uses, and to select the "best" technology mix (Polson and Spencer, 1991). Accordingly, improving the level of education, for example literacy in the local language, should be considered as an option in improving the performance of the village poultry farming.

Also, men are, on average, 10 percentage points more efficient than women. This result is different from that obtained by Aboki et al. (2015) for whom inefficiency is less among female than male. They explain this by the fact that in the Kurmi local Government Area of Taraba State (Nigeria) where they carried out their study, women were more involved in poultry farming than men, stay more at home caring for family poultry and hence they have developed caring techniques superior to that of men (Aboki et al., 2013). Our result is however corroborated by the finding of Habiyaremye et al. (2019) who indicated that male farmers are more technically efficient than their female counterparts. This can be explained by the fact that, in Mono and Donga regions of Benin where we carried out this study, male producers were more likely to provide shelter for their birds than female breeders, inasmuch as male producers have greater access to labor and financial means than females (Sodjinou, 2011). Furthermore, Thomsen (2005: 74) noted a difference in size and solidness between the structures raised by men and women. Thomsen (2005: 74) argues that this difference can partly be explained by the actual physical work needed for construction with women depending on male assistance, whether it is their husbands or a hired work force.

In the same way, breeders in the experimental village are significantly more efficient in village poultry production than those from non-experimental villages (on average 21 percentage points). Furthermore, the negative sign of community-based management (CBM) indicates that breeders who participate in CBM are more efficient than breeders who do not participate in CBM (on average only 3 percentage points). However, CBM does not have a significant effect on farmers' efficiency. These results indicate that the CBM produces significant effects on the entire intervention village rather than on the producers belonging to CBM groups. Say differently, CBM has positive effect not only on the performance of participants but also on that of non-participants of experimental villages. This cans be explained by the fact the CBM approach brings some changes to the peasant's behavior concerning the management of village poultry farming. Farmers from experimental villages are also more likely to adopt various village poultry improvement technologies such as vaccination, improved feed, henhouses and chick-houses (Sodjinou, 2011).

This indicates that when the farmer has the information and technical support through an approach based on the community, i.e. CBM, he can change his behavior over the traditional poultry farming to obtain increased performance. This is line with the finding of Hailemichael et al. (2017) who indicated that institutional support, such as contact with development agents as well as technical training, enhanced the use of inputs and scale of operation of poultry. The main policy implication of this result is that the government or development actors must invest in the dissemination of information and assistance on village poultry improvement in particular through community-based approaches. Finally, distance to market has a negative and significant sign (at 1% level); meaning that peasants who are closer to a market are less efficient than those who are situated far from a market. In other words, access to market for inputs and output seems to decrease peasants' efficiency in village poultry production. One kilometer farther away from the market would result in a 3 percentage points increase in breeders' efficiency.

### 3.3. Marginal products according to the participation in community-based management

Table 4 shows that there is significant difference (at 10% level) between participants and non-participants in terms of the marginal product of labor. In other words, the marginal product of labor is higher for participants in CBM (144 FCFA/man-day) than for non-participants of experimental (129 FCFA/man-day) and non-experimental (91 FCFA/man-day) villages. For the other inputs, there is no significant difference between participants and non-participants in CBM.

**Table 4. Marginal products according to breeders' participation in CBM**

| Marginal product of | Non-participant of Non-experimental villages (n=57) | Non-participant of experimental villages (n=101) | Participant(n=144) | Total (n=302) | F-stat |
|---|---|---|---|---|---|
| Vet (FCFA/FCFA) | 6.7 (4.2) | 8.9 (8.2) | 8.5 (9.1) | 8.3 (8.1) | 1.50 |
| Labor (FCFA/man-day) | 91.4 (88.0) | 129.1 (142.0) | 143.8 (159.0) | 129.0 (143.3) | 2.76* |
| Capital (FCFA/FCFA) | 3.9 (3.3) | 3.5 (2.9) | 3.5 (3.3) | 3.6 (3.2) | 0.28 |
| Feed (FCFA/FCFA) | 2.5 (1.5) | 3.1 (2.6) | 3.0 (2.2) | 3.0 (2.3) | 1.27 |

