QUADRATIC ALMOST IDEAL DEMAND SYSTEM OF FOOD CONSUMPTION PATTERN IN SOUTH-EASTERN NIGERIA

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ABSTRACT

Engel curves are, in general, non-linear in expenditure with observed hump-shaped relationships for some food items. Thus, allowing for flexible household income responses. This study, therefore, presents households food consumption pattern in south-eastern Nigeria using theory-consistent consumer-demand model. The analysis was done on micro-data from a sample of 790 food-consuming households. The results showed that households in the region observe less diversified diets as they expend a higher proportion of their food expenditure on carbohydrate foods. The results from the Quadratic Almost Ideal Demand System **(***QUAIDS) model showed that the resulting Engle curves of fish, plantain, fufu, and all food commodities in the fruits and vegetable category are non-linear. Most of the food commodities were normal goods with chicken (2.261) as luxury food commodity, and rice (1.160), yam (1.111), tomato (1.240) and pepper (1.185) on the verge of being luxury food commodities. However, tomato and pepper would change from luxury food commodities to necessary food commodities while fufu can change from necessary to luxury food commodity as income of households reached the point where they can afford a more diverse diet. Households in south-eastern Nigeria need chevon, mutton, plantain, potato, fufu, and orange for their daily consumption with their current level of food expenditure. Nevertheless, the price variables were of less effect on food consumption in the region then the income variables. Thus, policies thrust targeted at improving household income or expanding household disposable income in the region would be effective in improving household food consumption besides price stabilization policies.*

Keywords: food, QUAIDS, price, income, elasticities

INTRODUCTION

For a developing country like Nigeria, the consumption pattern is food-skewed. With more than half of what citizens earn spent on the consumption of food items, four out of ten individuals have monthly real per *capita* expenditure of less than ₦11452.50 (National Bureau of Statistics, NBS, 2019). In 2019, consumption expenditure accounted for 56.36% of Nigeria real Gross Domestic Product (GDP), with 56.65% of total household expenditure spent on food compared with 60.00% and 60.20% in 2010 (NBS, 2019), representing a 6.26% and 6.08% decline in consumption expenditure GDP share and household food expenditure respectively. Nigeria top food items in the 2019 report were starchy roots, tubers and plantains (6.28%), rice (4.92%), vegetables (4.38%), fish and sea food (3.32%), grains and flours (3.19%), pulses, nuts and seeds (2.97%), meat (2.96%), fruits (2.52%), oil and fats (2.46%), and poultry and poultry products (2.19%) accounting for 34.56% of the total household food expenditure and 24.80% of the total household expenditure. Further disaggregation by geo-political zones showed that the south-east zone of the country accounted for 11.48% of the total food expenditure in 2019 after north-east with the least at 6.14% (NBS, 2019).

Measuring consumption of a region over a period to provide indication of consumption habits of a household is important. However, of more importance is testing whether the consumption patterns of the region correlate with food items using valid statistical theory. Incomes not only vary across households; income elasticities also vary across food commodities. Capturing the income effect for households at different points in the income distribution is, therefore, of importance in order for a demand model to predict responses to food consumer tax reform. Some studies (Dalhatu and Ala, 2010; Adetunji and Rauf, 2010; Ogunniyi *et al.*, 2012; Ojogho and Ojo, 2017b; Colen *et al.*, 2018; Masters *et al.*, 2018; Almås *et al.*, 2019), however, have used demand systems model to predict the behaviour of household food demand on the proportional, linear, or monotonic relationship assumption between income and budget share against empirical Engel curve studies. Most of them supports higher order income terms for some, though not all, expenditure share equations. Such assumptions fail to account for Engel curvature that allows the classification of food items and the possibility of some food commodities being luxuries at a low-income level, and necessities at a higher income level.

This study presents household food commodities consumption pattern in south-eastern Nigeria for disaggregated food commodities sub-utility conditional on food expenditure using the QUAIDS Engel curves to capture the non-linearity in food consumption behavior of households. It updates the earlier food demand studies to predict household behaviour in expenditure on food consumption under unobserved real incomes in Nigeria.

METHOD AND DATA

The study was carried out in Abia, Anambra and Imo states in south-eastern zone of Nigeria. Administratively, the three States are divided into 65 Local Government Areas (LGAs) with 17 in Abia, 21 in Anambra and 27 in Imo State. The three States represents 14.61% of Nigeria population, NPC, 2006).

The region expends 11.48% of total household food expenditure (NBS, 2019), representing 6.50% in the national total household food expenditure. The monthly income in the states is between ₦18061.23 and ₦41065.56 with a poverty incidence of 30.67% in Abia, 14.78% in Anambra and 28.86.1% in Imo State, and household food expenditure of 57.83%, 57.17% and 49.42% respectively (2019).

