A Food Demand System Estimation for Rural Malawi: Estimates Using Third Integrated Household Survey Data

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Abstract

In contrast to the myriad of empirical work on food demand in other countries, very few studies have considered zero expenditures on some food groups. Those which have attempted have been based on techniques which result in endogeneity and inefficient estimates which in turn may misinform policy calibration. Improving on methodological flaws of previous studies, the present study censors zero expenditures in the first stage using simulation based maximum likelihood multivariate probit. In the second stage, Quadratic Almost Ideal Demand System which allows for a more realistic assumption of curvature in Engels curve is estimated. In turn, food expenditure and price elasticities are derived. In view of the high expenditure elasticities, considering a policy option that would enhance rural consumer income is desirable, since it will result in high consumption thereby providing more incentives for food production.

JEL classification: D12, C31, Q19

Key words: QUAIDS model, food demand elasticities, Rural Malawi

Introduction

With volatile exchange rate in Malawi, there have been unstable commodity prices being observed on the supermarkets. Among different commodity groups, flexible-upward food prices have been the topic for many consumers. These unstable prices have resulted in changing food consumption and expenditure patterns among consumers. Given that income influences food expenditures; it is most likely that the distribution of income influences distribution of food expenditures. Food policy analysts are more interested to understand area specific responses of households to changing prices and income.

Blundell (1988) noted that there are few aspects of political economy that do not require some knowledge of consumers' behaviour. Given the important use of demand and expenditure elasticities in policy analysis, it is surprising that not even a study that is forth coming has examined the food expenditure patterns in Malawi using cross sectional data. Thus, a proper estimation of elasticities and projected direction of change is an important instrument that could guide the future policy decisions in Malawi. In the process, the techniques used in estimating these elasticities have to conform to a functional form that is based on realistic assumptions. In this context, the present paper applies the multi stage Quadratic Almost Ideal System Technique on Malawi's food demand system which allows for nonliearity in expenditure and checks for non-expenditure on some food groups. With current computing power, nonlinear estimation of the QUAIDS in itself is not so difficult that linear approximations should be considered. Demand elasticity computed in this complete food system explains the level of demand for the commodities by an individual household given the structure of relative prices, real incomes and a set of individual characteristics.

The application of the model to food demand in Malawi is interesting because not very much is known about food demand dynamics in the country. Since rural households may respond differently to changes in prices and income than urban households, we form the first food demand study that focuses only on rural households to examine their responses to price and income changes. The organisation of the paper is as follows: In the next section, the Quadratic Almost Ideal Demand System is defined and its theoretical properties are shown and description of the data used in the analysis. Section three presents the findings and provides a discussion of some of the study's implications.

Methodology

Theoretical and Econometric Construct

Fist Stage Multivariate Probit for Censoring Expenditure

Households are characterized as economic agents that maximize utility, U_j, subject to budget constraint. This paper assumes that a household has already made a decision on the amount of income to spend on food. Given this income and a vector of food items in the market, a household makes a decision on whether to spend on given food item *j,* if the utility realized from consumption of food item *j* is greater than that of reallocating the same expenditure on a different food item. As a result it is common to frequently find zero per item expenditure in household surveys. Despite of preference, household may also report zero expenditures on some food item due to non-affordability, permanent non-consumers, non-consumers during the survey period.

Whatever the reason for zero expenditure, inclusion of such expenditures as zeros in the demand estimation results in biased estimates. This requires a technique that escapes sample selection arising due to zero expenditure. The most popular one was proposed by Heien and Wessells (1990) and later refined by Shonkwiler and Yen (1999). The procedure involves estimation of several probit models independently. However, given that observations from each model are cross-sectional and collected from same households, the estimation would suffer from endogeneity (Greene, 2003). This may arise due to correlation of errors between different equations as decision to allocate expenditure on a given food group may not be independent to the probability of allocating expenditure on another food group. To overcome this problem, this study uses systems estimation by employing multivariate probit model.

