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Heterogeneity in Rural Household Food Demand and Its Determinants in Ondo State, Nigeria: An Application of Quadratic Almost Ideal Demand System

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Abstract

This study described the food demand of rural households of Nigeria with a view to identifying its determinants and responsiveness to price and household food expenditure.The study made use of 121 rural households in Ondo state using a 3-stage random sampling technique.Demand for food groups in this study was estimated using Quadratic Almost Ideal Demand System (QUAIDS). The Wald test revealed that the QUAIDS model was significantly corrected for endogeneity and that the inclusion of demographics in the model significantly improved estimates. Food group grains and starch basket had the largest share (49%) of household total food expenditure. Grains and starch was expenditure inelastic, animal protein was a luxury, Fruits and Vegetables group was inelastic, while Fats and Oils were elastic. Own price elasticities were all negative as expected in both uncompensated and compensated price elasticity estimates. The Hicksian cross-price elasticities showed that all food groups were net substitutes. Arising from the foregoing, the study concludes that animal protein group and fat and oil group are income responsive while others are inelastic. The study further revealed that all food groups are normal food and price inelastic with the exception of fats and oil (price elastic). Price, household size, total food expenditure, and expenditure on food away-from-home were key determinants of food demand among rural households in Ondo state.Therefore policy directed at increasing both farm income and non-farm income to increase expenditure and promote food security should be given more attention.

Keywords: food, demand elasticity, rural household, food group, endogeneity

1. Introduction

Agriculture over the years in Nigeria has proved itself a major factor behind the growth of Nigerian economy and more of a pillar of national food security. However, Nigeria is listed by FAO among nations that are at the moment technically unable to meet their food needs from rain fed production at low level of inputs and appear likely to remain so even at intermediate levels of inputs at some time between 2000 and 2025 (NINCID, 1999).With the growing population of Nigeria, production of food is not increasing in a way that can meet up with the high demand (Ojo, 2003). Nigeria annual population growth rate is put at 2.83 percent, food production is increasing at 2.5 percent annually and food demand is increasing at 3.5 percent (NBS, 1996). This obvious disparity between food demand and supply coupled with population pressure and resultant food price hike has led to a big gap between food availability and requirement with an enormous challenge on the national food security. As observed by Omonona (2000), the problem highlighted above become more germane in view of the reality that Nigeria's agriculture, food production in particular, rest in the hand of resource poor, small holder-peasant farmers who live in the rural areas. More to this, is the high involvement of the farmers in cash crop production which is largely market oriented with little attention to food crop production. Therefore, Ondo state was used in this study because of the position it occupies as the leading Cocoa (the major cash crop in Nigeria) producing state in Nigeria and also because its rural areas as the main production centres. Also, cocoa farmers believe that they derive more income from cocoa production than food crop production; hence they devote most of their resources such as land, time and money toward cocoa production as against food crop production (Olayemi, 1970; Alabi et al., 2004). The resultant effect of these is the shortages in food production in cocoa producing areas. This is why Hamzat et al. (2006)

observed that the absence of appropriate, well established farming system in cocoa farms poses a serious threat to food security and nutritional status of the farming households in cocoa growing areas.

A number of studies carried out in various parts of the developed world showed that the very rapid transition to urban-industrial diets and lifestyles within Africa, Latin America and Asia is followed by a rapid epidemiological transition, whereby chronic diseases common in the developed countries become much more prevalent in developing countries (Akinyele, 2007).

In recent times Nigeria has experienced some rapid changes in her demographic and socio-economic environment which can be associated with food consumption patterns. Changing consumption patterns have both positive and negative health implications (Lopriore & Muehlhoff, 2003). Likewise, a diversity of seasonal crops, among them fruits and legumes are becoming more available nationwide due to improved weather conditions and market fundamentals.It is however not clear presently whether food group compositions demand among rural households in Ondo state are similar and also which factors drives the food group demand composition.

Fabiosa (2005) observed that despite differences in preferences, consumers seem to follow general phases in the evolution of their consumption behaviour. This is described in a well-established law in economics called the Engel curve, which reflects that as household income rises, the proportion of income spent on food declines, suggesting relatively low income elasticity for food. Therefore, the importance of calorie intake coupled with the concern about undernourishment in developing countries has led to increasing number of studies on the determinants of calorie intake. More prominent in the empirical studies is the relationship between income and calorie intake (Abdulai & Aubert, 2004).

