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# Main Factors that Affect the Economic Efficiency of Broiler Breeder Production

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## ABSTRACT

This study aimed at identifying the factors that affect the economic efficiency of broiler breeder production using the analysis of stochastic profit frontier function. Data were collected in 48 broiler breeder farms contracted by a commercial company located in southwestern Paraná, Brazil. The collected data refer to the last batch of fertile eggs that was delivered to the company, between January, 2008, and July, 2009. The following parameters were evaluated: production of hatching eggs per hen (number of eggs/hen), hatchability (hatch %), feed intake per hatching egg (g feed/ egg), production scale (number of birds/batch), farmer's experience in production activities, and labor type. Factors, such as area of occupied land, electricity costs, and invested capital were also evaluated. Results showed that the cost of electricity, as well as area of occupied land, production scale, and feed intake per hatching egg significantly affect the economic efficiency of the broiler breeder farms in Southwestern Paraná, Brazil.

## INTRODUCTION

During the last few years, poultry production has greatly developed. In 2008, chicken meat accounted for 2.94% of total Brazilian exports volume, and it is the fourth largest product in exports revenues (Mendes *et al.*, 2014).

Productivity developments and production-chain coordination progress increased the competitiveness of the poultry industry in Brazil, which is based in a vertical production system that integrates small farmers and large poultry companies. The main governance process of the chain is vertical integration. This allows poultry farmers to reduce both capital investments in farming and their risks (Figueiredo *et al.*, 2006).

The increasing competitiveness of the domestic and foreign markets has demanded the improvement of management pratices by the farmers in order to increase the technical and economic efficiency of their farms. Yamaki *et al.* (2009) applied the analysis of principal components as a management tool for broiler breeder production, and emphasized the need of continuous update of the agricultural process management.

Farm profitability depends on internal and external factors. The main internal factors are economy of scale; farmer's age; time dedicated to farm activities; use of machinery; land productivity; application of management technologies (Duffy & Nanhou, 2003); distance to consumer markets, processing plants, and service providers; environmental conditions, such as soil, relief, weather; possibility of placing the product in the market (downstream connection); possibility of using urban labor, and retirement pensions (Sousa Filho & Batalha, 2005).

The management of broiler breeders needs to solve several contradictions of this activity, such as animal welfare vs. productivity, production vs. reproduction, emerging diseases vs. consumer market, and costs vs. profits. The main challenge faced by producers is to find the balance between these factors and finetune all factors in order to increase profitability (Mendes *et al.*, 2005).

Jiang *et al.* (1998) used a deterministic economic model to evaluate the profitability of broiler breeder production. The authors applied a model based on profit equations with a fixed amount of broiler meat output and found both linear and nonlinear relationships between economic values and production circumstances. The authors concluded that, in general, economic values are sensitive to production levels and product and feed prices.

The economic evaluation of broiler breeder production is very challenging for two main reasons: 1) several factors affect its profitability, which makes statistical analysis difficult, and 2) production information are hard to obtain from the genetic companies. These challenges have been reported by several authors, including Groen *et al.* (1998), Faridi *et al.* (2011) and Yassin *et al.* (2012).

Groen *et al.* (1998) developed a deterministic model for the economic evaluation of broiler production and the derivation of economic values in broiler breeding. Four production stages were distinguished in their model: multiplier breeder, hatchery, commercial grower, and processor. Faridi *et al.* (2011) tested three Narushin-Takma (NT) models for their ability to describe different curves obtained from broiler breeder flocks, whereas Yassin *et al.* (2012) developed a management information system to evaluate the tactical management of a breeder flock using individual farm analysis with a deterministic simulation model (IFAS). Despite the considerable difficulty of obtaining information from the genetic companies and dealing with a great number of variables, Yassin *et al.* (2012), Faridi *et al.* (2011), and Groen *et al.* (1998) were able to evaluate some data obtained from industry and found consistent results.

