J. Bangladesh Agril. Univ. 8(1): 121–126, 2010 **ISSN 1810-3030**

Household demand for dairy products in Bangladesh: An Application of AIDS Model

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Abstract

A variation of the Almost Ideal Demand System (AIDS) model of Deaton and Muellbauer (1980) has been employed to determine the impacts of per capita total expenditure, food prices and demographic variables on household demand for dairy products in Bangladesh. The budget shares are generally more responsive to per capita total expenditure than to prices. With respect to demographic effects, it is found that family size and occupation of the household head have a statistically significant impact on household demand behavior.

Key words*:* Household, Demand, Dairy Products, AIDS, Elasticity

Introduction

The importance of bovine livestock to our economy cannot be over stated. Even though the sub-sector contributes only 2.92% to the GDP, it provides full and part time employment to about 20% of our rural population and accounts for 18% of our agricultural export earnings and in FY 2005-06, the growth rate of this sub sector was 6.15 percent. While the focus of this paper is dairy, meat and egg are also important contributors to our protein needs. Furthermore, the trade and export of leather products, bones and offal also have a significant contribution to our economy. Draft power is still a significant source of power for cultivation saving imported energy cost.

The consumption of milk and milk products in Bangladesh is very low even when compared to neighboring countries. The average daily consumption is 42ml per day/person against a recommended allowance of 250ml/day. However, the production of milk, meat and egg have been increasing over the past several years while the production for milk was 1.74 and 2.28 million ton in 2001 and 2007, respectively(Bangladesh Economic Review, 2007).

The household demand for a particular dairy product is usually influenced by its own price, prices of close substitutes, per capita total expenditure and demographic variables. The purpose of the present study is to gain a better understanding of the factors affecting the household demand for dairy products in Bangladesh. In doing so, the study considers the simultaneous
impacts of per capita total expenditure, food prices and demographic variables such as family size and occupation of the household head on household demand within a framework consistent with economic theory.

Estimation of a complete demand system within a framework consistent with classical demand theory was originated with Stone's (1954) pioneering contribution and now constitutes a large body of theoretical and applied literature. Although several models have been proposed so far, the most important one in current use is the Almost Ideal Demand System (AIDS) model suggested by Deaton and Muellbauer (1980). However, the original AIDS model, postulated by Deaton and Muellbauer, does not portray any demographic variables such as family size or dependency. Ray (1982) extended this AIDS model by including family size by using the Barten (1964) type household utility function.

In this study, the AIDS model is extended by simultaneous incorporation of family size and occupation of the household head to observe the impact of per capita total expenditure and food prices along with the above household characteristics on the budget shares.

The present study differs from some earlier studies (Ferdous, 1997 ; Khanam and Ferdous, 2000 ; Mullah and Ferdous, 2006 etc.) in the sense that the AIDS model considered here also includes the price variable . The study further aims at estimating own price and cross-price elasticity's of the household demand for different dairy products which was not done in those earlier studies.

Materials and Methods

The Data

The present study is based on the full set of micro-level cross section Household Income and Expenditure Survey (HIES-2000) data of 7440 households published by Bangladesh Bureau of Statistics (BBS-2002). The data were aggregated into the following 8 categories : (a) meat, (b) eggs, (c) milk, (d) butter, (e) ghee (f) cards, (g) sweets and (h) tea / coffee.

Theoretical Background

The Almost Ideal Demand System (AIDS) Model

The AIDS model started life from Engel curve estimation proposed by Leser (1976) as -

$$W_i = \alpha_i + \beta_i \log X \qquad \text{..... (1)}$$

where, W_i and X are budget share for the i-th item and total household expenditure respectively and α_i, β_i are the parameters.

