Journal of Quantitative Economics, Vol. 8 No.1, January 2010

APPLICATION OF THE QUAIDS MODEL TO THE FOOD SECTOR IN INDIA

SURABHI MITTAL[1]

Abstract

Higher economic growth has led to diversification of the consumption bundle of households away from staple food. This has implications for the food policy as demand projections for different commodities impacts the farmers decision to diversify its production base which further has implications for the issue of food security. Thus it becomes important to project the demand, based on most realistic demand elasticities. Using the households consumer expenditure survey of the major National Sample Survey rounds, the paper estimates the price and expenditure elasticity's of different food items/ groups in India. A two-stage Quadratic AIDS (QUAIDS) model is used to compute coefficients and calculate the demand elasticity's. In this model assumption of linearity in the expenditure function is given away.

Keywords: QUAIDS Model, Food Demand Elasticity, India

JEL Classification: Q11, Q18

1. Introduction

Knowledge of demand structure and consumer behaviour is essential for a wide range of development policy questions like improvement in nutritional status, food subsidy, sectoral and macroeconomic policy analysis. An analysis of food consumption patterns and how they are likely to shift due to change in income and relative price in particular help in assessing the food security-related policy issues in the agricultural sector. With high economic growth, the average per capita income in the country increase accompanied by a fall in the per capita consumption of staple food. This decline indicates improvement in the welfare, as laid down by Engel's law. Diversification in the food basket due to urbanization improves the quality of life by adding to the nutritional status and welfare of the population (Kumar 1997; Rao, 2000).

The change in demand structure is based on a matrix of price and income elasticity of demand for food groups. With rise in income or fall in prices, the consumption bundle either change or diversify. In the short run, with relatively inflexible production, change in the structure of demand is the main determinant of observed changes in market prices. In medium and long runs, the structure of final demand is an important element of more complete model that seeks to explain the levels of production and consumption, price formulation, trade flows, income levels

[1] Senior Fellow, ICRIER, New Delhi 110003, India

and government fiscal revenues. These have direct implication on poverty and incidence of hunger in the country.

A proper estimation of the elasticities and projected direction of change is as important instrument that guides the future policy decisions. Thus, the techniques used in estimating these elasticities have to be based on a functional form that is based on realistic assumptions. The present paper in this context applies the multi stage Quadratic Almost Ideal System Technique on the food demand system. Demand elasticity computed in this complete system explains the level of demand for the commodities by an individual given the structure of relative prices, real incomes and a set of individual characteristics such as age, type of household (expenditure groups) and geographical environment (rural or urban).

2. Literature on Estimation of Demand System

The basic objective of the theory of consumer behaviour is to explain how a rational consumer makes decision on - what to consume, when confronted with various prices and a limited budget. At this level of generality, the usefulness of this theory for empirical purposes is that it establishes a set of constraints that the demand parameters must satisfy, thus limiting the number of independent parameters to be estimated and ensuring consistency in the results obtained.

There are two approaches that can be followed to estimate the parameters of demand equation. One consists of specifying estimable single equation demand function and estimates income and price elasticities for a commodity in a constant elasticity demand equation. The use of relative prices and real income in the equation as exogenous variable makes the demand equations homogeneous of degree zero in prices and income. This ensures that there is no money illusion in demand in the sense that it is not affected by a proportional increase in all prices and incomes. This approach is simple but has serious drawbacks (Sadoulet and Janvry 1995). The estimated parameters, in general, do not satisfy the requirements of demand theory, particularly the budget constraint.

In an alternative approach to the estimation of demand equation parameters, three demand systems have received considerable attention in literature: Linear Expenditure System (LES) developed by Stone (1954), the Almost Ideal Demand System (AIDS) developed by Deaton and Muellbauer (1980) and the combination of these two systems into a Generalized Almost Ideal Demand System (GAIDS) proposed by Ballino (1990). Other complete demand systems found in the literature but not widely used are the Rotterdam model of Theil (1976) and Barten (1969) and the translog model of Christensen, Jorgenson and Lau (1975). Each approach has certain drawbacks like, the LES model is better applied to large categories of expenditure than to individual commodities, since it does not allow for inferior goods and implies that all goods are gross complements. The econometric problem with the AIDS model is that the demand equations appear to be unrelated, since none of the endogenous quantities or budget share appear on the right-hand side of the equations. Muellbauer and Pashardes (1992) point out that most studies of demand systems use static models, which do not account for hypothesis of symmetry and homogeneity, derived from consumer theory. Thus, there is a need for a dynamic demand system which gives more realistic and econometrically viable results.

Demand and income elasticities are not necessarily constant across the consumer groups. Thus the functional form that are used to estimate income elasticities of food demand should be flexibility in the functional form and allow income elasticities to differ between rich and poor households. The functional form should be able to be estimated when a household has zero consumption of particular foods, otherwise those households have to be dropped from the sample, which could cause sample selection bias (Deaton 1989). If this property is not allowed in the functional form, it inevitably results in biased results. Similarly, if changes in relative prices are not accounted for then it can lead to omitted variable bias. Thus the more comprehensive study by Kumar (1998) computed the expenditure and price elasticities for food and non-food commodities using various econometric techniques- Transcendental Logarithmic Demand System (TLDS), Normalized Quadratic Demand System (NQDS) and Linear Expenditure Demand System (LEDS) and non-econometric Food Characteristic Demand System (FCDS). But still all these models assumed a linearity in expenditure.