In this context, this study aimed at analyzing the factors under the control of the poultry companies that may influence the economic efficiency of broiler breeder farmers. It especifically estimated farmers' economic efficiency measures; evaluated the effect of parameters related to economic inefficiency in broiler breeder farms; and defined which farm size, as defined by the number of birds housed, is the most economically efficient.

## MATERIAL AND METHODS

Data from 48 broiler breeder farmers contracted by a broiler company located in the southwest of the state of Paraná, Brazil were collected. Data refer to the last batch of fertile eggs delivered to the company between January 2008 and July 2009.

The economic efficiency of the contracted farmers was determined using profit (total revenue per flock minus effective operational costs) and fixed farm factors.

The profit frontier function was estimated based on electricity ($) and labor ($) costs, and on the costs related to occupied land area and capital used for production ($/m$^2$).

Economic inefficiency took into consideration the following factors: number of fertile eggs produced by hen (eggs/hen), hatchability (hatch %), feed intake per fertile egg produced (g/egg), and production scale (birds/flock). Other factors, such as farmer's experience (years) and labor (hired labor = 0 and family labor = 1).

The applied economic model was that proposed by Zilli (2003), who used stochastic analysis to identify factors that determine the economic efficiency of broiler farmers. This model was adapted for broiler breeder production, which parameters are different from those of broiler production

The economic efficiency of broiler breeder farmers was compared with the best economic efficiency obtained among those evaluated in the study. This allows a more realistic understanding of the relative efficiency of a farm than comparing a farmer's economic efficiencies with an unattainable ideal efficiency level. In addition, this evaluation method prevents comparisons with nonexistent farmers and provides information on the amplitude of the difference between the best and the worst economic efficiency values. Therefore, the efficiency frontier was obtained from the observed values of supplies and products, rather than from estimated values.

The technical efficiency of a farmer is determined by comparing the results of his/her production input to output with those of the other farmers in the sample.

When a farmer needs more inputs for a determined product compared with other farmers, he/she is considered inefficient, whereas if he/she produces more with less inputs than the other farmers, he/she is considered efficient.

The stochastic frontier model is a regression model estimated by maximum likelihood with a non-normal and non-symmetric disturbance (Greene, 2005). An example of a general stochastic frontier functional formulation is $y_i = f(x_i, \beta) + v_i - u_i = f(x_i, \beta) + e_i$, where $v_i$ represents the random error component and $u_i$ is the technical inefficiency component. The random error term, $v_i$, is assumed to be independent and identically distributed (i.i.d), with half normal distribution, as well as independent from the term $u_i$. Therefore, the error term, $e_i = v_i - u_i$, is not symmetric as long as $u_i \geq 0$.

The Ordinary Least Square (OLS) method of estimating linear regression parameters provides consistent estimates of the parameters of the stochastic frontier model, with the assumption that $v_i$ and $u_i$ distributions are independent of $x_i$, except for the parameter β0, when $E(e_i) = -E(u_i) \leq 0$. However, the OLS method does not provide estimates of specific technical efficiency.

In addition of obtaining parameter estimates of production technology β from $f(x_i, \beta)$, the objective of using OLS was to estimate the specific technical inefficiency $u_i$. This requires to extract error estimators $v_i$ and technical efficiency $u_i$ from the estimation of $e_i$ for each farmer. A few assumptions on distribution of both error components are needed in order to estimate the specific technical efficiency. This problem can be solved by estimating the parameters by the Maximum Likelihood method.

The econometric model can be standardized according to the type of data used, that is, in cross sections or panel data. For the purpose of this study, data were assumed to be cross-sectional with k inputs available for n farmers producing one single product.

Econometric models are classified as deterministic or stochastic frontier models, depending on random error assumptions and on the definition of inefficiency. The focus of this study was the stochastic frontier model.