An M-equation multivariate probit is formulated as:

$$d^*_{hm} = z'_{hm}\alpha_i + v_{hm} \qquad [1]$$

$$w^*_{ih} = x'_{ih}\beta_i + \varepsilon_{ih} \qquad [2]$$

$$y_{im} = 1 \; if \; y_{im}* > 0 \; and \; 0 \; otherwise$$

Then

$$w_{ih} = d_{ih} w^*_{ih} \qquad [3]$$

ε_{hm}, $m = 1,...,10$ are error terms distributed as multivariate normal, each with a mean of zero, and variance-covariance matrix V, i is food category, h is household identification, w_{hm} and d_{hm} are observed expenditure shares and indicator of whether household h spent on ith food category while w^*_{hm} and d^*_{hm} are their latent counterparts, $\mathbf{z_{ih}}$ and $\mathbf{x_{ih}}$ are vectors of explanatory variables, $\mathbf{v_{hn}}$ and $\boldsymbol{\varepsilon}_{\mathbf{hm}}$ are stochastic components. Model [1] has a structure similar to that of a seemingly unrelated regression (SUR) system, except that the dependent variables are binary indicators. As for the SUR case, the equations need not include exactly the same set of explanatory variables.

A number of algorithms in multivariate normal cases have been widely used with computations based on standard linear numerical approximations, such as those based on the Newton–Raphson method. However, these are relatively inefficient and may provide poor approximations

(Hajivassiliou and Ruud 1994). As a solution to the problem, this study applies a simulation based method to maximum likelihood estimation of the multivariate probit regression model as described by Cappellari and Jenkins, (2003). The most popular simulation method for evaluating multivariate normal distribution functions is the Geweke–Hajivassiliou–Keane (GHK) smooth recursive conditioning simulator - see Borsch-Supan et al. (1992), Borsch-Supan and Hajivassiliou (1993), Keane (1994), and Hajivassiliou and Ruud (1994). The GHK simulator exploits the fact that a multivariate normal distribution function can be expressed as the product of sequentially conditioned univariate normal distribution functions, which can be easily and accurately evaluated. The log-likelihood function for a sample of N independent observations is given by;

$$L = \sum_{i-1}^{N} W_i \log \Phi_{10}(\mu_i;\Omega) \qquad [4]$$

Where W_i is an optional weight for observation i = 1, . . . ,N, and $\Phi_{10}(.)$ is the decuple standard normal distribution with arguments μ_i and Ω, where

$$\mu_i = (K_{i1}\beta_1'X_{i1}, K_{i2}\beta_2'X_{i2}, \ldots\ldots\ldots, K_{i10}\beta_{10}'X_{i10}) \qquad [5]$$

The log-likelihood function depends on the decuple standard normal distribution function $\Phi_{10}(.)$. After estimating multivariate probit, we obtain estimates of the cumulative distribution ($\hat{\Phi}$) and probability density functions ($\hat{\phi}$) which are then used as arguments in the second step of QUAIDS estimation.

Quadratic Almost Ideal Demand System

The almost ideal demand system (AIDS) of Deaton and Muellbauer (1980) has been used widely to model consumer demand behavior over the past three decades. The approach has been empirically applied by different researchers to analyze demand for commodities in different countries. Earlier work includes that of Blanciforti and Green (1983) who applied it to US food consumption data. Ray (1982) applied it to examine household consumption patterns using household expenditure surveys for India. Later, Chester and Rees (1987) also applied the AIDS framework to British National Food Survey data and Fulponi (1989) to French expenditure time-series data.

Nevertheless, the AIDS model has a difficulty in capturing the effects of non-linear Engel curves, as observed in various empirical demand studies. This has led to growth of a body of literature providing evidence on the importance of relaxing nonlinearity in the budget share equations (Lewbel, 1991; Banks et al., 1997). A quadratic term in logarithm of income is added to AIDS model and leads to the Quadratic AIDS (QUAIDS) model specification. This increased flexibility of the demand system representation and is thus achieved in a parsimonious way through the addition of the quadratic term.