3. Two-Stage QUAIDS Model

The present paper works with the complete demand system which takes into account mutual interdependence of a number of commodities in the budget decisions of the consumer and makes demand projections after taking into account urbanization, regional variations in dietary pattern and income distribution. The demand system works under the assumption that there are no price variations within clusters and, hence, unit value variations across households in the same cluster are only due to quantity differentials and measurement errors (Deaton, 1988, 1990). This assumption allows one to use within-cluster variations in demand to estimate the impact of income and consumer characteristics on demand including the quantity effects. This relation can then be used to remove the predicted effects of income and household characteristics on demand and to explain the residual cross-cluster variations in demand by prices only.

QUAIDS model is an extended form of AIDS model, where the assumption of linearity in the expenditure function is given away. The model is quadratic in per capita expenditure under the assumption that there is a non-linear relationship between income and expenditure. Several demand studies have confirmed the appropriateness of QUAIDS in modeling preferences. Abdulai (2002) applied QUAIDS to the food expenditure data from Switzerland, Moro and Sckokai (2000) on Italian food expenditure data, Banks et al. (1997) and Blundell and Robin (1999) used expenditure data on broad consumption goods from the U.K., and Fisher et al. (2001) applied the model to the U.S. aggregate consumption data, Abdulai and Aubert (2004) on Tanzanian food expenditure data, Meenkashi and Ray (1999) using Indian food expenditure data, Gould and Villarreal (2006) using food expenditure data from urban China, and Molina and Gil (2005) using aggregate consumption data from Peru.

The present paper applies the two-stage budgeting framework on the food sector to model the consumption behaviour of households in India. This model has been extensively used in the demand elasticity estimations for the fish sector by Blundell et al. (1993), Dey (2000) for Bangladesh and Kumar (2004, 2005) for India. In the first stage, the household makes decisions on how much of its total income (expenditure) is to be allocated for food consumption, conditional on consumption of the non-food goods and the household and demographic characteristics. In the second stage, the household allocates the total food expenditure among different items/groups (rice, wheat, coarse cereals, pulses, milk, edible oils, vegetables, fruits, meat, fish, eggs, sugar, other food, and non-food).

The specific functional form used in the two stages are as follows:

Stage 1: Food expenditure function

$$Ln(M) = \alpha + \gamma_1 Ln(P_f) + \gamma_2 Ln(P_{nf}) + \beta_o Ln(Y) + \beta_1 (\ln Y)^2 + \sum \theta_j Z \quad \ldots (1)$$

Where M is the per capita food expenditure; Y is the per capita total expenditure (income); P_f is the household specific price index for food; P_{nf} is price index of non-food. Socio-demographic and conditioning variables (vector Z) include ratio of adults in the household, family size, and urban dummy. Equation 1 is estimated by the OLS method, and homogeneity of degree zero in prices and income was imposed by restricting

$\gamma_1 + \gamma_2 + \beta_0 + 2\beta_1 Ln(Y) = 0$ at the sample mean of Ln(Y).

Deaton and Muellbauer (1980) suggest approximating the price index P by the Stone geometric price index.

$$\ln P^* = \sum_i w_i \ln p_i$$

Stage 2: Quadratic-AIDS (QUAIDS) Model

In stage 2, quadratic extension to Deaton and Muellbauer's (1980) almost ideal model for food demand system is used. The specific functional form for ith items/groups is as follows:

$$S_i = a_i + \sum_j b_{ij} Ln(FP_i) + c_{0i} Ln\left(M/I\right) + c_{1i}(Ln M/I)^2 + d_i Urban + \sum_k e_{ik} IMR_k \quad \ldots (2)$$

Where FPi is the price of ith items/groups; I is the Stone geometric price index; Urban is a binary dummy variable for urban areas. The parameters of the model (a_i, b_{ij}, c_i, d_i and e_{ik}) were estimated by imposing the homogeneity (degree zero in prices), symmetry (cross price effects are same across the good) restrictions. The following restrictions were econometrically imposed.

Homogeneity: $\sum_{j=1}^{n} b_{ij} = 0$; Symmetry: $b_{ij} = b_{ji}$, $c_{11}/c_{10} = c_{21}/c_{20} = \ldots\ldots = c_{n1}/c_{n0}$;

The homogeneity and symmetry restrictions are imposed at sample mean. Given the quadratic specification of the demand system (Equations 1 and 2) a test of symmetry additionally requires that the ratio of the coefficients on the food expenditure and the square terms in food expenditure be the same for all items/groups (Blundell et al 1993). The predicted value of food expenditure obtained from stage 1 is used as the explanatory variable in stage 2. The income and price elasticities are computed as:

Food income elasticity

$$\eta_i = (c_{i0} + 2c_{i1} Ln(F) / w_i) + 1$$

Uncompensated price elasticity

$$\xi_{ij} = \left(\frac{b_{ij}}{w_i}\right) - (c_{i0} + 2c_{i1} Ln(F))\left(w_j / w_i\right) - k_{ij}$$

where k_{ij} is Kronecker delta, which takes the value of one for own-price elasticity and zero for cross-price elasticity; and w_i is the share of the i^{th} items/groups used as a weight in constructing Stone's price index. Once the expenditure and uncompensated price elasticities are estimated, the compensated own and cross-price elasticities are computed using the Slutsky equation in elasticity form:

$$\xi_{ij}^{H} = \xi_{ij} + w_j \eta_i$$

where ξ_{ij}^{H} is the compensated (Hicksian) price elasticity.