Previous studies on food demand in Nigeria have made use of double logarithms function, almost ideal demand system and its variants (Oyekale, 2000; Tsegai & Kormawa, 2002; Akinleye, 2009), and quadratic almost ideal demand system (Obayelu et al., 2009). The use of QUAIDS with test and correction of expenditure endogeneity serves as value addition of this study apart from the fact that the study is being carried out in the rural part of Ondo state which is noted more for production of cash crop than food crop.

This paper is premised on theoretical perspectives of Engel's law, that as income increases, people spend a smaller proportion of their total income on food; and Bennett's laws, that the richer one becomes, the less he or she spends on starchy staples. More so, the preference-based demand modeling approach was adopted. The preference-based approach to modelling choice behaviour treats the individual's tastes, summarized by a preference relation, as his or her primitive characteristic. The theory is developed by first imposing rationality axioms on the individual's preferences and then analyzing the consequences of these preferences on his or her choice behaviour. The preference-based approach to modelling choice behaviour provides a useful framework for analyzing data on demand.

The Quadratic Almost Ideal Demand System (QUAIDS) employed as analytical tool in this study can better approximate non-linear Engel curves in empirical analysis. Since a QUAIDS model produces a considerably larger regular region than the locally flexible forms, it can be classified as effectively globally regular, where corresponding utility and indirect functions, and cost functions satisfy their theoretical properties for all non-negative demand, price and all utility levels as appropriate (Jing Xi et al., 2004).

Arising from the foregoing, this study seeks to improve knowledge and understanding of food expenditure patterns, incorporates household demographics and corrects for expenditure endogeneity.

The specific objectives are to (1) profile food demand across income groups and (2) estimate demand elasticity of food groups.

Therest of this paper is organised into two sections, methodological issues are addressed in section two, and section three presents and discusses the results from the analysis with the conclusion.

2. Methodology

2.1 Study Area

The empirical setting for the study consists of rural communities in Ondo state of Nigeria. Three-stage random sampling technique was used to select the sample respondents for the analysis. Two local government areas were randomly selected in the first stage; two villages were selected from each local government area in the second stage, and random selection of respondent households from the selected communities proportionate to size was done in the third stage. Thus, a total of 121 households were randomly sampled. These respondents were either household heads or those who had good idea of the household food purchases and consumption pattern.However, the sampling unit observedin this study was households.

2.2 Analytical Framework

Descriptive statistics of mean, standard deviation, frequency and percentagewere employed to describe socioeconomic and other relevant variables considered in this study. The complete food demand estimation was carried out using Quadratic Almost Ideal System (QUAIDS) model. The quadratic almost ideal demand system (QUAIDS) model developed by Banks et al. (1997), which has budget shares that are quadratic in log total expenditure, is an example of the empirical demand systems that have been developed to allow for this expenditure nonlinearity. The QUAIDS model was estimated using nlsur (Non Linear Seemingly Unrelated Regression)command in STATA with theoretical restrictions of adding-up, homogeneity, and symmetry imposed during estimation. The empirical specification of the QUAIDS budget share equations is given as follows:

$$w_i = \alpha_i + \sum_{J=1}^{J} \gamma_{ij} \ln p_j + \beta_i \ln\left[\frac{m}{a(p)}\right] + \frac{\lambda_i}{b(p)}\left\{\ln\left[\frac{m}{a(p)}\right]\right\}^2 + \sum_{s=1}^{L} \delta_{is} z_s + \varepsilon_i \tag{1}$$

w_i= household's expenditure share of i^th food group, for i=1, 2, 3 and 4

w_1=share of grains and starch food basket (grain and starch)

w_2=share of animal protein food basket (animal protein)

w_3=share of fruits and vegetables food basket (fruits and vegetables)

w_4=share of fats and oils food basket (fats and oils)

p_i=price of food i^{th} (₦/grain equivalent (GE) kg), for i=1, 2, 3 and 4

p_1=price of a basket of grains and starch (PGRST) (₦/kg)

p_2=price of a basket of animal protein (PFMEM) (₦/kg)

p_3= price of a basket of fruits and vegetables (PFAV) (₦/kg)

p_4= price of a basket of fats and oils (PFAOL) (₦/kg)

m=household's total expenditure on all food in the demand system (₦/week)

z_i=socioeconomic variables

z_1=household's size (Head count)

z_2=household's expenditure on food-away-from-home (FOOD-AWAY) (₦/week)