The study focused empirical analysis on protein, carbohydrate, and fruits and vegetables as aggregate food groups using a target population of food consuming households from March 2016 and May 2017. A three-stage sampling procedure was used to select households in the three States. The first stage used a simple random sampling of 3 Local Government Areas (LGAs) from each State. The LGAs were Isuikwuato in

Abia State, Ihiala in Anambra State, and Ikeduru in Imo State. The second stage involved a simple random sampling of 2 communities in each LGA from a sampling frame of communities in the respective LGAs. The communities were Imenyi and Ohaise in Isuikwuato LGA of Abia State, Umueze and Ikenga in ihiala LGA of Anambra State, and Akabo and Okwu in Ikeduru LGA of Imo State. The sample size for the study in each community was determined using the sample-size estimator as used by Ojogho and Ojo (2017a), given estimates of the food expenditure variance for the different communities at 95% confidence interval and a 0.03 margin of error. The sample-size estimator is given as:

$$n_i = \frac{z^2_{\alpha/2} s^2_i}{e^2 + \frac{z^2_{\alpha/2} s^2_i}{N_i}} \quad [1]$$

Where,

$z_{0.025} = 1.96$,

s^2_i is the food expenditure variance of the i^{th} community,

N_i is the target population size of the i^{th} community, and

$e = 0.03$.

A simple random sample of households in each community was then taken from the list of the target population in the region developed from a pilot survey. The sample sizes were respectively 112 in Imenyi and 96 in Ohaise in Isuikwuato LGA of Abia State, 204 in Umueze and 156 in Ikenga in ihiala LGA of Anambra State, and 184 in Akabo and 168 in Okwu in Ikeduru LGA of Imo State making up a total of 209 in Abia state, 360 in Anambra state and 352 households in Imo state. 971 copies of questionnaire were administered but only 825 copies of questionnaire were retrieved from the respondents making a response rate of 85%. However, 790 copies of questionnaire were valid for analysis as only data from 6 or more in 10 respondents who consumed food commodities under study were used in the final analysis. The prices of food commodities were measured as the sum of the transaction's costs incurred by a household during purchase and the retail prices in ₦/Kg, while the quantity consumed of food commodities by a household was the quantities purchased at market price per Kg.

Model Specification

The study assumes specific functional shape of the food consumer preference in a competitive market, and the weak separability between food commodities included in the model with a sufficient homotheticity condition of each sub-utility function for the first stage of the two-stage budgeting. The study argues that the decision making process on the demand-side is done by one of the parents or one of the couple hereafter called household head.

The Quadratic Almost Ideal Demand System (QUAIDS) of Banks *et al.* (1997) was used to estimate a complete food demand system for the commonly consumed food commodities in the region. The QUAIDS model is given, in its budget share form, as:

$$w_i = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \ln p_j + \beta_i \left[\ln\left(\frac{m}{a(p)}\right)\right] + \frac{\lambda_i}{b(p)}\left[\ln\left(\frac{m}{a(p)}\right)\right]^2$$

[2]

where;

w_i is the share of expenditure of the i^{th} commodity,

m is expenditure on a sub-food group containing elementary food commodities,

p_j is price of j^{th} commodity,

$a(p)$ is a price index, homogenous of degree one in prices, defined as $\ln a(p) = \alpha_0 + \sum_{i=1}^{k} \alpha_i \ln p_i + \frac{1}{2}\sum_{i=1}^{k}\sum_{j=1}^{k} \gamma_{ij} \ln p_i \ln p_j$,

$b(p)$ defined as $b(p) = \prod_{i=1}^{k} p_i^{\beta_i}$ is a function that is homogenous of degree zero in prices,

n is the number of elementary food commodities entering the demand model in a sub-foods group,

p is a vector of prices, α_i, β_i and λ_i are parameters to be estimated, p_j is the market price of the j^{th} commodity, α_i are the constant coefficient in the share equation representing the value of the budget share in the absence of income- and price- effects, γ_{ij} slope coefficient associated with the j^{th} commodity in the i^{th} share equation, β_i is the log-expenditure coefficient of the i^{th} commodity in the i^{th} share equation, λ_i is the log-expenditure square coefficient of the i^{th} commodity in the i^{th} share equation.

To account for the distances from rationality, the study assumes that there is an additive zero-mean error term associated with each of the n expenditure share equations. Thus, an error term ϵ_i was added to the right-hand side of [2] for estimation purposes. $\epsilon \equiv [\epsilon_1, \epsilon_2, \ldots, \epsilon_k]$ was assumed to have a multivariate normal distribution with covariance matrix Σ. However, the adding-up condition implies that Σ is singular.

Therefore, one of the n-demand equations was dropped from the system with the remaining $(n-1)$ equations estimated by maximum likelihood, while the parameters of the final equation were recovered using the regularity conditions. The regularity conditions of adding-up, homogeneity and symmetry were imposed such that the resulting model is consistent with the theory of utility maximization.

