CONSUMER DEMAND FOR MEAT IN KENYA: AN EXAMINATION OF THE LINEAR APPROXIMATE ALMOST IDEAL DEMAND SYSTEM

Mumina Shibia
Research Assistant, Department of Agricultural and Applied Economics, Texas Tech University, 205D Agricultural Sciences Building, Lubbock, TX, USA 79409-2132. Phone: (806) 701-9108; e-mail: mumina.shibia@ttu.edu.

Shaikh Mahfuz Rahman
Associate Professor, Department of Agricultural and Applied Economics, Texas Tech University, 215 Agricultural Sciences Building, Lubbock, TX, USA 79409-2132. Phone: (240) 350-8432; e-mail: shaikh.m.rahman@ttu.edu

Benaissa Chidmi
Associate Professor, Department of Agricultural and Applied Economics, Texas Tech University, 204A Agricultural Sciences Building, Lubbock, TX, USA 79409-2132. Phone: (806)742-1921; e-mail: benaissa.chidmi@ttu.edu.

Selected paper prepared for presentation at the 2017 Southern Agricultural Economics

Association (SAEA) Annual Meetings in Mobile, AL: Feb 4-7, 2017

Abstract

Per capita consumption of meat products has been rapidly increasing in Sub-Saharan African countries including Kenya. This paper examines a household demand system for five meat products in Kenya: beef with bones, boneless beef, mutton, chicken, and pork. The Linear Approximate Almost Ideal Demand System (LA/AIDS) model is used because of its flexibility and ease of application with household expenditure data. The LA/AIDS model is estimated using household consumption data obtained from Kenya Integrated Household Budget Survey of 2013. Expectedly, the estimates of uncompensated and compensated own price elasticities of demand for all five meat products are negative but larger than –1. Although the estimates of uncompensated cross price elasticities are negative implying that these meat products are gross complements, the estimates of compensated cross price elasticities are found to be positive indicating a quite strong substitution between these meat products. Expenditure elasticities of demand for the meat products are positive implying normal goods. Mutton/goat is a necessity good (elasticity <1) among the Kenyan households.

Key words: LA-AIDS, Meat demand, Elasticities, Kenya

Introduction

The Livestock sector contributes to 12% of Kenya's Gross Domestic Product (GDP), 40% to the agricultural GDP and 50% of employment in the agricultural sector (Ministry of Livestock Development 2010). The estimated contribution is 4.54 billion dollars, which is slightly less than that from crops and horticulture (5.25 billion US dollars) for arable agriculture (IGAD Center for Pastoral Areas & Livestock Development 2013). Of the total GDP, animal production contributes to 5.5%, 22% of agricultural GDP and more than 40% agricultural commodities farm gate value (Kenya National Bureau of Statistics 2015; Ministry of Agriculture, Livestock and Fisheries (MAL&F) 2015).

Consequently, the economy is supported by dairy and meat products, eggs, hides, skins, and wool. The arid and semi-arid lands (ASALs) produces about 67% of meat under the pastoral production system (Institute of Policy Analysis and Research 2004).

Demand for livestock products is rapidly increasing in sub-Saharan Africa (Delgado et al. 1999). Meat consumption projection indicates an increase from 5.5 is to 13.3 million tons by 2025 (Rosegrant et al. 2005). The incremental demand has been associated with "livestock revolution" (Delgado 2003; Thornton 2010). Kenya's domestic market is robust with a population of 44.6 million that has a strong culture of meat consumption (Kenya Market Trust 2014). On average, beef, chicken, mutton, goat, and camel account for more than 80% of meat consumed in the country (Export Processing Zones Authority (EPZ) 2005).

The total average projected consumption for developing countries is 44kg by the year 2050 (Thornton 2010). The Country's average per capita meat consumption for red and white meat is 10.8kg and 1.1 kg (MAL&F 2015). The urban low and high-income segments consume 16 kg to 19 kg per capita/year (Tegemo 2005; USAID 2012). Moreover, Nairobi and Mombasa city households largely consume estimated total volume of 17% (Kenya Market Trust 2014). Notwithstanding, the urban consumption comprise of 40% projections for the year 2050. This suggests that meat is largely consumed in the urban areas. However, the household consumption is characterized by product varieties with beef being the most dominant (Gamba 2005) while poultry, fish, and pork the least consumed (Food and Agricultural Organization (FAO) 2009).