The marginal product of labor (about FCFA 129 per man-day, see table 4) is lower than the average price paid for labor in the research villages, i.e. FCFA 520 per man-day. This suggests that farmers would earn more by selling their labor than using it in poultry production. Based on this, one can say that it would be advisable to increase capital input, expenses for vet, and feed. Clearly, an increase in expenses for vet by FCFA 100, ceteris paribus, would improve the producer's revenue by FCFA 830. The increase of capital and expenses in feed by FCFA 100 would increase producer's revenue by FCFA 360 and FCFA 300, respectively. Therefore, overall, an increase in expenses in vet treatment (especially expenses in village poultry vaccination) is the main option for the improvement of poultry breeders' revenue. In other words, vaccination plays an important role in the improvement of village poultry performance. However, most village poultry producers have poor access to veterinary and extension services, and hence are either unaware of the benefits of disease control, or unable to access the vaccines and drugs needed to protect their birds. When animal health services are unavailable and bird mortality is high, awareness and interest in improved husbandry practices does not generally exist (Kryger et al., 2010: 33). Therefore, targeting village poultry vaccination could be an important way to increase the survival rate of chickens. Finally, it is worth noting that the marginal products of all inputs, for participants as well as non-participants, are lower than their average products. This indicates that the average products of these inputs are decreasing and have already reached their maximum. In other words, village poultry producers analyzed in this study are experiencing decreasing average products.

### 3.4. Gender difference in marginal products

For participants in the CBM, women have a marginal product of vet (9.3 FCFA / FCFA) higher than men (7.7 FCFA / FCFA) (table 5). It follows that women would gain FCFA 9.3, ceteris paribus, per one FCFA increase in veterinary expenses, compared to FCFA 7.7 for men. Regarding capital and labor, women have a higher marginal product than men. Thus, increasing labor use by one man-day would, ceteris paribus, increase women's production by FCFA 147 compared to FCFA 141 for men. In other words, if women increase labor use, they would increase their poultry production faster than men. For capital, women have a slightly higher marginal product than men. On the other hand, for the feed, men have a higher marginal product than women. In all cases, however, the difference between men and women is not significant at 5% level. But, from the above results, we can say that women have a marginal product which is almost equivalent to that of men, and in some cases (e.g. vet and labor) the marginal product is higher for women than for men.

**Table 5.Marginal products for female and male participant in CBM**

| Marginal product of | Female (n=59) | Male (n=99) | Total (n=158) | t test |
|---|---|---|---|---|
| Vet (FCFA/FCFA) | 9.3 (10.1) | 7.7 (8.0) | 8.5 (9.1) | 1.07 |
| Labor (FCFA/man-day) | 147.0 (177.1) | 140.6 (139.8) | 143.8 (159.0) | 0.24 |
| Capital (FCFA/FCFA) | 3.6 (3.3) | 3.4 (3.3) | 3.5 (3.3) | 0.35 |
| Feed (FCFA/FCFA) | 2.9 (2.4) | 3.1 (2.1) | 3.0 (2.2) | -0.51 |

In short, we can say that, for the participants in CBM, although they have less access to credit and labor, women have a marginal product which is almost equivalent to that of men, and in some cases (e.g. vet and labor) these marginal products are actually higher for women than for men. On the other hand, for non-participants in CBM, men have a marginal product of labor which is higher than that of women. For other factors of production, men and women non-participants in CBM have almost the same marginal product. For the participants in CBM, an increase in expenses in vet would be more effective for women than for men. In fact, an increase in the expenses in vet by FCFA 100 would, ceteris paribus, lead to an increase of FCFA 930 for women compared to FCFA 770 for men. The main implication of this result is that women would perform better if they had more money to finance the vaccination of their birds.