Income elasticity of demand for an individual items/groups $< \eta_i^{y} >$ is estimated as the product of expenditure elasticity of the individual items/groups $< \eta_i >$ and food expenditure elasticity with respect to total income (η^{y}): $\eta_i^{y} = \eta_i \times \eta^{y}$

4. Data

An ideal set for measuring the structural shifts in food demand patterns would require records on food consumed, prices, income by source and standard demographic information for a large number of families before and after these families migrated from rural to urban areas (Kumar, 1998). Since such data sets are not available, the best possible way is to look into the household level consumer expenditure survey of the National Sample Survey Organization (NSSO). NSSO collects data on household consumption expenditure at the national level in the form of various rounds by adopting sample survey techniques. The paper uses household unit level data for the round numbers 38, 43, 50 and 55 of the NSS data pertaining to the periods 1983, 1987-8, 1993-4 and 1999-2000 respectively for the analysis. These rounds provide household data in terms of quantity and value of commodities by expenditure groups, rural-urban locations and by states. The data are disaggregated with the level of individual crops, food and non-food items, total consumer expenditure and family size.

The data refer to the average per capita consumption over the 30 day recall in each of the expenditure classes. Prices for rural and urban areas are computed implicitly as expenditure divided by the quantities of each of the expenditure classes in each round, which is then deflated by the consumer price index to obtain the real prices (Mittal, 2006). From the expenditure and quantity data, the unit value information and expenditure shares are calculated for each household. For the purpose of analysis four expenditure groups are formed for both rural and urban households on the basis of the poverty lines adopted by the Planning Commission (Radhakrishna and Ravi 1990; Kumar 1998). Based on the expenditure groups of the NSS, households with expenditure below 75 per cent of the poverty line are defined as very poor; those between 75 per cent and the poverty line as poor; those at 150 per cent of the poverty line are termed as non-poor and those above 150 per cent of the poverty line are termed as rich.

5. Empirical Analysis

5.1 Model Estimation

Estimation of the QUAIDS model in two stage framework for the household consumers are presented in Table 1.

Table 1. Coefficients of Estimated Two Stage QUAIDS Model.

Stage 1. Estimated Food Expenditure Function, India

Variable	*Regression coefficient*	*Standard error*	*t-Value*
Intercept	-143.876	1.441	-99.817
Ln (price index for food)	-0.075	0.021	-3.547
Ln (price index for non-food)	-0.630	0.019	-33.735
Ln (per capita total expenditure)	0.627	0.056	11.176
Ln (per capita total expenditure)^2	0.007	0.005	1.421
Family size	-0.028	0.007	-4.172
Urban dummy	0.051	0.008	6.259
Time trend	0.073	0.001	102.212
Adjusted R2	0.97		
Number of observations	920		

Stage 2. Estimated Parameters of the QUAIDS Food Demand System, India

Groups	*Cereals*	*Pulses*	*V&F*	*Milk*	*Edible Oil*	*Sugar*	*MFE*
Intercept	7.5432	0.0420	-1.9183	0.4933	-0.3629	0.5471	-5.3445
	(7.96)	(0.16)	(-6.67)	(0.73)	(-1.33)	(2.64)	
Food price (Rs/kg) in logarithmic form							
Cereal	0.0907	-0.0260	0.0195	-0.1067	-0.0242	-0.0340	0.0807
	(9.20)	(-13.40)	(6.88)	(-17.83)	(-11.81)	(-22.02)	
Pulses	-0.0260	0.0161	0.0048	0.0008	-0.0042	0.0003	0.0082
	(-13.40)	(6.04)	(4.06)	(0.35)	(-2.09)	(0.19)	
V&F	0.0195	0.0048	0.0081	-0.0073	0.0004	0.0037	-0.0293
	(6.88)	(4.06)	(4.36)	(-3.03)	(0.34)	(4.22)	
Milk	-0.1067	0.0008	-0.0073	0.0751	0.0081	0.0161	0.0139
	(-17.83)	(0.35)	(-3.03)	(11.37)	(3.26)	(8.48)	
Edible oil	-0.0242	-0.0042	0.0004	0.0081	0.0140	-0.0030	0.0090
	(-11.81)	(-2.09)	(0.34)	(3.26)	(5.34)	(-1.72)	
Sugar	-0.0340	0.0003	0.0037	0.0161	-0.0030	0.0120	0.0048
	(-22.02)	(0.19)	(4.22)	(8.48)	(-1.72)	(5.11)	
MFE	0.0807	0.0082	-0.0293	0.0139	0.0090	0.0048	-0.0873
	(12.29)	(4.45)	(-11.99)	(2.77)	(4.70)	(3.52)	
Ln (per capita food expenditure)	-0.5009	0.1633	0.0570	0.0246	0.1976	0.0223	0.0362
	(-3.58)	(6.17)	(1.43)	(0.25)	(6.93)	(1.02)	
Ln (per capita food expenditure)^2	0.0295	-0.0229	-0.0041	0.0207	-0.0282	-0.0012	0.0062
	(1.46)	(-5.95)	(-0.71)	(1.47)	(-6.82)	(-0.38)	
Urban dummy	-0.1401	-0.0005	0.0157	0.0302	0.0165	-0.0002	0.0784
	(-24.97)	(-0.43)	(9.62)	(7.65)	(13.69)	(-0.24)	
Year	-0.0029	-0.0001	0.0010	-0.0004	0.0000	-0.0003	0.0027
	(-6.02)	(-1.14)	(6.64)	(-1.13)	(0.18)	(-2.83)	
DW Statistics	1.3790	1.4376	2.1415	0.9570	1.6475	1.4828	