The QUAIDS model is derived from indirect utility function (V) of the consumer given by:

$$\ln V = \left\{ \left[\frac{\ln x - \ln a(p)}{b(p)} \right]^{-1} + \lambda(p) \right\}^{-1} \qquad [6]$$

where x is total food expenditure, p is a vector of prices, $a(p)$ is a function that is homogenous of degree one in prices, and $b(p)$ and $\lambda(p)$ are functions that are homogenous of degree zero in prices; ln$a(p)$ and ln$b(p)$ are specified as Translog and Cobb-Douglass equations as originally specified in Deaton and Muellbauer's AIDS model. The $\lambda(p)$ is set to equal zero in Deaton and Muellbauer's AIDS model. From equation 6 we expand;

$$\ln a(p) = \alpha_0 + \sum_{i=1}^{J} \alpha_i \ln p_i + 0.5 \sum_{i=1}^{J} \sum_{j=1}^{J} \gamma_{ij} \ln p_i \ln p_j \qquad [7]$$

$$b(p) = \prod_{i=1}^{J} p_i^{\beta i} \qquad [8]$$

$$\lambda(p) = \sum_{i=1}^{J} \lambda_i \ln p_i \qquad [9]$$

Where, i= 1, ... ,J represent commodities After application of the Roy's identity to equation [6], the QUAIDS expressed in budget shares form is given by;

$$w_{ih} = \alpha_i + \sum_{j=1}^{J} \gamma_{ij} \ln p_j + \beta_i \ln\left[\frac{x}{a(p)}\right] + \frac{\lambda_i}{b(p)} \left\{\ln\left[\frac{x}{a(p)}\right]\right\}^2 + \varepsilon_{ih} \qquad [10]$$

Where, w_i is the share of group expenditure allocated to food product i, p_j is the price of food category j, and x is the per capital expenditures on all food commodities. The parameter α_i embodies effect of household demographic factors. Building equation [9] from equation [5], it is possible to restate the equation for each i in (2) as:

$$w_{ih} = \hat{\Phi}\left[\alpha_i + \sum_{i=1}^{J} \gamma_{ij} \ln p_j + \beta_i \ln\left[\frac{x}{a(p)}\right] + \frac{\lambda_i}{b(p)} \left\{\ln\left[\frac{x}{a(p)}\right]\right\}^2\right] + \delta\hat{\phi} + \varepsilon_{ih} \qquad [11]$$

Where, $\hat{\Phi}$ and $\hat{\phi}$ are cumulative distribution and probability density functions, respectively, estimated in first step using Multivariate probit. The demand theory requires that the above system to be estimated under restrictions of adding up, homogeneity and symmetry. The adding up is satisfied if $\sum_{i=1}^{J} w_i = 1$ for all x and p which requires;

Adding up $\quad \sum_{i=1}^{J}\alpha_i = 1, \sum_{i=1}^{J}\beta_i = 0,\ \sum_{i=1}^{J}\gamma_{ij} = 0,\ \sum_{i=1}^{J}\lambda_i = 1$

Homegeneity in prices $\quad \sum_{i=1}^{J}\gamma_{ij} = 0$

Slutsky Symmetry $\quad \gamma_{ij} = \gamma_{ji}$

These conditions are satisfied by dropping one of the *n* demand equations from the system and recovering parameters of the omitted equations from the estimated equations using nlcm STATA command.

In order to derive conditional expenditure on food prices elasticities, equation (11) is firstly differentiated with respect to ln*x* and lnp_j, such that

$$\eta_i = \frac{\partial w_i^*}{\partial \ln x} = \Phi\left(\beta_i + \frac{2\lambda_i}{b(p)}\left\{\ln\left[\frac{x}{a(p)}\right]\right\}\right) \text{ and} \qquad [12]$$

$$\eta_{ij} = \frac{\partial w_i^*}{\partial \ln p_j} = \Phi\left(\gamma_{ij} - \eta_i\left(\alpha_j + \sum_{k=1}^{J}\gamma_{ij}\ln p_k\right) - \frac{2\lambda_i\beta_j}{b(2)}\left\{\ln\left[\frac{x}{a(p)}\right]^2\right\}\right) \qquad [13]$$

From equation 12 and 13, the conditional expenditure elasticities are then obtained by

$$\in_i = \frac{\eta_i}{w_i^*} + 1 = \frac{\Phi}{w_i}\left(\beta_i + \frac{2\lambda_i}{b(p)}\left\{\ln\left[\frac{x}{a(p)}\right]\right\}\right) + 1 \qquad [14]$$

With a positive *β* and a negative *λ*, for example as suggested for clothing and alcohol in Lewbel's empirical study (1997), the budget elasticities will appear to be larger than unity at low levels of expenditure, ultimately becoming less than unity as the total expenditure increases and the term in *λ* becomes more important and dominates. Such commodities thereby have the features of luxuries at low levels of total expenditure and necessities at high levels.

