

Estimation of Household Demand Elasticities for Selected Livestock Products Using the Almost Ideal Demand System (Aids) Model in Delta State, Nigeria

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Abstract

This study estimated household demand elasticities for selected livestock products—beef, fish, egg, chicken and goat meat—in Delta State, Nigeria. Specifically, the study described the socioeconomic characteristics of household heads, examined factors associated with household expenditure shares for the selected livestock products, and estimated own-price, cross-price and expenditure elasticities. A multistage sampling procedure was used to select 120 household heads, and primary data were collected with a structured questionnaire. Descriptive statistics and an Almost Ideal Demand System (AIDS) model were employed for the analysis. The results show that 95.0% of the respondents were male, the mean age was 43.67 years, mean household size was 6.70 persons, and mean monthly household income was ₦110,125. The estimated own-price elasticities were -0.4869 for beef, -1.1845 for fish, -1.0879 for egg, -1.3146 for chicken and -1.4437 for goat meat, indicating that beef demand was price inelastic while demand for the other products was price elastic. Cross-price elasticities indicated both substitution and complementary relationships among the livestock products. Expenditure elasticities were 0.4588 for beef, 1.4483 for fish, 0.9912 for egg, 1.0684 for chicken and 0.9505 for goat meat, implying that fish and chicken were expenditure-elastic (luxury) goods, while beef, egg and goat meat were expenditure-inelastic (necessity) goods within the study sample. Major constraints to consumption included high prices, low household income, rapid spoilage and inadequate supply. The study recommends measures to improve domestic livestock production, reduce avoidable price instability, and strengthen household income-earning capacity to improve access to livestock-derived foods.

Keywords —AIDS model; household demand; livestock products; expenditure elasticity; price elasticity

Introduction

The livestock and animal-source food sector is important to household nutrition, food security and agricultural development in Nigeria. However, consumption of animal-source foods remains constrained by factors including product prices, household income, market conditions, availability and inadequate processing and storage facilities. Nigeria's per capita meat consumption remains relatively low compared with several other African countries, while

demand for animal-source foods is expected to rise with population growth, urbanization and income growth (OECD/FAO, 2021). Livestock-derived foods can contribute important nutrients to household diets because meat, fish, eggs and other animal-source foods provide high-quality protein and several essential micronutrients (FAO, 2020; Grace et al., 2018). Nevertheless, the affordability and accessibility of these foods vary across households. Consequently, understanding how consumers respond to changes in prices and expenditure is important for designing policies that improve food access while supporting domestic production. Demand for livestock products is influenced by demographic and socioeconomic characteristics as well as market prices. Income growth generally increases the capacity of households to purchase higher-value foods, while changes in relative prices can induce substitution among alternative sources of animal protein. The magnitude of these responses is captured by demand elasticities, which are useful for producers, traders and policymakers when assessing likely consumer responses to price and income changes (Godfray et al., 2018; OECD/FAO, 2021).

The concept of demand elasticity is therefore central to decisions concerning production, pricing, marketing and food policy. In particular, estimates of own-price elasticities indicate the responsiveness of demand to changes in the price of a product, cross-price elasticities describe the relationship between competing or complementary products, and expenditure elasticities indicate how demand responds to changes in household purchasing power. Evidence from Nigeria shows that demand for animal protein varies across locations and household characteristics (Nwosu & Ebisike, 2022; Boluwaji et al., 2024; Offor et al., 2024; Olumide et al., 2024). Despite existing studies, there is limited empirical evidence on the joint demand relationships among beef, fish, egg, chicken and goat meat in Delta State. This study therefore aimed to estimate household demand elasticities for these selected livestock products in Delta State. Specifically, the study: (i) described the socioeconomic characteristics of the respondents; (ii) examined socioeconomic and expenditure-related factors associated with household budget shares for the selected livestock products; and (iii) estimated the own-price, cross-price and expenditure elasticities of demand for the products.

The study is relevant because the selected products represent alternative sources of animal protein and are likely to compete for household food expenditure. Estimating their demand responses provides evidence that can inform livestock production, marketing and price-stabilization policies in Delta State.

