Estimating The Demand For Food And Non-Food Items Using An Almost Ideal Demand System Modelling Approach[T]

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Abstract

An Almost Ideal Demand System model is used to examine consumer behaviour in India using household survey data for the period 1973-74 through to 1993-94. The empirical results indicate that, for commodity groups, demand is inelastic, except for other foods and non-foods. The expenditure elasticity estimates indicate that milk and non-foods are luxury goods, while pulses, cereals, edible oil, meats, fruits and vegetables and other foods are necessities in the Indian diet. The results indicate that, for any increase in future expenditure, the largest percentage increase will be allocated to non-foods, followed by cereal, other foods, milk, fruits and vegetables, edible oil, pulses and meats, in that order. Estimates of future food supply and demand growth in India indicate that the gap between growth in domestic demand and domestic production is large, particularly for commodities such as pulses (deficit growing at 2.47% p.a.), but low for others like edible oils (0.02% p.a. deficit) and cereal (0.26% p.a. deficit). As a result, India is likely to see large increases in food imports in the future.

Key words: AIDS and LA/AIDS models, India, demand for food and non-foods.

1. Introduction

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India, is experiencing fundamental economic and social transformation. These forces are causing wrenching changes resulting in market development, changes in tastes and preferences, changes in relative price of agricultural and non-agricultural products, urbanisation and disparity of incomes. The changes in taste engendered by urbanisation and economic growth has given consumers greater freedom and alternatives in their consumption decisions. This has induced a notable shift in their food consumption patterns away from traditional products toward value-added products. The perceived cost of overcoming explicit trade barriers has decreased as a result of macroeconomic stabilisation and structural adjustment policies advocated by multilateral agencies and implemented by the Government of India. The changes in relative prices of agricultural and non-agricultural products and urbanisation have spurred growth in domestic demand for both agricultural and non-agricultural products.

Recent domestic and international trade and marketing policies initiated by the Government of India are going to have significant impact on the demand for food and non-food items not only in India but globally. Despite dramatic increases in food production, the rapid population growth and increases in per capita income of households have caused India to still import significant quantities of agricultural products. The future of imports of agricultural products to India depends largely on sustained growth in the demand for agricultural products. Knowledge about the structure of household demand for food products is of critical importance to exporters to the Indian food economy. To understand the potential of household demand for agricultural products, an analysis of the structure of demand for food in this potentially high growth market is essential.

A number of previous studies have estimated food demand relationships in India. These studies have employed complete demand system modelling approaches that take into account mutual interdependence of a large number of commodities in the budget decisions of consumers. Of particular relevance are the studies by Radhakrishna and Ravi (1990) and Kumar et al. (1994). Radhakrishna and Ravi (1990) employed the linear expenditure system model while Kumar et al. (1994) employed the food characteristic demand system modelling approach to examine the structure of food demand of households in India. Both studies found that cereal consumption, which constitutes the largest share of the household food basket, has the lowest demand and expenditure elasticity. Radhakrishna and Ravi (1990) found that milk and non-foods are luxury products for rural dwellers, while non-food items is a luxury product for urban dwellers. For Kumar et al. (1994), they found that non-food items is a luxury product for both rural and urban dwellers.

Understanding the consumption pattern of households in one of the largest producing and consuming countries under recent changing policies is particularly important for exporting countries of agricultural products. This study seeks to provide an insight into the structure of household demand for food and non-food items, focusing primarily on the demand for food in India. This study uses pooled cross-sectional and time-series data on expenditures on broad food groups and non-food items published by the National Sample Survey Organisation (NSSO) of India for the period 1973-74 through to 1993-94.

The rest of this paper is organised as follows. Section 2 describes briefly historical trends in household expenditure on food and non-food items in India during the study period. Section 3 discusses the LA/AIDS model and provides a description and sources of data used in the analysis. Section 4 presents the empirical results of the LA/AIDS model of the Indian food sector. Section 5 presents a summary of the major findings.