ε_i = error term

By taking first derivative of the Equation (1) with respect to expenditure and prices, we have the following intermediate results:

$$\mu_i \equiv \frac{\partial w_i}{\partial \ln m} = \beta_i + \frac{2\lambda_i}{b(p)}\left\{\ln\left[\frac{m}{a(p)}\right]\right\} \tag{2}$$

$$\mu_{ij} \equiv \frac{\partial w_i}{\partial \ln p_j} = \gamma_{ij} - \mu_i\left(\alpha_j + \sum_k \gamma_{jk} \ln p_k\right) - \frac{\lambda_i \beta_j}{b(p)}\left\{\ln\left[\frac{m}{a(p)}\right]\right\}^2 \tag{3}$$

The expenditure elasticities are derived by:

$$e_i = 1 + \frac{\mu_i}{w_i} \tag{4}$$

The uncompensated price elasticities are derived by:

$$e_{ij}^u = \frac{\mu_{ij}}{w_i} - \delta_{ij} \tag{5}$$

The Hicksian or compensated price elasticities are obtained from the Slutsky equation as:

$$e_{ij}^c = e_{ij}^u + w_j e_i \tag{6}$$

2.3 Expenditure Endogeneity

This study took a step further to correct for endogeneity that could result from using expenditure in the demand equations. If not corrected for, this could lead to inconsistent demand parameters estimates. We made use of the augmented regression technique which is more suitable in a system of non-linear equations like ours (Bundell & Robin, 1999; Hausman, 1978). Take for instance a regression of y_1, the dependent variable, on X, a set of exogenous variables, and y_2, an exogenous variable. i.e., $y_1 = X'\beta + \pi y_2$. The augmented regression procedure involves two stages. The first stage is an OLS regression of y_2, the endogenous variable, on Z, the instrument, with X. The residual, v, from this stage is generated and added as an additional variable in the second stage of the procedure. The second stage entails regression of y_1 on X, y_2 and v. The estimates from this stage are identical to the two-stage least square regression technique. To implement this, the main challenge is the choice of instrument that must fulfill the relevance and the exogeneity conditions. The relevance condition is that the instrument must correlate sufficiently with the endogenous variable, in our own case, food expenditure, while the exogeneneity condition is that the instrument must not correlate with the error term in the demand model. We identified household income as a good instrument as Bopape (2006) put it that "because total household income is exogenous in the household food expenditure allocation model, it is not unreasonable to assume that it (total household income) satisfies the exogeneity condition". However, the first condition of relevance is testable as revealed in the reduced Equation that household income significantly and positively influences food expenditure. The expenditure endogeneity was corrected for in the study to improve estimates, the expenditure elasticity estimates in particular.

3. Results and Discussions

3.1 Summary Statistics of Socio-Economic Characteristics of the Rural Household

This section presents and discusses summary statistics of selected socio-economic characteristics of the respondents as shown in Table 1. On the average, household size of the sample was 6.14, with dependency ratio of 51%, which shows that a half of household members were not working. About 37% of the households were headed by women and on the average at the age of 50 years. The average years of formal schooling was estimated at seven (7) years. This implies that an average rural household head could read and write. The average weekly per capita expenditure on food-away-from-home was very low, less than 2% of the weekly expenditure on at-home-food expenditure. This shows that food commodities are actually demanded for home consumption and the conservative communal eating habit that characterized the rural households. The per capita weekly household expenditure on non-food items was about one thousand Naira and 11% of weekly expenditure on food. The frequently purchased non-food items expenditure was about 68% of the expenditure on non-food items in the rural households, while the infrequent is about 32%. Total monthly household income, on the average, was about eight thousand Naira per capita. About 74% of the sampled households owned land and 39% of the households did not have their own house. On the average, the value of the household productive assets was about nine hundred thousand naira. More so, the result shows that about 68% of the households did not have access to any form of credit, while about 87% belonged to one social organization or another. Farming was the major occupation of household heads of about 38% of the sample while trading (45%) was the major occupation of household spouses. Expectedly, 63% of the sampled households were native of their communities.