The study employed the Almost Ideal Demand System (AIDS) developed by Deaton and Muellbauer (1980). The AIDS framework is attractive because it provides a flexible system for estimating expenditure shares and allows economically relevant restrictions such as adding-up, homogeneity and symmetry to be considered in demand-system estimation (Mizobuchi & Tanizaki, 2014).

Methodology

The study was conducted in Delta State, Nigeria. Delta State is located in the southern part of Nigeria and comprises three agricultural zones: Delta North, Delta Central and Delta South. The state has 25 Local Government Areas and diverse ecological conditions, ranging from mangrove and swamp vegetation in the southern areas to forest and savannah conditions in the north. The state capital is Asaba, while Warri is an important commercial centre. The state was created from the former Bendel State on 27 August 1991 (Delta State Government, 2024).

A multistage sampling procedure was used to select 120 household heads. In the first stage, one Local Government Area was purposively selected from each agricultural zone: Ika South from

Delta North, Okpe from Delta Central and Bomadi from Delta South. In the second stage, one community was selected from each LGA. In the third stage, two villages were selected from each LGA, producing six villages. Finally, 20 household heads were randomly selected from each village using household lists obtained from village leaders. This produced a total sample of 120 respondents. Primary data were collected with a structured questionnaire.

Descriptive statistics, including frequencies, percentages and means, were used to summarize respondents' socioeconomic characteristics and consumption patterns. The AIDS model was used to estimate the expenditure-share relationships and derive the reported demand elasticities for the selected livestock products.

Aids Model Specification

The general expenditure-share equation of the Almost Ideal Demand System is specified as:

$$w_i = \alpha_i + \sum_j \gamma_{ij} \ln(p_j) + \beta_i \ln(X/P) + \theta_i Z + \varepsilon_i, \quad i = 1, \dots, 5$$

where w_i is the budget share of product i ; p_j is the price of product j ; X is total household expenditure on the products included in the demand system; P is the price index; Z represents observed socioeconomic characteristics; α_i , γ_{ij} , β_i and θ_i are parameters; and ε_i is the random error term.

B = household budget share of beef

F = household budget share of fish

C = household budget share of chicken

E = household budget share of egg

M = household budget share of goat meat

p_B = price of beef (₦/kg)

p_F = price of fish (₦/kg)

p_C = price of chicken (₦/kg)

p_E = price of egg (₦/crate)

p_M = price of goat meat (₦/kg)

MAR = marital status of household head (single = 0; married = 1)

AGE = age of household head (years)

HHS = household size (number of persons)

INC = household income (₦/month)

EDU = educational level of household head

X = total household expenditure on products included in the demand system

P = Stone price index, $\ln(P) = \sum_j w_j \ln(p_j)$

The reported estimation also includes the squared logarithm of total expenditure (LNEXPD2) and socioeconomic variables as expenditure-share shifters, as presented in Table 4.2.

The demand elasticities reported in this study were obtained from the estimated demand-system parameters. Own-price, cross-price and expenditure elasticities were interpreted using the signs and magnitudes reported in Tables 4.3 and 4.4.

Results and Discussion

Socioeconomic Characteristics of Respondents

Table 4.1 shows that 95.0% of the household heads were male and 5.0% were female. The mean age was 43.67 years, indicating that the respondents were predominantly middle-aged. Mean household size was 6.70 persons. Educational attainment was relatively high: 5.83% had no formal education, 10.00% had primary education, 49.17% had secondary education and 35.00%

had tertiary education. Mean monthly household income was ₦110,125. The distribution also shows that 17.5% of respondents were single and 82.5% were married. Mean monthly consumption frequencies were 18.50 for beef, 20.38 for fish and 9.63 for eggs. These figures provide an indication of the frequency with which the selected products entered household consumption during the reference period.