However, AIDS, which is obtained from the price-independent generalized logarithmic **(PIGLOG)** cost function after the choice of appropriate functional forms, is given as :

$$W_i = \alpha_i + \beta_i \log\left(\frac{X}{P}\right) + \sum_j \gamma_{ij} \log p_j \quad ; \quad \text{.....(2)}$$

i = 1,2,...,n

where, P is a price index defined by

$$\log P = \alpha_0 + \sum_k \alpha_k \log p_k + \frac{1}{2}\sum_k \sum_j \gamma_{kj} \log p_k \log p_j \qquad \text{..... (3)}$$

and the parameters are to satisfy the following restrictions :

Adding up restrictions: $\sum_i \alpha_i = 1 \qquad \sum_i \gamma_{ij} = 0 \qquad \sum_i \beta_i = 0$

Homogeneity restriction: $\sum_j \gamma_{ij} = 0$

Symmetry restriction : $\gamma_{ij} = \gamma_{ji}$

Since the price formulation (3) makes (2) a non-linear system of equation, to avoid this, Deaton and Muellbauer (1980) adopted the Stone (1953) index as a convenient approximation :

$$\log P \cong \log P^* = \alpha_0 + \sum_k W_k \log p_k$$

Where, e^{α_0} could be interpreted, using the utility basis of the PIGLOG model, as the cost in reference year for an individual to subsist. The resulting linear system then takes the form :

$$W_i = \alpha_i + \beta_i \left[\log X - \alpha_0 - \sum_k W_k \log p_k \right] + \sum_j \gamma_{ij} \log p_j \qquad \text{..... (4)}$$

Modeling household characteristics in AIDS

The AIDS model, specified in equation (4), is without any demographic variables. Ray (1982) incorporated the family size by using the Barten (1964) type household utility function and suggested the model as -

$$W_i = \alpha_i + \beta_i \log\left(\frac{x}{P^*}\right) + \sum_j \gamma_{ij} \log p_j + \eta_i \log z \quad \text{..... (5)}$$

where, log P^* = $\alpha_0 + \sum_k W_k \log p_k$ and $x = \frac{X}{z}$ is the per capita household expenditure and γ_{ij}, η_i denote the effects of prices and family size, respectively, on budget share. Here the use of family size, z, as a deflator for X follows Houthakker (1957), Weisskoff(1971), and Sener(1977).

Model Specification

In order to further improve equation (5), the AIDS model is extended by incorporating the household characteristic 'Occupation of the household head'. Thus, the final equation becomes –

$$W_i = \alpha_i + \beta_i \log m + \sum_j \gamma_{ij} \log p_j + \eta_i \log z + \sum_k \psi_{ik} D_k + \varepsilon_i \text{ .....(6)}$$

i,j=1,2,...,8 ; k=1,2,3,4

where, ψ_{ik} is the parameter of the model.

Also $m = \frac{x}{P^*}$

p_j = prices of different commodities.

D_1 = 1, if the household head is a Cultivator/Farmer
0, otherwise
D_2 = 1, if the household head is a Service holder/Professional
0, otherwise
D_3 = 1, if the household head is a Businessman
0, otherwise
D_4 = 1, if the household head's occupation is Other than these
0, otherwise.

Here, for occupation variable, the category 'Unemployed' is considered as the reference category.

Elasticity Formulae

From the AIDS model specified in equation (6), price elasticity (PE), expenditure elasticity (EE) and size elasticity (SE) are derived as follows :

$$PE = W_i^{-1}\left(\gamma_{ij} - \beta_i W_j\right) - \delta_{ij} \quad \text{... (7a)}$$

$$EE = 1 + \frac{\beta_i}{W_i} \quad \text{... (7b)}$$

$$SE = 1 + \frac{\eta_i}{W_i} \quad \text{... (7c)}$$

where δ_{ij} in (7a) is the Kronecker delta which takes the value of one when i=j and zero when $i \neq j$.

Estimation

Data based on household-expenditure surveys often present a major estimation problem. This problem stems from the fact that, for any given household, many of the goods have zero consumption. As a solution to this problem of non-consumption, demand equations can be estimated by the censored regression model of Tobin (1958) (Tobit model) given by –

$$y_i = \beta' x_i + \varepsilon_i \ , \text{ if RHS} > 0$$

$$= 0, \text{ otherwise}$$

where, y_i is the dependent variable; x_i is a k×1 vector of known constants; β is a k×1 vector of unknown parameters; ε_i are residuals that are independently and normally distributed with mean 0 and a common variance σ^2. In the present study, the AIDS model has been estimated by Tobit regression for all the food items under consideration.