Note: Figures in parenthesis are the t-value. V&F=Vegetables and fruits; MFE= Meat, fish and eggs.

Stage 1 present the coefficients of the estimated parameters of total food expenditure function. The explanatory variables included in the model explain 97 per cent of the total variation in the food expenditure function. The coefficients of food and non-food price factors have a negative and significant effect on the total food expenditure and are as per expectation. Per capita total expenditure and its square term are positive. The square term of per capita food expenditure is not significantly different from zero. This implies that the relation between expenditure and income change may not be non-linear. The linear term of per capita total expenditure is positive and significant; indicating that the response of total food expenditure on income change is substantial. The family size variable is negative and significant. This implies that with a member added into a family the per capita expenditure on food declines due to reallocation of resources. Urbanization has a positive impact on food expenditure. Time trend is positive and significant. The time trend variable illustrates the impact of taste and preferences and thus it means that over the period of time the tastes and preferences of the households are changing. Since taste and preferences change with time and can't be quantified in number, thus the decomposition model assumes that the time trend will be capturing the effect of changing tastes and preferences on food consumption (Mittal, 2007).

The estimation of the parameters of the quadratic demand system of the food group-- cereals, pulses, vegetables and fruits, milk, edible oil, sugar and meat, fish and eggs are given in Table 1 stage 2. The squared terms of per capita expenditure on food are significant only for pulses and edible oil. If the parameters are insignificant then it means that the expenditure elasticity's are more or less constant across the income groups. Urbanization has a negative effect on cereals, pulses and sugar consumption. The consumption of vegetables and fruits, milk and edible oil increase with urbanization. The coefficient of own price is positive and highly significant for the share of food groups. Even when prices rise the households maintain the share of expenditure on the staple food in their food basket. The time trend is negative and significant for cereal, pulses and sugar. This implies that across years the share of these commodities in total food expenditure declines, but the decline is marginal due to a small coefficient.

5.2 Demand Elasticity

Demand elasticities are an important parameter in projecting food demand. The magnitude of these elasticities depends largely on the methodology used in computing the price and expenditure elasticity. Using the QUAIDS model the price and expenditure elasticity were computed at mean level for 1999. Price elasticity, own- price elasticity and cross-price elasticity of different expenditure groups across rural-urban can be seen in Appendix Tables A1-A3. Table 2 present expenditure elasticity for rural, urban and all-India. The elasticities are computed for the commodity group's cereals, pulses, vegetables and fruits, milk, edible oil, sugar and meat, fish and eggs.

The expenditure elasticity of food items is lower in urban households as compared to the rural households, urban households have higher expenditure budget as compared to the rural ones. Similar pattern is also observed between different expenditure group households- poor households have higher expenditure elasticity than the rich households (Appendix Table A1). The All India expenditure elasticity for cereals is very low (0.17) but positive. It is nearly zero for urban households while for rural households it is around 0.2. The expenditure elasticity for milk and meat, fish and eggs is greater than one and for sugar and vegetables & fruits is also high. This implies that as share of expenditure on food increases the proportion of expenditure on these food groups is much higher than on other food groups. The demand for high-value foods is more income elastic as compared to that for staple food. Therefore it is observed that, inspite of having positive expenditure elasticity, the annual per capita consumption of cereal has shown a decline.