Previous studies mainly focused on the demand for food products, preferences, consumption, and implications for food security. Bett et al. (2012) analyzed the demand for indigenous chicken in rural and urban areas using Linear Approximate Almost Ideal Demand System (LA-AIDS) Model. Juma et al. (2010) demand for sheep and goat meat based on preferences and consumption behavior. Musyoka et al. (2010) consumption and food security. Gamba (2005) characterized consumption of meat products and eggs in Nairobi City County. Chantylew and Belete (1997) assessed the demand for beef, mutton and goat, pork, and chicken. Bouis et al. (1992) implications of household expenditure information on the demand for food products. However, a few studies have applied a demand system approach that allows for flexibility of substitution.

The estimation of demand systems for food has gained considerable research interest because of elasticities and its roles in predicting marketing decisions and policy. With household incorporating differentiated meat products in their meals (Gamba 2005) there could be a change in preferences and consumption. Consumers buy beef under different cuts, namely bone, boneless, minced, offals, liver, hooves and head. However, many studies ignore this differentiation, producing an aggregate elasticity figure that might not be relevant for marketing and policy inferences.

Therefore, the main objective of this study was to evaluate the demand for meat with some disaggregation for beef in Kenya. That is, we estimate a demand system of beef with bones, boneless beef, goat and mutton, chicken and pork. Evaluating the demand for meat would facilitate redefining strategies for consumption and marketing and would provide insights into policies targeting the livestock sector.

Empirical framework

Economic analysis of household consumer behavior has substantial importance to food products demand (Akinbode et al. 2015*)*. Stone (1954) initiated estimation of demand as a system of equations. This approach has a wider application because of commodity substitution (Bett et al. 2012). Consequently, there have been growing research interest using a systems approach relative to a single equation.

Most prominent approaches were the Linear and Quadratic Expenditure System (LES and QES), the Almost Ideal Demand System (AIDS) and Quadratic AIDS (QUAIDS) (Bett, et al. 2012; Akinbode *et al.*, 2015). Emphasis has been in the Almost Ideal Demand Model (AIDS) within the systems approach to demand (Deaton and Muellbauer, 1980; 2009).

According to Deaton and Muellbauer (1980; 2009), a demand system must satisfy adding-up, homogeneity of degree zero, symmetry and the negativity restriction. To avoid singularity of covariance matrix one of the budget share equation is dropped and the demand system estimated (Bett, et al. 2012; Akinbode, 2015). The first three restrictions are used to recover the parameters of the dropped equation and elasticities. The utility is maximized in the Marshallian demand function while the costs are minimized in the Hicksian demand function. Hence the negativity restriction is associated with the convexity of the utility function (Akinbode 2015).

The AIDS model flexibility, acceptability, and wider application has been reported in earlier studies (Green and Alston 1990; Akinbode 2015; Wadud 2006; Bett et al. 2012). According to Deaton and Muellbauer 1980 the AIDS model is specified as (1);

$$(1) \qquad W_i = (\alpha_i) + \sum_j \gamma_{ij} \ln P_j + \beta_i \ln\left(\frac{X}{P}\right) + u_{it},$$

where X is total expenditure on the group of goods being analysed, P is the price index for the group, P_j is the price of the jth good within the group, W_i is budget share allocated to the ith good ($W_i = P_i Q_i / X$) and Q is the quantity of good i purchased. The price index (P) is defined as (2);

$$(2) \qquad \ln P = \alpha_0 + \sum_{i=1}^{n} \alpha_i \ln P_i + \frac{1}{2} \sum_{i=1}^{n} \sum_{j=1}^{n} \gamma_{ij} \ln p_i \ln p_j$$

Irrespective of AIDS model being commonly used, the price index (P) often raises empirical difficulties, especially when aggregate annual data are used, Stone's (geometric) price index (P*) is commonly used instead of P (Green and Alston 1990). This has resulted in the wide application of the Linear Approximation Almost Ideal Demand System (LA-AIDS). According to Green and Alston (1990), the LA-AIDS can be written as (3):

$$(3) \qquad W_i = (\alpha_i - \beta_i \ln \zeta) + \sum_j \gamma_{ij} \ln P_j + \beta_i \ln\left(\frac{X}{P^*}\right),$$

Where W_i is the budget share for ith good ($W_i = P_i Q_i / X$), Q_i is the quantity consumed of good i and X is the total expenditure on the meats with bone, boneless meat, goat and mutton, chicken and pork. The $\ln P^*$ is a price index given by $\ln P^* = \sum_k w_k \ln P_k$ and u_i is the random error term.

In practice, the Linear Approximation Almost Ideal Demand System (LA-AIDS) model is more accepted, flexible, and easily estimated (Taljaard et al. 2004; Bett et al. 2012; Barnett and Seck, 2006). Moreover, the model has gained popularity and widely applied in demand analysis relative to AIDS (Green and Alston 1990). Contrary to the LA-AIDS, the PIGLOG model has non-linearity and multicollinearity properties (Barnett and Seck, 2006).