2. Trends in household expenditure on food and non-food items in India

This section describes historical trends in household expenditure on food and non-food items in India during the period 1973-74 through to 1993-94. The pattern of consumption of food and non-foods is changing in India (Table 1). Table 1 indicates that total per capita expenditure of non-food items increased while that for cereals decreased dramatically during the study period. During the period 1973-74, non-food items comprised about 31% of total budget of households, increasing to 39% in 1993-94. In 1973-74, Indian households spent roughly 36% of their budget on cereals, but it declined to about 22% in 1993-94. Expenditure on pulses increased slightly from 3.4% in 1973-74 to 3.7% in 1993-94. In 1973-74, the budget shares for other food groups were 6.6% for milk, 4.0% for edible oils, 2.7% for meats, 5.4% for fruits and vegetables. The budget shares for milk and fruits and vegetables of total household budget increased dramatically to 8.9% and 8.0%, respectively in 1993-94. There were modest increases in the budget shares for edible oils (4.6%) and meats (3.3%). The expenditure on other foods had remained constant over the study period.

Table 1: Trends in household expenditure on food and non-foods in India

Round	Pulses	Cereal	Milk	Edible oil	Meats	Fruits & veges.	Other foods	Non-foods
27	3.4	36.0	6.6	4.0	2.7	5.4	11.0	31.0
28	3.2	38.0	6.7	4.2	2.9	5.6	11.0	29.0
32	3.6	30.0	6.7	3.9	2.9	5.5	10.0	37.0
38	3.4	27.0	7.9	4.4	3.2	6.5	10.0	37.0
42	4.0	25.0	8.8	5.4	4.0	7.3	10.0	35.0
43	3.9	23.0	7.9	5.3	3.3	7.3	10.0	39.0
50	3.7	22.0	8.9	4.6	3.3	8.0	11.0	39.0

Source: NSSO (1995)

Table 1 shows that the increase in expenditure on pulses, milk, meats, fruits and vegetables and edible oils increased quite dramatically while expenditure on cereal declined by about 38% over the period 1973-74 through to 1993-94. This trend supports the general assertion that economic growth and urbanisation in India has given consumers greater freedom and alternatives in their expenditure decisions. This led to a shift in food expenditure pattern away from traditional products- cereals, to high-quality products, such as milk and fruits and vegetables and non foods.

3. The Model

The Almost Ideal Demand System (AIDS) modelling approach is a method for estimating demand systems. In 1980, Deaton and Muellbauer suggested the AIDS model as a particular representation of price-independent generalised logarithmic (PILOG) preferences. As Chalfant et al. (1991) notes, the AIDS model is consistent with the aggregation of individual preferences. The Linear Approximation of the Almost Ideal Demand System (LA/AIDS) employed in this study was chosen to estimate the parameters of Indian household demand system. The LA/AIDS model is flexible, consistent with the aggregation of individual preferences and provides an arbitrary first-order approximation of the demand system that satisfies the axioms of choice exactly (Deaton and Muellbauer, 1980). In addition, the LA/AIDS technique is employed in the analysis because of the relative ease of imposition of the theoretical restrictions of homogeneity, Slutsky symmetry and adding-up in the estimation of the Indian demand system.

Following Deaton and Muellbauer (1980), the budgetary share (W) allocated to the i-th commodity in the Almost Ideal Demand System (AIDS) is

(1) $$w_i = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \ln P_j + \beta_i \ln\left(\frac{X}{P}\right)$$

where w_i is budget share of the i-th good; X is total expenditure on all goods; P_j is the price of the j-th good in the group; and P is the price index defined by

(2) $$\ln P = \alpha_0 + \sum_{i=1}^{n} \alpha_i \ln P_i + \frac{1}{2} \sum_{i=1}^{n} \sum_{j=1}^{n} \gamma_{ij} \ln P_i \ln P_j$$

where α_0, α_i, β_i, and γ_{ij} are parameters to be estimated; and n=1,…, 8.

Deaton and Muellbauer (1980) suggest replacing the expression in (2) with a Stone's geometric index defined by

(3) $$\ln P = \sum_{k=1}^{n} w_k \log P_k$$

where w_k is the mean of the budget share in periods t and t-1.

Substituting (3) in (1) gives an expression of budget shares in terms of the Stone geometric index as

(4) $$w_i = \alpha_i + \sum_{i=1}^{n} \gamma_{ij} \ln P_i + \beta_i \ln\left(\frac{X}{P^*}\right)$$

The budget share equation in (4) is referred to in the econometric literature as the linear approximate of the almost ideal demand system (LA/AIDS) because the model yields a system linear in parameters.

