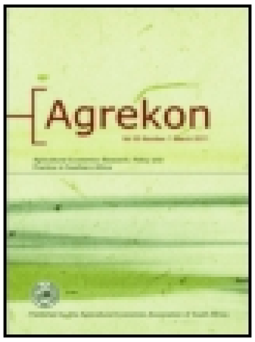

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Gendered analysis of the demand for poultry feed in Kenya

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ABSTRACT

This paper uses a translog cost function approach to study the farm-level demand for poultry feed in Kenya. The study estimates the demand elasticities of the three common types of poultry feed; mixed feed, grain, and leafy vegetables. The estimated model was used to obtain estimates of Marshallian demand elasticities for poultry feed in Kenya for male-headed and female-headed households. The elasticities reported can be used by researchers and policy analysts to evaluate policy effects of changes in feed demand quantities within the livestock economy in Kenya. Moreover, these parameters can provide more reliable estimates of the total change in feed demand than relying on subjective measures of elasticities. Furthermore, the results of this study are essential in enhancing gender equitable policy formulation. Our findings show that own price elasticities of demand for all the feed types are negative and less than unit in absolute value for the sample of farmers surveyed, indicating that the feed types are relatively inelastic. The cross-price elasticities indicate that vegetables and grain are compliments while the rest of the poultry feed types are substitutes. The results also show that there are substantial gender differences in feed demand and elasticities of feed demand with respect to feed prices.

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Poultry feed; mixed feed demand; translog cost function; gender

1. Introduction

Development of the livestock sector is viewed as one of the important pathways for reducing poverty and improving food security in many households in developing countries (Thornton 2010; Food and Agriculture Organization [FAO] 2012). In Kenya, poultry farming is a major livestock subsector contributing to both income and food security of many households, particularly those residing in rural areas. Nationally, the subsector contributes about 7.8% to the national Agricultural Gross Domestic Product (GDP) and about 0.34% of the total GDP (Economic Survey 2018). Small scale poultry farming, which is practiced by over 80% of the rural farmers is mainly dominated by women farmers (Kitalyi 1998; Okitoi et al. 2007; Ndegwa et al. 2015) and women perform many of the activities even when male farmers are the owners of the poultry enterprises (Mutua 2018; Patel et al. 2016; Zewdu et al. 2016). Therefore, women form an important link between the success of the poultry

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enterprise and its contribution to alleviating poverty. Income generated from livestock production faces a control challenge (Panda 2016). However, in smallholder poultry farming income is controlled by women, providing a good avenue that can provide positive spiral events that will lead the women and rural households out of poverty if channelled and consolidated well (Jensen and Dolberg 2003; Patel et al. 2016; Sanyang 2012).

Research indicates that despite there being benefits that are derived from poultry farming, the subsector faces several constraints that hinder the full realisation of its potential. These constraints include lack of markets, diseases such as Newcastle or Ngumboro infestation, inadequate and inaccessibility to quality poultry feeds among others. Inadequate and inaccessibility of quality poultry feeds is considered one of the most important constraint faced by smallholder farmers. In poultry production, feed costs account for over 70% of the production costs, making it critical for successful poultry production (Mwanzia 2010; Munguti and Charo-Karisa 2011). The high production costs are due to high feed prices emanating from the high cost of ingredients used to manufacture the feeds. Notably, key ingredients in feed manufacture include fish and soy (Allegretti et al. 2018; Gitonga 2014). This results in a food-feed competition as these ingredients are also used as food. Therefore, manufacture of quality and affordable feeds depends on availability of the ingredients for use as human food and for feed manufacture. Additionally, an increase in feed ingredient prices results in an increase in feed prices across the livestock sector apart from affecting the food available among households. Therefore, to sustain production and avoid unnecessary production decline in one sector, ingredient substitution must be done in a way that benefits all the enterprises and the food production component. In the poultry subsector, high and fluctuating prices of poultry feed hamper sustained supply of the products to the market. Furthermore, farmers are forced to abandon the enterprises due to increased cost of production, thus reduced output and resultant profits (Bett, Njehia, and Njoroge 2015). The effect of high production costs is likely to have greater impact on resource-poor producers which is made worse if the producers are women due to the inaccessibility of productive resources and differences in priorities, hence negating the potential of poultry enterprise in improving food security and reducing poverty in rural areas (Alders et al. 2018). The demand for production inputs such as feed is influenced by among other factors, the price of the feed, the type of poultry under production, income and the gender of the producer (Zewdu et al. 2016). Gender analysis shows that the experiences of women and men in production differ as women are faced with certain resource constraints that may not be constraints to men. Additionally, women have different priorities compared to men (Panda 2016).

The potential contribution of the poultry subsector to poverty alleviation and food security calls for robust gender-equitable policies and interventions that can promote growth and development of an efficient feed subsector, and improve poultry productivity through increased access to affordable and cost-effective feed. The formulation of such policies will, however, need reliable empirical evidence on how changes in feed prices impact feed demand and supply sides of the feed subsector taking into consideration producer gender differences. Estimates of feed demand elasticities would provide an important ingredient for policy analysis and development of effective policy interventions and tools to improve the feed markets in Kenya. In this regard, the results will enable the development of policies to increase feed uptake and thus increase production given the differences in gender needs, expectations and priorities. In the formulation of gender-equitable strategies, it is essential to take into consideration the differences in gender in terms of experiences, needs and priorities to achieve equitable outcomes for women and men. However, rigorous empirical studies on feed demand are scarce in Kenya, as in other developing countries.

