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ESTIMATION OF HOUSEHOLD DEMAND THROUGH ALMOST IDEAL DEMAND SYSTEM MODEL

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ABSTRACT. There are quite a number of models to describe the consumer expenditure. Not all models are well suited to explain the household budget, cross section data and some of them are overly restrictive. The Almost Ideal Demand System (AIDS) model permits a fairly simple interpretation of the estimated coefficients. The cross sectional data collected from the sample respondents were subjected to AIDS analysis to estimate the household demand for different commodities. The data collected on household food expenditure and demographic aspects were used in the estimation of AIDS. In the AIDS, the average budget shares were linearly related to composite food prices, real per capita food expenditure and household size. The homogeneity and symmetric restrictions were also imposed in the estimation of structural parameters of AIDS model. The results would show that most of the estimated parameters are statistically significant. The structural parameter estimates are of interest for technical comparisons. The statistical significance of these coefficients suggests that food demands were responsive to prices, total food expenditure level and household size, as measured from the survey data.

INTRODUCTION

There are quite a number of models to describe the consumer expenditure. Not all models are well suited to explain the household budget, cross section data and some of them are overly restrictive. The Almost Ideal Demand System (AIDS) proposed by Deaton and Muellbauer (1980) suffers from neither of these drawbacks. The advantages of their system are: (i) it gives an arbitrary first order approximation to any demand system, (ii) it satisfies the axioms of choice exactly, (iii) it aggregates perfectly over consumers, (iv) it has a functional form, which is consistent with the household budget data, (v) it is simple to estimate in its linear expenditure form and (vi) it can be used to test homogeneity and symmetry conditions.

Moreover, the AIDS, in addition to the above desirable properties, does not impose the severe substitution limitations implied by additive demand models such as the Linear Expenditure System (LES). Hence, AIDS was preferred over the other approaches for the present study.

The model expresses the i^{th} budget share w_i, as a function of logarithm of total expenditure Y,

$$w_i = \alpha_i + \beta_i \log Y \qquad (1)$$

where, w_i = Budget share of i^{th} good, and

Y = Total expenditure

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α_i and β_i are the parameters of the i^{th} good.

This model was further extended by Deaton and Muellbaeur (1980) to include the effect of prices. The resultant demand system for the AIDS was derived by using duality concepts from a particular cost function, defined as the minimum expenditure necessary to attain a specific level of utility at given prices. Considering the following general cost function,

$$\log C(u,p) = (1-u)\log a(p) + u \log b(p) \tag{2}$$

where,

$$\log a(p) = \alpha_0 + \sum_k \alpha_k \log p_k + \tfrac{1}{2}\sum_k \sum_j \gamma_{kj} \log p_k \log p_j \tag{3}$$

$$\log b(p) = \log a(p) + \beta_0 \prod_k p_k \beta_k \tag{4}$$

C (u,p) = Cost function for utility “u” and prices “p”

M(u,p) = Minimum expenditure function at utility level “u” and prices “p”

C(u,p) = M(u,p) = Y

From equation (2)

$$\log C(u,p) = \log a(p) - u \log a(p) + u \log b(p)$$

$$= \log a(p) + u[\log b(p) - \log a(p)]$$

Using equation (4), we get

$$\log C(u,p) = \log a(p) + u\beta_0 \prod_k p_k \beta_k \tag{5}$$

That is,

$$\log C(u,p) = \alpha_0 + \sum_k \alpha_k \log p_k + \tfrac{1}{2}\sum_k \sum_j \gamma_{kj} \log p_k \log p_j + u\beta_0 \prod_k p_k \beta_k \tag{6}$$

And applying Shepard’s Lemma, which is by differentiating equation (6) with respect to prices, compensated demand functions are obtained. Mathematically the Shepard’s Lemma is

$$\frac{\partial C(u,p)}{\partial p_i} = q_i(u,p)$$

i.e., $$\frac{\partial C(u,p)}{\partial p_i} = q_i \tag{7}$$

By multiplying both sides of (7) by $\frac{p_i}{C(u,p)}$

Equation (7) becomes $$\frac{p_i}{C(u,p)} \frac{\partial C(u,p)}{\partial p_i} = \frac{p_i q_i}{C(u,p)}$$

i.e., $$\frac{\partial \log C(u,p)}{\partial \log p_i} = \frac{p_i q_i}{C(u,p)}$$

i.e., $$\frac{\partial \log C(u,p)}{\partial \log P_i} = W_i(u,p) = W_i \tag{8}$$

where, W_i = expenditure share of the i^{th} good; differentiating (6) partially with respect to logarithm of prices, we get,

$$\frac{\partial \log C(u,p)}{\partial \log p_i} = \alpha_i + ½ \sum_j \gamma_{ij} \log p_j + u \beta_0 \prod_k p_k \beta_k$$

from (8)

$$W_i = \alpha_i + ½ \sum_j \gamma_{ij} \log p_j + u \beta_0 \prod_k p_k \beta_k \tag{9}$$