Adding up

$\sum_{i=1}^{k} \alpha_i = 1$, $\sum_{i=1}^{k} \beta_i = 0$, $\sum_{i=1}^{k} \lambda_i = 0$, and $\sum_{i=1}^{k} \gamma_{ij} = 0, \ \forall j$

Homogeneity

$\sum_{i=1}^{k} \gamma_i = 0, \forall j$

Slutsky symmetry

$\gamma_{ji} = \gamma_{ij}, \forall i,j$

Expenditure- (budget share-) and price-elasticities were reported since it is impossible to determine at a glance which food commodities are luxuries, necessities, inferior or normal for QUAIDS. To achieve this, the geometric means of the price and expenditure variables were first computed and then the price elasticities and conditional budget share elasticities were computed at the geometric means. The expenditure (budget share) elasticities were estimated using:

$$\eta_i = 1 + \frac{\mu_i}{w_i} \qquad [3]$$

The uncompensated own- and cross-price elasticities were estimated using:

$$\varepsilon_{ij}^{m} = -\partial_{ij} + \frac{\mu_{ij}}{w_i} \qquad [4]$$

Compensated own- and cross-price elasticites were estimated using:

$$\varepsilon_{ij}^{h} = \varepsilon_{ij}^{m} + \eta_i w_j \qquad [5]$$

where;

$$\mu_i = \beta_i + \frac{2\lambda_i}{b(p)}.\ln\left(\frac{m}{a(p)}\right) \quad [6]$$

$$\mu_{ij} = \gamma_{ij} - \mu_i(\alpha_j + \sum_{k=1}^{n}\gamma_{jk}\ln p_k) - \frac{\lambda_i\beta_j}{b(p)}\left[\ln\left[\frac{m}{a(p)}\right]\right]^2 \quad [7]$$

δ_{ij} is the Kronecker delta,

$a(p)$ and $b(p)$ are as defined above,

p_k is the price of the k^{th} commodity.

The i^{th} food commodity was then considered normal if $\eta_i > 0$, inferior if $\eta_i < 0$, luxury if $\eta_i > 1$, necessity if $\eta_i < 1$, substitute if $\varepsilon_{ij}^m > 0, \forall i \neq j$ and complement if $\varepsilon_{ij}^h < 0, \forall i \neq j$.

RESULTS

Table 1 shows the summary statistics of the QUAIDS model variables for commonly consumed food commodities in South-eastern Nigeria. The results showed that households in the area expended about 42.70% of the food expenditure on carbohydrate foods with coefficient of variation of 36.68%, 37.60% on protein foods with coefficient of variation of 13.58% and 19.70% on fruits and vegetables with coefficient of variation of 47.21%. Among the carbohydrate foods, rice consumption had the larger budget share (33.5%), followed by *garri* (17.0%) and least with potato consumption (6.8%). In the protein foods category, chicken demand had the largest budget share (34.4%), followed by beef (23.1%) and least with fish and mutton consumption with equal budget share (13.6%). Demand for onion took about 41.3% of the food expenditure on fruits and vegetables in the region. This was followed by tomato (29.3%) and least with pepper (14.1%). Plantain (₦111.8), fish (₦306.4) and tomato (₦184.6) were the cheapest of the food commodities in each food category respectively per Kg. The average prices per Kg of *garri* and beef were ₦238.20 and ₦900.50 respectively.

The resulting coefficients and the associated standard error from the last iteration of the QUAIDS model are presented in Table 2. The estimated model produced a data-coherent and plausible description of consumer behavior in the region from which budget and price elasticities measures associated with income and price changes could be calculated. More than half of the coefficients of the explanatory variables for food commodities were statistically significant. All own-price effects were statistically significant for the food commodities in the fruit and vegetable category. However, the price-effects were less statistically significant then the income-effect.

The coefficients of quadratic log-expenditure term for fish, plantain, tomato pepper and orange were respectively 0.019, -0.034, -0.046, -0.031 and 0.017. The coefficients of the quadratic log-expenditure term of fish, plantain, *fufu*, and all food commodities in the fruits and vegetable category were significant. The own-price effects of chicken, plantain, rice, *fufu*, onion, tomato, pepper and orange were 2.278, 0.291, 0.156, 0.232, 1.254, 0.529, 0.255 and 0.126 respectively. The cross-price effects of chevon on chicken, *fufu* on plantain, rice on plantain, tomato on onion, pepper on onion and pepper on tomato were respectively 0.400, -0.240, -1.560, -0.755, -0.527 and 0.326.