In this paper, we estimate the demand elasticities for three common poultry feeds used by smallholder farmers in Kenya; mixed feed,[1] grain and vegetables. Demand studies in developing countries provide a framework of analysis that is adopted in the analysis of the demand in the developing countries (Kavoi, Hoag, and Pritchett 2009). A key difference in production systems is that in developed countries poultry production is commercialised and automated and use of feed is commercially driven. In developing countries, poultry production adopts a combination of systems with smallholder farmers undertaking a combination of locally available feed resources and complementing with commercial feeds (Mbugua 2014). Feed substitution without taking into consideration their nutritive value results in poor quality products and thus poor market and reduced incomes. We further delve into the gender differences in the demand for poultry feed to derive gender inclusive policy implications for improving feed demand, and stimulating increased productivity of the poultry subsector.

1.1 Limitations of the study

In this research on feed demand, a number of limitations are identified. Firstly, there is a limitation of income differences between the farmers as some undertake poultry production as a part-time exercise while others as a main economic activity. Secondly, research on the nutritive content of locally used feeds is limited thus determining the nutritive content is not possible. Additionally, the sample size for the female-headed households is small compared to the male-headed households. Thus, the findings of this paper may not be representative of the whole county, but rather the farmers interviewed especially for Kirinyaga.

1.2 Organisation of the paper

The paper is organised as follows; Section 1 introduces the paper, Section 2 describes the study areas, sampling, data and description of, the econometric framework and estimation strategies, followed by results and discussions in Section 3. The last section (Section 4) summarises and concludes, highlighting key findings and policy implications for the feed subsector in Kenya.

2. Methods

2.1 Sampling, data sources and data collection procedure

The study utilised cross-sectional data collected from a random sample of 386 farmer households residing in Kisii, Kirinyaga and Nakuru Counties, in July 2015. Yamane (1967) provides a simplified formula to calculate sample sizes when the population is known. This is represented as follows:

$$n = \frac{N}{1 + N(e^2)} \tag{1}$$

where n is the sample size, N is the population size, and e is the level of precision. This formula was used to calculate the sample sizes used in the survey for poultry. A 95% confidence level was assumed in the calculation of the sample sizes for poultry farmers. According to the Sub-county officers from the three counties i.e., Kisii, Kirinyaga and Nakuru there were around 6000 active poultry farmers distributed as follows; 2365 farmers in Kisii, 876 farmers in Kirinyaga and 2554 farmers in Nakuru. Using Yamane's formula, a sample of 388 was selected and distributed according to proportion to size as follows; 175 farmers in Kisii County, 63 farmers in Kirinyaga County and 151 farmers in Nakuru. Stratified purposive sampling was employed to select sub-counties that had a high population of poultry farmers. Then random sampling was used to identify the specific respondents at all the wards in a selected subcounty. The sample frame composed of a census of active smallholder poultry farmers in the survey sites compiled by the respective Sub-County Agricultural Officers for the sites targeted for this study. The data were collected through face to face interviews using a structured questionnaire administered by trained enumerators. The survey questionnaires for farmers captured important variables, including the socioeconomic and demographic attributes of farmer households, the types and quantities of feed used in poultry farming, the quantity of feed purchased used on the farm; the quantity of feed mixed on the farm; the source of feed and prices paid for the purchased feed.

2.2 Model specification

The present study is anchored on the producer theory which postulates that firms or producers either aim to maximise profits or minimise costs subject to technological constraints (Varian and Varian 1992). Using this theory, the production function which is a technological relationship between any particular combination of inputs and the resulting levels of outputs was formulated (Debertin 1986). An extension of the production function was formulated to incorporate producer behaviour which is important in decision making, especially for smallholder farmers who have to make joint decisions on production and consumption. Rational farmers faced with scarcity of resources have to make a decision that achieves optimal production and maximises utility. This requires operation in such a way that minimises costs.

According to Diewert (1971) the estimation of input elasticities can be done indirectly from a cost or profit function and it involves postulating a functional form for the cost or profit function. Once the functional form is formulated it can be differentiated with respect to input prices to obtain derived demand functions. Pope (1982) stated that when there exists a one-to-one correspondence between the production and cost or profit function, either the cost or profit function can be used to derive the properties of the production function. Derivation of the input elasticities indirectly from a cost or profit function has the ability to accommodate a multiple output as well as a multiple input framework (Tocco, Bailey, and Davidova 2013). Several functional forms such as Cobb–Douglas, constant elasticities of substitution (CES), the variable elasticity of substitution (VES), nested-CES and the translog can be used to estimate the cost function (Chaudhary, Mushtaq, and Kaukab 1998).

This study adopted the translog cost function due to its flexibility and ability to use more than one factor. Additionally, the translog specification is a second-degree flexible function in prices and fixed inputs whose estimation imposes no restriction as it integrates the input demand functions to the output supply function and uses input prices rather than input quantities. Differentiating the function with respect to input or output price (or what is known as the Hoteling's lemma), gives the cost-share equation for that specific input or output, the cost shares. The cost shares are the basic forms used to compute price elasticities of inputs and output (Christensen, Jorgensen, and Lau 1971).