Substituting (5) in (6), then by solving for u in terms of p and Y, we get,

$$\log Y = \alpha_0 + \sum_k \alpha_k \log p_k + ½ \sum_k \sum_j \gamma_{kj} \log p_k \log p_j + u\beta_0 \prod_k p_k \beta_k$$

$$u\beta_0 \prod_k p_k \beta_k = \log Y - (\alpha_0 + \sum_k \alpha_k \log p_k + ½ \sum_k \sum_j \gamma_{kj} \log p_k \log p_j) \tag{10}$$

Substituting equation (10) in (9), we get

$$W_i = \alpha_i + ½ \sum_j \gamma_{ij} \log p_j + \log Y - (\alpha_0 + \sum_k \alpha_k \log p_k + ½ \sum_k \sum_j \gamma_{kj} \log p_k \log p_j) \tag{11}$$

Then AIDS in the budget share form is,

$$W_i = \alpha_i + ½ \sum_j \gamma_{ij} \log p_j + \log Y - \log P$$

$$W_i = \alpha_i + \tfrac{1}{2}\sum_j \gamma_{ij} \log p_j + \log(Y/P), \qquad \text{for } i = 1,2,3,\ldots,n \tag{12}$$

where, P is a price index defined in terms of individual prices by

$$\log P = \alpha_0 + \sum_k \alpha_k \log p_k + \tfrac{1}{2}\sum_k \sum_j \gamma_{kj} \log p_k \log p_j \tag{13}$$

The adding up restrictions imply $\sum_i \alpha_i = 1, \ \sum_i \gamma_{ij} = 0, \ \sum_i \beta_i = 0$

$\sum_i \gamma_{ij} = 0$; Homogeneity

$\gamma_{ij} = \gamma_{ji}$ = symmetry

These constraints ensure that the system satisfied adding up, homogeneity in prices and income and Slutsky symmetry conditions, where α_i, β_i, γ_{ij}, (i, j = 1…n), are parameters.

The price formulation (13) makes the demand system (12) a non-linear system of equations for estimation requiring maximum likelihood techniques. The large number of parameters which need to be estimated, in addition to the collinearity frequently found among prices often results in computational problems, particularly if the sample size in a group is not very large. Due to such problems, the maximum likelihood estimation procedure did not converge. The AIDS presented in equation (12) does not incorporate family size explicitly. To include family size, Ray (1980) used the household utility function and replaced ‘P’ by a normalized price ‘mp’ where ‘m’ denotes family size. Hence in the present study, family size “m” was used, as a deflator for total expenditure.

$$W_i = \alpha_i + \beta_i \log\left(Y/mp^k\right) + \sum_j \gamma_{ij} \log\left(p_{jm}\right)$$

$$W_i = \alpha_i + \beta_i \log\left(Y/p^k\right) + \sum_j \gamma_{ij} \log p_j + \theta \log m \tag{14}$$

where, $y = Y/m$ is per capita household expenditure and $\gamma_{ij}, \theta\left(= \sum_i^m \gamma_{ij}\right)$ are effects of prices and family size respectively. The AIDS model was estimated by Shazam Computer Package.

Elasticities : The demand elasticities corresponding to the linear version of the AIDS model are:

Own price $e_{ii} = (\gamma_{ii} - \beta_i w_i)/w_i - 1$

Cross price $e_{ij} = (\gamma_{ij} - \beta_i w_j)/w_i$

Real expenditure $e_{iy} = (\beta_i / w_i) + 1$

Household Size $e_{im} = (\theta_i - \beta_i)/w_i$

The AIDS model permits a fairly simple interpretation of the estimated coefficients. The intercept represents an average budget share when all logarithm prices and real expenditure are equal to 1. The β_i (expenditure coefficients) represents the change in the i^{th} expenditure share with respect to a change in real income, all else held constant. A negative expenditure coefficient implies that the commodity is a necessity while positive coefficient indicates the commodity is a luxury. Thus the expenditure share w_i will increase with an increase in total expenditure for $\beta_i > 0$, while the opposite will be true for $\beta_i < 0$. The price coefficients represent the change in budget share for a given proportional change in price with real income held constant.