Table 2. Expenditure Elasticity of Demand for Major Food Groups in India

Groups	*Rural*	*Urban*	*All-India*
Cereals	0.21	0.09	0.17
Pulses	0.62	0.57	0.59
Vegetables and Fruits	0.75	0.73	0.72
Milk	1.27	1.15	1.19
Edible oil	0.57	0.53	0.55
Sugar	0.83	0.84	0.82
Meat, Fish and Egg	1.38	1.26	1.30

Behavioural characteristics of the consumer demand systems are measured in the form of elasticity. Thus, consumer response to price change is summarized in terms of own price elasticity and cross-price elasticity. Both compensated and uncompensated price elasticities are computed. The uncompensated elasticity of demand represents changes in the quantity demanded as a result of changes in prices, capturing both price effect and income effect. Compensated elasticity of demand refers to the portion of change in quantity demand, which captures only the price effect. The own-price elasticity has the expected negative signs (Table 3). The price elasticity is lowest for cereals and pulses and highest for meat, fish and eggs. This implies that even a marginal increase in the price of meat and its products will lead to a substantial decline in its consumption. This is true for both the rural and urban households and also across different expenditure groups. High-value commodities are very sensitive to prices. Whereas cereals are the staple food in India thus even with higher price fluctuations the consumption fall is not of that magnitude.

Table 3. Own-price Elasticity of Demand for Major Food Groups in India

Groups	*Rural*	*Urban*	*All-India*
Uncompensated own-price elasticity			
Cereals	-0.50	-0.44	-0.48
Pulses	-0.77	-0.77	-0.77
Vegetables and fruits	-0.97	-0.98	-0.98
Milk	-0.73	-0.84	-0.78
Edible oil	-0.78	-0.81	-0.80
Sugar	-0.73	-0.72	-0.73
Meat, fish and eggs	-2.38	-2.13	-2.26
Compensated own-price elasticity			
Cereals	-0.46	-0.43	-0.45
Pulses	-0.74	-0.75	-0.75
Vegetables and fruits	-0.92	-0.93	-0.92
Milk	-0.62	-0.74	-0.68
Edible oil	-0.76	-0.79	-0.78
Sugar	-0.72	-0.70	-0.71
Meat, fish and eggs	-2.33	-2.09	-2.22

Any positive sign of compensated cross-price elasticity (Appendix Table A2-A3) indicates the substitution relationship among pairs of goods and a negative sign indicates the complementary relationship among goods. In the Indian household food basket pulses are complementary to cereals, while meat, fish and eggs can substitute cereals, although the substitutability is stronger the other way round because large numbers of households are vegetarian and cereal is the main staple food. This substitution trend is stronger in rural regions than in urban regions.

6. Policy Implications

With high economic growth and increasing per capita incomes a diversification in consumption pattern is observed. The economy is moving from being a supply-driven economy to a demand-driven economy. Thus, India's agriculture and food policy is confronted with a situation where balance is to be maintained between the policy to retain country's food security and on the other side the twin objective of improving livelihood conditions of the farmers and also to take care of consumer demand preferences. This is to be managed with very little impact on prices so as to protect the poor vulnerable population of the country. To achieve this goal it is important to have a realistic consumer demand estimates to plan the food supply policy. With the increasing food prices, global shortage of food grains and even in India narrowing of gap between supply and demand of food items, it becomes essential to have a view of the changing consumption pattern and their responsiveness to the prices and incomes.

This puts forward the importance of demand models with more realistic approach. The model that makes the demand projections based on most realist assumptions can help to formulate medium and long-term agricultural policies in a better way. Various studies using different demand models have projected the food demand for India. Using the elasticity's of the two stage QUAIDS model the cereal demand in 2020 is projected to be 245.1 million metric tonnes (mt) (Mittal, 2008). Rosegrant et al (1995) provided cereal projections for IFPRI's 2020 vision based on the International Model for Policy Analysis of Agricultural Commodities and Trade as 237.3 mt. The study by Kumar (1998) used the FCDS model and the cereals demand is projected to be 265.7 mt in 2020. Bhalla (2001) projected cereal demand to be 374.7 mt. Thamarajakshi (2001) estimated the total cereals demand to be 274 mt for 2020. These projections are under different assumptions of population growth, economic growth and urbanization. In the long run to sustain the growth of the agriculture sector and development of the small land holder, farmers need to be monitored to identify, select and support diversification in their production pattern based on the projected demand. Different models have been used to give this huge variation in demand projections. This huge variation makes it difficult for the policy makers to choose amongst the available projections.

To show that the results from the QUAIDS model are much closer to the actual numbers, a small validation exercise was undertaken (annexure table A4). The per capita annual projection for demand of cereals for 2005 as estimated by this model is 143.62 kg. The NSS consumer expenditure survey round 61st showed that the actual cereal consumption annual per capita for cereals in the year 2004-05 had been 141.69 kg. The projected demand numbers using the QUAIDS model elasticities are very close (in the range of 2-4% difference) to the actual consumption numbers. This creates a belief in the model which is based on the assumption of non-linearity in income and demand and takes into account the mutual interdependence of a number of commodities in the budget decisions. The elasticity's worked out using the QUAIDS model are addition to the literature of elasticity's used by policy makers to project demand for different time periods across income groups. These elasticity's would also help in formation of price policies that act as motivations to the farmers and also the indication for the consumption basket. This has implications on household food security too.

References

Abdulai, A., (2002), "Household demand for food in Switzerland. A quadratic almost ideal demand system", *Swiss Journal of Economic Statistics*, 138, 1-18.

Abdulai, A. and Aubert, D., (2004), "A cross-section analysis of household demand for food and nutrients in Tanzania", *Agricultural Economics*, 3 (1), 67-79.