Table 1: summary Statistics of QUAIDS Model Variables for Food Commodities in South-eastern Nigeria

Statistics	Protein: ω_p =0.376, s.d =0.1379, c.v =36.68%					Carbohydrate: : ω_c =0.427, s.d =0.058, c.v =13.58%						Fruits and vegetables: ω_p =0.197, s.d =0.093 c.v =47.21%			
	w_f	w_b	w_c	w_{ch}	w_m	w_{pl}	w_g	w_r	w_y	w_{po}	w_{fu}	w_{to}	w_{pe}	W_{orange}	w_{onion}
Mean	0.136	0.231	0.344	0.153	0.136	0.130	0.170	0.335	0.176	0.068	0.121	0.293	0.141	0.153	0.413
Std. dev.	0.091	0.114	0.198	0.071	0.068	0.047	0.054	0.072	0.048	0.031	0.059	0.088	0.045	0.069	0.113
C.V	66.91	49.35	57.56	46.41	50.00	36.15	31.76	21.49	27.27	45.59	48.76	30.03	31.91	45.10	27.36
Min.	0.014	0.056	0.019	0.054	0.051	0.035	0.045	0.187	0.036	0.024	0.030	0.073	0.040	0.034	0.154
Max.	0.438	0.542	0.702	0.390	0.378	0.308	0.303	0.565	0.375	0.227	0.475	0.577	0.257	0.500	0.772
	p_f	p_b	p_c	p_{ch}	p_m	p_{pl}	p_g	p_r	p_y	p_{po}	p_{fu}	p_{to}	p_{pe}	p_{orange}	p_{onion}
Mean	306.4	900.5	677.5	992.4	985.3	111.8	238.2	391.4	179.3	121.5	438.5	184.6	619.7	428.2	425.63
Std. dev.	38.55	38.42	73.52	100.9	85.60	30.10	161.9	100.4	30.23	49.29	100.3	26.59	140.9	179.4	71.04
C. V	12.58	4.26	10.85	10.16	8.69	26.92	67.96	25.65	16.86	40.57	22.87	14.40	22.74	41.90	16.69
Min.	200.0	780.0	600.0	850.0	790.0	130.4	936.8	213.3	300.0	460.0	411.1	108.7	945.5	1000	742.42
Max.	450.0	1000	900.0	1500	1300	266.7	2500	625.0	350.0	500.0	666.7	333.3	1200	1500	877.2

Source: Authors' computation from Field Survey Data, 2017; w_i and p_i are respectively the budget share and price of the i^{th} food commodity.

Table 2: Parameters Estimates and Associated Standard Errors of the QUAIDS Model for Food Commodities in South-eastern Nigeria

Food Items	Parameters								
	α_i	β_i	λ_{i1}	γ_{i1}	γ_{i2}	γ_{i3}	γ_{i4}	γ_{i5}	γ_{i6}
Protein									
Fish	0.353	0.146	0.019*	0.174					
	(0.739)	(0.190)	(0.011)	(0.138)					
Beef	-1.508	-0. 407	-0.021	-0.161	0.540				
	(1.133)	(0.312)	(0.020)	(0.256)	(0.649)				
Chicken	4.252***	0.772***	0.022	0.112	-1.006	2.278**			
	(0.878)	(0.242)	(0.016)	(0.346)	(0.739)	(1.000)			
Chevon	-1.376**	-0.360**	-0.018	-0.090	0.400*	-0.922**	0.442		
	(0.617)	(0.171)	(0.011)	(0.176)	(0.231)	(0.416)	(0.315)		
Mutton	-0.721	-0.150	-0.002	-0.036	0.227	-0.463	0.170	0.102	
	(0.650)	(0.181)	(0.012)	(0.105)	(0.191)	(0.391)	(0.171)	(0.146)	
Carbohydrate									
Plantain	-0.320***	-0.278***	-0.034***	0.291***					
	(0.074)	(0.037)	(0.006)	(0.069)					
Garri	0.050	-0.083	-0.011	0.071	0.021				
	(0.140)	(0.083)	(0.011)	(0.072)	(0.044)				
Rice	0.670***	0.144	0.012	-0.156*	-0.065	0.155*			
	(0.146)	(0.094)	(0.013)	(0.090)	(0.051)	(0.087)			
Yam	0.102	-0.073	-0.012	0.046	0.017	-0.030	0.023		
	(0.128)	(0.080)	(0.011)	(0.071)	(0.025)	(0.049)	(0.034)		
Potato	0.045	0.009	0.003	-0.012	0.005	-0.009	0.00006	0.007	
	(0.096)	(0.056)	(0.007)	(0.050)	(0.016)	(0.026)	(0.013)	(0.009)	
Fufu	0.453***	0.281***	0.043***	-0.240***	-0.050	0.105	-0.056	0.009	0.232**
	(0.125)	(0.067)	(0.010)	(0.057)	(0.078)	(0.077)	(0.074)	(0.048)	(0.116)
Fruit and Vegetables									
Onion	1.738***	0.587***	0.060***	1.254***					
	(0.167)	(0.092)	(0.012)	(0.363)					
Tomato	-0.233	-0.361***	-0.045***	-0.755***	0.529**				
	(0.182)	(0.099)	(0.012)	(0.288)	(0.231)				
Pepper	-0.394***	-0.271***	-0.031***	-0.527***	0.326***	0.255***			
	(0.119)	(0.037)	(0.004)	(0.109)	(0.097)	(0.063)			
Orange	-0.111	0.045	0.017**	0.028	-0.100	-0.054	0.126***		
	(0.170)	(0.069)	(0.007)	(0.120)	(0.079)	(0.058)	(0.020)		