Therefore, the study used weekly data for households to examine the demand for meat products in Kenya. The data obtained were prices, quantities consumed and expenditure for beef with bones, boneless beef, goat and mutton, pork, and chicken. The LA/AIDS Model was used to allow for the imposition of symmetry and homogeneity restrictions consistent with the demand theory. With reference to Deaton and Muellbauer (1980), the LA-AIDS was specified as (4):

(4) $$W_i = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \ln P_i + \beta_i \ln\left(\frac{X}{P^*}\right) + \varepsilon_i$$

W_i is the budget share allocated to *ith* good ($W_i = P_i Q_i / X$), X is the total expenditure on the meats with bone, boneless meat, goat and mutton, chicken, and pork, $\ln p_j$ the natural logarithm of price of *ith* good, P is the price index, $\alpha_{ij}, \gamma_{ij,}$ and β_i are parameters, ε_i is the disturbance term. The adding-up (5), homogeneity (6), and symmetry restrictions (7) were imposed on equation (4) and estimated own price, cross price, and expenditure elasticities.

(5) $$\sum_{i}^{n} \alpha_i = 1, \quad \sum_{i=1}^{n} \beta_i = 0, \quad \sum_{i}^{n} \gamma_{ij} = 0,$$

(6) $$\sum_{j=1}^{n} \gamma_{ij} = 0$$

(7) $$\gamma_{ij} = \gamma_{ji}$$

Uncompensated own price elasticities (8)

(8) $$\eta_i = \frac{\partial w_i}{\partial \ln p_i} \Big/ wi - 1$$

Uncompensated cross price elasticities (9 and 10)

(9) $$\eta_{i\,j} = \frac{\partial w_i}{\partial \ln p_j} \Big/ wi$$

(10) $$\eta_{i\,j} = \eta_{ij} + w_j\left(1 + \frac{\beta_i}{w_i}\right)$$

Compensated elasticities (11)

(11) $$\eta_{ij}^{*} = \eta_{ij} + w_j \left(1 + \frac{\beta_i}{w_i}\right)$$

Expenditure elasticity is given by (12)

(12) $$\eta_i = \frac{\beta_i}{w_i} + 1$$

Two stage budgeting and seperability

The study assumes two-stage budgeting characterized by a consumer allocating the total expenditure in two stages. The first stage comprises of an allocation of total expenditure to a broad group of goods and at the second stage subsequently allocates to the individual commodities (Dearton and Muellbauer, 2009). According to Dearton and Muellbauer (2009), stage one requires knowledge of total expenditure and appropriately defined group prices while at the second stage individual expenditures are functions of group expenditure and prices within the group. The results of allocation using one step and complete information is the same as the two stage process. The allocation requires perfect information in the sense that the outcomes are identical.

The weak separability of the utility function is a necessary and sufficient condition for the broad group at the second stage (Dearton and Muellbauer 2009; Taljaard et al. 2004). A demand function is weakly separable if the marginal rate of substitution between any two goods that belongs to the same group are independent of quantities of goods outside the group. (Mas-Collel et al. 1995).

The study assumed the five meat products are weakly separable and were modeled together. Taljaard et al. (2004) conducted two tests of weak separability using F and likelihood ratio test. This research recommended that beef, chicken, pork, and mutton are weakly separable and should be modeled together. Therefore, the empirical model consists of five budget share equations corresponding to each meat product estimated using the seemingly unrelated regression technique.

Data and Estimation Issues

The study used secondary data obtained from Kenya Integrated Household Budget Survey 2005-2006 (Kenya National Bureau of Statistics (KNBS) 2015). A total sample size of 358 households was obtained from 540 urban and 1,260 rural clusters. When estimating the demand models with cross-sectional data there is a need to include household's socio-economic characteristics such as household age, the number of children, household size, religion, and location. However, the data used was price, quantities and expenditure information for various meat categories.

The test for endogeneity, validity of restrictions, the overall test of significance and heteroscedasticity were conducted. An important concern in the estimation of demand is endogeneity of the total expenditure X. Correlation of the total expenditure with the random error term leads to parameter estimators that are inconsistent and biased (Green, 2012). Consequently, eendogeneity was tested using Hausman under the null hypothesis of exogeneity.
Hausman test has a chi-square distribution with degrees of freedom equal to the number of unknown parameters in Ω which is the Seemingly Unrelated Regression (SUR) estimator and Ω^* 3 Stage Least Squares (3SLS) estimator (13).

$$(13) \quad m = \left(\Omega^* - \Omega\right)' \left\{Var\left(\Omega^*\right) - Var\left(\Omega\right)\right\}^{-1} \left(\Omega^* - \Omega\right)$$

Assuming exogeneity of the Right Hand Side (RHS) variables in the demand system, the SUR estimators are consistent and asymptotically efficient. The presence of endogeneity would imply SUR estimators are no longer consistent but the 3 SLS is inefficient but consistent (Green, 2012; Taljaard, 2006).