The Breusch-Pagan-Godfrey (BPG) test confirmed the presence of heteroscedasticity in the data set and to overcome this problem, we divided the model throughout by the square root of per capita total expenditure ($\sqrt{x}$). The model thus becomes a without intercept model and hence the regression-through-the-origin model was used for estimation. Then the resulting equation is –

$$\frac{W_i}{\sqrt{x}} = \frac{\alpha_i}{\sqrt{x}} + \frac{\beta_i \log m}{\sqrt{x}} + \frac{\sum_j \gamma_{ij} \log p_j}{\sqrt{x}} + \frac{\eta_i \log z}{\sqrt{x}} + \frac{\sum_k \psi_{ik} D_k}{\sqrt{x}} + \frac{\varepsilon_i}{\sqrt{x}} \quad \text{.....(8)}$$

i,j=1,2,...,8 ; k=1,2,3,4

Results and Discussions

The heteroscedasticity-corrected Tobit parameter estimates of the AIDS model as represented by equation (8) for different dairy products are shown in Table 1. The values in parentheses denote the corresponding p-values.

It is evident from Table 1 that the expenditure coefficient is statistically significant for all the dairy products considered in the present study. Thus, the budget shares for all the items are highly responsive to the expenditure variable.

Table 1 reveals a good amount of price responsiveness of budget share since a large number of price coefficients (43 out of 64) have p-values smaller than 0.05. The significance of the vast majority of the γ's implies some degree of sensitivity of the budget shares to prices. The estimated coefficients of the price variable suggest that except for meat and butter, the households are quite responsive to changes in prices in adjusting their consumption of corresponding items. With the exception for ghee and cards, unit percentage increases in own-prices yield percentage increases in budget shares. As for instance, 1% increase in the price of milk will result in 7% increase in the budget share for milk.

However, cross-price impacts, on the other hand, have substantially raised the demand for most of the goods under consideration. For example, 1% increase in the price of milk will yield 8.01% increase in the budget share for sweets.

Table 1 also indicates that the size coefficient (η_i) is highly significant for most of the items considered in the present study suggesting that household size has great impact on budget share. Moreover, the negative values of η_i for meat, butter, cards and sweets imply that with the increase of household size, the budget shares for these items will decrease.

It is also evident from Table 1 that the households whose heads are cultivators show responsiveness towards the items eggs, ghee, cards, sweets and tea / coffee. Among these items, households having head as a cultivator (D_1) spend more on cards, sweets and tea / coffee and less on the others than the households having head as an unemployed. Similarly, the budget shares are higher for meat, butter, ghee and sweets and lower for eggs and tea / coffee for the households having head as a service holder (D_2) or professional than the households having head as an unemployed. Again the households having head as a businessman (D_3) or other occupations (D_4) spend more on meat, butter and sweets and less on ghee and tea / coffee than the households having head as an unemployed.

These results are quite striking, but may be attributed to the fact that 'unemployed' is considered as the reference category in the present study and most of the household heads are usually the oldest persons who are unemployed but their sons or daughters or other household members are working.

Table 1. Tobit parameter estimates of AIDS model (Household size = 7440)