Factors Affecting Household Expenditure Shares for Livestock Products

For beef, the price coefficient was positive and statistically significant at the 1% level, indicating that beef's budget share increased with its own price within the estimated system. Although such a positive share response may appear counterintuitive, budget-share coefficients should not be interpreted directly as quantity-demand elasticities; the economically meaningful price response is captured by the derived elasticities in Table 4.3. The expenditure coefficient was positive and significant at the 1% level, indicating a positive association between total expenditure and the beef expenditure share. Marital status and education had negative coefficients, while age, household size and household income had positive coefficients. These results suggest that household characteristics influence the allocation of expenditure across livestock products.

For fish, the own-price coefficient was negative and significant at the 1% level, indicating a reduction in the fish expenditure share as fish price increased. The LNEXPD coefficient was negative and significant at the 1% level, while the squared expenditure term was also negative and significant. Age and household income had negative coefficients, whereas marital status, household size, occupation and education had positive coefficients. These findings indicate that household characteristics and expenditure conditions were associated with the share of household expenditure devoted to fish. For egg, the own-price coefficient was negative, while the coefficients of beef and fish prices were positive and statistically significant. The expenditure coefficient was negative and significant, indicating an inverse association between total expenditure and the egg expenditure share in the estimated system. Marital status, age, household size, occupation and education had negative coefficients, while household income had a positive coefficient. The signs of these coefficients should be interpreted as effects on expenditure shares rather than as direct quantity responses. For chicken, the own-price coefficient was negative and significant at the 1% level. The expenditure coefficient was positive and significant at the 5% level. Beef and fish prices had positive coefficients, while egg price had a negative coefficient. Household size and occupation were negatively associated with the chicken expenditure share, whereas marital status, age, education and household income had positive coefficients. The results suggest that both market prices and household characteristics were associated with chicken expenditure allocation. For goat meat, the own-price coefficient was negative and significant at the 1% level. Prices of beef, fish, egg and chicken had positive coefficients, while the expenditure coefficient was positive and significant at the 1% level. Marital status, age, household size, occupation and education had negative coefficients. The negative own-price coefficient is consistent with the expected direction of own-price response, while the positive coefficients on prices of other products indicate potential substitution in expenditure shares; the derived cross-price elasticities provide the appropriate basis for classifying these relationships.

Own-Price, Cross-Price and Expenditure Elasticities

Table 4.3 presents the Marshallian (uncompensated) and Hicksian (compensated) elasticities. The Marshallian elasticities incorporate both substitution and income effects, whereas Hicksian elasticities isolate the substitution effect by holding utility constant. The discussion below

focuses primarily on the Marshallian estimates because they reflect the combined effect of price changes and changes in purchasing power.

Own-Price Elasticities

The diagonal elements of Table 4.3 are the own-price elasticities. The estimates are -0.4869 for beef, -1.1845 for fish, -1.0879 for egg, -1.3146 for chicken and -1.4437 for goat meat. Beef demand is therefore price inelastic, while demand for fish, egg, chicken and goat meat is price elastic. In absolute terms, a 1% increase in price is associated with approximately a 0.49% reduction in beef demand, 1.18% reduction in fish demand, 1.09% reduction in egg demand, 1.31% reduction in chicken demand and 1.44% reduction in goat meat demand, based on the reported Marshallian elasticities. The results indicate greater price sensitivity for fish, egg, chicken and goat meat than for beef.

Cross-Price Elasticities

Cross-price elasticities measure the responsiveness of demand for one product to a change in the price of another product. Positive values indicate substitution, while negative values indicate complementarity. The reported Marshallian estimates show several positive cross-price relationships, including beef–fish (0.1749), beef–egg (0.7171), beef–chicken (0.3613), fish–beef (0.0429), fish–chicken (0.0389), egg–beef (0.1432), chicken–beef (0.0898) and goat meat–chicken (0.5708), among others. Negative relationships include beef–goat meat (-0.0205), fish–egg (-0.0050), egg–chicken (-0.2310), chicken–egg (-0.3214) and goat meat–beef (-0.0348). These results indicate that the selected animal-protein products are not uniformly substitutes; both substitution and complementary relationships exist. Because cross-price elasticities are directional, the relationship from product i to product j should be interpreted separately from the relationship from product j to product i .