To ensure that the LA/AIDS model provides a satisfactory approximation of the true demand system that is consistent with the underlying utility maximisation it is important to impose the basic demand restrictions of adding-up, homogeneity, and symmetry. The demand restrictions are expressed in terms of the model coefficients as follows:

$$(5) \quad \sum_{i=1}^{n} \alpha_i = 1; \quad \sum_{i=1}^{n} \gamma_{ij} = 0; \quad \sum_{i=1}^{n} \beta_i = 0 \quad \text{(Adding-up)}$$

$$(6) \quad \sum_{j=1}^{n} \gamma_{ij} = 0 \quad \text{(Homogeneity)}$$

$$(7) \quad \gamma_{ij} = \gamma_{ji} \quad \text{(Symmetry)}$$

The adding-up restriction ensures that the sum of individual expenditure is equal to total expenditure. The homogeneity restriction ensures that the demand equation is homogenous of degree zero in incomes and prices. The Slutsky symmetry assures consistency of choice on the part of the consumer. Assume that the group prices are fixed, the Marshallian or uncompensated measures of own-price and cross-price elasticities are computed from the estimated parameters of the LA/AIDS model in (4), following Hayes et al. (1989), as

$$(8) \quad \varepsilon_{ii} = 1 + \frac{\gamma_{ij}}{W_i} - \beta_i$$

$$(9) \quad \varepsilon_{ij} = \frac{\gamma_{ij}}{W_i} - \beta_i \left(\frac{W_j}{W_i} \right)$$

where ε denotes the uncompensated price elasticity measure.

The expenditure elasticity measure is given by:

$$(10) \quad \eta_{ii} = 1 + \left(\frac{\beta_i}{W_i} \right)$$

where the variables are as defined above.

Data

The estimation of the LA/AIDS model for India requires data on budget shares of food groups and non-food items and their corresponding prices. Data on expenditure on pulses, cereal, milk, meats, edible oil, fruits and vegetables, other foods (which includes beverages, drinks, spices and condiments) and non-foods were obtained from national household sample surveys conducted by the National Sample Survey Organisation (NSSO) of India for the period 1973-74 to 1993-94. Budget shares of food groups and non-food items were obtained by dividing household expenditure on a particular commodity group by total household expenditure. National retail price for food groups and non-food items are available, but retail prices for urban and rural dwellers are not published. Retail prices for urban and rural dwellers were calculated by weighting the respective aggregate price indices by the share of consumption by urban and rural dwellers. Data on price indices of food groups and non-food items were obtained from Ravi (1999).

4. Model Results

The LA/AIDS model in (4) is estimated using the iterative seemingly unrelated regression procedure in SHAZAM (Version 8.0) econometric package (White, 1993), which converges to the maximum likelihood estimator. Because food and non-food expenditure shares sum to one, a demand system composed of eight individual expenditure share equations would be singular. Therefore, one of the equations must be omitted to estimate the equations as a system. The non-foods equation was chosen for deletion in this study. The final model estimated consist of seven budget share equations of pulses, cereal, milk, edible oil, meats, fruits and vegetables, and other foods. The model was estimated, with restrictions in (4) to (6) imposed, and using 336 effective observations (8 equations and 42 observations). The system approach was adopted in preference to single equation estimation because it accounts for the relationship between different goods and accommodates the presence of contemporaneous correlation between error terms of the different equations within the system. The systems approach permits the imposition of demand theory restrictions and provides a more-efficient parameter estimates than single OLS estimation of each equation (Ahmadi-Esfahani, 1998). The usefulness of the system approach is that it yields maximum likelihood estimates that are invariant to the equation deleted in the final model estimation (Chalfant, 1987).