The conditional, Marshallian (uncompensated) price elasticities are derived as

$$\in_{ij}^{u} = \frac{\eta_{ij}}{w_i^*} - \vartheta_{ij} = \frac{\Phi}{w_i^*}\left(\gamma_{ij} - \eta_i\left(\alpha_j + \sum_{k=1}^{J}\gamma_{ij}\ln p_k\right) - \frac{2\lambda_i\beta_j}{b(2)}\left\{\ln\left[\frac{x}{a(p)}\right]^2\right\}\right) - \vartheta_{ij} \qquad [15]$$

Where, ϑ_{ij} is the Kronecker delta equating one when *i* = *j*, and zero otherwise. Using the Slutsky equation, the conditional, Hicksian (compensated) price elasticities are given by:

$$\in_{ij}^{c} = \in_{ij}^{u} + \in_i w_j \qquad [16]$$

Data Description

The study uses the Third Integrated Household Survey (IHS-3) which was conducted by the National Statistical Office (NSO) in Malawi from March 2010 to March 2011. The Survey was a nationally representative sample survey designed to provide information on the various aspects of household welfare in Malawi. The survey collected information from a sample of 10,038 rural households statistically designed to be representative at both national, district and rural levels enabling the provision of reliable estimates for these levels. A stratified two-stage sample design was used for IHS-3. The primary sampling units (PSUs) selected at the first stage are the census enumerations areas (EAs) defined for the 2008 Malawi Population and Housing Census. The EA was the smallest operational area established for the census with well-defined boundaries, corresponding to the workload of one census enumerator. The EAs had an average of about 235 households each. A total of 768 EAs were selected across the country. In each district, a minimum of 24 EAs were interviewed while in each EA a total of 16 households were interviewed.

The data refer to the average per capita consumption over the 7 day recall in each of the expenditure classes. Prices are computed implicitly as expenditure divided by the quantities of each of the expenditure classes in each round. Expenditure and quantity data were collected on 125 food items. However, to model all food items as independent food categories and hence a system of 125 equations would be prohibitive given computational technological limits. Thus, aggregation of related food items was the available alternative. In this respect, all food items were aggregated into 10 different food categories including; Cereals, Grains and Cereal Products; Roots, Tubers, and Plantains; Nuts and Pulses; Vegetables; Meat, Fish and Animal Products; Fruits; Milk/Milk Products; Fats/Oil; Sugar/Sugar Products; Spices/Condiments and Miscellaneous. Table 1 details these food categories and their associated food items.

Table 1: food category aggregation

Food Category	**Food items**
Cereals, Grains and Cereal Products	Maize flour *mgaiwa*; Maize flour refined; Maize bran flour; Maize grain; Green maize; Rice; Finger millet; Sorghum; Pearl millet; Wheat flour; Bread; Buns, scones; Biscuits; Spaghetti, macaroni, pasta; Breakfast cereal; Infant feeding cereals
Roots, Tubers, and Plantains	Cassava tubers; Cassava flour; White sweet potato; Orange sweet potato; Irish potato; Potato crisps; Plantain, cooking banana; Cocoyam

Food Category	Food items
Nuts and Pulses	Bean, white; Bean, brown; Pigeonpea; Groundnut; Groundnut flour; Soyabean flour; Ground bean; Cowpea; Macademia nuts
Vegetables	Onion; Cabbage; Rape; Nkhwani; Chinese cabbage; Other cultivated green leafy vegetables; Gathered wild green leaves; Tomato; Cucumber; Pumpkin; Okra; Tinned vegetables; Mushroom
Meat, Fish and Animal Products	Eggs; Dried fish; Fresh fish; Beef; Goat; Pork; Mutton; Chicken; Other poultry - guinea fowl, doves, etc; Small animal – rabbit, mice, etc.; Termites, other insects; Tinned meat or fish; Smoked fish; Fish Soup/Sauce
Fruits	Mango; Banana; Citrus – naartje, orange, etc.; Pineapple; Papaya; Guava; Avocado; Wild fruit; Apple
Milk/Milk Products	Fresh milk; Powdered milk; Margarine - Blue band; Butter; Chambiko; Yoghurt; Cheese; Infant feeding formula (for bottle)
Sugar, Fats, and Oil	Sugar; Sugar Cane; Cooking oil
Beverages	Tea; Coffee; Cocoa, millo; Squash; Fruit juice; Freezes (flavoured ice); Soft drinks (Coca-cola, Fanta, Sprite, etc.); Chibuku beer; Bottled water Maheu; Bottled/canned beer (Carlsberg, etc.); Thobwa; Traditional beer; Wine or commercial liquor; Locally brewed liquor
Spices/Condiments and Miscellaneous	Salt; Spices; Yeast, baking powder, bicarbonate of soda; Tomato sauce (bottle); Hot sauce (Nali, etc.); Jam, jelly; Sweets, candy, chocolates; Honey