Expenditure Elasticities

Table 4.4 shows expenditure elasticities of 0.4588 for beef, 1.4483 for fish, 0.9912 for egg, 1.0684 for chicken and 0.9505 for goat meat. Fish and chicken are expenditure elastic because their elasticities exceed one, while beef, egg and goat meat are expenditure inelastic because their elasticities are positive but less than one. Thus, all five products are normal goods within the sample, but fish and chicken are more responsive to changes in household expenditure than beef, egg and goat meat. A 1% increase in expenditure is associated with approximately a 1.45% increase in fish demand and a 1.07% increase in chicken demand, holding other conditions constant.

Conclusion and Recommendations

This study estimated household demand elasticities for beef, fish, egg, chicken and goat meat in Delta State using an AIDS demand-system framework. The results indicate that household expenditure shares were associated with product prices, total expenditure and selected socioeconomic characteristics. Marshallian own-price elasticities were negative for all five products. Beef demand was price inelastic, whereas fish, egg, chicken and goat meat were price elastic. Cross-price elasticities revealed both substitution and complementary relationships among the products. Expenditure elasticities were positive for all products, with fish and chicken being expenditure-elastic and beef, egg and goat meat being expenditure-inelastic. These findings suggest that changes in prices and household purchasing power can materially affect the

composition of household demand for animal-source foods.

Based on the findings, policies should support increased domestic production of livestock products through improved access to inputs, animal-health services, feed and production incentives. Measures that reduce avoidable supply constraints and excessive price fluctuations should also be strengthened. In addition, programmes that improve household income-earning capacity can enhance consumers' purchasing power and access to nutrient-dense livestock-derived foods. Efforts to improve storage, distribution and market infrastructure are also recommended to reduce losses and improve the regular availability of perishable products.

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Table 4.1. Socioeconomic characteristics of household heads

Characteristic	Category	Frequency	Percentage (%)	Mean
Sex	Male	114	95.00	
	Female	6	5.00	
Age (years)	21–30	8	6.67	
	31–45	60	50.00	
	46–60	52	43.33	43.67
Household size	1–4	13	10.83	
	5–8	85	70.83	
	9–11	22	18.33	6.70
Education	No formal education	7	5.83	
	Primary education	12	10.00	
	Secondary education	59	49.17	
	Tertiary education	42	35.00	
Monthly household income (₦)	10,000–49,000	5	4.17	
	50,000–99,000	48	40.00	
	100,000–149,000	45	37.50	
	150,000–199,000	21	17.50	
	200,000–249,000	1	0.83	110,125
Marital status	Single	21	17.50	
	Married	99	82.50	
Monthly beef consumption frequency	1–15	64	53.33	
	16–30	30	25.00	
	31–45	24	20.00	
	46–60	2	1.67	18.50
Monthly fish consumption frequency	1–15	37	30.83	
	16–30	70	58.33	
	31–45	10	8.33	
	46–60	3	2.50	20.38
Monthly egg consumption frequency	1–15	107	89.17	
	16–30	13	10.83	9.63

Source: Computed from field survey data, 2024.