Source: Authors' computation from Field Survey Data, 2017; *values in parentheses are standard errors; ***significant @ 1% level, **significant @ 5% level, *significant @ 10% level.*

Table 3 presents the expenditure-, uncompensated own- and cross-price elasticities of the food commodities in the region. The results showed that chicken, *garri*, rice, yam, tomato and pepper had positive expenditure elasticities of 2.261, 1.018, 1.160, 1.111, 1.240 and 1.185 respectively in the region. A greater magnitude of expenditure elasticity was evident in the case of chicken (2.26).

Table 3: Estimates of Expenditure, Uncompensated Own-price and Cross-price Elasticities of the QUAIDS Model for Food Commodities in South-eastern Nigeria

Food Items	Parameters						
	η_i	ε^m_{i1}	ε^m_{i2}	ε^m_{i3}	ε^m_{i4}	ε^m_{i5}	ε^m_{i6}
Protein							
Fish	-0.107	-0.373	-0.148	-0.181	0.130	-0.065	
	(0.123)	(0.310)	(0.222)	(0.132)	(0.184)	(0.201)	
Beef	0.641***	-0.076	-0.432	-0.690***	0.251	0.571	
	(0.104)	(0.376)	(0.487)	(0.220)	(0.330)	(0.366)	
Chicken	2.261***	0.353	-0.466	-0.477*	-0.708***	-0.086	
	(0.081)	(0.340)	(0.335)	(0.290)	(0.276)	(0.295)	
Chevon	0.441***	0.231	0.135	-0.594***	-0.257	0.206	
	(0.088)	(0.206)	(0.218)	(0.119)	(0.257)	(0.209)	
Mutton	0.159***	-0.028	0.270	-0.319***	0.145	-0.785**	
	(0.090)	(0.200)	(0.215)	(0.114)	(0.186)	(0.299)	
Carbohydrate							
Plantain	0.886***	-0.571***	0.0005	-0.113***	-0.101**	-0.053	0.029
	(0.074)	(0.089)	(0.054)	(0.031)	(0.047)	(0.099)	(0.065)
Garri	1.018***	0.023	-1.002***	-0.112***	-0.030	0.148	0.250***
	(0.067)	(0.071)	(0.089)	(0.037)	(0.050)	(0.116)	(0.083)
Rice	1.160***	-0.201***	-0.173	-0.809***	-0.041	-0.087	0.038
	(0.045)	(0.075)	(0.067)	(0.051)	(0.055)	(0.110)	(0.088)
Yam	1.111***	-0.098	-0.015	-0.030	-0.991***	0.079	0.151***
	(0.059)	(0.062)	(0.052)	(0.031)	(0.059)	(0.089)	(0.067)
Potato	0.789***	-0.034	0.044	-0.043*	0.009	-0.899***	0.025
	(0.102)	(0.052)	(0.047)	(0.024)	(0.035)	(0.127)	(0.052)
Fufu	0.607***	-0.006	0.127	-0.053	0.043	0.022	-1.100***
	(0.103)	(0.061)	(0.059)	(0.033)	(0.045)	(0.091)	(0.109)
Fruit and Vegetables							
Onion	1.044***	-0.417***	-0.582	-0.539***	0.033		
	(0.052)	(0.107)	(0.110)	(0.124)	(0.092)		
Tomato	1.240***	-0.355***	-0.608	0.199***	0.026		
	(0.057)	(0.075)	(0.096)	(0.093)	(0.075)		
Pepper	1.185***	-0.164***	0.088	-0.744***	0.039		
	(0.063)	(0.040)	(0.045)	(0.078)	(0.043)		
Orange	0.253***	-0.109***	-0.138	-0.100***	-0.352***		
	(0.070)	(0.032)	(0.039)	(0.046)	(0.057)		

Source: Authors' computation from Field Survey Data, 2017; *values in parentheses are standard errors; ***significant @ 1% level, **significant @ 5% level, *significant @ 10% level.*

The results also showed that beef, chevon, mutton, plantain, *fufu*, and potato also had positive but less than unit expenditure elasticities of 0.641, 0.441, 0.159, 0.886, 0.607 and 0.789 respectively in the region. Only fish had a non-significant negative expenditure elasticity of -0.107. Consistent with the economic theory that the negative effect of rising food prices is a decrease in food demand, all Marshallian own-price elasticities for the food commodities in the study area were negative.