The cross sectional data collected from the sample respondents were subjected to AIDS analysis to estimate the household demand for different commodities. The data collected on household food expenditure and demographic aspects were used in the estimation of AIDS. Based on the consumption pattern of the sample households, eight major food commodities were identified. They were rice, other cereals, pulses, oils, sugar, fruits, vegetables and milk.

The household expenditure on these selected food commodities were expressed as a fraction of total food expenditure. Household size was the only demographic variable used in the model. In the AIDS, the average budget shares were linearly related to composite food prices, real per capita food expenditure and household size. The homogeneity and symmetric restrictions were also imposed in the estimation of structural parameters of AIDS model. The different elasticity estimates, viz., own price, cross price, income and household size were derived from the parameter estimates of AIDS.

PARAMETER ESTIMATES OF THE AIDS MODEL

The estimated parameters based on the AIDS model for major food items for all the respondents are presented in Table 1. A look at Table 1 would show that most of the estimated parameters are statistically significant. The structural parameter estimates are of interest for technical comparisons. The statistical significance of these coefficients suggests that food demands were responsive to prices, total food expenditure level and household size, as measured from the survey data. These results are in broad agreement with the earlier studies (Kailasam 1991 and Kalamani 2001).

It could be seen from Table 1 that the expenditure coefficient was found to be significant for rice, oils, fruits and vegetables, thus revealing the fact that the expenditure share on rice, oils, fruits and vegetables would change with an increase in real income, with prices held constant. The expenditure coefficients for oils, fruits and vegetables were negative which indicate that the expenditure share on these commodities would decrease as real income increased. This indicated that these commodities were necessities and hence they were income inelastic.

The household size coefficient for all the income inelastic items showed positive value. The household size coefficients for rice was found to be negative and significant. It indicated that any increase in the household size would tend to reduce the expenditure share of these commodities. Conversely, oil and vegetables had positive and significant household size coefficients which illustrated that any increase in the household size would tend to increase the expenditure share of oils and vegetables. The own price coefficients for all commodities except sugar had positive value indicating their price inelastic nature. Thus the sample respondents were found to give more importance to almost all the commodities irrespective of price changes. The findings are in tune with *a priori* expectation of the behaviour of the respondents.

ELASTICITIES BASED ON AIDS

As discussed earlier, the different elasticity estimates, viz., own price, cross price, income and household size were derived from the parameter estimates of AIDS and are presented in Table 2. This would show that the own price elasticities for all the commodities, except cereals and milk, were negative. This is in conformity with the basic principles of the theory of demand, Among the food items the magnitude of elsticities was low in fruits and vegetables. Rice, the staple food, had an estimated own price elasticity of -0.8436, which indicated that if the rice price increased by 10 per cent, then demand for rice would decrease by 8.436 per cent.

Values of estimated cross price elasticities suggested that the food demand was responsive to relative price changes. Among the cross price elasticities for different commodities, most of the products were classified as cross complements (having negative values). Regarding expenditure (income) elasticities, as expected, the income elasticity for rice, pulses and sugar were more than unity which implied that these goods were income elastic. Household size elasticity for most of the commodities except rice and pulses were positive which implied their staple nature for the sample households.

The foregoing discussions would lead to the conclusion that own price elasticities for rice, sugar and vegetables were negative. Also, it was found that household size had positive effects for staples and negative for income elastic goods. This analysis confirmed that the respondents' were rational in their decision making behaviour, as economic agents. Also, as all the respondents were poor, their response to price and income changes were more or less the same.