The estimated coefficients of the seven-equation system are presented in Table 2. Nearly half of the estimated parameters are significant at a 10% level. The parameters of the omitted equation (the non-foods equation) were derived using the adding-up restrictions. The diagnostic test statistic of the goodness-of-fit of the estimated equations and the presence of autocorrelation are presented in Table 2. The estimated R^2-values range from 0.66 for the meats equation to 0.92 for the cereal equation. The high R^2-values indicate that the model explains well the budget shares of food products in the household budget. The estimated Durbin-Watson (D-W) statistics range from 2.121 for the other food demand equation to

2.491 for the fruits and vegetables demand equation. The D-W statistics show no evidence of the presence of autocorrelation in the residuals, suggesting that the specification of the model is consistent with household consumption patterns in India. Motonicity condition is satisfied if the predicted budget shares are all between 0 and 1. All the predicted budget shares were between 0 and 1, implying that the monotonicity condition is satisfied. This ensures that the predicted quantities consumed are positive.

Table 2: Parameter estimates of the LA/AIDS model: Indian household survey data

Para. esti.	Pulses	Cereal	Milk	Edible Oil	Meats	Fruits & veges.	Other foods	Non-foods
α_{i0}	4.45E-02 (9.62E-03)	0.54584 (6.69E-02)	-1.78E-02 (2.86E-02)	3.93E-02 (9.37E-03)	4.23E-02 (2.23E-02)	2.60E-02 (1.92E-02)	0.14157 (1.66E-02)	1.8E-01 (-)
α_{i1}	1.71E-02 (4.50E-03)	-	-	-	-	-	-	-
α_{i2}	-2.05E-02 (7.09E-03)	8.93E-02 (5.05E-02)	-	-	-	-	-	-
α_{i3}	-8.32E-03 (1.08E-02)	-1.31E-02 (3.38E-02)	6.50E-02 (4.52E-02)		-	-	-	-
α_{i4}	4.25E-03 (3.30E-03)	-2.05E-02 (7.36E-03)	-3.50E-03 (1.03E-02)	2.30E-02 (3.97E-03)	-	-	-	-
α_{i5}	6.51E-04 (5.43E-03)	-2.86E-03 (9.29E-03)	-3.08E-02 (1.28E-02)	1.11E-03 (4.83E-03)	1.44E-02 (1.46E-02)		-	-
α_{i6}	5.07E-03 (4.84E-03)	-9.76E-03 (9.25E-03)	1.69E-03 (1.20E-02)	1.02E-02 (4.07E-03)	1.88E-02 (1.21E-02)	-9.67E-03 (1.15E-02)		-
α_{i7}	5.11E-03 (2.92E-03)	1.04E-02 (1.51E-02)	4.02E-03 (1.22E-02)	-7.59E-03 (2.89E-03)	-5.25E-09 (3.33E-03)	-1.56E-03 (3.23E-03)	-1.19E-02 (8.73E-03)	
α_{i8}	1.8E-01 (-)	-3.4E-03 (-)	-3.3E-02 (-)	-1.5E-02 (-)	-6.9E-03 (-)	-1.3E-03 (-)	1.60E-03 (-)	-7.3E-02 (-)
β_i	-5.74E-03 (1.47E-03)	-9.65E-02 (1.50E-02)	5.74E-03 (4.71E-03)	-5.57E-03 (1.60E-03)	-3.71E-03 (1.31E-03)	-5.82E-03 (1.76E-03)	-4.79E-03 (3.84E-03)	1.1E-01 (-)
DS[c]	R^2=0.80 D-W=2.22	R^2=0.92 D-W=2.31	R^2=0.76 D-W=2.31	R^2=0.83 D-W=2.45	R^2=0.66 D-W=2.48	R^2=0.84 D-W=2.49	R^2=0.70 D-W=2.12	-

[a]Standard errors are given in parenthesis
[b]Derived from imposed restrictions.
[c]Denotes diagnostic statistics.

Table 3 presents the estimated price elasticities for food groups and non-food items in

India. Diagonal elements represent the own-price elasticities. The elasticity estimates were calculated at the mean budget shares observed in the sample. The uncompensated own-price elasticities of demand for food groups and non-foods are negative and statistically significant at a 90% confidence level. The exception is milk for which the own-price elasticity of demand is statistically non-significant at a 90% confidence level. This indicates that the demand for milk within the range observed during the study period appear to be price-indifferent. The uncompensated own-price elasticities of demand for food groups range from –0.487 for edible oil to –1.143 for fruits and vegetables. Generally, the own-price elasticities of demand for food groups are less than one. The exceptions are fruits and vegetables estimated to be –1.143, and other foods estimated to be -1.11. As expected, own-price elasticities of demand for food groups is generally smaller than that for non-foods, reflecting the continuing importance of food items in the Indian diet. Most of the cross-price elasticities are statistically non-significant at a 90% confidence level, suggesting that, in general, substitution between food-groups is non-existent in India.