The validity of homogeneity and symmetry restrictions were tested under the null hypothesis that demand is homogenous of degree zero in prices and wealth and symmetry respectively and alternative hypothesis not null. The overall significance of the explanatory variables was tested using the null hypothesis all the parameters are jointly equal to zero.

Table I shows the descriptive statistics of quantities, prices, total weekly expenditures and budget shares of each of the five meat products considered in the study. The beef with bones had a higher quantity and price relative to chicken and other meat categories. However, the budget share for chicken is larger than the beef with bones. The results are consistent with earlier findings of a higher budget share reported for chicken (Bett et al. 2012). The boneless beef and mutton and the goat had a similar budget share. The pork had the least price and budget share. The result conforms to economic theory as the sum of budget shares adds up to one.

Table 1: Descriptive Statistics

Variable	Bone beef	boneless beef	goat/mutton	chicken	pork
Quantity (kg)	1.46	0.88	0.95	1.05	0.73
	(1.305)	(0.494)	(0.580)	(0.442)	(0.443)
Price	205.83	140.67	139.75	204.39	97.29
(ksh/kg)	(193.293)	(82.254)	(104.187)	(87.374)	(96.815)
Budget share	0.28	0.16	0.15	0.32	0.09
	(0.040)	(0.031)	(0.031)	(0.054)	(0.027)

Note: Figures in the parentheses are standard deviation. Currency in Ksh (Kenya shillings) and 1 USD=103ksh. The quantity was estimated in kilogram (kg) and 1kg = 2.2 lb.

Results and Discussion

Tests results

The test results for endogeneity, the validity of restrictions and the overall significance are presented in table 2, 3 and 4 respectively. The findings of Hausman test implies that at 5percent significance level we failed to reject the null hypothesis. Consequently, there is no evidence of endogeneity of total expenditure. Therefore, the SUR estimators are consistent for estimation of LA-AIDS model.

Table 2: Hausman's Specification Test Results

Efficient under H0	**Consistent under H1**	**DF**	**Statistic**	**Pr > ChiSq**
OLS/SUR	3SLS	28.00	0.00	1.00

The tests for the validity of homogeneity and symmetry restrictions were not significant. The results suggested a failure to reject the null hypothesis. Consequently, the validity of the restrictions holds.

Table 3: Test Results for Homogeneity and Symmetry Restrictions

Restriction	Wald Statistic	Pr > ChiSq
Homogeneity	1.75	0.1863
Symmetry	0.27	0.6022

The test for the overall significance suggests that we reject the null hypothesis at 5 percent significance level. The results imply an evidence that all the price parameters are jointly significant.

Table 4: Overall Significance Test

Test Type	**Statistic**	**Pr > ChiSq**
Wald	577.17	<.0001

Determinants for meat products

The LA-AIDS model parameter estimates are presented in table 5. The dependent variables were the budget share for each meat product.

Table 5: Parameter Estimates for LA-AIDS

Dependent variable (shares)	Constant α_i	**lnp1** γ_{i1}	**lnp2** γ_{i2}	**lnp3** γ_{i3}	**lnp4** γ_{i4}	**lnp5** γ_{i5}	**ln(X/P*)** β_i
Bone beef (w1)	0.321	0.021**	-0.005*	0.007*	-0.029***	-0.003	0.009**
	(0.013)	(0.009)	(0.003)	(0.004)	(0.006)	(0.011)	(0.004)
Boneless beef (w2)	0.170	-0.009	0.015***	0.003	-0.022***	0.014*	-0.001
	(0.01)	(0.007)	(0.003)	(0.003)	(0.004)	(0.008)	(0.003)
Goat/mutton (w3)	0.127	-0.016**	0.001	0.012***	0.013***	-0.003	-0.007***
	(0.009)	(0.006)	(0.002)	(0.003)	(0.004)	(0.007)	(0.003)
Chicken(w4)	0.293	0.048***	-0.009**	-0.015***	0.049***	-0.085***	0.013***
	(0.016)	(0.011)	(0.004)	(0.005)	(0.007)	(0.014)	(0.005)
Pork (w5)	0.089	-0.044***	-0.002	-0.007***	-0.011***	0.078***	-0.015***
	(0.006)	(0.004)	(0.002)	(0.002)	(0.003)	(0.005)	0.002

Standard errors in parentheses and *** p<0.01, ** p<0.05, * p<0.1

Some parameters significantly influenced the budget share of the various meat products.