The stochastic production frontier takes into account random shocks, which are determined as $y_i = f(x_i, \beta) \exp\{v_i\}ET$, where $[f(x_i, \beta) \exp\{v_i\}]$ is the stochastic production frontier. Thus, the technical efficiency is defined as $ET = y_i / f(x_i, \beta) \exp\{v_i\}$, obtained from the ratio between the observed product and the maximum product in an environment characterized by $\exp\{v_i\}$. In this case, $y_i$ gives the maximum value of $[f(x_i, \beta) \exp\{v_i\}]$ if and only if $ET_i = 1$. However, $ET_i < 1$ provides a measure of technical inefficiency from stochastic elements that vary among the production units.

Multicollinearity and simultaneity problems were expected since cross-sectional data were used. These problems may reduced by increasing the sample pool, but this was not possible in the present study due to the limited number of farmers contracted by the poultry company.

The parametric approach of the log-linear Cobb-Douglas function was used to estimate the frontier functions. Coefficients were obtained by maximum likelihood estimation (MLE) using Frontier 4.1 statistical package (Coelli, 1996).

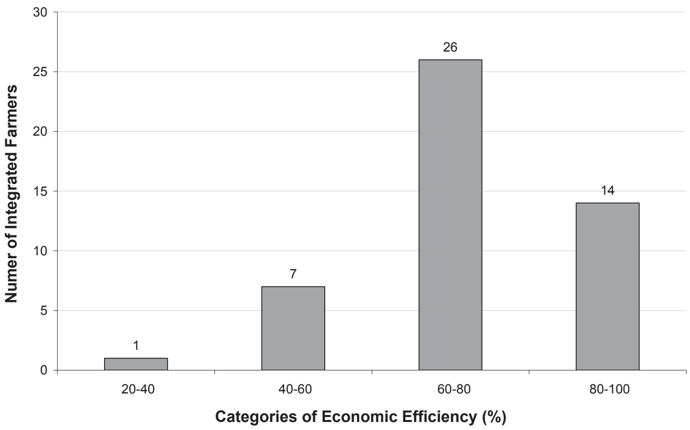
## RESULTS AND DISCUSSION

The profit frontier obtained for the evaluated broiler breeder farmers using the Maximum Likelihood Estimation (MLE) provided consistent coefficients. The maximum likelihood statistical test yielded an economic inefficiency of 28.365. A likelihood ratio (LR) of 12.159 was obtained, which exceeded the critical LR value proposed by Kodde & Palm (1986). Therefore, it may inferred that the stochastic frontier approximation is statistically different from the Ordinary Least Squares (OLS) approximation, where the distribution of the efficiency effects in the frontier function is considered independent. The null hypothesis of the absence of inefficiency effects was, therefore, rejected which led to the belief that the variable effects may be present in the model. Therefore, given this result, the hypothesis that gamma coefficient was equal to zero was tested to infer about σu.

If the variance is zero, the error term can be neglected and the coefficients can be consistently estimated by OLS. The estimated gamma was approximately 0.999, and therefore different from zero (standard error = 0.0576). Still, gamma is not different from 1, which indicates that the stochastic frontier model may not be significantly different from the deterministic frontier, which does not consider the random errors of the profit function.

In total, 48 observations were used in the model, resulting in an average efficiency of 0.738 or 73.8% for the broiler breeder farmers of southwestern Paraná, Brazil. Figure 1 shows the distribution of farmers per interval of economic efficiency.

**Figure 1 –** Number of integrated farmers of broiler breeder for each of the categories of economic efficiency (%).




The signs of coefficients estimated for the profit frontier, shown in Table 1, were expected. In addition, some of the coefficients were not significant (P≤0.000). As observed in Table 1, the cost with electricity ($\beta_2$), which is one of the main operation costs in poultry production (Turco *et al.*, 2002), presented a negative sign and was significant at 99% confidence level. According to the estimated electricity coefficient, for each 1% increase in electricity costs, profit decreased in approximately 0.45%. Although electricity costs had a significant impact on farmer's profit, the electricity price in Paraná ($ 0.07/kWh) is an advantage since it is substantially cheaper than in the other southern Brazilian states (average of $ 0.12/kWh).