Table 3. Estimated price elasticity for food and non-foods: Indian household survey data

	Elasticity with respect to the price of:							
Commodity	Pulses	Cereal	Milk	Edible oils	Meats	Fruits & veges	Other foods	Non-foods
Pulses	**-0.517**	-0.524	-0.220	0.126	0.023	0.152	0.159	0.053
Cereal	-0.059	**-0.593**	-0.020	-0.056	0.001	-0.012	0.071	0.085
Milk	-0.111	-0.192	**-0.156**	-0.049	-0.404	0.017	0.045	-0.042
Edible oil	0.098	-0.417	-0.068	**-0.487**	0.028	0.233	-0.155	0.036
Meats	0.025	-0.056	-0.958	0.040	**-0.544**	0.599	0.012	0.040
Fruits & veges	0.081	-0.124	0.033	0.161	0.292	**-1.143**	-0.015	0.017
Other foods	0.051	0.113	0.042	-0.071	0.001	-0.012	**-1.110**	0.018
Non-foods	-0.022	-0.189	-0.068	-0.035	-0.014	-0.063	-0.030	**-1.173**

Table 4 presents the estimated expenditure elasticity for food groups and non-foods. The estimated expenditure elasticity is significant for all commodity groups at a 90% confidence level. All the expenditure elasticities are positive, as expected. The estimated expenditure elasticity range from 0.67 for cereals to 1.33 for non-foods. Consumption of food is inelastic, except for milk. The expenditure elasticity of the consumption of fruits and vegetables and other foods are close to one, while the consumption of non-food items is elastic. Based on the empirical results, with the exception of milk, food consumed by Indian households are necessities. Milk and non-food items are luxury products; an increase in income would lead to an increase in consumption of these products.

In order to estimate the marginal expenditure shares, this study adopts the approach proposed by Powell (1974). Marginal expenditure share is calculated by multiplying the estimated expenditure elasticities by the corresponding expenditure share and presented in Table 4. Column 4 of Table 4 presents the estimated marginal expenditure shares of commodities. Table 4 indicates that, for any increase in future expenditures, the largest percentage increase will be allocated to non-foods, followed by cereal, other foods, milk, fruits and vegetables, edible oil, pulses and meats, in that order. The finding that the smallest percentage of increase will be allocated to meats is consistent with the fact that most households are vegetarians in India. The empirical results demonstrate that cereal consumption will continue to decrease into the future, suggesting a decline in the importance of cereal in Indian diet. The marginal share of pulses is relatively small compared with other food groups, suggesting that a smaller percentage of expenditure will be allocated to future pulse consumption, given an increase in incomes of households in India. Comparison of expenditure share of pulses with those in Table 1 suggests a slight decline in household consumption of pulses.

Table 4. Expenditure elasticity, Expenditure shares, and Marginal expenditure shares of various commodity groups: Indian household survey data

Commodity	Expenditure elasticity	Expenditure share	Marginal expenditure share
		Percentage	
Pulses	0.840	3.60	3.02
Cereal	0.665	28.80	19.15
Milk	1.075	7.70	8.28
Edible oil	0.877	4.50	3.95
Meats	0.883	3.20	2.83
Fruits and veges	0.911	6.50	5.92
Other foods	0.954	10.40	9.91
Non-foods	1.330	35.30	46.94
Total		100.00	100.00