The study is based on the premise that feed production accounts to over 70% of the production costs and therefore changes in the feed cost are expected to affect the overall production costs. Other production costs may include the cost of treatment and labour. However, in small-scale production, these costs are small as the production is undertaken in conjunction with other enterprises not as the only primary enterprise. In addition, in smallholder productions, commercial feed may be used as the main feed or as a complement of other feeds such as grains and vegetables which are easily available and affordable. Although, this complementation does not take into account the nutritive value of the feed they use, the farmers operate as if they have similar nutrition component.

Following Binswanger (1974) the translog total feed cost function for poultry production in Kenya can be specified in the following equation:

$$\ln C^* = \varphi_0 + \ln \phi_q Q + \sum_{i=1}^{3} \varphi_i \ln P_i + \frac{1}{2}\sum_{i=1}^{3}\sum_{j=1}^{3} \varphi_{ij} \ln P_i \ln P_i + \sum_{i=1}^{3} \varphi_{iq} \ln P_i \ln Q; \quad i = (1, 2, 3) \qquad (2)$$

where C^* is the total cost of feed used in production for the enterprise derived as the total costs of the three variable feed inputs (Vegetables, Grains and Purchased mixed feed), Q is the output (number of poultry units), P_i is the money price per kilogram of feed type and $\varphi_0\ \varphi_q\ \varphi_i\ \varphi_{ij}\ \varphi_{iq}$ represents parameters to be estimated. The translog cost function specified in Equation (2) was estimated using Maximum Likelihood Estimation (MLE).[2] We then applied the Shephard's Lemma to derive the three optimal cost-share equations, one for each of the feed types. The cost share for the equations for leafy vegetables, grains and purchased mixed feed is specified in the following equation:

$$\frac{\partial \ln C^*}{\partial P_i} = S_i = \frac{P_i X_i}{C^*} = \alpha_i + \sum_j \varphi_{ij} \ln P_j + \gamma_{iy} \ln Q, \quad (i = 1, 2, 3,) \tag{3}$$

where X_i is the quantity of feed i (vegetables, grains and purchased mixed feed), S_i is the expenditure share for feed i. The parameters and symbols are as identified earlier. The farm-level feed demand model can be specified as

$$S_i = \alpha_i + \sum_{j=1} \varphi_{ij} \ln P_j + \sum_{f=1} \beta_i \ln W_f + \gamma_{iy} \ln Q + \varepsilon_i \tag{4}$$

where i indexes the three feed types used in poultry production, f indexes quasi-fixed factors (W). These include age to control for the effect of farming experience on input demand; distance in kilometres (km) to nearest trading centre to control for effect of market access on input demand; education to control for the effect of access to information on input demand; marital status to control for the effect of access to labour on input demand; employment to control for the effect of access to extra sources of income on input demand; production system to control for the effect of capital outlay on input demand; and bird type to control for the effect of bird type on input demand. Separate models of feed demand (in Equations (3) and (4)) were estimated for male and female-headed households.

For statistical specification, additive errors with zero expectations and finite variance are assumed for each of the four demand equations of the model. The covariance of the errors of any two of the equations for the same farmer may not be zero, but the covariance of the errors of any two equations corresponding to different farms is assumed to be identically zero. Under these assumptions, an asymptotically efficient method of estimation is used to estimate jointly the system of demand Equations (3) and (4) by application of the seemingly unrelated regression (SURE) method (Zellner 1962). The estimator is a Maximum Likelihood Estimator (MLE). Symmetry constraints ($\varphi_{ij} = \varphi_{ji}$) and adding up restrictions were imposed on the equations. The adding up restriction was imposed by excluding one equation, in this case, the share equation for vegetables. Further, the estimated parameters (φ_{ij}) which have little economic meaning of their own were used to derive the own and cross-price elasticity of factor demand (Binswanger 1974).

$$\eta_{ij} = \frac{\phi_{ij}}{S_i} + S_j \quad \text{for all } i, j; i \pm j \tag{5}$$

$$\eta_{ii} = \frac{\phi_{ij}}{S_i} + S_i - 1 \quad \text{for all } i \tag{6}$$

2.3 Data and summary statistics

The study utilised cross-sectional data collected from a sample of 388 poultry farmers surveyed in Kisii, Kirinyaga and Nakuru counties, in Kenya. These counties have high levels of poverty (51%, 25% and 43%, respectively) according to Kenya National Bureau of Statistics (KNBS 2015) and encompass wide and diverse agro-ecological environments. The number of female-headed households was 52 while that of male-headed households was 334. The survey was conducted by the International Centre for Insect Physiology and Ecology (*icipe*) in July 2015. The data were collected through face to face interviews using a structured questionnaire; administered by enumerators trained by *icipe*. The survey questionnaires captured important variables, including the socioeconomic and demographic attributes of farmer households, the types and quantities of feed used in poultry farming; the source of feed and prices paid for the purchased feed. Tables 1 and 2 present the descriptive statistics of the surveyed household, comparing between male- and female-headed households. According to the results, there were significant differences in the means between male-headed households and

Table 1. Selected socioeconomic characteristics of poultry farmers.