**Table 1 -** Coefficients estimated by the profit frontier model of the broiler breeder farmers.

| | Variables | Coefficients | Standard Error | t Test |
|---|---|---|---|---|
| $\beta$ | Intercept | 6.382 | 0.483 | 13.213*** |
| $\beta^{0}$ | Labor Type | - 0.105 | 0.101 | - 1.039 |
| $\beta^{1}$ | Electricity | - 0.456 | 0.055 | - 8.235*** |
| $\beta^{2}$ | Land use | 1.488 | 0.214 | 6.948*** |
| $\beta^{3}$ | Invested Capital | - 0.088 | 0.173 | - 0.506 |
| $\sigma^{4}$ | Quadratic Sigma | 0.0374 | 0.008 | 4.887*** |
| $\sigma^{2}$ | Quadratic Sigma u | | | |
| $\sigma^{2u}$ | Quadratic Sigma v | | | |
| $\gamma^{v}$ | Gama | 0.999 | 0.0576 | 17.373 |

*Significant at 90% confidence kevel; ** Significant at 95% confidence level; *** Significant at 99% confidence level

The coefficient of labor cost ($\beta_1$) was also negative. Although labor is one of the main production costs, it was not statistically significant. This result suggests that merely reducing labor costs does not increase profit due to the impact of labor on bird performance, which may adversely affect farmer's profitability.

The work inside broiler breeder houses is often unhealthy and tiresome, causing the migration of farm workers to the cities in search for a better quality of life (Carvalho *et al.*, 2011), and therefore, the possible lack of labor is cause of concern.

The coefficient obtained for land area occupied for production, *β3*, was positive and different at 99% confidence level. The coefficient estimate indicated that a 1% increase in the occupied area is associated with 1.48% increase in profit.

The invested capital coefficient (*β4*) was not significant (p≤0.000) and negative, which suggests that increasing capital investments reduces profit. Broiler production in Brazil uses cutting-edge equipment and services (Pereira & Nääs, 2005); however, broiler breeder production has not changed much over the past years and has not incorporated as many technologies applied in broiler production, which may explain the negative sign obtained for *β4.*

The signs obtained for the variables that influence the farmer's economic inefficiency, shown in Table 2, were expected. However, the statistical significance of some of the variables require attention, such as production of hatching eggs per bird ($\delta_1$), hatchability ($\delta_{2)}$, feed intake per hatching egg ($\delta_{3),}$ production scale ($\delta_{4)}$, farmer's experience ($\delta_5$), and the labor type ($\delta_{6)}$.

The coefficient of the production of hatching eggs per bird ($\delta_1$) was not statistically significant and presented a negative sign, which indicates that farmers become more inefficient as the production of hatching eggs per bird is reduced. The term $\delta_1$ was expected to be statistically significant, because egg production is the most important driver of farmer's pay. However, it suggests that there are other performance parameters that may significantly influence (p≤0.000) input costs and, consequently, farmer's pay. Ali & Hossain (2010) studied the economic performance of the poultry farmers in Bangladesh and reported that the live performance directly affected the farmer's pay.

**Table 2 –** Estimated coefficients for the economic inefficiency of broiler breeder farmers.

| | Variables | Coefficients | Standard Error | t Test |
|---|---|---|---|---|
| $\delta_1$ | Production of hatching eggs/hen | - 0.546 | 0.597 | - 0.916 |
| $\delta_2$ | Hatchability | - 0.128 | 0.853 | - 0.150 |
| $\delta_3$ | Feed intake/ hatching egg | 1.124 | 0.375 | 3.000*** |
| $\delta_4$ | Production scale | - 0.256 | 0.084 | - 3.050*** |
| $\delta_5$ | Farmer's experience | - 0.032 | 0.062 | - 0.510 |
| $\delta_6$ | Labor type | - 0.045 | 0.099 | - 0.499 |