## 4. Conclusion and Implications

An inefficiency effect exists amongst village poultry breeders, which means that there is room to increase village poultry output, given existing technology. Educated farmers and those living far from markets seem to be more efficient in village poultry production than non-educated farmers and those living near markets. Also, community-based management has a positive effect on breeders' efficiency not only for participants in CBM, but also for non-participants of experimental villages.

**Acknowledgements**

The author is grateful to the Danish International Development Agency (DANIDA) for funding this study through the second phase of the Benin Agricultural Sector Development Support Program (PADSA II). Furthermore, the author is grateful to Arne Henningsen, John Rand, Bernhard Brümmer, and Simon Bolwig for their valuable suggestions that helped us to improve this paper. Of course, all errors are the sole responsibility of the author.

## References

Adesina, A.A. & Djaton, K.K. (1997). Relative efficiency of women as farm managers: profit function analysis in Côte d'Ivoire. Agricultural Economics 16, 47-53.

Ahlers, C., Alders, R., Bagnol, B., Cambaza, A.B., Harun, M., Mgomezulu, R., Msami, H., Pym, B., Wegener, P., Wethli, E., Young, M. (2009). Improving village chicken production: a manual for field workers and trainers. ACIAR Monograph No. 139. Australian Centre for International Agricultural Research: Canberra, Australia.[Online] Available: http://www.fao.org/sustainable-food-value-chains/training-and-learning-center/details-materials/en/c/276919/ (8 January 2020)

Aigner, D., Lovell, C.A.K. & Schmidt, P. (1977). Formulation and estimation of stochastic frontier production function models. Journal of Econometrics, 6; 21-37.

Akter S., Jabbar, M.A. & Ehui, S.K. (2003). Competitiveness and efficiency in poultry and pig production in Vietnam. Socio-economic and Policy Research Working Paper 57. International Livestock Research Institute, Nairobi, Kenya.[Online] Available: https://cgspace.cgiar.org/handle/10568/1770(8 January 2020)

Alabi, R.A., & Aruna, M.B. (2005). Technical efficiency of family poultry production in Niger-Delta, Nigeria. Journal of Central European Agriculture, 6, 531-538.

Alders R.G., & Pym, R.A.E. 2009.Village poultry: still important tomillions, eight thousand years afterdomestication. World's Poultry Science Journal, 65, 181-190.

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, 325-332.

Boahene, K., Snijders, T.A.B., Folmer, H. (1999).An integrated socioeconomic analysis of innovation adoption: the case of hybrid cocoa in Ghana.Journal of Policy Modeling, 21, 167–184.

Bravo-Ureta, B.E., & Pinheiro, A.E. (1993). Efficiency analysis of developing country agriculture: a review of the frontier function literature. Agricultural and Resource Economics Review, 22, 88-101.

Coelli, T., & Battese, G. (1996). Identification of factors which influence the technical inefficiency of Indian farmers. Australian Journal of Agricultural Economics, 40, 103-128

Coelli, T.J., Rao, D.S.P., O'Donnell, C.J., & Battese, G.E. (2005). An introduction to efficiency and productivity analysis, second edition. (2nd ed.) Springer Science+Business Media, LLC.

Coelli; T., & Henningsen, A. (2010). Frontier: Stochastic Frontier Analysis. R package version 0.997-0.[Online] Available: http://CRAN.R-project.org/package=frontier(8 January 2020)

DE/MAEP (Direction de l'Elevage/ Ministère de l'Agriculture, de l'Elevage et de la Pêche) (2008). Rapport annuel 2007. Cotonou.

Dey, M.M. & Kanagaratnam, U., (2007). Community based management of small scale fisheries in Asia: Bridging the gap between fish supply and demand. Working Papers, The WorldFish Center, number 37170, June. [Online] Available: https://ideas.repec.org/b/wfi/wfbook/37170.html (8 January 2020)

Doss, C.R. (2006). Analyzing technology adoption using microstudies: limitations, challenges, and opportunities for improvement. Agricultural Economics, 34, 207–219

FAO (Food and Agriculture Organization, 2015). Secteur Avicole Bénin. Revues nationales de l'élevage de la division de la production et de la santé animales de la FAO. No. 10. Rome.[Online] Available: http://www.fao.org/3/a-i4583f.pdf. (8 January 2020)

Greene, W.H. (2008). Econometric analysis. (6thed.). Pearson Edition, New Jersey.