Table 1. Summary statistics of socio-economic characteristic of rural households

Variables (unit)	**Mean value/** Dominant indicator	Standard deviation
Household size (Head count)	6.14050	0.29230
Dependency ratio (%)	0.51784	0.02234
Gender of household head (Male=1, Female=0)	0.62810	0.04412
Age of household head (years)	49.81818	1.62640
Education of household head (years of schooling)	7.05785	0.51040
Household expenditure on food-away-from-home (₦)	151.3584	23.52667
Household expenditure on non-food items (₦)	1003.408	74.15412
Household expenditure on frequently non food items (₦)	680.6026	53.86583
Household expenditure on infrequently non food items (₦)	313.5047	41.26813
Monthly household head income (per capita)	8169.951	1028.403
Land ownership (own land=1, otherwise=0)	0.73554	0.04026
House ownership (own house=1, otherwise=0)	0.61157	0.04449
Productive assets of household (₦)	920347.9	136347
Access to credit (yes=1, no=0)	0.32231	0.04266
Membership of social organisation (member=1, otherwise 0)	0.86777	0.03092
Major occupation of household head	38.46 % into farming	-------
Major occupation of household spouse	45.45 % into trading	--------
Nativity of household (Native=1, Otherwise=0)	0.63636	0.04391

Source: Computed from survey data (2011).

Table 2. Food Groups Composition and Share

Food Share	Income quartiles				
	All households	First	Second	Third	Fourth
W1 (Grains & Starch)	0.48858	0.51562	0.48909	0.49247	0.45700
	(0.09557)	(0.07139)	(0.10235)	(0.10499)	(0.09496)
W2 (Animal Protein)	0.24402	0.20787	0.23680	0.23688	0.29476
	(0.08668)	(0.08612)	(0.08623)	(0.07837)	(0.07590)
W3 (Fruits & Vegetables)	0.20431	0.20370	0.20160	0.21957	0.19187
	(0.05367)	(0.05745)	(0.06492)	(0.05287)	(0.03313)
W4 (Fats & Oils)	0.06309	0.07280	0.07251	0.05108	0.05636
	(0.03536)	(0.04786)	(0.03898)	(0.01930)	(0.02423)
Food Expenditure	8438.87	7618.27	7129.83	8103.79	10914.75
	(4351.03)	(2952.80)	(2817.43)	(3313.45)	(6433.65)

Source: Computed from survey data (2011).

Note: Standard deviation are quoted in parenthesis.

Table 2 reveals that the poorest households have lowest share of animal protein across all income quartiles. This can be attributed to high unit price of the food basket which limits the quantity; hence the share that can be afforded by this group. Expectedly, the richest households have the largest share of animal protein (29%) across all income groups, reflecting their nutritional knowledge and status.

Both fruits and vegetables basket and fats and oils basket have relatively consistent share across all income quartiles. However, the poorest households have the least food expenditure and the richest have the highest as expected. This provides empirical support to the assertion that relationship between demands for food commodities and income is not always linear.

3.2 Demand Elasticities of Food Commodities

Table 3 presents the estimated coefficients for the endogeneity-adjusted QUAIDS model. The quadratic expenditure term is statistically significant in one of the expenditure share equations. It is in the expenditure share equations for animal protein, fruits and vegetables, and oils and fats that the null hypothesis of expenditure linearity is not rejected. However, the hypothesis that the quadratic expenditure term is zero is strongly rejected in grain and starch equation. Moreover, Table 4 shows that the demographic effect is highly significant in the model, and that the endogeneity is significantly corrected for in the QUAIDS model. Only 5 of the 16 price effects are significantly different from zero at the 10% significance level, suggesting that there is not much quantity response to movements in relative prices, possibly due to the level of aggregation in the commodity groups. Half (4 out of 8) of the coefficient estimates on the demographic variables are statistically different from zero at 1% significance level. Households with large sizes consume more grains and starch while their small-sized counterparts consume more animal protein (meat, egg, milk and fish). These results are as expected, given that grains provide a relatively cheap source of calories compared to such foods as meat and fish, and that household size is negatively correlated with income.