Plantain (-0.571), rice (-0.809), yam (-0.991), and potato (-0.899) in the carbohydrate group, had absolute uncompensated own-price elasticity less than unit. On the other hand, results showed that *garri* (-1.002) and *fufu* (1.100) *had* significantly greater own-price elasticity than unit. Only chicken (-0.477) and mutton (-0.785) in the protein food group had significant own-price elasticities with value less than unit. In the fruits and vegetable food group, onion (-0.417), pepper (-0.774) and orange (-0.352) were significant at 1% level with own-price elasticities value of less than unit.

The results also show that all six food commodities under carbohydrate food group, plantain (0.886), *garri* (1.018), rice (1.160) and yam (1,111), had expenditure elasticities greater than the absolute value of their uncompensated own-price elasticities.

Similarly, pepper (1.819) and onion (1.044), in the fruits and vegetable food group, had expenditure elasticities greater than the absolute value of their uncompensated own-price elasticities. In the protein food group, only chicken (2.261) had expenditure elasticities greater than the absolute value of their uncompensated own-price elasticity. The coefficients of the cross-price elasticities in majority of the food commodities like tomato and onion (-0.355), pepper and onion (-0.164), pepper and tomato (-0.744), beef and chicken (-0.690), and *garri* and rice (-0.112) are negative.

The results of the compensated own- and cross-price elasticities are presented in Table 4. In line with microeconomic theory, all compensated own-price price elasticities (Hicksian) were negative. The compensated cross-price elasticities between chicken and chevon (-0.248), and chevon and chicken (-0.557) were negative.

Table 4: Estimates of Compensated Own-price and Cross-price Elasticities of the QUAIDS Model for Food Commodities in South-eastern Nigeria

Food Items	Parameters					
	ε^h_{i1}	ε^h_{i2}	ε^h_{i3}	ε^h_{i4}	ε^h_{i5}	ε^h_{i6}
Protein						
Fish	-0.388	-0.060	0.127	0.190	-0.044	
	(0.310)	(0.221)	(0.132)	(0.184)	(0.201)	
Beef	-0.100	-0.284	-0.167	0.353	0.608*	
	(0.376)	(0.487))	(0.221)	(0.330)	(0.366)	
Chicken	0.316	-0.246	0.300	-0.557**	-0.031	
	(0.332)	(0.328)	(0.284)	(0.269)	(0.289)	
Chevon	0.215	0.233	-0.248**	-0.190	0.231	
	(0.206)	(0.218)	(0.120)	(0.258)	(0.209)	
Mutton	-0.043	0.357	-0.012	0.204	-0.764***	
	(0.200)	(0.215)	(0.115)	(0.186)	(0.300)	
Carbohydrate						
Plantain	-0.456***	0.132**	0.037	0.043	0.049	0.108
	(0.088)	(0.053)	(0.030)	(0.045)	(0.097)	(0.064)
Garri	0.174***	-0.829***	0.086**	0.159***	0.283**	0.353***
	(0.070)	(0.088)	(0.035)	(0.049)	(0.115)	(0.081)
Rice	0.096	0.169**	-0.420***	0.332***	0.177	0.241***
	(0.077)	(0.069)	(0.054)	(0.056)	(0.116)	(0.090)
Yam	0.059	0.165***	0.174***	-0.795***	0.218**	0.258***
	(0.060)	(0.051)	(0.030)	(0.058)	(0.088)	(0.065)
Potato	0.026	0.113**	0.036	0.085***	-0.845***	0.066
	(0.051)	(0.046)	(0.024)	(0.034)	(0.126)	(0.051)
Fufu	0.101*	0.250***	0.087***	0.176***	0.117	-1.027***
	(0.060)	(0.058)	(0.032)	(0.044)	(0.089)	(0.105)
Fruit and Vegetables						
Onion	-0.015	-0.069	-0.049	0.138		
	(0.103)	(0.106)	(0.119)	(0.086)		
Tomato	-0.049	-0.245***	0.545***	0.100		
	(0.075)	(0.095)	(0.092)	(0.073)		
Pepper	-0.017	0.262***	-0.578***	0.075		
	(0.040)	(0.044)	(0.078)	(0.042)		
Orange	0.051	0.052	0.081*	-0.313***		
	(0.032)	(0.038)	(0.045)	(0.056)		

Source: Authors' computation from Field Survey Data, 2017; *values in parentheses are standard errors; ***significant @ 1% level, **significant @ 5% level, *significant @ 10% level.*

DISCUSSION

The summary statistics of the QUAIDS model variables for commonly consumed food commodities in South-eastern Nigeria are as presented in Table 1. The results show that households in the region expend on carbohydrate foods, protein foods, and fruits and vegetables of the food expenditure in the ratio 4:3:2. The results suggest that households in the region demand more of carbohydrate food commodities with expenditure on rice highest during the period of the study. Plantain, fish and tomato are the cheapest food commodities per Kg in the carbohydrate, protein, and fruits and vegetables food categories respectively. The results suggest that expenditure on carbohydrate foods is less variable among the households than it is for protein, and fruits and vegetables. Similarly, households in south-eastern Nigeria are more alike in their demand for rice and yam among carbohydrate foods, and in their demand for onion among fruits and vegetables than other food commodities in the region. Relatedly, the results suggest that cheaper starchy foods such as rice, plantain, and yam are predominant in household food consumption basket, suggesting less diversified diets.