Ballino, C., (1990), "A Generalized Version of the Almost Ideal and Translog Demand Systems", *Economics Letters*, 34, 127-129.

Banks, J., Blundell, R. and Lewbel, A., (1997). "Quadratic Engel curves and consumer demand", *Review of Economics and Statistics*, 4, 527–539.

Barten, A.P., (1969), "Maximum Likelihood Estimation of a Complete System of Demand Equations", *European Economic Review*, 1, 7-73.

Bhalla, G.S., (2001), "Demand and supply of food and feed grains by 2020" in the book *Towards Hunger Free India* edited by M.D. Asthana and Pedro Medrano. New Delhi, Manohar Publishers.

Blundell, R., Pashardes, P. and Weber, G., (1993), "What Do We Learn about Consumer Demand Pattern from Micro Data?", *American Economic Review*, 83, 570-597.

Blundell, R.W. and Robin, J.M., (1999), "Estimation in Large and Disaggregated Demand Systems: An Estimator for Conditionally Linear Systems", *Journal of Applied Econometrics*, 14, 209-232.

Christensen, L., Jorgenson, D. and Lau, L., (1975), "Transcendental Logarithmic Utility Functions", *American Economic Review*, 65, 367-383.

Deaton, A.S. and Muellbauer, J., (1980), "An Almost Ideal Demand System", *American Economic Review*, 70(3), 359-368.

Deaton, A., (1988), "Quality, Quantity and Spatial Variations of Prices", *American Economic Review*, 78, 418-430.

Deaton, A., (1989), "Household Survey Data and Pricing Policies in Developing Countries", *World Bank Economic Review*, 3, 183-210.

Deaton, A., (1990), "Price Elasticities from Survey Data: Extensions and Indonesian Results", *Journal of Econometrics*, 44, 281-309.

Dey, M.M., (2000), "Analysis of Demand for Fish in Bangladesh", *Aquacultures, Economics and Management*, 4, 63-81.

Fisher, D. , Fleissig, A.R. and Serletis, A., (2001), "An empirical comparison of flexible demand system functional forms", *Journal of Applied Econometrics*, 16(1), 59-80.

Gould, W. and Villarreal, H.J., (2006), "An Assessment of the Current Structure of Food Demand in Urban China", *Agricultural Economics*, 34, 1-16.

Kumar, Praduman, (1997), “Food Security: Supply and Demand Perspective”, *Indian Farming*, December, 4-9.

Kumar, Praduman, (1998), “Food Demand and Supply Projections for India”, Agricultural Economics Policy Paper 98-01, New Delhi, India: Indian Agricultural Research Institute.

Kumar, Praduman, (2004), “Fish Demand and Supply Projections in India”, ICAR-ICLARM Project, Division of Agricultural Economics, New Delhi: Indian Agricultural Research Institute, March.

Kumar, Praduman, Dey, M.M. and Paraguas, F.J., (2005), “Demand for Fish by Species in India: Three Stage Budging Framework”, *Agricultural Economics Research Review*, 18(2),167-187.

Meenakshi, J.V. and Ray, R., (1999), “Regional Differences in India’s Food Expenditure Pattern: A Completed Demand Systems Approach”, *Journal of International Development*, 11, 47-74.

Mittal, Surabhi, (2006), “Structural Shift in Demand for Food: projections for 2020”, ICRIER Working Paper No 184. August.

Mittal, Surabhi, (2007), “What Affects Changes in Cereal Consumption?”, *Economic and Political Weekly*, Vol. 42 No. 5, February 3, 2007. Pp. 444-447.

Mittal, Surabhi, (2008), “Demand-Supply Trends and Projections of Food in India”, ICRIER Working paper No. 209. March.

Molina, J.S. and Gil, A.I., (2005), “The Demand Behavior of Consumers in Peru: A Demographic Analysis using the QUAIDS”, *Journal of Developing Areas*, 39(1), 191-206.

Moro, D. and Sckokai, P., (2000), “Heterogenous Preferences in Household Food Consumption in Italy”, *European Review of Agricultural Economics*, 27(3), 305-323.

Muellbauer, J. and Pashardes, P. (1992), “Tests of Dynamic Specification and Homogeneity in Demand Systems” in L. Philips and L. D. Taylor (eds.) *Aggregation, Consumption and Trade: Essays in Honour of Hendrik Houthakker, Advanced Studies in Theoretical and Applied Econometrics*, Kluwer Academic Publishers. 55-98.

Radhakrishna, R. and Ravi, C., (1990), *Food Demand Projections for India*, Hyderabad: Centre for Economics and Social Studies.

Rao, C.H.H., (2000), “Declining Demand for Foodgrains in Rural India: Causes and Implications”, *Economic and Political Weekly*, 22 January, 201-206.

Rosegrant, M.W., Agcaoili-Sombilla, M. and Perez, N.D., (1995), “Global Food Projections to 2020: Implications for Investment”, 2020 Discussion Paper No. 5, Washington, D.C.: IFPRI.

Sadoulet, E. and Janvry, A., (1995), *Demand Analysis in Quantitative Development Policy Analysis*, Baltimore and London: The Johns Hopkins University Press.