Table 4.2. Almost Ideal Demand System parameter estimates

Variable	Beef	Fish	Egg	Chicken	Goat meat
VARIABLES					
CONSTANT	0.2456***; (0.0326)	0.1379***; (0.0255)	0.0756*; (0.0408)	0.3875***; (0.0260)	0.1401***; (0.0175)
LNPB	0.0583***; (0.0067)	-0.0034; (0.0029)	0.0245***; (0.0052)	0.2420***; (0.0035)	0.0018; (0.0034)
LNPF		-0.0222***; (0.0034)	0.0141***; (0.0040)	0.1144***; (0.0034)	0.0022**; (0.0023)
LNPE			-0.0067; (0.0092)	-0.0748***; (0.0060)	0.0246***; (0.0042)
LNPC				-0.0695***; (0.0079)	0.0589***; (0.0040)
LNPG					- 0.0446***; (0.0040)
LNEXPD	0.0644***; (0.0076)	-0.0306***; (0.0070)	-0.0592***; (0.0103)	0.0187**; (0.0077)	0.0227***; (0.0049)
LNEXPD2	0.0056***; (0.0004)	-0.0029** * ; (0.0005)	-0.0043***; (0.0007)	0.0003***; (0.0006)	0.0013***; (0.0003)
MARITAL STATUS	-0.00047; (0.0062)	0.0017*; (0.0090)	-0.0007; (0.0093)	0.0028***; (0.0086)	-0.0010**; (0.0005)
AGE	0.0001***; (0.0005)	-0.000009; (0.0001)	-0.0001***; (0.0002)	0.00003; (0.0001)	-0.00001; (0.0001)
HOUSEHOLD SIZE	0.0005***; (0.0005)	0.00005***; (0.0002)	-0.0001**; (0.0002)	-0.0008***; (0.0002)	-0.0001** * ; (0.0001)
OCCUPATION	0.0001; (0.0001)	0.00016***; (0.0005)	-0.0010**; (0.0005)	-0.0021; (0.0005)	-0.0002***; (0.0003)
EDUCATION	-0.00005**; (0.0001)	0.00008**; (0.0001)	-0.00012***; (0.0001)	0.00010**; (0.0001)	-0.00007***; (0.0001)
HOUSEHOLD INCOME	0.0582***; (0.0067)	-0.0003; (0.0029)	0.0245***; (0.0052)	0.0242***; (0.0035)	0.0018; (0.0034)

Source: Computed from field survey data, 2024. Note: ***, ** and * denote significance at 1%, 5% and 10%, respectively; standard errors are in parentheses.

Table 4.3. Marshallian and Hicksian price elasticities of demand

Product	Beef	Fish	Egg	Chicken	Goat meat
LIVESTOCK PRODUCTS					
	MARSHALLIAN / UNCOMPENSATED ELASTICITY	MARSHALLIAN / UNCOMPENSATED ELASTICITY	MARSHALLIAN / UNCOMPENSATED ELASTICITY	MARSHALLIAN / UNCOMPENSATED ELASTICITY	MARSHALLIAN / UNCOMPENSATED ELASTICITY

BEEF	-0.4869	0.1749	0.7171	0.3613	-0.0205
FISH	0.0429	-1.1845	-0.0050	0.0389	0.0113
EGG	0.1432	0.0204	-1.0879	-0.2310	0.0951
CHICKEN	0.0898	0.0467	-0.3214	-1.3146	0.2497
GOATMEAT	-0.0348	0.4814	0.3017	0.5708	-1.4437
	HICKSIAN / COMPENSATED ELASTICITY	HICKSIAN / COMPENSATED ELASTICITY	HICKSIAN / COMPENSATED ELASTICITY	HICKSIAN / COMPENSATED ELASTICITY	HICKSIAN / COMPENSATED ELASTICITY
BEEF	-0.4372	0.0289	0.9303	0.5182	0.0501
FISH	0.1262	-0.9920	0.3516	0.3014	0.1293
EGG	0.2168	0.1905	-0.7729	0.0090	0.1994
CHICKEN	0.1650	0.2206	0.0008	-1.0775	0.3563
GOATMEAT	0.0355	0.2106	0.6026	0.7923	-1.3442

Source: Estimates from the AIDS model.

Table 4.4. Expenditure elasticities of demand

	Beef	Fish	Egg	Chicken	Goat meat
Expenditure elasticity	0.4588	1.4483	0.9912	1.0684	0.9505

Source: Estimates from the AIDS model.

EDITORIAL NOTE FOR AUTHORS: The manuscript has been language-edited and internally harmonized. Before journal submission, verify the AIDS/QUAIDS specification and exact elasticity formulae against the estimation software output, because the reported model includes a squared expenditure term (LNEXPD2). The numerical results in Tables 4.2–4.4 were retained rather than recalculated.