Habiyaremye, N., Tabe-Ojong, M.P.J., Ochieng, J., & Chagomoka, T. (2019). New insights on efficiency and productivity analysis: Evidence from vegetable-poultry integration in rural Tanzania. Scientific African, 6, e00190

Hailemichael, A., Gebremedhin, B., & Tegegne, A. (2017). Status and drivers of village poultry production and its efficiency in Ethiopia. NJAS - Wageningen Journal of Life Sciences, 83, 30–38

Henningsen, A., & Henning, C.H.C.A. (2009). Imposing regional monotonicity on translog stochastic production frontiers with a simple three-step procedure. Journal of Productivity Analysis, 32, 217–229

Islam, F.S.M. & Jabbar, M.A. (2005). Smallholder poultry model for poverty alleviation in Bangladesh: a review of evidence on impact. Livestock Research for Rural Development. Volume 17, Article #112. [Online] Available:http://www.lrrd.org/lrrd17/10/fakh17112.htm(8 January 2020)

Kryger, K.N., Thomsen, K.A., Whyte, M.A., & Dissing, M. (2010). Smallholder poultry production – livelihoods, food security and sociocultural significance. FAO, FAO Smallholder Poultry Production Paper No. 4. Rome.[Online] Available: http://www.fao.org/3/al674e/al674e00.pdf. (8 January 2020)

Kumbhakar, S.C., & Lovell, C.A.K. (2003). Stochastic frontier analysis. (1st ed.). Cambridge University Press.

Meeusen, W., & van Den Broeck, J. (1977). Efficiency Estimation from Cobb-Douglas Production Functions with Composed Error. International Economic Review, 18, 435-444.

OECD, 2001. Measuring productivity: Measurement of aggregate and industry-level productivity growth. OECD Manual, Paris.[Online] Available: http://www.oecd.org/sdd/productivity-stats/2352458.pdf. (8 January 2020)

Oladeebo, J.O., & Ambe-Lamidi, A.I. (2007). Profitability, Input Elasticities and Economic Efficiency of Poultry Production among Youth Farmers in Osun State, Nigeria. International Journal of Poultry Science, 6, 994-998

Olsen, J.V., & Henningsen, A. (2011). Investment Utilization and Farm Efficiency in Danish Agriculture. Knowledge Centre for Agriculture, Agro Food Park, Skejby/Århus, Denmark.

Polson R.A. and Spencer D.S.C., 1991. The technology adoption process in subsistence agriculture: the case of cassava in southwestern Nigeria. Agricultural System, 36, 65–78.

Quiggin, J., & Bui-Lan, A. (1984). The Use of Cross-Sectional Estimates of Profit Functions for Tests of Relative Efficiency: A Critical Review. Australian Journal of Agricultural Economics, 28, 44-55

Quisumbing, A.R. (1996). Male-Female Differences in Agricultural Productivity: Methodological Issues and Empirical Evidence. World Development, 24, 1579-1595.

Sodjinou, E. (2011). Poultry-Based Intervention as Tool for Poverty Reduction and Gender Empowerment: Empirical Evidence from Benin. PhD Thesis, University of Copenhagen, Denmark

Sodjinou, E., Henningsen, A., & Koudande O.D. (2013). Improving village poultry's survival rate through community-based poultry health management: evidence from Benin. Tropical Animal Health and Production, 45, 59-66

Thomsen, K.A. 2005. Poultry as development: an ethnography of smallholders and technical development assistance in Benin. MSc. thesis, Department of Anthropology, University of Copenhagen.

Turlach, B.A. + Weingessel, A. (2010). Quadprog: Functions to solve Quadratic Programming Problems. R package version 1.5-3, [Online] Available: http://CRAN.R-project.org/package=quadprog