For instance prices of beef with bones, boneless meat, mutton and chicken and the total expenditure significantly influence the budget share of beef with bones. However, the parameter estimates do not have much implications relative to elasticities.

The different types of elasticities were computed using equations 8-12 and the LA-AIDS model parameters. The own price uncompensated elasticities of all the five meat products are relatively inelastic and statistically significant (table 6). Similarly, Tarljaard et al. (2004) reported own price elasticities of -0.75, -0.35, -0.37, -0.47 for beef, chicken, pork, and mutton for South Africa's meat products. These estimates are relatively lower in absolute terms than the results of this study. The own price elasticities for indigenous and exotic chicken previously reported were -0.77 and -0.11 respectively (Bett et al. 2012). Consistent with this study, chicken has the least own price elasticity. Similarly, inelastic demand for meat products was reported previously in Bangladesh (Wadud, 2006) and in Kenya Chantlylew and Belete (1997).

Table 6: Uncompensated and Expenditure Elasticities

	Bone beef	Boneless beef	Goat/mutton	Chicken	Pork
Bone beef	**-0.948*** **	-0.028	-0.047**	0.132***	-0.134***
	(0.023)	(0.019)	(0.017)	(0.032)	(0.013)
Boneless beef	-0.063	**-0.805*** **	0.016	-0.119**	-0.019
	(0.042)	(0.033)	(0.029)	(0.053)	(0.026)
Goat/mutton	0.134**	0.051	**-0.81*** **	-0.219***	-0.049
	(0.059)	(0.046)	(0.041)	(0.076)	(0.034)
Chicken	-0.245***	-0.173***	0.087***	**-0.643*** **	-0.124***
	(0.041)	(0.032)	(0.028)	(0.053)	(0.025)
Pork	0.003	0.043*	-0.005	-0.236***	**-0.765*** **
	(0.030)	(0.024)	(0.021)	(0.039)	(0.016)
Expenditure	1.0257***	0.9894***	0.8937***	1.0993***	0.9594***
	(0.0101)	(0.0363	(0.0374)	(0.0352)	(0.005)

Note: Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1 and bolded values are own price elasticities

Some uncompensated cross-price elasticities are negative and others positive. The negative sign implies gross complements while positive substitutes. Goods are gross complements if an increase in the price of one good causes less of the other good purchased. The Chicken has a substitution relationship for beef with bones. The results suggest that a 10 percent increase in the price of chicken increases the demand for beef with bones by 1.3%.

Moreover, boneless beef has also a substitution relationship with goat/mutton and pork. Consequently, all the meat products are complements except chicken, goat/mutton, and boneless meat. The results suggest that meat products are mainly gross complements and a few are substitutes. The findings are similar to a previous study which reported meats within the various categories are more of gross complements than they are substitutes (Tarljaard et *al.*, 2004; Bett et *al.*, 2012).

The expenditure elasticities of all the meat products were positive and significant. Therefore, can be considered as normal to luxury good as expected a *priori* (table 6). Chicken and beef with bones has income elasticity of greater than 1 and they can be considered as a luxury good.

The expenditure elasticities for boneless beef and pork are less than 1 but in economic terms approximately close to 1, which is a luxury good. The relatively less income elasticity on Goat/mutton could imply a necessity animal protein source. The results imply that a 10 percent increase in income would increase the demand for mutton/goat, bone beef, boneless beef, chicken and pork by 9%, 10.3%, 9.9%, 11% and 9.6% respectively.

Previous studies reported less consumption of pork and preferences associated with high-income urban consumers (Chantlew and Belete 1997; Gamba et al. 2005). Among the different products, pork, fish, and camel were previously modeled under "other meats". However, the expenditure elasticities were reported as relatively elastic (Bett et al. 2012). The grouping of emerging meat products and lack of product differentiation could underestimate the demand for these commodities.

In addition to mutton/goat (0.19), indigenous chicken and beef were also reported as necessities among the available meat products in Kenya with income elasticities of 0.65 and 0.64 (Bett et al. 2012). In the same study, the income elasticities for exotic chicken, goat meat, and other meats were 1.14, 1.34 and 2.1 respectively. South Africa's meat products were also reported as normal goods with beef (1.24), mutton (1.2) and chicken (0.53) (Tarljaard et al. 2004). Poultry, pork, beef, and mutton were also reported as normal and luxury goods in Malaysia. The income elasticities of beef were (0.32), pork (0.65), Mutton 0.5, poultry (0.48) and other meats (-5.1) (Sheng et al., 2014).

Table 7 shows compensated own and cross price elasticities. The compensated own price elasticities for all the five meat products are relatively inelastic, has negative signs as expected a priory and significant.