Table 1. Parameter Estimates of AIDS Model - Category I

	Constant	Rice	Cereals	Pulses	Oils	Sugar	Fruits	Vegetables	Milk	Real per capita exp.	Household size
Rice	-0.6545***	0.1344***	-0.0120*	-0.0330**	-0.0007	-0.0083	-0.0260***	-0.0303***	-0.0241***	0.2956***	-0.2712***
	(0.1292)	(0.0171)	(0.0063)	(0.0145)	(0.0220)	(0.0074)	(0.0062)	(0.0081)	(0.0044)	(0.0349)	(0.0393)
Cereals	0.1240***	-0.0120*	0.0384***	0.0072	-0.0208*	-0.0002	-0.0042	-0.0066**	-0.0018***	-0.0104	0.0114
	(0.0360)	(0.0063)	(0.0041)	(0.0089)	(0.0110)	(0.0085)	(0.0028)	(0.0028)	(0.0003)	(0.0090)	(0.0112)
Pulses	-0.0499	-0.0330**	0.0072	0.0329	0.0244	0.0234	-0.0111	-0.0264***	-0.0175***	0.0258	-0.0049
	(0.1324)	(0.0145)	(0.0089)	(0.0380)	(0.0363)	(0.0219)	(0.0073)	(0.0085)	(0.0050)	(0.0320)	(0.0362)
Oils	0.6784**	-0.0007	-0.0208*	0.0244	0.1141*	-0.0458	-0.0015	-0.0237*	-0.0459***	-0.1967***	0.1648***
	(0.2180)	(0.0220)	(0.0110)	(0.0363)	(0.0636)	(0.0481)	(0.0118)	(0.0138)	(0.0132)	(0.0502)	(0.0566)
Sugar	-0.0216	-0.0083	-0.0002	0.0234	-0.0458	-0.0041	-0.0008	-0.0008	0.0367**	0.0076	0.0109
	(0.0505)	(0.0074)	(0.0085)	(0.0219)	(0.0481)	(0.0195)	(0.0043)	(0.0039)	(0.0163)	(0.0116)	(0.0127)
Fruits	0.1623**	-0.0260***	-0.0042	-0.0111	-0.0015	-0.0008	0.0524***	-0.0021	-0.0067***	-0.0271*	0.0228
	(0.0501)	(0.0062)	(0.0028)	(0.0073)	(0.0118)	(0.0043)	(0.0048)	(0.0046)	(0.0024)	(0.0138)	(0.0157)
Vegetables	0.4719***	-0.0303***	-0.0066**	-0.0264**	-0.0237	-0.0008	-0.0021	0.1068***	-0.0168***	-0.0835***	0.0748**
	(0.0839)	(0.0081)	(0.0028)	(0.0085)	(0.0138)	(0.0039)	(0.0046)	(0.0067)	(0.0038)	(0.0235)	(0.0305)
Milk	0.2893***	-0.0241***	-0.0018***	-0.0175***	-0.0459***	0.0367**	-0.0067***	-0.0168***	0.0762***	-0.0112	-0.0086
	(0.0303)	(0.0044)	(0.0003)	(0.0050)	(0.0132)	(0.0163)	(0.0024)	(0.0038)	(0.0172)	(0.0168)	(0.0052)

Note: Figures in parentheses indicate the standard errors; *** significant at 1% level of probability, ** significant at 5% level of probability, * significant at 10% level of probability

Table 2. Matrix of food items, price, expenditure and household elasticities

	Rice	Cereals	Pulses	Oils	Sugar	Fruits	Vegetables	Milk	Income	Household size
Rice	-0.8436	-0.0779	-0.2196	-0.2263	-0.0582	-0.1518	-0.2431	-3.8148	1.9942	-1.9060
Cereals	-0.2367	0.0285	0.2221	-0.4888	0.0031	-0.0945	-0.1347	-1.4241	0.7232	0.5795
Pulses	-0.3714	0.0572	-0.7251	0.1696	0.2070	-0.1164	-0.2748	-2.2894	1.2357	-0.2807
Oils	0.2565	-0.0593	0.2037	-0.2969	-0.1769	0.0500	0.0186	-0.1311	0.1269	1.6047
Sugar	-0.3494	-0.0159	0.7452	-1.5666	-1.1429	-0.0427	-0.0634	-3.6851	1.2493	0.1104
Fruits	-0.2760	-0.0496	-0.1248	0.0711	0.0003	-0.1650	0.0269	-1.0991	0.5821	0.7698
Vegetables	-0.0386	-0.0240	-0.1216	-0.0347	0.0119	0.0233	-0.1643	-0.7330	0.4119	1.1148
Milk	-0.2229	-0.0149	-0.1748	-0.4662	0.3978	-0.0646	-0.1639	0.8302	0.8794	0.0279

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