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Demand for Feed among Commercial Chicken Farms in Ghana: A Two Step Estimation Procedure

Background of Study

Domestic poultry production, particularly chicken production, has gained renewed interest among governments, development organizations, non-governmental organizations, and policy makers across sub-Saharan Africa in recent years. Several factors ranging from the importance of poultry production to food security and poverty alleviation to the declining market share of domestic production have combined to ignite this renewed interest. Recent trends in economic development or growth in sub-Saharan Africa has translated into increasing demand for animal protein, especially chicken products. However, a large proportion of this demand is increasingly being meet with imports to the disadvantage of weakening supply response of domestic production to demand; adding more urgency to the need for a competitive domestic sector to take advantage of this demand growth. In Ghana, a similar narrative persists. The contribution of domestic chicken supply to total consumption declined from 67.48 percent in 1993 to 27.12 percent in 2014. Within the same period, imports increased from 5,392 metric tons in to 141,238 metric tons; representing the third highest poultry imports in sub-Saharan Africa. This supply trend has generated a common perception that increasing tariffs on imported chicken products will somehow turnaround the weak supply response of domestic chicken production to the expanding consumer demand. What this belief fails to recognize is the potential differentiation of live-birds (main chicken broiler product supplied by domestic producers) and ready-to-cook (RTC) chicken (supplied by imports). A number of differing features including distinct price elasticity, distribution channels, and product features characterizes each product market that influence their strategic position in the chicken market space. For example, the channel of routine choice for live-birds is “direct-to-consumers” whereas “wholesalers and retailers” dominates the distribution channels for RTCs. Bulk purchases associated with wholesale and retail channels and their attendant price advantage, among other factors, may contribute in part to the relatively low price of RTC’s. In addition, price responsiveness differs for each product.

According to Al-hassan et al (2014) the price of local chicken grew by 8.9 percent per annum compared to an 11.54 percent growth in the price of imported chicken between 2001 and 2010. Yet, in the same period, the quantity of imported chicken increased from 12,422 to 112,635 whereas domestic chicken supply only increased from 20,804 to 36,803; i.e. live-birds are more responsive to price changes than imported frozen chicken, ceteris paribus. In the context of product features, imports offer several relative convenient forms such as cut, chill, frozen, and ready-to-cook, whereas domestic chicken are predominantly sold as live birds. It can, then be hypothesize that in the minds of consumers, the two products might be unique, wherein; RTCs meet their everyday chicken needs and live-birds meet their needs for festive occasions. Any attempt to increase productivity and market share of domestic production should, therefore, recognize the uniqueness of the two products.

As with most poultry production systems across the world, feed cost has been consistently identified as a much greater constraint to production expansion and profitability than the traditional narrative may suggest. For example, a recent study by Etuah (2014) shows that broiler farmers in Ghana’s Ashanti Region rank high feed costs as the severest constraint to their production ahead of “competition from cheap imports” and “lack of government support”. So, among chicken producers, there is increasing interest to lower production cost via reducing feed cost, yet, a review of the literature revealed that no studies have estimated feed demand relationships for Ghana’s chicken industry using a national-level data; hence, the present study. The issue of feed-food competition nexus also, heightens the severity of the feed constraint situation. Maize, which constitutes about 60 percent of chicken feed, is the second most important staple crop in Ghana. The yield per hectare of maize is low and shortfalls in domestic production for human consumption exist. The net result is a continuing shortage of maize for feed use that translates into high feed price.

In fact, in a recent study by Amanor-Boadu et al. (2016), feed cost is estimated to accounts for 74.2 percent of total variable cost in broiler operations and 92.3 percent in egg or layer operations. Both regional and scale variations in feed cost exist. For instance, in broiler operations, feed cost as a proportion of total variable cost range between 92.9 percent for the three northernmost regions (Upper East, Upper West, and Northern Regions) compared with 77.5 percent in Ashanti Region. In the same study, feed cost share of total variable cost averaged 74.8 percent for small-scale farms compared to 73.2 percent for medium-scale and 72.6 percent for large-scale operations. From the same study, feed cost and gross margin were shown to exhibit a direct positive relationship. High feed cost regions were estimated to contribute less to total gross margin, so were small-scale operations having the least gross margins.