Table 7: Hicksian Own and Cross Price Elasticities

	Bone beef	Boneless beef	Goat/mutton	Chicken	Pork
Bone beef	**-0.579*** **	0.064***	0.085***	0.056***	0.348***
	(0.025)	(0.009)	(0.011)	(0.015)	(0.030)
Boneless beef	0.292***	**-0.727*** **	0.104**	-0.148***	0.539***
	(0.041)	(0.032)	(0.039)	(0.055)	(0.108)
Goat/mutton	0.455***	0.121***	**-0.749*** **	0.319***	0.320***
	(0.059)	(0.046)	(0.041)	(0.056)	(0.112)
Chicken	0.145***	-0.086***	0.159***	**-0.495*** **	-0.283***
	(0.041)	(0.032)	(0.028)	(0.053)	(0.106)
Pork	0.348***	0.118***	0.06***	-0.106**	**-0.420*** **
	(0.030)	(0.024)	(0.021)	(0.039)	(0.015)

Standard errors in parentheses and *** p<0.01, ** p<0.05, * p<0.1

The compensated own price elasticity of goat/mutton is more elastic (-0.75) relative to beef with bones (-0.56), boneless beef (-0.73**)**, chicken (-0.5) and pork (-0.42). Previously own compensated elasticities for Indigenous Chicken , Exotic Chicken, Beef, Mutton and Goat were reported as -0.19, -0.07, -0.55, -0.6, -0.51 respectively (Bett et al. 2012). The result is consistent with the findings of this study that compensated own price elasticity of goat/ mutton is relatively elastic.

The results in table 7 implies that 10 percent increase in the price of mutton/goat will decrease the demand for mutton/goat by 7.5 percent, while for beef with bones, boneless beef, chicken and pork

5.8%, 7.3%, 5% and 4.2% respectively. The own price compensated elasticity of beef (5.5%) reported earlier is quite similar to beef with bones (5.8%), however boneless beef is relatively more elastic (7.3%).

The findings of meat demand in South Africa indicated that pork was more elastic (-0.31) relative to mutton (-0.28), chicken (-0.91) and beef (-0.16) (Tarljaard et *al.*, 2004). Most of the meat products has positive compensated cross price elasticities as expected of *priory*. The results suggests that meat products are substitutes *except* chicken and boneless beef, chicken and pork. Similar to own price elasticities all the cross price elasticities for meat products are significant.

The consumption of pork shows a strong substitution in response to the price of boneless beef (0.54). If, for example, the price of pork reduces by 10 percent the demand for boneless beef reduces by 5.4 percent. Consumption of beef with bones for the price of goat/mutton has second strongest substitution response (0.46) implying a 10 percent increase in the price of boneless beef reduces the demand for goat/ mutton by 4.6%. Thirdly, beef with bones for price of pork (0.35), pork for the price of goat/mutton (0.32), chicken for the price of mutton (0.32) and beef with bones for the price of chicken (0.15). All other cross price elasticities are less than 0.1.

The findings of a previous study reported a strong substitution between consumption of pork and beef (0.38), mutton for the price of chicken (0.17), chicken for beef (0.14) and pork for mutton (0.1) (Tarljaard et *al.*, 2004). Kenya's meat products were earlier reported as more of complements than are substitutes. Mutton was reported as an inferior meat product relative to indigenous chicken and goat (Bett, et al. 2012). The same study reported indigenous chicken as substitute to beef and other meat products. However, the indigenous chicken was also a complement to exotic chicken, mutton and goat.

The results in table 7 suggests that chicken has complementary relationship with boneless beef and pork but a substitute to beef with bones. The results implies that reducing price of chicken by 10 percent would decrease the demand for beef with bones by 0.5 percent. But for complementary relationship a 10 percent reduction in the price of chicken leads to approximately 14.8 percent increase in the demand for boneless beef.

Conclusion

The elasticity estimates in this study are consistent with the economic theory that own price elasticities are negative. Uncompensated elasticities suggest that own price elasticities are significant and meat products are more of complements than substitutes within the different categories.

Both the compensated own price and cross price elasticities for meat products are significant. Most compensated cross price elasticities have positive signs as expected of *priory* implying they are substitutes. The results suggest evidence of different interrelationships among the meat products.

The income elasticities of all the meat products were positive, significant and can be considered as normal to luxury good. The results were bone beef (1.03), boneless beef (0.99), goat/mutton (0.89), chicken (1.1), and pork (0.96). The findings imply that mutton/goat is a necessity good among the meat products while bone beef and chicken a luxury good contrary to earlier studies.

The estimates of elasticities are useful in redefining strategies for consumption of meat and would provide insights into policies targeting livestock sector. Thus the study has important implications for policy in the livestock sector and adds to the growing literature on meat demand using LA-AIDS model.