Expenditure on food-away-from-home has a significant positive effect on consumption of grains and starch; and on the contrary, it has a significant but negative effect on consumption of animal protein.

Literatures (e.g. Agbola, 2003; Bopape et al., 2007) suggest that it is easier to interpret price and income effects in terms of elasticities. Estimates of expenditure elasticities are presented in Table 5. The first column presents expenditure elasticity estimates for the entire sample by the endogeneity-adjusted QUAIDS model, while the other columns reports those for QUAIDS model with endogeneity. All expenditure elasticity estimates are positive, as would be expected for broadly defined food aggregates like the ones considered in this study. All of the estimates are statistically different from zero at 1% significance level. Grains are expenditure inelastic across all household groups. Animal protein (Meat, Egg, Milk and fish) are luxuries with expenditure elasticity of 1.62913. This implies that ten percent increase in income will increase demand for animal protein by close to 16 percent. Expenditure elasticity of Fruits and Vegetables group is inelastic, while that of Fats and Oils is elastic.

Table 3. Estimated price, income, and demographic effects

	Grain/Starch	**Animal Protein**	**Fruits/Vegetables**	**Fats/Oils**
Constant	0.17429	0.62505***	0.16426*	0.03640
	(0.23054)	(0.17098)	(0.09637)	(0.08024)
PGRST	0.51585*	-0.41167*	-0.08492	-0.01926
	(0.28309)	(0.25178)	(0.10161)	(0.08977)
PFMEM	-0.41167*	0.29741	0.08052	0.03374
	(0.25178)	(0.24951)	(0.07086)	(0.06469)
PFAV	-0.08492	0.08052	-0.03026	0.03465**
	(0.10161)	(0.07086)	(0.03008)	(0.01634)
PFAOL	-0.01926	0.03374	0.03465**	-0.04910
	(0.08977)	(0.06469)	(0.01634)	(0.03198)
LNEXP	-0.50356***	0.38160**	0.07195	0.05000
(0.14361)		(0.16950)	(0.10549)	(0.08969)
(LNEXP)^2	-0.11799**	0.07122	0.03567	0.01110
	(0.06718)	(0.06626)	(0.03217)	(0.02588)
Household Size	0.01138***	-0.0123458***	0.0023956	-0.001429
	(0.00380)	0.0038163	0.0027808	0.0020958
FOOD-AWAY	0.000023***	-0.0000213***	-1.01e-06	-7.30e-07
	(0.00000)	(0.00000)	(0.00000)	(0.00000)
V	0.12706***	-0.15399***	0.04421	-0.0173868
	(0.04707)	(0.04668)	(0.03277)	(0.030245)

Note: (1) the number of observation in all model is N=121. (2) Figure in parentheses are standard error. (3) *, **, *** coefficients are significant at the 10%, 5%, and 1% level, respectively. (4) All prices are in logarithms, P=price, GRST=grains & starch, FMEM =fish, meat, egg and milk, FAV=fruits and vegetables, FAOL=fats and oil, LNEXP= Logarithm of total food expenditure and $(LNEXP)^2$ =square of Logarithm of food expenditure.

Source: Computed from survey data (2011).

Table 4. Results of the wald tests for QUAIDS specification, demographic effects and expenditure endogeneity

Chi^2 valuedf			*p*-value
Expenditure endogeneity (all equations)	12.21	3	0.0067
QUAIDS specification	3.92	3	0.2697
Demographic effects	16.66	6	0.0106

Table 5. Estimated expenditure elasticities

	Expenditure elasticities(1)	**Expenditure elasticities(2)**
Grain/Starch	0.74273***	1.03661***
	(0.20942)	(0.04530)
Animal Protein	1.62913***	0.97153***
	(0.29781)	(0.07386)
Fruits/Vegetables	0.79299***	0.96799***
	(0.20528)	(0.06808)
Fats/Oil	1.22936***	0.93026***
	(0.46403)	(0.11800)

Note: (1) the number of observation is N=121. (2) Figure in parentheses are standard error. (3) 1-endogeneity corrected model and 2-endogeneity model (4) *, **, *** coefficients are significant at the 10%, 5%, and 1% level, respectively.