Empirical Findings

The QUAIDS model is estimated using nonlinear seemingly unrelated regression (NLSUR) procedure, with theoretical restrictions of adding-up, homogeneity, and symmetry imposed during estimation. Table 3 presents the estimated coefficients for the QUAIDS model. The cumulative distribution function (CDF) and probability density function (PDF) estimates are predicted from Multivariate probit for which estimation results are presented in Table 6. The CDF and PDF were fed as arguments in the QUAIDS model. To preserve the adding-up restriction, one equation (the Beverage in this case) was omitted. The coefficients of this equation were recovered by *nlcm* STATA command. The elasticities are all evaluated at mean values. The quadratic expenditure term is statistically significant for all expenditure share equations. Thus, as per results presented below (Table 3) strongly support the rejection of the hypothesis that the quadratic expenditure term is zero across all equations. This unveils the suitability of the QUAIDS model over the traditional LA/AIDS model.

Expenditure elasticities are key behavioral parameters in policy models such country-specific Computable General Equilibrium (CGE) models. Table 2 comprises the expenditure elasticity estimates for rural households. Our expenditure elasticity estimates accord with economic intuition. All the food items are estimated to have positive expenditure elasticities.

Table 2: Expenditure Elasticity - Rural

Food category	Expenditure Elasticity	Expenditure Share
Cereals	0.060	0.205
Root tubers	0.595	0.042
Legumes	0.721	0.066
Vegetables	0.404	0.137
Meat	1.821	0.216
Fruits	1.636	0.018
Milk product	0.930	0.008
Sugars/Fats	1.784	0.203
Spices	3.323	0.067
Beverage	1.556	0.037