Limitations and future research

The study did not incorporate socio-economic characteristics in estimating the demand systems. The household size, household age sex, occupation, location and religion among others are recommended as explanatory variables. The study used truncated LA-AIDS model and applying censoring in a two-stage approach could be appropriate considering zero- consumption of goods. The first stage process involves the application of a binary choice model. The second stage a censored LA-AIDS by incorporating the Inverse Mills Ratio (IMR) from stage one estimation. The socio-economic variables could explain the change in preferences from the chicken as a necessity good to mutton/goat. Future studies could analyze weak separability of meat products and incorporate fish and camel in the demand systems.

Acknowledgment

The researchers acknowledge the Kenya National Bureau of Statistics (KNBS) for providing the data for this study. Appreciation goes to the Texas Tech University for the Institutional Support and Borlaug Higher Education for Agricultural Research and Development (BHEARD).

References

Akinbode, S.O. 2015. "A linear approximation almost ideal demand system of food among households in South-West Nigeria." *International Journal of Social Economics* Vol. 42 Iss 6pp. 530 – 542. http://dx.doi.org/10.1108/IJSE-08-2014-0165.

Alston J. M. and Chalfant, J. A. 1993. "The silence of the lambdas: a test of the almost ideal and Rotterdam models." *American Journal of Agricultural Economics* vol. 75, 304–313.

Barnett, W.A. and Seck, O. 2006. "Rotterdam vs almost ideal models: will the best demand specification please stand up?" Paper No. 417, Munich Personal RePEc Archive (MPRA), Munich. https://mpra.ub.uni-muenchen.de/417/1/MPRA_paper_417.pdf.

Bett, H. K., Musyoka, M. P., Peters, K. J. and Bokelmann, W. 2012. Demand for Meat in the Rural and Urban Areas of Kenya: A Focus on the Indigenous Chicken. *Economics Research International*. vol. 2012, doi:10.1155/2012/401472.

Bouis, H., Haddad, L. and Kennedy, E. 1992. "Does it matter how we survey demand for food? Evidence from Kenya and the Philippines." *Food Policy*, vol. 17, no. 5, pp. 349–360.

Chantylew, D. and Belete, A. 1997. "A statistical analysis of demand for beef, mutton/ goat, pork and chicken in kenya, 1961–1991." *Agrekon* 36, 1–11.

Deaton A. and Muellbauer, J. 1980. "An almost ideal demand system." *The American Economic Review* vol. 70, 312–326.

Deaton, A. and Muellbauer, J. 2009. *Economics and consumer behaviour*. Cambridge university press.

Deaton, A. and Muellbauer, J. 1980b. "Almost ideal demand systems". *The American Journal of Agricultural Economics* Vol. 80 No. 1, pp. 208-220.

Delgado, C. L. 2003. "Rising consumption of meat and milk in developing countries has created a new food revolution."*Journal of Nutrition* vol. 133, no. 11, pp. 3907S–3910S.

Delgado, C., Rosegrant, M., Steinfeld, H.Ehui, S.and Courbois, C. 1999. Livestock to 2020: the next food revolution. IFPRI. Food, Agriculture, and the Environment Discussion Paper 28. Washington, D.C. (USA): IFPRI. https://cgspace.cgiar.org/handle/10568/333.

Export Processing Zones Authority (EPZ), 2005. Meat production in Kenya. http://www.epzakenya.com/UserFiles/files/MeatIndustry%20sector%20profile.pdf.

Food and Agricultural Organization (FAO), 2009. *The State of Food and Agriculture 2010-11*, Livestock in a balance. Electronic Publishing Policy and Support Branch Communication Division-FAO. Rome, Italy. http://www.fao.org/docrep/012/i0680e/i0680e01.pdf.

Food and agricultural Organization (FAO), 2005. Livestock Sector Brief for Kenya. http://www.fao.org/ag/againfo/resources/en/publications/sector_briefs/lsb_KEN.pdf.

Gamba, P. 2005. *Urban Domestic Consumption Patterns for Meat: Trends and Policy Implications*. Working Paper. Tegemeo Institute of Agricultural Policy and Development. Egerton University.

http://ageconsearch.umn.edu/bitstream/202626/2/tegemeo_workingpaper_17.pdf .

Green W.H., 2012. *Econometric Analysis*. 7th edition, Boston, Pearson.

Green, R. and Alston, J.M. 1990. Elasticities in AIDS Models. *American Journal of Agricultural Economics* vol. 72, 2, 442-445.

IGAD Center for Pastoral Areas & Livestock Development (ICPALD), 2013. The Contribution of Livestock to the Kenyan Economy, ICPALD 4/CLE/8/2013. http://igad.int/attachments/714_The%20Contribution%20of%20Livestock%20to%20the%20Kenyan%20Economy.pdf .