The foregoing suggests that such a high share of variable cost is attributable to feed prompts rethinking the poultry problem as a production instead of a trade problem. The increasing imports of poultry meat may have their foundation in domestic production’s inability to keep pace with demand and attributing them to a price problem may lead to erroneous policy responses. If feed cost is a major constraint to production, as most farmers believe, then the import control could lead to a dynamic market response that begins with increasing poultry meat prices followed by entry into the industry and production expansion of those already in it. The expanding production would lead to increasing demand for feed, which would lead to increasing feed prices. If the price elasticity of feed demand is higher than that of meat demand, then it is hypothesized that feed costs will rise faster than product prices, leading to increasing financial stress on poultry farmers. This stress would lead to exits, reducing production and exacerbating the product price problem on the demand side.

These are compelling enough reasons to explore producers' feed choice behavior, specifically producers' decision mechanism regarding the use of on-farm feed and commercial feed. With feed constituting the major cost component in chicken operation, production response has increasingly been affected by feed price and supply fluctuations. This necessitates the examination of farmer's feed choice decision factors and their attendant effect on profit margins. Understanding these factors could help identify potential sources of efficiency in feed production to enable the evolution of higher volume feed mills that could provide advantages of scale economies to poultry farmers. In the end, identifying the factors that influence producer margins would help policymakers and investors develop the appropriate policies and strategies to enhance industry competitiveness. Thus, this study contributes directly to the ongoing discourse on how to address the multitude of challenges facing the poultry industry in Ghana by focusing on what has been identified by both farmers and their supporters as the industry's Achilles' heel: feed and feed cost.

Tobit Model for the Proportion of Feed Used

The empirical application of the Tobit model to chicken feed demand assumes that chicken producers make feed acquisition and intensity/consumption decisions simultaneously. The statistical specification of this model is based on the existence of a latent utility random variable that represents the proportion of feed type, *m*, needed to produce the desired quantity of output to maximize expected utility of profit. The latent utility random variable is continuous, real-valued and linked directly to the observed feed proportion variable (used as the proxy for feed consumption or usage) a_i via the transformation

$$\begin{aligned} a_i &= 0 \quad \text{if} \quad a_i^* \le 0 \\ &= a_i^* \quad \text{if} \quad 0 < a_i^* < 100 \\ &= 100 \quad \text{if} \quad a_i^* \ge 100 \end{aligned} \tag{2}$$

The observed feed proportion variable is subject to a ceiling effect with several of its value clustered at both 0 and 100. If a producer acquires $(\kappa_i = 1)$ feed type m, then we have $0 < a_i \le 100$; if a producer decide not to acquire $(\kappa_i = 0)$ feed type m, then $a_i = 0$. Formally, the utility-proportion relationship takes the form of

$$a_i = 1\{a_i^* > 0\} a_i^* \tag{3}$$

where $1\{Q\}$ represents an indicator function. If event Q holds, $1\{Q\} = 1$, then all or a proportion of producer $i's$ feed is constituted of feed type m; if not then $1\{Q\} = 0$, producer i, does not use feed type m. In order to model producer feed demand decision, the Tobit model is defined in a latent variable framework as follows:

$$a_i^* = x_i\beta + u\,, \tag{4}$$

where x_i is a vector of farm and personal characteristics for producer i, market prices, external shocks, and production flexibility; β is a vector of parameters to be estimated, and u is a vector of independently and normally distributed random noise with mean zero and variance σ^2.

Assuming a_i is normally distributed with mean $x_i\beta$ and variance σ^2 i.e. $a_i \sim N(x_i\beta, \sigma^2)$, then for a producer with $\kappa_i = 0$, the contribution to the likelihood of limit observations is determined by

$$P(a_i = 0 / x_i) = P(a_i^* \leq 0) = 1 - \Phi\left(\frac{x_i\beta}{\sigma}\right) \tag{5}$$

For a producer with $\kappa_i = 1$, the contribution to the likelihood of positive observations are determined by

$$P(a_i = a_i^*) = P(0 < a_i < 100) = \frac{1}{\sigma}\phi\left(\frac{a_i - x_i\beta}{\sigma}\right) \tag{6}$$

and

$$P(a_i = 100) = P(a_i^* \leq 100) = \Phi\left(\frac{100 - x_i\beta}{\sigma}\right) \tag{7}$$

where $\phi(\cdot)$ and $\Phi(\cdot)$ are, respectively, the standard normal probability density function (pdf) and the standard normal cumulative distribution function (cdf). Note that $1 - \Phi(x_i\beta/\sigma)$ is the estimated probability of observing a zero or lower limit value at particular values of x_i; $1/\sigma\left[\phi(a_i - x_i\beta/\sigma)\right]$ is the estimated probability of observing an uncensored positive observation at particular values of x_i; and $\Phi\left[(100 - x_i\beta)/\sigma\right]$ is the estimated probability of observing an upper limit value at particular values of x_i. Equations (5), (6) and (7) are evaluated for the values of the unknown parameter vector, β and the scalar, σ^2, using the log-likelihood function:

$$\ln L_{Tobit} = \sum_{a_i=0} \ln\Phi\left(-\frac{x_i\beta}{\sigma}\right) + \sum_{a_i=a_i^*}\left[\frac{1}{\sigma}\phi\left(\frac{a_i - x_i\beta}{\sigma}\right)\right] + \sum_{a_i=100}\left[\Phi\left(\frac{100 - x_i\beta}{\sigma}\right)\right] \tag{8}$$

The value of a_i in the model can then be estimated using the following expression (Maddala 1983):

$$\begin{aligned} E(a_i) &= P(a_i = 0) * 0 \ + \ P(0 < a_i^* < 100) * E(a_i / 0 < a_i < 100) \ + \ P(a_i = 100) * 100 \\ &= 0 \ + \ x_i\beta(\Psi_2 - \Psi_1) \ + \ \sigma(\psi_1 - \psi_2) \ + \ (1 - \Psi_2) * 100 \end{aligned} \tag{9}$$

where $\Phi\left(x_i\beta/\sigma\right)$ and $\Phi\left[(100 - x_i\beta)/\sigma\right]$ are denoted by Ψ_1 and Ψ_2, respectively; ψ_1 and ψ_2 are the corresponding values of the unit normal density. The first and last terms represents the probability that the dependent variable is at the lower and upper limits times their respective values. The second two terms represent the probability that the dependent variable is between 0 and 100 times the expected value of, given that it is between the limits.

Double Hurdle Models for Feed Demand

The body of work on hurdle models originated by Cragg (1971) is a generalization of the Tobit model, built around the concept of decomposing a demand decision into two separate decisions: an acquisition decision and an intensity decision. The conceptual basis for decomposing demand into separate stochastic process rests on the notion that producers must overcome two hurdle decisions before recording positive feed use. The first stage decision involves the choice of a feed type and the second stage decision involves the choice of the use intensity (or proportion) of selected feed type. Theoretically, the two hurdle decisions – acquisition and intensity – can be tackled as a sequence or taken jointly depending on the economic process of interest. Formally, the sequential decision mechanism can be defined by the following mathematical representations:

(10)

and

$$a_i = 1\left\{a_i^* > 0 / \kappa_i = 1\right\} a_i^* / (\kappa_i = 1), \tag{11}$$

where (10) is the first hurdle or acquisition decision, which is represented by a probit model based on the latent variable relations:

$$\kappa_i = 1 \text{ if } \kappa_i^* > 0 \text{ and } 0 \text{ if } \kappa_i^* \leq 0$$

and

$$\kappa_i^* = h_i\gamma + \upsilon \qquad (12)$$

where κ_i^* is a latent acquisition variable taking the value 1 if $a_i > 0$, and 0 otherwise; γ is the vector of parameter estimates for the probit model; h_i represents the vector of covariates hypothesized to influence the acquisition decision (farm and personal characteristics); and $\upsilon$is a vector of independently and normally distributed random noise with mean zero and variance σ^2 i.e. $\upsilon \sim N(0,\sigma^2)$. The acquisition or non-acquisition of a feed type is modelled as a probability choice where acquisition occurs with probability:

$$P(\kappa_i = 1) = P(a_i^* > 0) = \Phi(-h_i\gamma) \qquad (13)$$

and non-acquisition occurs with a probability:

$$P(\kappa_i = 0) = P(a_i^* \le 0) = 1 - \Phi(-h_i\gamma) \qquad (14)$$

Equation (11) is the second hurdle or intensity decision that explains the outcome of a continuous decision of the proportion of feed used and defined by a lognormal regression model.

$$\ln a_i = z_i\theta + \varepsilon_i \qquad (15)$$

where z_i is a vector of covariates hypothesized to influence intensity of feed use, θ ε_i i.e. $\varepsilon_i \sim N(0,1)$. The parameters of equations (10) and (11) are estimated separately under the assumption of independency between the disturbances υ_i and ε_i. Their interpretation lends itself to the assumption that producers decide first whether or not to acquire a given feed type, then conditional on acquisition only do they determine the use intensity. This suggests that only a sub-set of producers faces both hurdle decisions. As a result, the model inference for the framework given by (10) and (11), applies to only producers in the sub-sample that passes the first hurdle.