Variable	All households (*n* = 386)	Male-headed (*n* = 334)	Female-headed (*n* = 52)	t-Statistic
Age of household head (Years)	52.05 (0.65)	51.58 (0.71)	55.10 (1.72)	−1.84*
Education level of household head (Years)	9.30 (0.24)	9.19 (0.26)	9.96 (0.71)	−1.09
Household head is married (1=Yes, 0=Otherwise)	0.81 (0.02)	0.92 (0.02)	0.19 (0.06)	16.38***
Household is engaged in business (1=Yes, 0=Otherwise)	0.62 (0.02)	0.65 (0.03)	0.38 (0.07)	3.76***
Distance to a feed trader (Km)	3.74 (0.56)	3.68 (0.64)	4.08 (0.66)	−0.24
Household size (No.of persons)	3.77 (0.10)	3.91 (0.10)	2.87 (0.30)	3.80***
Income (Kshs)	60,874.26 (7,573.39)	55,523.90 (7,484.60)	95,240.00 (28,946.83)	−1.80*
Production system (1=Free range, 0=Otherwise)	0.53 (0.03)	0.53 (0.03)	0.58 (0.07)	−0.63
Main breed of chicken (1=local, 0=otherwise)	0.88 (0.02)	0.90 (0.02)	0.81 (0.06)	1.83***
Number of chicken	32.68 (0.98)	32.72 (1.08)	32.19 (2.23)	0.18

Note: Standard errors in parentheses.

female-headed households. In particular, the results show that the difference in age between male-headed households and female-headed households was significant at 10%. Additionally, the study found out that poultry production in the study area is dominated by local breeds of poultry, and at least half of the farmers surveyed keep their poultry on a free-range system. An average farmer in the sample keeps about 32 chickens (Table 1). The difference in income earned from poultry by female-headed households was significant at 10%. This shows that female headed households were earning higher incomes compared to their male counterparts.

Table 2 reports the mean quantity of feed demanded, unit prices and average expenditure reported by farmers surveyed. We note comparable quantities of feed demanded between the female and male-headed households, except for leafy vegetables which are mostly used by females. Furthermore, there are no significant differences between the two farmer categories with respect to feed expenditure and feed prices. Feed expenditure was highest for mixed feed followed by grains and vegetables (Table 2). The results further show that female-headed households on average used more of all types of feed when compared to the male-headed household. This indicates that as production become sensitive to gender differences and the different experiences, needs and priorities set, increase in feed demand will be driven by female producers.

3. Estimation results: estimated elasticities of demand for poultry feeds

Examining the responsiveness of farmers to prices of poultry feed is important for understanding the structure of their production, and thus essential for the formulation of a variety of micro policy actions for increased poultry productivity in farm households. This study derived the own-price and

Table 2. Monthly feed quantity and expenditure.

	Pooled (*n* = 386)	Male headed (*n* = 334)	Female headed (*n* = 52)	T-statistic
Feed quantity (kg per month)				
Grains	55.00 (4.40)	56.24 (4.73)	50.15 (11.47)	0.42
Vegetables	48.37 (4.58)	45.14 (3.81)	72.79 (26.54)	−1.96*
Mixed feed	286.14 (53.72)	254.91 (54.91)	478.99 (185.85)	−1.32
Unit price (Kshs/kg)				
Vegetables	28.00 (0.55)	27.72 (0.58)	29.77 (1.63)	−0.37
Grain	38.42 (0.20)	38.40 (0.21)	38.61 (0.66)	−1.28
Mixed feed	54.62 (1.01)	54.51 (1.06)	55.30 (3.23)	−0.26
Feed expenditure (Kshs per month)				
Grains	2114.79 (166.68)	2146.31 (180.82)	1833.00 (368.57)	0.56
Vegetables	1247.83 (111.82)	1211.42 (114.25)	1523.57 (419.85)	−0.90
Mixed feed	16,214.38 (3,331.32)	14,484.87 (3,466.87)	26,949.91 (10,602.97)	−1.38

Note: Standard errors in parentheses.

cross-price elasticities for the three variable inputs by evaluating Equations (5) and (6) using estimated coefficients from the translog cost function and the associated expenditure shares. For brevity, we do not discuss the results of the cost function and the expenditure share functions, but are presented in Appendices 1 and 2. Our ensuing discussion focusses on the estimated elasticities of demand for the three feed types used by farmers in the study areas. The elasticity estimates are reported in Table 3. The results show that the own price elasticities of demand for all the feed types are negative and less than a unit in absolute value for the sample of farmers surveyed, indicating that the feed types are relatively inelastic (Kumar et al. 2010; Varian and Varian 1992). The results are consistent with Fabiosa, Jensen, and Yan (2004) and Mbugua (2014) who also found out that own-price elasticities are negative. These results are also in line with the expectation among factors of production (Kavoi, Hoag, and Pritchett 2009) that as prices of an item, in this case feed, increase, its quantity demanded tend to reduce and as the price decreases the quantity demanded tend to increase. Among the three estimated own feed price elasticities, vegetable elasticity is the highest indicating that demand for leafy vegetables as poultry feed is highly responsive to changes in prices. Thus, as the price of vegetables increases the quantity demanded decreases given that available resources are diverted towards meeting the basic needs such as household food needs. The cross-price elasticities indicate that the three feed types are considered as substitutes by the producers. For instance, vegetables appear to be weak substitutes to both grain and mixed feed. This substitution of feed indicates a need to educate the farmers on the nutritive balancing of the feed using the available resources so as to improve production and quality of products.