Institute of Policy Analysis and Research (IPAR), 2004. *Strategies for improving the contribution of livestock sector to food security and increased incomes in Kenya: the case of red meat*. Policy Brief 10.

Juma, M. Ngigi, G. P., Baltenweck, I. and Drucker, A. G. 2010. "Consumer demand for sheep and goat meat in Kenya." *Small Ruminant Research* vol. 90, no. 1–3, pp. 135–138.

Kenya Market Trust (KMT), 2014. Kenya Livestock & Meat Market Analysis for Cattle, Goat & Sheep. http://www.kenyamarkets.org/download/get/kenya-livestock-meat-analysis1/35.

Kenya National Bureau of Statistics (KNBS). 2015. Economic Survey 2015. KEN-KNBS-KIHBS-2015-2016-v01. Ministry of devolution and national planning.

http://www.knbs.or.ke/index.php?option=com_content&view=article&id=309:2015-economic-survey-report-highlights&catid=82:news&Itemid=593.

Kenya National Bureau of Statistics (KNBS). 2015. Kenya Integrated Household Budget Survey 2015-2016. KEN-KNBS-KIHBS-2015-2016-v01. Ministry of devolution and national planning. http://statistics.knbs.or.ke/nada/index.php/catalog/8/sampling.

Koc, A. and Alpay, S. 2002. "*Household demand in Turkey: an application of almost ideal demand system with spatial cost index*". Working Paper No. 226, Economic Research Forum, Cairo.

Langyintuo, A.S., Ntoukam, G., Murdock, L., Lowenberg-DeBoer, J., Miller, D.J., 2004. Consumer preferences for cowpea in Cameroon and Ghana. *Agricultural Economics* 30, 203–213.

Ministry of Agriculture, Livestock and Fisheries (MAL&F), 2015. Strategic Plan 2031-2017. http://www.kilimo.go.ke/wp-content/uploads/2015/05/MoALF_Strategic-Plan_2013-2017.pdf.

Mas-Collell, A and Whinston, M.D, 1995. *Micro-economic Theory.* Oxford University Press, New York.

Moschini, G. 1995, "Units of measurement and the Stone price index in demand system estimation". *American Journal of Agricultural Economics* Vol. 77 No. 1, pp. 63-68.

Musyoka, M., Lagat, J., Ouma, D., Wambua, T. and Gamba, P. 2010. "Structure and properties of urban household food demand in Nairobi, Kenya: implications for urban food security." *Food Security* 2, 179–193.

Rosegrant M. W., S Cline. A., W. Li, T. B. Sulser, and Valmonte-Santos, R.A. 2005. *Looking Ahead: Long-Term Prospects for Africa's Agricultural Development and Food Security*. 2020 Discussion Paper No. 41, International Food Policy Research Institute, Washington, DC, USA.

Stone, J.R.N. 1954. "Linear expenditure systems and demand analysis: An application to the pattern of British demand." *Economic Journal* 64:511-527.

Taljaard, P. R., Alemu, Z. G. and van Schalkwyk, H. D. 2004. "The demand for meat in South Africa: an almost ideal estimation." *Agrekon* vol. 43, pp. 430–443.

Tegemeo, 2005. Urban Domestic Consumption of Agricultural Policy and Development, Egerton University.

http://ageconsearch.umn.edu/bitstream/202626/2/tegemeo_workingpaper_17.pdf .

Thornton, P. K. 2010. "Livestock production: recent trends, future prospects," *Philosophical Transactions of the Royal Society* vol. 365, no. 1554, pp. 2853–2867.

Umberger, W.J., Feuz, D.M., Calkins, C.R., Killinger, K.M. 2000. Consumer preference and willingness-to-pay for flavor in beef steaks. In: Paper Submitted to International Food and Agribusiness Management Association Meetings (IAMA), Chicago, IL June 24–25.

USAID (2012), End Market Analysis of Kenyan Livestock and Meat– A desk study. Micro Report #184.https://www.microlinks.org/sites/microlinks/files/resource/files/Kenya_Livestock_End_Market_Study.pdf .

Vanslembrouck, I., Van Huylenbroeck, G., Verbeke, W. 2002. Determinants of the willingness of Belgian farmers to participate in agri-environmental measures. *Journal of Agricultural Economics* 53, 489–511.

Wadud, M.A. 2006, "An analysis of meat demand in Bangladesh using the almost ideal demand system". *The Empirical Economic Letters* Vol. 5 No. 1, pp. 30-35.

Williamson, C. and Shah, M. M. 1981. *"Models of expenditure systems for Kenya: International Institute for Applied Systems Analysis" A-2361.* Laxenburg Austria, Working Paper, pp. 81–71.