The results from the last iteration of the QUAIDS model, presented in Table 2, show that the quadratic term of the log-expenditure is significant for some of the food commodities. The significance of the quadratic log-expenditure term implies that the QUAIDS model better describes the food budget-share in relation to food prices and expenditure as the resulting Engle curves of fish, plantain, *fufu*, and all food commodities in the fruits and vegetable category are non-linear. This is contrary to the proportional, linear, or monotonic relationship assumption between income and budget share as used by other studies like Ojogho and Ojo, 2017b; Colen *et al.*, 2018; Masters *et al.*, 2018; Almås *et al.*, 2019. This also implies that the demands for plantain, fish, onion, tomatoes and orange are not homothetic.

With positive β_i and λ_i, onion will remain a luxury food commodity in the region irrespective of the levels of total food expenditure. There seems a likelihood of other food commodities in the region becoming necessary food commodities. Tomato and pepper with positive β_i and λ_i,, for example, would change from being luxury food commodities to necessary food commodities as household total conditional food expenditure increases. Such transformation in tomato and pepper consumption explains a change of consumer behaviour on these food commodities as household food expenditure reached the point when they could afford a more diverse diet.

Similarly, hump-shape Engel curve of *fufu*, onion and orange imply that the consumption of *fufu* is transformed from being necessary food commodity to luxury food commodity. Such transformation in plantain, tomato and pepper consumption explains a change of household consumption pattern on these food commodities as household food expenditure reached the point when they could afford a more diverse diet.

These results comply with demand theory and reflect the level of economic development that is fuelled by the increase of the disposable incomes of food consumers in the region. Fish has a tendency of becoming a necessary food commodity from its current inferior commodity status. Thus, as conditional food expenditure increases, the budget shares of fish, *fufu*, onion and orange will increase but will eventually decrease in the long-run while the budget shares of plantain, tomato and pepper will first decrease but will eventually increase in the long-run as food expenditure increases. Only plantain, tomato and pepper exhibit the inverse hump-shaped Engle curve as the coefficient of the quadratic log-expenditure term are negative. However, the overall quality of food consumption among households can be said to be poor as the composition of food budgets is in the direction containing fewer luxuries and fewer necessities.

The price variables are less statistically significant then the income variables, which is probably due to low food price variations during the period under study. This implies that household food consumption in the region is less of food prices dependent than household income. Thus, household conditional income has greater effect than food prices in household food consumption pattern. The own-price effects of chicken, plantain, rice, *fufu*, onion, tomato, pepper and orange show a positive relationship with their respective budget shares. The coefficients of chicken, plantain, rice, *fufu*, onion, tomato, pepper and orange show that unit increase in the price of chicken, plantain, rice, *fufu*, onion, tomato, pepper and orange will result in 2.278%, 0.291%, 0.156%, 0.232%, 1.254%, 0.529%, 0.255% and 0.126% increase in the budget shares of chicken, plantain, rice, *fufu*, onion, tomato, pepper and orange respectively.

The price of chevon has positive effect on the budget share of chicken. Similarly, the price of pepper has positive effect on tomato. The cross-price coefficient of chevon on chicken shows a 0.4% increase the budget share of chicken with a unit increase in the price of chevon. Similarly, the cross-price effect coefficient of pepper on tomato shows that unit increase in the price of pepper will increase the budget share of tomato by 0.326%. Negative relationship exists between the price *fufu* on plantain, rice on plantain, tomato on onion, and pepper on onion. A unit increase in the price of *fufu* on plantain, for example, will decrease the budget share of plantain by 0.240%.

Table 3 presents the expenditure, uncompensated own- and cross-price elasticities of the food commodities. Results show that all food commodities, except fish, are normal goods such that an increase in household conditional food expenditure will increase the expenditure on these food commodities except fish. Percentage increase in household food expenditure will result in more than proportionate percentage increase in the demand for chicken, *garri*, rice, yam, onion, tomato and pepper but a less than proportionate percentage increase in the demand for other food commodities like beef and orange. The implication is that chicken, *garri*, rice, yam, onion, tomato and pepper are luxury food commodities in the region given their current income level, and as such households can be dissuaded from consuming them though increase in their prices at constant income. Hence, any policy instrument that increases household expenditure on these food commodities will more than increase the consumption of chicken under protein, *garri*, rice and yam under carbohydrate, and tomato and pepper under fruits and vegetables of household food commodities basket in the region.