With regard to gender, the results show differences in price elasticity of feed demand between female and male-headed households. For instance, own-price elasticity for the grain is inelastic for male farmers, but elastic for their female counterparts. This implies that grain demand of female poultry farmers is responsive to price changes, but the demand is not very responsive for their male counterparts as a unit change in the price of grain results to more than a unit change in quantity demanded among female-headed households. The results, however, show that demand for mixed feed is inelastic with respect to price of mixed feed and vegetables for both farmer categories; but the value of elasticity (absolute terms) for female-headed households almost doubles the male-headed elasticities for mixed feed and is more than double for vegetables. The cross-price elasticities show that male-headed households use vegetables, mixed feed and grains as substitutes in poultry feeding. However, female-headed households appear to use vegetables to compliment grains, but as substitutes to mixed feed; possibly due to the high cost of the mixed feed. These results support differences in gender expectations, needs, and priorities. Therefore, demand at the household for the poultry feed need a gendered outlook.

Table 3. Own and cross-price elasticities of demand.

Type of feed	Price		
All farmer categories	Grain	Vegetable	Mixed feed
Grain	−0.6203** (0.2565)	0.2013 (0.4543)	0.1656** (0.0726)
Vegetable	0.0724 (0.1634)	−0.6241 (0.5620)	0.0733 (0.0603)
Mixed feed	0.5373** (0.2356)	0.6612 (0.5442)	−0.2218*** (0.0806)
Male farmer	Grain	Vegetable	Mixed feed
Grain	−0.4124 (0.2648)	0.2716 (0.4948)	0.1026 (0.0820)
Vegetable	0.0934 (0.1698)	−0.6129 (0.6038)	0.0508 (0.0669)
Mixed feed	0.3104 (0.2481)	0.4480 (0.5894)	−0.1490 (0.0906)
Female farmer	Grain	Vegetable	Mixed feed
Grain	−1.0476 (0.7362)	−0.1069 (1.0170)	0.2180* (0.1249)
Vegetable	−0.0515 (0.4896)	−0.2865 (1.4251)	0.2000* (0.1188)
Mixed feed	1.0971* (0.6286)	2.0919* (1.2417)	−0.2574* (0.1431)

Note: Standard errors in parentheses.
*$p < 0.1$.
**$p < 0.05$.
***$p < 0.01$.

4. Conclusions and policy implications

This paper estimated the price elasticities of demand for three types of poultry feed (leafy vegetables, grain and mixed feed) commonly used by smallholder poultry farmers in Kenya, comparing between female and male poultry farmers. The own-price elasticities of demand estimates from our analysis suggest that the three feed types are relatively inelastic. The cross-price elasticities indicate complementarity between vegetables and grain and substitutability of the rest of the feeds. The results also show substantial gender differences in elasticities of feed demand with respect to feed prices. For example, we find that the demand for grain is not very responsive to price of grain among male farmers but highly responsive among female farmers. We, however, found high own price responsiveness of demand for leafy vegetables and mixed feed among both farmer categories; although the value of elasticity (absolute terms) for female-headed households almost doubles the male-headed elasticities for mixed feed. Further, whereas male farmers use vegetables and mixed feed as compliments to grains their female-headed households counterparts use vegetables as substitutes to grains and compliments to mixed feed. These findings show substantial gender differences in feed demand and elasticities of feed demand with respect to feed prices. The findings, therefore, suggest that there is a need to develop gender equitable policies that take into account the differences in priorities, experiences and needs of the producers. However, further research is needed given that the sample size for female headed households ($n = 52$) was small in comparison to the male headed households though greater than the recommended of above 30 observations. Moreover, in order to stimulate and advance rural development, strategies being implemented and targeting smallholder producers should be gender specific and geared at increasing feed consumption demand and development of the feed market to ensure accessibility of affordable feed. Among the ways of ensuring the accessibility of affordable feed is the development of innovative and cheaper alternatives to the convention feeds at the household level and later at the manufacturing level.

Notes

1. Mixed feed is the aggregate of the different commercially manufactured feeds that the household purchase to supplement and/or complement the local feeds such as grains and vegetables.
2. The total cost function can also be estimated using Ordinary Least Squares (OLS) as it is linear in the parameters, (see Coelli et al. 2005). Both OLS and MLE estimators will generate asymptotically equivalent results if the standard assumptions are correct (Binswanger 1974).

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References

Alders, R.G., S.E. Dumas, E. Rukambile, G. Magoke, W. Maulaga, J. Jong, and R. Costa. 2018. Family poultry: Multiple roles, systems, challenges, and options for sustainable contributions to household nutrition security through a planetary health lens. *Maternal & Child Nutrition* 14: e12668.

Allegretti, G., E. Talamini, V. Schmidt, P.C. Bogorni, and E. Ortega. 2018. Insect as feed: An energy assessment of insect meal as a sustainable protein source for the Brazilian poultry industry. *Journal of Cleaner Production* 171: 403–12. doi:10.1016/j.jclepro.2017.09.244.

Bett, E., B. Njehia, and S. Njoroge. 2015. Impact of poultry feed price and price variability on commercial poultry production in Murang'a County, Kenya. *Journal of Economics and Finance* 6, no. 1: 46–53.

Binswanger, H.P. 1974. A cost function approach to the measurement of elasticities of factor demand and elasticities of substitution. *American Journal of Agricultural Economics* 56, no. 2: 377–86.

Chaudhary, M.A., A.K. Mushtaq, and H.N. Kaukab. 1998. Estimates of farm output supply and input demand elasticities: The translog profit function approach. *The Pakistan Development Review* 374: 1031–50.