The joint decision mechanism proceeds along similar lines of the sequential decision mechanism except that the second stochastic process takes the form $a_i = 1\{a_i^* > 0\} a_i^*$. This statistical specification of the joint decision mechanism is predicated on the assumption that all producers (including those who elect to acquire or not acquire a given feed type) face both hurdle decisions. In this case, the disturbances, υ_i and ε_i are assumed to be distributed according to a bivariate normal distribution specified as

$$\begin{bmatrix} \upsilon \\ \varepsilon_i \end{bmatrix} \sim N\left(\begin{bmatrix} h_i\gamma \\ z_i\theta \end{bmatrix}, \begin{bmatrix} 1 & \rho\sigma \\ \rho\sigma & \sigma^2 \end{bmatrix} \right) \tag{16}$$

where ρ which represents the correlation coefficient between the error terms of the acquisition and intensity equations, distinguish between an "independent double hurdle model" ($\rho = 0$) and a "dependent double hurdle model" ($0 < \rho \leq 1$). The sequence in which the hurdle decisions are taken is not separably identifiable; hence, the model inference applies to all producers in the sample (Cragg 1971). The probability density function of the observed censored variable a_i of the hurdle models is a discrete-continuous mixture that assigns a probability mass $P(a_i = 0)$ to the discrete component ($a_i = 0$) and a density function $f_+(a_i)$ to the continuous component ($a_i > 0$). The joint lognormal density function is given by

$$\ln L_{Hurdle} = \sum_0 \ln\left[1 - \Phi(h_i\gamma)\Phi\left(\frac{x_i\beta}{\sigma}\right)\right] + \sum_+ \ln\left[\Phi(h_i\gamma)\frac{1}{\sigma}\phi\left(\frac{a_i - x_i\beta}{\sigma}\right)\right]$$

where $\sum_0$ is a sum over all zero observations and $\sum_+$ is the sum overall positive observations; $\Phi(\cdot)$ and $\phi(\cdot)$ respectively, denote the cdf and pdf of a $N(0,1)$ random variable. The first term represents the log-likelihood of the probit model for acquisition and the second term represents a lognormal model for the positive values of feed proportion. As specified in equations (4), (12) and (15), xi represents farm and personal characteristic variables, hi represents the vector of covariates hypothesized to influence the acquisition decision whiles zi represents a vector of social and economic covariates hypothesized to influence intensity of feed use.

Model Selection

The hypothesis tested is whether feed demand decisions are taken jointly but simultaneously, jointly but separately or sequentially. This hypothesis is tested by first estimating the Tobit, and double hurdle models discussed in the previous sub-sections.

The test for the sequential double hurdle model against the Tobit model is given as:

H_0: Tobit, with a log-likelihood function given in equation

H_1: Sequential double hurdle model (a probit model and a lognormal regression model, estimated separately), with a log-likelihood function given in equation

$$\lambda_{ST} = 2(\ln L_{\text{Probit}} + \ln L_{\text{Lognormal regression}} - \ln L_{\text{Tobit}})$$

The test for the joint double hurdle model against the Tobit model is given as:

H_0: Tobit, with a log-likelihood function given in equation

H_1: Joint double hurdle model (a probit model and a lognormal regression model, estimated simultaneously), with a log-likelihood function given in equation

$$\lambda_{JT} = 2(\ln L_{\text{Joint Hurdle}} - \ln L_{\text{Tobit}})$$

The test for the sequential double hurdle model against the joint double hurdle model is given as:

H_0: Tobit, with a log-likelihood function given in equation

H_1: Joint double hurdle model (a probit model and a lognormal regression model, estimated simultaneously), with a log-likelihood function given in equation

$$\lambda_{SJ} = 2(\ln L_{\text{Probit}} + \ln L_{\text{Lognormal regression}} - \ln L_{\text{Joint Hurdle}})$$

Conclusion

Feed supply is an important issue confronting Ghanaian chicken producers in need of relevant empirical research. The purpose of this study was to understand the factors associated with producers decisions to use on-farm feed, and the proportion of feed which is produced on-farm and how these decisions influences profit margins. In doing so, the study determines if producers make these decisions sequentially or simultaneously. The study is motivated by the lack of empirical studies on chicken feed demand and the need to identify social and economic factors that influence the choice over different feed type and proportion for effective policy formulation.

Reference

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