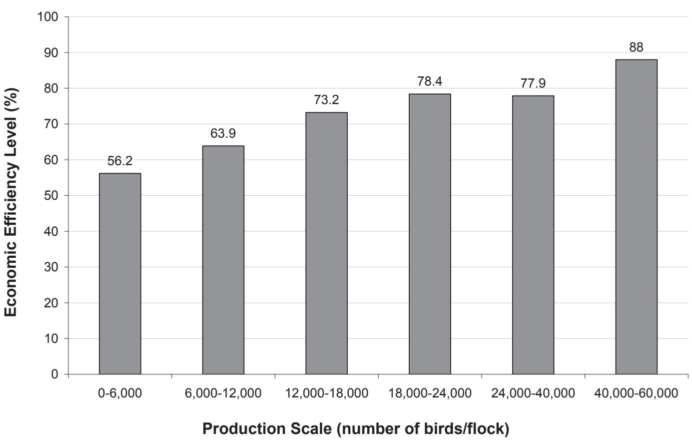
*Significant at 90% confidence kevel; ** Significant at 95% confidence level; *** Significant at 99% confidence level

Hatchability coefficients ($\delta_2$) were not statistically different (p≤0.000), although the model included data from two different broiler breeder strains with different hatchability results. The negative sign of this coefficient indicates the inefficiency is reduced as hatchability increases.

The estimated coefficient of feed intake per hatching egg ($\delta_3$) was approximately 1.12 (p<0.01) and positive, which suggested that an increase of 1% increase in feed intake per hatching egg is associated with approximately 1.12% reduction in profit. The positive relationship between feed intake per hatching egg and inefficiency was expected, since feed intake represents 70-80% of the total costs of poultry production (Nascimento *et al.*, 2005). According to Goodwin *et al.* (2005), the contracting companies should constantly perform and update cost and revenue evaluations.

The production scale coefficient ($\delta_4$) was statistically significant at 99% confidence level and presented a negative sign, which indicated that increasing production scale reduces inefficiency. This relationship between production scale and inefficiency suggests that that production scale may determine the exclusion of inefficient farmers from this activity. Moreover, this situation is aggravated when the farmers are not provided with guarantees or do not obtain credit to build larger units, their situation in the poultry business may be aggravated. As most broiler breeder farms in the evaluated region do not rear more than 40,000 birds, it is difficult to determine the production scale required to consider farmers efficient. In Figure 2, the sample was divided in six production scales to demonstrate the effect of scale on economic efficiency. The results show that efficiency (%) increases as a function of production scale increase.

**Figure 2 –** Economic efficiency level (%) of broiler breeder farmers for each of categories of production scale (number of birds/flock).




Although the farmer's experience in farm activities ($\delta_5$) was not statistically significant, it presented a negative sign, which suggests that experience contributes for the improvement of the farmer's economic efficiency. Ali & Hossain (2010) did not find any differences in farmer's experience with broiler production in Faridpur District, Bangladesh, with 34% of the farmers were highly experienced, 31% presented intermediate experience and 35% had little experience.

Labor type ($\delta_6$) was not statistically significant and presented a negative sign, which suggests that family labor is associated with a higher economic efficiency in broiler breeder production. Ondersteijna *et al.* (2003) studied the economic performance of dairy farms and reported that the education was the main farmer characteristic for improving production capacity and operational management.

According Tsoulouhas & Vukina (2001) most of the recent studies on broiler contracting system has focused on the management of risks between the contracting companies and the contracted farmers, using limited databases. The present study, on the other hand, used a broad set of production data and provided useful information on broiler breeder production in southwestern Paraná, Brazil.

## CONCLUSIONS

This study showed that electricity costs and area of occupied land for broiler breeder production negatively and positively affected the economic efficiency of broiler breeder farmers, respectively.

Labor costs, investments, hatching egg/hen, hatchability, farmer's experience, and labor type did not influence the economic inefficiency of the farmers. The production scale negatively affected economic inefficiency.

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