Christensen, L.R., D.W. Jorgensen, and L.J. Lau. 1971. Conjugate duality and the transcendental logarithmic production function. *Econometrica* 39: 255–6.

Coelli, T.J., D.S.P. Rao, C.J. O'Donnell, and G.E. Battese. 2005. *An introduction to efficiency and productivity analysis*. 2nd (ed). New York, NY: Springer Science and Business Media.

Debertin, D.L. 1986. *Agricultural production economics*. 2nd ed, 427. New York: Macmillan Publishing Company.

Diewert, W.E. 1971. An application of the Shephard duality theorem: A generalized Leontief production function. *The Journal of Political Economy* 79: 481–507.

Economic Survey. 2018. *Kenya National Bureau of Statistics*. Nairobi: Government Printer. ISBN: 978-9966-102-06-5.

Fabiosa, J.F., H.H. Jensen, and D. Yan. 2004. Output supply and input demand system of commercial and backyard poultry producers in Indonesia. *Working Paper 04-WP 363*, Center for Agricultural and Rural Development, Iowa State University, Iowa.

FAO. 2012. *Livestock sector development for poverty reduction: An economic and policy perspective – Livestock's many virtues*. Edited by J. Otte, A. Costales, J. Dijkman, U. Pica-Ciamarra, T. Robinson, V. Ahuja, C. Ly and D. Roland-Holst, 161. Rome.

Gitonga, K. 2014. *Animal feed Situation in Kenya*. GAIN Report.

Jensen, H.A., and F. Dolberg. 2003. A conceptual framework for using poultry as a tool in poverty alleviation. *Livestock Research for Rural Development* 15, no. 5: 1–17.

Kavoi, M.M., D.L. Hoag, and J. Pritchett. 2009. Production structure and derived demand for factor inputs in smallholder dairying in Kenya. *African Journal of Agricultural and Resource Economics* 3, no. 2: 122–43.

Kenya National Bureau of Statistics. 2015. *Statistical abstract*. Nairobi: Government Printer.

Kitalyi, A.J. 1998. *Village chicken production systems in rural Africa: Household food security and gender issues* (No. 142). Food & Agriculture Organization.

Kumar, P., P. Shinoj, S.S. Raju, A. Kumar, K.M. Rich, and S. Msangi. 2010. Factor demand, output supply elasticities and supply projections for major crops of India. *Agricultural Economics Research Review* 23, no. 1: 1–14.

Mbugua, W.M. 2014. Analysis of demand for antibiotics in poultry production in Kiambu County, Kenya. M.Sc diss., University of Nairobi.

Munguti, J., and H. Charo-Karisa. 2011. Fish feeds and aquaculture development in Kenya. In: *Samaki News: Aquaculture development in Kenya towards food security, poverty alleviation and wealth creation*, Vol. 7 no. (1), 27–9.

Mutua, B.M. 2018. *Challenges facing indigenous chicken production and adoption levels of biosecurity measures in selected areas of Makueni county, Kenya*. M.Sc diss., South Eastern Kenya University.

Mwanzia, R. ed. 2010. *Kenya Poultry Update*. Kenya Poultry Partnership. Wednesday, 19, 2010. Kenya Poultry Partnership. Ed. Mwanzia Rosemary. Kenya Poultry Updates. 19 September 2010.

Ndegwa, J.M., R. Mead, P. Norrish, D. Shepherd, C. Kimani, A. Wachira, and D. Siamba. 2015. Evaluating interventions uptake in indigenous chicken production in a participatory research with smallholder farmers in Kenya. *Journal of Agricultural Studies* 3, no. 2: 145–65.

Okitoi, L.O., H.O. Ondwasy, M.P. Obali, and F. Murekefu. 2007. Gender issues in poultry production in rural households of Western Kenya. *Livestock Research for Rural Development* 19, no. 2: 17. http://lrrd.cipav.org.co/lrrd19/2/okit19017.htm.
Panda, A.K. 2016. Family poultry production for poverty alleviation and gender equity in India. In *Empowering farmwomen through livestock and poultry intervention*, 108. ICAR-Central Institute for Women in Agriculture, Bhubaneswar, India.
Patel, S.J., M.D. Patel, J.H. Patel, A.S. Patel, and R.N. Gelani. 2016. Role of women gender in livestock sector: A review. *Journal of Livestock Science* 7: 92–6.
Pope, R.D. 1982. To dual or not to dual? *Western Journal of Agricultural Economics* 7: 621–30.
Sanyang, S.E. 2012. Agro-enterprise development to support women groups in poultryproduction and marketing: A case study of central river region of the Gambia. *Modern Economy* 3, no. 7: 891. doi:10.4236/me.2012.37112.
Thornton, P.K. 2010. Livestock production: recent trends, future prospects. *Philosophical Transactions of the Royal Society B: Biological Sciences* 365: 2853–67. doi:10.1098/rstb.2010.0134.
Tocco, B., A. Bailey, and S. Davidova. 2013. The theoretical framework and methodology to estimate the farm labour and other factor-derived demand and output supply systems. Factor Market Working Paper No. 44, 17. Centre for European Policy Studies (CEPS), Belgium (Accessed on 10 July 2018). http://aei.pitt.edu/58564/.
Varian, H.R., and H.R. Varian. 1992. *Microeconomic analysis (Vol. 2)*. New York: Norton.
Yamane, T. 1967. *Elementary sampling theory*. Vol. 1, 371–90. Englewood Cliffs, NJ: Prentice.
Zellner, A. 1962. An efficient method of estimating seemingly unrelated regression equations and test for aggregation bias. *Journal of the American Statistical Association* 57, no. 298: 348–68.
Zewdu, A., G. Zenebe, B. Abraha, T. Abadi, and N. Gidey. 2016. Assessment of the gender Role in Agricultural activities at Damota Kebele of Haramaya District, Eastern Hararghe Zone, Ethiopia. *Journal of Culture, Society and Development* 26: 20–6.