Table 3: IFGNLS Estimates of the QU-AIDM Parameters – Rural

	Expenditure share									
	Cereals (1)	Root tubers (2)	Legumes (3)	Vegetables (4)	Meat (5)	Fruits (6)	Milk product (7)	Sugars/Fats (8)	Spices (9)	Beverage (10)
Constant	0.162*** (0.0128)	-0.0412*** (0.00859)	-0.0133 (0.00962)	0.219*** (0.0135)	-0.0916*** (0.0146)	-0.00538 (0.00532)	-0.116*** (0.00454)	0.607*** (0.0136)	0.399*** (0.00911)	-0.120*** (0.0108)
lnp1	0.0938*** (0.000732)									
lnp2	-0.00965*** (0.000430)	0.0377*** (0.000503)								
lnp3	-0.00958*** (0.000407)	-0.00149*** (0.000328)	0.0364*** (0.000450)							
lnp4	-0.0160*** (0.000595)	-0.00588*** (0.000490)	-0.00478*** (0.000461)	0.0652*** (0.000939)						
lnp5	-0.0253*** (0.000559)	-0.00440*** (0.000442)	-0.00596*** (0.000439)	-0.0136*** (0.000624)	0.0806*** (0.000881)					
lnp6	-0.00549*** (0.000293)	-0.000896*** (0.000257)	-0.000837*** (0.000215)	-0.00348*** (0.000330)	-0.00160*** (0.000281)	0.0202*** (0.00031)				
lnp7	-0.00559*** (0.000304)	0.000210 (0.000253)	-0.000516** (0.000216)	-0.00371*** (0.000330)	0.000310 (0.000297)	4.70e-05 (0.00023)	0.0203*** (0.00039)			
lnp8	-0.0128*** (0.000722)	-0.00961*** (0.000621)	-0.00814*** (0.000570)	-0.00692*** (0.000823)	-0.0188*** (0.000813)	-0.0044*** (0.000434)	-0.0066*** (0.00047)	0.060*** (0.0014)		
lnp9	0.00189*** (0.000533)	-0.00456*** (0.000425)	-0.00814*** (0.000570)	-0.00497*** (0.000583)	-0.00771*** (0.000586)	-0.00297*** (0.000304)	-0.0062*** (0.000323)	0.0145*** (0.00077)	0.018*** (0.0006)	
lnp10	-0.0112*** (0.000513)	-0.00144*** (0.000428)	-0.00179*** (0.000391)	-0.00586*** (0.000581)	-0.00357*** (0.000525)	-0.000534* (0.000306)	0.00193*** (0.000309)	-0.0074*** (0.00079)	-0.0051*** (0.00053)	0.0544*** (0.00113)
lnexp	0.00240 (0.00149)	-0.0161*** (0.00102)	-0.0125*** (0.00115)	0.0158*** (0.00161)	-0.0270*** (0.00180)	-0.00717*** (0.000635)	-0.0213*** (0.00054)	0.0543*** (0.00160)	0.0420*** (0.00110)	-0.0257*** (0.00310)
$(\text{Lnexp})^2$	0.00191*** (0.000340)	0.00102*** (0.000239)	0.00105*** (0.000258)	0.00317*** (0.000359)	-0.00293*** (0.000416)	-0.000174 (0.000157)	-0.0022*** (0.000141)	0.00746*** (0.000408)	0.00360*** (0.000267)	-0.00493*** (0.000294)
ϕ	0.0708*** (0.0172)	-0.0277** (0.0110)	-0.0605*** (0.0120)	-0.0271 (0.0168)	0.317*** (0.0181)	-0.0221*** (0.00698)	0.0678*** (0.00605)	-0.283*** (0.0163)	-0.175*** (0.0115)	0.105*** (0.0132)

***, **, and * indicate statistical significance at 1 percent, 5 percent, and 10 percent, respectively.
In parenthesis are standard errors

Table 4: Uncompensated (Marshallian) Price Elasticity of Demand (QU-AIDM) – Rural

Price of → Demand for ↓	(1) Cereals	(2) Root tubers	(3) Legumes	(4) Vegetables	(5) Meat	(6) Fruits	(7) Milk product	(8) Sugars/Fats	(9) Spices	(10) Beverage
Cereals	**-0.193**	0.208	-0.255	0.333	0.082	0.165	0.030	0.302	1.107	0.055
Root tubers	0.059	**-0.191**	-0.068	-0.057	-0.035	0.068	-0.068	0.031	0.033	0.180
Legumes	-0.059	-0.066	**-0.231**	0.050	0.038	-0.056	-0.042	0.037	0.533	0.134
Vegetables	0.119	-0.111	0.111	**-0.113**	0.030	0.088	0.052	0.230	1.572	0.094
Meat	-0.169	-0.128	0.191	0.214	**-1.593**	0.065	0.023	0.197	0.890	0.025
Fruits	-0.035	-0.036	-0.033	0.044	-0.012	**-1.064**	-0.013	0.028	0.187	0.051
Milk product	-0.032	-0.007	-0.024	-0.032	0.009	-0.016	**-1.557**	-0.006	3.401	0.042
Sugars/Fats	-0.123	-0.063	-0.113	0.359	0.018	0.018	-0.272	**-1.435**	1.974	0.687
Spices	-0.019	0.037	-0.156	0.156	-0.048	-0.035	1.095	0.253	**-1.866**	0.551
Beverage	-0.071	-0.085	-0.084	-0.060	-0.018	0.063	-0.015	-0.014	-0.037	**-1.008**