Stone, R., (1954), “Linear Expenditure System and Demand Analysis: An Application to the Pattern of British Demand”, *Economic Journal*, 64, 511-527.

Thamarajakshi, R., (2001), “Demand and Supply of foodgrains in 2020” in the book *Towards Hunger Free India* edited by M.D. Asthana and Pedro Medrano. New Delhi, Manohar.

Theil, H., (1976), *Theory and Measurement of Consumer Demand*, Amsterdam: North-Holland.

Appendix Tables

Table A1. Expenditure elasticity of demand for major food groups in India

Groups	*Rural*					*Urban*					*All India*				
	Very Poor	*Poor*	*Non-Poor*	*Rich*	*All*	*Very Poor*	*Poor*	*Non-Poor*	*Rich*	*All*	*Very poor*	*Poor*	*Non-Poor*	*Rich*	*All*
Cereals	0.31	0.30	0.26	0.17	0.21	0.23	0.20	0.15	0.04	0.09	0.28	0.26	0.23	0.11	0.17
Pulses	0.91	0.78	0.68	0.53	0.62	0.79	0.73	0.67	0.51	0.57	0.83	0.75	0.67	0.52	0.59
V& F	0.79	0.78	0.77	0.76	0.75	0.78	0.77	0.76	0.74	0.73	0.77	0.76	0.76	0.74	0.72
Milk	3.03	2.07	1.50	1.20	1.27	1.59	1.40	1.26	1.15	1.15	2.02	1.69	1.38	1.16	1.19
Oil	0.92	0.78	0.66	0.46	0.57	0.80	0.71	0.64	0.46	0.53	0.85	0.74	0.64	0.45	0.55
Sugar	0.97	0.90	0.86	0.83	0.83	0.84	0.84	0.85	0.87	0.84	0.88	0.86	0.84	0.84	0.82
MFE	1.75	1.62	1.48	1.38	1.38	1.51	1.44	1.36	1.28	1.26	1.60	1.52	1.42	1.30	1.30

Note: V&F=Vegetables and fruits; MFE= Meat, fish and eggs.

Table A2. Own-price elasticity of demand for major food groups in India

Groups	*Rural*					*Urban*					*All India*				
	Very Poor	*Poor*	*Non-Poor*	*Rich*	*All*	*Very Poor*	*Poor*	*Non-Poor*	*Rich*	*All*	*Very Poor*	*Poor*	*Non-Poor*	*Rich*	*All*
Uncompensated own-price elasticity															
Cereals	-0.53	-0.53	-0.52	-0.48	-0.50	-0.50	-0.49	-0.47	-0.42	-0.44	-0.52	-0.52	-0.51	-0.45	-0.48
Pulses	-0.76	-0.77	-0.77	-0.76	-0.77	-0.82	-0.81	-0.79	-0.75	-0.77	-0.79	-0.79	-0.78	-0.75	-0.77
V & F	-0.97	-0.97	-0.97	-0.97	-0.97	-0.97	-0.98	-0.98	-0.98	-0.98	-0.97	-0.97	-0.97	-0.98	-0.98
Milk	0.76	-0.10	-0.57	-0.84	-0.73	-0.43	-0.62	-0.75	-0.88	-0.84	-0.04	-0.37	-0.64	-0.86	-0.78
Oil	-0.80	-0.80	-0.79	-0.77	-0.78	-0.84	-0.84	-0.83	-0.79	-0.81	-0.82	-0.82	-0.81	-0.78	-0.80
Sugar	-0.60	-0.67	-0.72	-0.75	-0.73	-0.76	-0.75	-0.74	-0.70	-0.72	-0.69	-0.70	-0.73	-0.73	-0.73
MFE	-3.16	-2.83	-2.52	-2.25	-2.38	-2.67	-2.46	-2.29	-2.06	-2.13	-2.91	-2.68	-2.43	-2.15	-2.26
Compensated own-price elasticity															
Cereals	-0.40	-0.43	-0.45	-0.45	-0.46	-0.44	-0.44	-0.44	-0.41	-0.43	-0.42	-0.44	-0.45	-0.44	-0.45
Pulses	-0.72	-0.74	-0.75	-0.74	-0.74	-0.79	-0.78	-0.77	-0.74	-0.75	-0.76	-0.76	-0.75	-0.74	-0.75
V & F	-0.90	-0.90	-0.91	-0.92	-0.92	-0.91	-0.91	-0.92	-0.93	-0.93	-0.91	-0.91	-0.91	-0.93	-0.92
Milk	0.84	-0.01	-0.46	-0.72	-0.62	-0.34	-0.52	-0.64	-0.78	-0.74	0.04	-0.28	-0.54	-0.75	-0.68
Oil	-0.76	-0.77	-0.77	-0.76	-0.76	-0.81	-0.81	-0.80	-0.78	-0.79	-0.79	-0.78	-0.78	-0.77	-0.78
Sugar	-0.58	-0.65	-0.70	-0.74	-0.72	-0.74	-0.73	-0.72	-0.69	-0.70	-0.67	-0.69	-0.71	-0.72	-0.71
MFE	-3.11	-2.78	-2.47	-2.20	-2.33	-2.62	-2.41	-2.24	-2.01	-2.09	-2.86	-2.63	-2.38	-2.10	-2.22

Note: V&F=Vegetables and fruits; MFE= Meat, fish and eggs.