A review of earlier Indian demand studies reveal that the elasticity estimates reported vary considerably. For example, the estimated expenditure elasticity estimates reported by Radhakrishna and Ravi (1990) range from 0.029 for coarse grains to 1.595 for non-foods for rural dwellers. For urban dwellers, the expenditure elasticity ranges from -0.26 for coarse grains to 1.403 for non-foods. For Kumar et al. (1994), the expenditure elasticity estimates range between -0.132 for coarse grains and 2.247 for non-foods for rural dwellers. For urban dwellers, the estimated expenditure ranges from -0.176 for coarse grains to 1.866 for non-foods. Comparison of expenditure elasticity estimates reveal that, overall, the elasticity estimates reported in this study compare quite favourably with those reported by Radhakrishna and Ravi (1990) for rural and urban dwellers in India. However, they differ considerably from those reported by Kumar et al. (1994). It is interesting to note that the low expenditure elasticity of cereal compared to other food groups and non-foods reported in this study is consistent with earlier Indian studies. The expenditure elasticity estimates reported in this study and earlier Indian studies differ for several reasons. The difference may be due to methodology used in the analysis. While the LA/AIDS modelling approach used in this study is similar to that employed by Radhakrishna and Ravi (1990), they differ in terms of the study period; this study incorporates a household sample survey round. The difference between the elasticity estimates reported in this study with those of Kumar et al (1994) may be due to the fact that Kumar et al. used a linear expenditure system modelling approach. Another reason for differences in the empirical results is the nature of aggregation of the data. This study examines consumer response at the aggregate level while earlier demand studies examined consumer behaviour reported elasticities for rural and urban dwellers in India.

Income growth and population growth will remain an important determinant of India's food balance. Based on Food and Agriculture Organisation's (FAO) time-series data on India’s population, the population growth rate for India was estimated to be 2.06 per cent per annum over the period 1974 through to 1994 (FAO, 1999). The Gross National Product growth rate for India for 1995 of 5.3 per cent per annum was obtained from Allinda (Allinda, 1995). By assuming these values for population growth rate and income growth rate, total demand and supply of agricultural products were estimated and presented in Table 5.

Table 5: Estimated gap between food demand and supply growth in India

	Pulses	Cereals	Milk	Edible oils	Meats	Fruits & veges
Supply [S]	2.29	3.92	4.56	4.87	3.59	3.20
Demand [D]	4.76	4.18	5.57	4.89	4.89	4.99
Gap [S-D]	-2.47	-0.26	-1.01	-0.02	-1.30	-1.79

The empirical results indicate a gap between food demand and supply growth in India. The domestic production increase required above the current domestic production growth rate are 2.47% for pulses, 1.79% for fruits and vegetables, 1.30 for meats, 1.01 for milk, 0.26 for cereal and 0.02% for edible oil. An important question facing exporters of agricultural products is whether India is capable of meeting its domestic demand for agricultural products. The experience of India suggests that the demand and supply of agricultural products will be influenced by a number of key economic, political, social and dietary and technological factors. The Government of India's investments in irrigation, rural infrastructure, agricultural research and extension services, coupled with domestic reforms in marketing and trade have helped India to achieve dramatic increases in food production over the last two-to-three decades. These policies may have shifted comparative advantage in the production of away from pulses to cereal production. This gave India a competitive edge in the export trade with significant quantities of wheat and rice exported in some years (Kelley, 1999). Thus, India is capable of becoming a major player in world trade for key commodities. It is important to note that although the empirical results of this study suggest that there is a potential market for export of agricultural products to Indian food economy, this potentially lucrative market should be approached cautiously.

5. Concluding Remarks

This study has applied a LA/AIDS model to examine the structure of demand for food and non-foods items in India using national household sample survey data for the period 1973-74 through to 1993-94. Seven expenditure share equations were estimated. The empirical findings are summarised. First, the expenditure elasticities for food groups are inelastic, except for milk. The implication is that food groups of pulses, cereals, meats, edible oil, fruits and vegetables and other foods are necessities in the Indian diet. Milk and non-foods are luxury goods. Second, in general, the own-price elasticities of demand for food groups are inelastic. Consumption of cereal has the lowest own-price elasticity of demand, suggesting the importance of cereal in the Indian diet. Third, the estimated expenditure shares reveal that for any increase in future expenditure the largest percentage increase will be allocated to non-foods, followed by cereal, other foods, milk, fruits and vegetables, edible oil, pulses and meats, in that order. Conservatively, one would say that the Indian food economy is stable, given that the own-price elasticities of demand for most food groups are inelastic. However, recent policy reforms in marketing and trade are likely to influence consumer behaviour. The estimated gap between food demand and supply growth indicate that the domestic demand for food could outstrip domestic supply, given an increase in income and population growth. As a result, India is likely to see large increases in food imports in the future.

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