Table 5: Compensated (Hicksian) Price Elasticity of Demand (QU-AIDM) – Rural

Price of → Demand for ↓	(1) Cereals	(2) Root tubers	(3) Legumes	(4) Vegetables	(5) Meat	(6) Fruits	(7) Milk product	(8) Sugars/Fats	(9) Spices	(10) Beverage
Cereals	**-0.181**	0.220	-0.243	0.345	0.094	0.177	0.043	0.314	1.119	0.068
Root tubers	0.084	**-0.166**	-0.043	-0.032	-0.010	0.093	-0.043	0.055	0.058	0.205
Legumes	-0.011	-0.018	**-0.183**	0.098	0.086	-0.008	0.006	0.085	0.581	0.182
Vegetables	0.174	-0.056	0.166	**-0.058**	0.086	0.143	0.107	0.285	1.627	0.149
Meat	0.224	0.265	0.584	0.607	**-1.200**	0.458	0.417	0.590	1.283	0.419
Fruits	-0.006	-0.007	-0.003	0.074	0.018	**-1.035**	0.017	0.057	0.216	0.081
Milk product	-0.024	0.001	-0.016	-0.025	0.017	-0.009	**-1.549**	0.002	3.409	0.050
Sugars/Fats	0.239	0.299	0.249	0.721	0.379	0.380	0.090	**-1.073**	2.336	1.049
Spices	0.205	0.260	0.068	0.380	0.176	0.189	1.319	0.477	**-1.642**	0.775
Beverage	-0.014	-0.027	-0.027	-0.003	0.040	0.120	0.042	0.043	0.020	**-0.951**

This indicates that all the commodities are normal goods, consumption of which will increase with rising incomes. Cereals have the hardest expenditure elasticity suggesting that as staple food products they are necessary items in the shopping lists at the lowest levels of expenditure. Expenditure elasticities for meat (1.82), fruits (1.64), spices (3.32), beverage (1.56) and surprising sugars/fats (1.78) are greater than one, indicating that they can be considered luxury goods. Although the expenditure elasticity for pork (0.930) is less than one, it is close enough to one, which is the cut-off point between luxury and necessary products. The relative low expenditure elasticity of vegetables (0.40) indicates that vegetables can be considered a necessity as a most affordable relish in rural Malawi's diets.

The interpretation of price and income effects is best discussed in terms of elasticities. Estimation results for own-price and cross-price uncompensated and compensated elasticities are reported in Table 4 and Table 5 respectively. The diagonal entries in Tables 4 and 5 represent the own-price elasticities, and the non-diagonal entries represent the cross-price elasticities. Note that cross-price elasticities are not symmetric, meaning that the consumer response for a commodity to a change in the price of another good is not necessarily the same as the consumer response for the other good to a change in the price of the commodity in question. As expected, almost all of own-price elasticities are negative. On the other hand, some cross-price elasticities are negative and some are positive. Negative cross-price elasticities imply that the relevant items tend to be complementary, while positive elasticities imply that they tend to be substitutes.

The uncompensated (Marshallian) price elasticities show that own-price elasticities ranged between –0.113 and –1.866. The own-price elasticity of meat, fruits, sugars/fats, milk products and spices were found to be greater than unity, while the elasticity for the cereals, root tubers, legumes as well as vegetables revealed inelastic demand. This indicates that a uniform percentage decrease in prices of all commodities would elicit a greater demand for meat, fruits, sugars/fats, milk products and spices. Cereals, root tubers and vegetables food groups show the lowest (absolutely) own-price elasticities, reflecting their status as staple-food groups. Except for root tubers and vegetables, all other foods are considered complements to cereals. An increase in the price of meat leads to a reduction in the demand for spices, fruits and beverage, and a cut in the expenditure on root tubers, but leads to an increase in the consumption of cereals, legumes, vegetables, milk products and sugars/fats. Therefore, cereals, legumes, vegetables, milk products and sugars/fats are substitutes for meat, while all the other food groups are complements.

The Hicksian (compensated) price elasticities provide a more accurate picture of cross-price substitution between commodity groups, since they are a measure of substitution effects net of income. In Table 5 of the compensated price elasticities, it can be observed that own price effects are relatively large and negative. They are, in absolute terms, smaller than the uncompensated elasticities. The fact that the signs of some Hicksian elasticities are different from those of the Marshallian elasticities suggests that expenditure effects are significant in affecting consumer demand decisions. Most of the cross-price elasticities are positive, indicating that the relevant food groups are substitutes, as would be expected. However, their low magnitudes suggest that substitution possibilities are quite limited.