Appendices

Appendix 1. Maximum likelihood for the total poultry feed cost function

	Coefficient		
	Pooled ($n = 386$)	Male-headed households ($n = 334$)	Female-headed households ($n = 52$)
Ln price of grains	2.137	2.097	1.26e-09
	(1.72)	(1.58)	(0.17)
Ln price of vegetables	1.274*	1.370*	3.739
	(1.99)	(2.03)	(1.62)
Ln price of Mixed feed	−2.410	−2.467	−2.739
	(−1.73)	(−1.66)	(−1.19)
Ln number of poultry units	0.134	−0.0965	−4.057
	(0.11)	(−0.07)	(−1.27)
Ln price of grains squared	0.0329	0.0733	−0.00646
	(0.68)	(1.40)	(−0.06)
Ln price of vegetables squared	0.0246	0.117	0.00148
	(0.11)	(0.47)	(0.00)
Ln price of Mixed feed squared	−0.000246	0.0243	−0.00941
	(−0.01)	(0.59)	(−0.10)
Ln number of poultry units squared	0.0909**	0.0987*	0.0908
	(2.64)	(2.57)	(1.15)
Ln price of grains*Ln price of vegetables	−0.0564*	−0.0704*	−0.0575
	(−2.00)	(−2.29)	(−0.87)
Ln price of grains* Ln price of mixed feed	0.0235	−0.00289	0.0639
	(0.70)	(−0.08)	(0.88)
Ln price of grains* Ln number of poultry units	0.272	0.236	0.474*
	(1.37)	(1.11)	(2.51)
Ln price of vegetables * Ln price of mixed feed	−0.0233	−0.0214	−0.0545
	(−0.90)	(−0.77)	(−0.75)
Ln price of vegetables * Ln number of poultry units	0.397	0.426	1.432
	(1.29)	(1.28)	(1.69)
Ln price of mixed feed *Ln number of poultry units	−0.364	−0.338	−0.505
	(−1.67)	(−1.45)	(−1.46)
Ln income	−1.046	−0.673	1.495
	(−1.01)	(−0.59)	(0.61)
Ln price of grains*income	−0.327	−0.308	−0.440*
	(−1.66)	(−1.45)	(−2.48)
Ln price of vegetables *income	−0.215	−0.296	−0.790
	(−0.85)	(−1.07)	(−1.23)
Ln price of mixed feed *income	0.455*	0.448	0.481
	(2.09)	(1.92)	(1.40)
Gender of the household head	−0.134	0	0
	(−0.70)	.	.
Ln price of grains *education	−0.00100	0.00209	−0.0209**
	(−0.28)	(0.53)	(−2.65)
Ln price of vegetables *education	0.000904	0.000502	0.00831
	(0.22)	(0.11)	(0.92)
Ln price of mixed feed *education	−0.00170	−0.00508	0.0181*
	(−0.43)	(−1.17)	(2.08)
Ln price of grain *marital status	0.0548	0.00467	0.0818
	(0.98)	(0.07)	(0.84)
Ln price of vegetables * marital status	0.0245	0.0185	0.0995
	(0.38)	(0.24)	(0.90)
Ln price of mixed feed * marital status	−0.0946	−0.0376	−0.131
	(−1.53)	(−0.52)	(−1.17)
Ln price of grain *employment status	−0.0122	0.0299	−0.249**
	(−0.33)	(0.75)	(−3.09)
Ln price of vegetables * employment status	0.00629	0.00206	0.0704
	(0.15)	(0.04)	(0.76)
Ln price of mixed feed * employment status	0.0157	−0.0290	0.250**
	(0.39)	(−0.66)	(2.82)

(*Continued*)

Continued.

	Coefficient		
	Pooled ($n = 386$)	Male-headed households ($n = 334$)	Female-headed households ($n = 52$)
Ln price of grain *Bird type	0.188**	0.167*	0.180
	(2.98)	(2.36)	(1.39)
Ln price of vegetables * Bird type	−0.180**	−0.111	−0.447**
	(−2.58)	(−1.41)	(−3.14)
Ln price of mixed feed * Bird type	−0.194**	−0.172*	−0.179
	(−2.81)	(−2.23)	(−1.24)
Ln price of grain *age	0.000562	0.000652	0.000967
	(0.40)	(0.42)	(0.30)
Ln price of vegetables *age	−0.00270	−0.00246	−0.00751
	(−1.66)	(−1.37)	(−1.85)
Ln price of mixed feed *age	0.00103	0.000508	0.00334
	(0.66)	(0.30)	(0.90)
Ln price of grain *distance to feed supplier	−0.00129	−0.00121	−0.0118
	(−0.84)	(−0.78)	(−1.29)
Ln price of vegetables * distance to feed supplier	0.00241	0.00271	−0.00293
	(1.05)	(1.13)	(−0.26)
Ln price of Mixed feed *distance to feed supplier	0.00119	0.000945	0.0197
	(0.71)	(0.56)	(1.91)
Ln price of grain *production system	0.00663	0.000735	0.0707
	(0.19)	(0.02)	(0.83)
Ln price of vegetables * production system	0.0282	0.0484	−0.0499
	(0.71)	(1.13)	(−0.49)
Ln price of mixed feed * production system	−0.0371	−0.0356	−0.0784
	(−0.97)	(−0.87)	(−0.81)
Constant	13.06**	10.57*	14.22
	(2.65)	(1.96)	(1.25)