Source: Computed from survey data (2011).

Tables 6 and 7 present estimates of the Marshallian and Hicksian own and cross price elasticities respectively. The diagonal estimates on the two tables represent the own price elasticities while on the off diagonal we have the cross price elasticities. Own price elasticities are all negative as expected. Based on the uncompensated price elasticity estimates, only grain and starch food basket is price inelastic, while all other food groups are price elastic. Hence, households respond more than proportionately to changes in the prices of these foods. However, when the substitution effects are considered, animal protein becomes price inelastic, with compensated own-price elasticity estimates of less than unity, while that of fruits and vegetables coming to unity. Marshallian cross-price elasticities show that almost all the food groups are complement except for fats and oils with grain/starch group and fruits and vegetables group, and animal protein group and fruits and vegetables group. Animal protein substitutability for fruits and vegetable can be viewed from the fact that some people are becoming vegetarian in households while some enlightened household could substitute fruits and vegetables for animal protein because of health reasons with increase in price of the later. In addition, the Hicksian cross-price elasticities show that all of the food groups are net substitutes. The Hicksian approach has been described to provide the better estimates because it accounts for compensation variation which gives true picture of welfare effect (Varian, 1992). Hence, Hicksian elasticity estimates would give better policy direction.

Table 6. Marshallian's uncompensated own and cross price elasticities

Food Group	Grain/Starch	Animal Protein	Fruits/Vegetables	Fats/Oil
Grain/Starch	-0.75836***	-0.03425***	-0.02176	0.07163
	(0.09882)	(0.17323)	(0.05040)	(0.04699)
Animal Protein	-0.49654	-1.15129***	0.07256**	-0.05385
	(0.16023)	(0.26487)	(0.08857)	(0.08049)
Fruits/Vegetables	-0.08202	0.29528	-1.16702***	0.16078***
	(0.12368)	(0.14850)	(0.07650)	(0.05806)
Fats/Oil	0.31486	-0.10586	0.42878***	-1.86714***
	(0.30438)	(0.31297)	(0.16019)	(0.44969)

Note: the number of observation is N=121. Figure in parentheses are standard error, *, **, *** coefficients are significant at the 10%, 5%, and 1% level, respectively.

Source: computed from survey data (2011).

Table 7. Hicksian's Compensated Own and Cross Price elasticities

Food Group	**Grain/Starch**	**Animal Protein**	**Fruits/Vegetables**	**Fats/Oil**
Grain/Starch	-0.39548***	0.14700	0.12999***	0.11849***
	(0.13868)	(0.13073)	(0.03749)	(0.04369)
Animal Protein	0.29942	-0.75375 ***	0.40541***	0.04893
	(0.20199)	(0.21582)	(0.07611)	(0.07523)
Fruits/Vegetables	0.30541***	0.48878***	-1.00501***	0.21081***
	(0.11884)	(0.12008)	(0.07547)	(0.05371)
Fats/Oil	0.91549***	0.19413	0.67996***	-1.78958***
	(0.34256)	(0.29038)	(0.17345)	(0.43314)

Note: the number of observation is N=121. Figure in parentheses are standard error, *, **, *** coefficients are significant at the 10%, 5%, and 1% level, respectively.

Source: computed from survey data (2011).

4. Conclusion

This study has made an attempt in modelling food consumption demand for rural households of Ondo state with a view to using best and parsimonious model. This study made use of highly rated demand model of QUAIDS which has been described to have a rank of three, that is, it best approximates, spans and fits the Engel curve. The QUAIDS model was corrected for endogeneity and adjusted for demographic effects. Findings from this study have shown that there is high differential in the consumption expenditure share among food from the same group and more importantly, differential across income groups. It has also been exposed in this study that consumption expenditure share varies across food groups, and more importantly along and across income groups. This study showed how demand for each food group is income responsive and found out that animal protein group and fat and oil group are income elastic while others are inelastic. The study further revealed that all food groups are normal food and price inelastic with exception of fats and oil (price elastic). More so, the study showed that all food groups are substitutes for one another. Arising from this, the study suggests that policy directed at increasing both farm income and non-farm income should be given paramount attention to increase expenditure and hence demand for food in the rural communities and make them food secured.

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