Consistent with the economic theory that the negative effect of rising food prices is a decrease in food demand, all Marshallian own-price elasticities for the food commodities in the region are negative. Plantain, rice, yam, and potato in the carbohydrate group, have absolute uncompensated own-price elasticity less than unit. For these food commodities, the quantity demanded is less sensitive to change in prices. On the other hand, results suggest that *garri* and *fufu* exhibit significantly greater own-price elasticity than unit. Household spending responds to the price increase of *garri* and *fufu* with the percentage increase in their prices greater than the proportional percentage decrease in food expenditure. However, large price elasticity of *garri* and *fufu* also indicates that households are not vulnerable to increases in the price of *garri* and *fufu*.

In the region, own-price elasticity higher than unit, as the case of *garri* and *fufu*, implies that the percentage reduction in quantities consumed would be higher in magnitude than the percentage increase in price, leading to a reduction in the expenditure on *garri* and *fufu*. On the other hand, households would be unable to substitute away from beef, plantain, rice, tomato, anion and pepper with less than unit in own-price elasticity when beef, plantain, rice, tomato, anion and pepper become more expensive, but would have to increase expenditure on them. Income support measures can help to counteract a fall in consumption resulting from the erosion of purchasing power on food commodities like beef, plantain, rice, tomato, anion and pepper in the event of inflation in food prices.

Plantain, *garri*, rice, yam, pepper, onion and chicken have expenditure elasticities greater than the absolute value of their uncompensated own-price elasticities. Household consumption of plantain, *garri*, rice, yam, pepper, onion and chicken is, therefore, more resilient to changes in household food expenditure than to the changes in price. As such, price support measures like price discount can help to counteract a fall in consumption resulting from the erosion of purchasing power such that household consumption of these food commodities can be sustained, and thus offer as substitutes for staple food commodities in the region.

The coefficients of the cross-price elasticities in majority of the food commodities like tomato and onion, pepper and onion, pepper and tomato, beef and chicken, and *garri* and rice are negative. Such an outcome reveals the importance of income effects on consumer decision to consume tomato and onion, pepper and onion, pepper and tomato, beef and chicken, and *garri* and rice where either of the paired food commodities is in the diet of the consumer. Some of the food commodities have minimal absolute cross-price elasticity that is close to zero as in plantain/*garri*, and plantain/potato. Thus, plantain and *garri*, and plantain and potato are weakly independent of the price of each other. The nature of the independence of these food commodities reflects those consumption patterns that are already established, and tend to remain unchanged even when food prices change. The cross-price elasticity of plantain and *garri*, plantain and *fufu*, and orange and other fruits and vegetables indicate that households would stick to the consumption of these food commodities to substitute for the reduction in other food commodities.

The compensated (Hicksian) own-price elasticities, in absolute terms, are lower than uncompensated (Marshallian) own-price elasticities. Thus, the effect of rising food prices in the region can be reduced by giving income compensation. All of Hicksian own-price elasticities are negative, which is consistent with economic theory that the negative effect of rising food commodity prices is a decrease in food commodity demand. The negative value of the cross-price elasticities between chicken and chevon, and that between chevon and chicken shows that chicken and chevon, and chevon and chicken are food complements. Chicken and chevon, and chevon and chicken in the protein food category are eaten together in a diet when either of the food commodities is in the meal.

The results differ slightly from Ojogho and Ojo (2017b). The difference may be due to the included quadratic term of the log expenditure square that allows the hump-shaped relationships observed for certain food commodities. This is different from the built-in assumption in AIDS, LA/AIDS and LES used in previous studies (Ojogho and Alufohai, 2010; Ojogho and Ojo, 2017a and b), where the hump-shaped relationships observed for some food commodities. Thus, it should be noted that those studies also built models for other households, and any comparisons warrant caution.

CONCLUSION

The study estimated the QUAIDS Engel curves of the complete demand function for common food commodities, and estimated the conditional price- and expenditure-elasticities to describe the food commodities consumption pattern in south-eastern Nigeria. It used micro-data from a random sample of 790 food consumer. Households in the region expend a higher portion of their conditional food expenditure on carbohydrate foods, followed by protein foods and least on fruits and vegetables. More of the food commodities in the region are normal goods with chicken, rice, yam, tomato and pepper as luxury food commodities. The consumption of tomato and pepper changes from luxury food commodities to necessary food commodities while the consumption of *fufu* changes from necessary to luxury food commodity as income of households reached the point where they can afford a more diverse diet. Onion will remain a luxury food commodity in the region irrespective of the levels of total food expenditure Households in south-eastern Nigeria households need chevon, mutton, plantain, potato, *fufu,* and orange for their daily consumption given their current level of food expenditure while the effect of rising food prices in the region can be reduced by income compensation.

However, higher order terms in expenditure than the quadratic Engel curve for food commodities consumption in south-eastern Nigeria is a concern for further research.

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