Note: *t* statistics in parentheses.
* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

Appendix 2. Estimated share functions for poultry feed demand

	All farmer categories ($n = 386$)			Male farmers ($n = 334$)			Female farmers ($n = 52$)		
Variables	Grain	Vegetable	MF[a]	Grain	Vegetable	MF	Grain	Vegetable	MF
Ln (Price of grains)	0.0329	−0.0564*	0.0235	0.0733	−0.0704*	−0.00289	−0.00646	−0.0575	0.0639
	(0.68)	(−2.00)	(0.70)	(1.40)	(−2.29)	(−0.08)	(−0.06)	(−0.87)	(0.88)
Ln (Price of vegetables)	−0.0564*	0.0246	0.0771*	−0.0704*	0.117	0.0862*	−0.0575	0.00148	0.126
	(−2.00)	(0.11)	(2.30)	(−2.29)	(0.47)	(2.35)	(−0.87)	(0.00)	(1.63)
Ln (Price of mixed feed)	0.0235	0.0771*	−0.000246	−0.00289	0.0862*	0.0243	0.0639	0.126	−0.00941
	(0.70)	(2.30)	(−0.01)	(−0.08)	(2.35)	(0.59)	(0.88)	(1.63)	(−0.10)
Ln (Number of bird)	0.272	0.397	−0.364	0.236	0.426	−0.338	0.474*	1.432	−0.505
	(1.37)	(1.29)	(−1.67)	(1.11)	(1.28)	(−1.45)	(2.51)	(1.69)	(−1.46)
Ln Income	−0.327	−0.215	0.455*	−0.308	−0.296	0.448	−0.440*	−0.790	0.481
	(−1.66)	(−0.85)	(2.09)	(−1.45)	(−1.07)	(1.92)	(−2.48)	(−1.23)	(1.40)
Gender (1=Male, 0=Female)	−0.0466	0.0187	0.0187						0
	(−0.74)	(0.27)	(0.27)		.	.		.	.
Marital status (1=Married, 0=Otherwise)	0.0548	0.000904	0.00103	0.00467	0.000502	0.000508	0.0818	0.00831	0.00334
	(0.98)	(0.22)	(0.66)	(0.07)	(0.11)	(0.30)	(0.84)	(0.92)	(0.90)
Age (Years)	0.000562	−0.00270	−0.00170	0.000652	−0.00246	−0.00508	0.000967	−0.00751	0.0181*
	(0.40)	(−1.66)	(−0.43)	(0.42)	(−1.37)	(−1.17)	(0.30)	(−1.85)	(2.08)
Education level (Years)	−0.00100	0.000904	−0.0371	0.00209	0.000502	−0.0356	−0.0209**	0.00831	−0.0784
	(−0.28)	(0.22)	(−0.97)	(0.53)	(0.11)	(−0.87)	(−2.65)	(0.92)	(−0.81)
Production system (1=Free range, 0=Otherwise)	0.00663	0.0282	0.00119	0.000735	0.0484	0.000945	0.0707	−0.0499	0.0197
	(0.19)	(0.71)	(0.71)	(0.02)	(1.13)	(0.56)	(0.83)	(−0.49)	(1.91)
Distance to supplier (Km)	−0.00129	0.00241	−0.0946	−0.00121	0.00271	−0.0376	−0.0118	−0.00293	−0.131
	(−0.84)	(1.05)	(−1.53)	(−0.78)	(1.13)	(−0.52)	(−1.29)	(−0.26)	(−1.17)
Employment status (1=Employed, 0=Unemployed)	−0.0122	0.00629	0.0157	0.0299	0.00206	−0.0290	−0.249**	0.0704	0.250**
	(−0.33)	(0.15)	(0.39)	(0.75)	(0.04)	(−0.66)	(−3.09)	(0.76)	(2.82)
Bird type (1=Local, 0=Otherwise)	0.188**	−0.180**	−0.194**	0.167*	−0.111	−0.172*	0.180	−0.447**	−0.179
	(2.98)	(−2.58)	(−2.81)	(2.36)	(−1.41)	(−2.23)	(1.39)	(−3.14)	(−1.24)
Inverse Mills ratio	0.0689***	−0.0931***	−0.0931***	0.0603***	−0.0843***	−0.0843***	0.126**	−0.157***	−0.157***
	(4.79)	(−6.85)	(−6.85)	(3.90)	(−5.91)	(−5.91)	(2.84)	(−3.66)	(−3.66)
Constant	2.137	1.274*	−2.410	2.097	1.370*	−2.467	0	3.739	−2.739
	(1.72)	(1.99)	(−1.73)	(1.58)	(2.03)	(−1.66)	.	(1.62)	(−1.19)

Note: *t*-statistic in parentheses.
[a]MF = Mixed feed.
*$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

Appendix 3. Map of study areas