Conclusions

This study represents an initial commitment of using the recent Malawi's Third Integrated Household Survey data to estimate a complete food demand system for rural Malawi. A Quadratic Almost Ideal Demand System (QUAIDS) specification introduced by Banks, Blundell and Lewbel (1996 and 1997) was employed in the analysis. The quadratic terms in the QUAIDS were found to be empirically important in describing household budget behaviour in rural Malawi, indicating that the traditional linear specification of Engel curves is not a suitable representation of food consumption behaviour in Malawi. Price and expenditure elasticities were computed for ten food aggregates and nonfood expenditure. The ten food aggregates included: cereals; root tubers; legumes; vegetables; meat; milk products; fruits; sugars/fats; spices and beverage.

These results are an important step forward in understanding household consumption habits in rural Malawi. The elasticities calculated in this study are powerful instruments in helping policy makers in devising polices targeted at poor people. Apparently, household income growth is likely to have higher impacts on food consumption than prices. The magnitudes of the former are higher than those of the latter. The present estimates indicate that policies such as a general price increase in food intended to assist producers would not have a significant adjustment in the consumers' consumption patterns as those that favour growth in incomes. Targeting income-related policies would mean that consumers would be able to purchase more, in particular meat, spices, fruits, sugar/fats and beverage which are identified to have high-expenditure elasticities, and hence considered luxuries. However, with an increase in income, food allocation patterns would fundamentally change with consumers spending more on meat, fruits, sugar/fats, spices and beverage away from vegetables, legumes among others. Furthermore, cereals being staple commodity are a necessity, and hence play an important role in household diets. Therefore, policy formulation should be careful not to impose taxes on the cereals.

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Table 6: Simulated Maximum Likelihood Multivariate Probit for deriving $\hat{\Phi}$ and $\hat{\phi}$ Estimates

VARIABLES	Cereals	Root tubers	Legumes	Vegetables	Meat	Fruits	Milk products	Sugars/Fats	Spices	Beverage
Income	0.528***	0.333***	0.334***	0.349***	0.450***	0.287***	0.265***	0.192***	0.152***	0.421***
	(0.0118)	(0.0110)	(0.0109)	(0.0130)	(0.0123)	(0.0110)	(0.0124)	(0.0212)	(0.0178)	(0.0113)
Household size	-0.0685***	-0.0354***	-0.0123**	-0.0169**	-0.0500***	-0.0383***	-0.0370***	0.0495***	0.0458***	-0.0412***
	(0.00611)	(0.00564)	(0.00558)	(0.00748)	(0.00673)	(0.00574)	(0.00697)	(0.0162)	(0.0115)	(0.00580)
Age of head	-0.00414***	-0.00381***	0.000302	-0.00309***	0.000860	-0.00399***	0.00638***	-0.00820***	-0.00804***	0.00363***
	(0.000808)	(0.000775)	(0.000760)	(0.000946)	(0.000871)	(0.000795)	(0.000985)	(0.00176)	(0.00133)	(0.000794)
Gender of head	0.0561*	-0.00682	0.0666**	0.0750**	-0.0710**	0.0600**	0.0582	-0.134*	-0.0300	-0.135***
	(0.0315)	(0.0294)	(0.0291)	(0.0378)	(0.0336)	(0.0300)	(0.0374)	(0.0693)	(0.0540)	(0.0304)
Education level	0.146***	0.140***	0.118***	0.181***	0.149***	0.213***	0.444***	0.145**	0.0543	0.293***
	(0.0187)	(0.0151)	(0.0153)	(0.0258)	(0.0220)	(0.0150)	(0.0165)	(0.0615)	(0.0351)	(0.0160)
Constant	-2.888***	-2.316***	-2.462***	-1.242***	-2.027***	-2.377***	-3.774***	1.126***	0.997***	-3.284***
	(0.102)	(0.0941)	(0.0940)	(0.119)	(0.109)	(0.0954)	(0.114)	(0.225)	(0.169)	(0.0988)
Observations	10,038	10,038	10,038	10,038	10,038	10,038	10,038	10,038	10,038	10,038
Log likelihood	-818.12	-818.12	-818.12	-818.12	-818.12	-818.12	-818.12	-818.12	-818.12	-818.12
Chi-Square	244.38	244.38	244.38	244.38	244.38	244.38	244.38	244.38	244.38	244.38

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

$\hat{\Phi}$ is cumulative density function and $\hat{\phi}$ is probability density function