Table A3. Price elasticity of demand for major food groups in India

Groups	*Rural*							*Urban*							*All India*						
	Cer.	*Pul.*	*V&F*	*Milk*	*Oil*	*Sugar*	*MFE*	*Cer.*	*Pul.*	*V&F*	*Milk*	*Oil*	*Sugar*	*MFE*	*Cer.*	*Pul.*	*V&F*	*Milk*	*Oil*	*Sugar*	*MFE*
Uncompensated price elasticity																					
Cereals	-0.50	-0.01	0.14	-0.13	-0.01	-0.05	0.23	-0.44	-0.02	0.22	-0.14	-0.01	-0.07	0.32	-0.48	-0.02	0.17	-0.13	-0.01	-0.06	0.26
Pulses	-0.37	-0.77	0.07	0.02	-0.06	0.01	0.12	-0.33	-0.77	0.08	0.03	-0.05	0.01	0.12	-0.35	-0.77	0.08	0.02	-0.06	0.01	0.12
V&F	0.05	0.02	-0.97	-0.08	-0.01	0.02	-0.21	0.06	0.02	-0.98	-0.07	-0.01	0.01	-0.17	0.06	0.02	-0.98	-0.08	-0.01	0.02	-0.19
Milk	-1.08	-0.07	-0.19	-0.73	-0.02	0.05	0.01	-0.75	-0.05	-0.18	-0.84	-0.03	0.04	0.00	-0.91	-0.06	-0.19	-0.78	-0.02	0.05	0.00
Oil	-0.32	-0.06	0.02	0.14	-0.78	-0.04	0.14	-0.26	-0.04	0.03	0.14	-0.81	-0.03	0.13	-0.29	-0.05	0.02	0.14	-0.80	-0.04	0.13
Sugar	-0.93	-0.01	0.04	0.32	-0.09	-0.73	0.09	-0.94	-0.02	0.03	0.32	-0.10	-0.72	0.09	-0.93	-0.01	0.04	0.32	-0.09	-0.73	0.09
MFE	0.67	0.04	-0.61	0.00	0.05	0.02	-2.38	0.65	0.03	-0.53	-0.05	0.03	0.02	-2.13	0.66	0.03	-0.57	-0.02	0.04	0.02	-2.26
Compensated price elasticity																					
Cereals	-0.46	-0.01	0.16	-0.11	0.00	-0.04	0.24	-0.43	-0.02	0.22	-0.13	0.00	-0.07	0.32	-0.45	-0.01	0.18	-0.12	0.00	-0.05	0.27
Pulses	-0.23	-0.74	0.12	0.07	-0.04	0.02	0.14	-0.26	-0.75	0.13	0.08	-0.03	0.02	0.14	-0.25	-0.75	0.12	0.07	-0.04	0.02	0.14
V&F	0.22	0.05	-0.92	-0.02	0.02	0.03	-0.19	0.15	0.04	-0.93	-0.01	0.01	0.03	-0.15	0.19	0.04	-0.92	-0.01	0.01	0.03	-0.17
Milk	-0.79	-0.02	-0.10	-0.62	0.02	0.08	0.06	-0.60	-0.02	-0.10	-0.74	0.01	0.06	0.03	-0.70	-0.02	-0.10	-0.68	0.02	0.07	0.05
Oil	-0.19	-0.04	0.06	0.19	-0.76	-0.03	0.16	-0.19	-0.03	0.07	0.19	-0.79	-0.02	0.15	-0.20	-0.03	0.07	0.18	-0.78	-0.03	0.15
Sugar	-0.74	0.02	0.10	0.40	-0.06	-0.72	0.12	-0.83	0.01	0.09	0.40	-0.07	-0.70	0.12	-0.79	0.01	0.10	0.40	-0.07	-0.71	0.12
MFE	0.99	0.09	-0.51	0.12	0.10	0.05	-2.33	0.81	0.06	-0.44	0.06	0.07	0.04	-2.09	0.89	0.08	-0.48	0.09	0.09	0.04	-2.22

Note: V&F=Vegetables and fruits; MFE= Meat, fish and eggs.

Table A4. Actual Consumption and Projected Demand for Cereal in 2005- Validation Exercise for QUAIDS Model.

Source	*Annual per capita consumption of cereals (kg)*	*Total Consumption (million metric tonnes)*
NSS report, 61st round	138.63	151.7
NSS unit level data 61st round	141.69	155.0
QUAIDS model projection	143.62	157.1

Note: Population figures as given by Registrar general for 2005 of 1094.10 millions.

QUAIDS model numbers are under the assumption of India GDP of 7%.

NSS report present numbers for all India rural and all India urban only thus calculations are done to arrive at the total all India numbers. It is assumed that urban and rural weights of 0.26 and 0.74 respectively.

♦ ♦ ♦