Items	α_i	β_i	γ_{i1}	γ_{i2}	γ_{i3}	γ_{i4}	γ_{i5}	γ_{i6}	γ_{i7}	γ_{i8}	η_i	ψ_{i1}	ψ_{i2}	ψ_{i3}	ψ_{i4}
Meat	-.0613 (.010)	.2367 (.000)	-.201 (.920)	.0085 (.069)	-.052 (.098)	.0621 (.020)	-.019 (.016)	-.068 (.000)	-.0957 (.008)	.0362 (.041)	-.082 (.008)	.0125 (.086)	.0089 (.000)	.0056 (.029)	.0213 (.000)
Eggs	-.0428 (.028)	.0896 (.000)	.0906 (.101)	.041 (.008)	.0151 (.000)	.0114 (.000)	.0471 (.000)	.0369 (.000)	-.0019 (.091)	-.0374 (.093)	-.014 (.080)	-.0454 (.000)	-.0007 (.000)	.0431 (.152)	-.0024 (.080)
Milk	-.0304 (.021)	-.039 (.044)	.0608 (.000)	-.0204 (.030)	.0701 (.002)	.0321 (.000)	.0129 (.068)	.0234 (.010)	.0878 (.851)	.0298 (.081)	.0438 (.001)	.0688 (.071)	.0001 (.064)	-.0007 (.061)	.0078 (.091)
Butter	-.265 (.000)	-.0251 (.000)	-.0714 (.581)	.0119 (.080)	-.0712 (.082)	-.0201 (.083)	-.008 (.016)	-.0253 (.035)	-.0230 (.000)	-.057 (.000)	-.0613 (.000)	-.0650 (.079)	.0270 (.005)	.0640 (.003)	.0450 (.000)
Ghee	.102 (.000)	-.0318 (.000)	-.0278 (.120)	-.0712 (.714)	.0083 (.006)	-.0124 (.001)	-.0159 (.000)	.0327 (.000)	-.0890 (.000)	-.0680 (.000)	.0290 (.064)	-.0390 (.000)	.0180 (.000)	-.0710 (.000)	-.0140 (.000)
Cards	.0668 (.000)	-.0632 (.000)	.0022 (.200)	.0210 (.805)	-.0017 (.601)	.0025 (.610)	-.0782 (.000)	-.0345 (.000)	.0650 (.000)	.0490 (.087)	-.0670 (.000)	.0960 (.000)	-.0520 (.093)	-.0279 (.087)	.0910 (.094)
Sweets	-.024 (.052)	.0319 (.037)	-.0256 (.002)	.0597 (.000)	.0801 (.001)	-.0037 (.013)	.0258 (.102)	.00128 (.039)	.0446 (.043)	.0027 (.017)	-.0053 (.003)	.0008 (.000)	.0397 (.022)	.0036 (.000)	.00148 (.002)
Tea / coffee	.041 (.016)	.0112 (.000)	.0121 (.000)	-.0225 (.000)	.0416 (.000)	.0034 (.000)	-.0241 (.000)	.0387 (.098)	.0140 (.000)	.0689 (.000)	.0235 (.030)	.0491 (.000)	-.0131 (.000)	-.0591 (.000)	-.0140 (.000)

Figures in the parenthesis indicate standard error

It can be observed from Table 2 that the own price elasticities for all the items are less than one (i.e., inelastic) except for meat, milk and butter for which these are greater than one (i.e., elastic). However, for the items eggs and ghee, elasticities of demand are close to one (i.e., almost unit elastic) implying that quantities demanded for these items nearly change by the same percentage with the price change.

Again the estimates of cross-price elasticities given in Table 2 show that the change in meat price has a strong and significant effect on demand for egg. If, for example, the price of meat increases by 10%, then the households would increase their demand for eggs by 12%. However, the meat-to-eggs cross price elasticity is positive because the price of meat and the demand for eggs move in the same direction suggesting that these dairy products are substitutes.

Table 2. Price elasticities

Items → ↓	Meat	Eggs	Milk	Butter	Ghee	Cards	Sweets	Tea / coffee
Meat	-1.110	1.2179	-1.829	-.0642	-.08974	.36254	-.24170	.02247
Eggs	1.0851	-.9762	.34594	.21517	-.7306	-.34025	.49250	.87451
Milk	-.0974	-.3214	-1.092	-.3209	.53302	-.08109	.28045	.32222
Butter	-.0743	.8210	-.2291	-1.011	-.44597	.14809	-.20080	-.99073
Ghee	.28107	.10176	.05649	.6031	-.93312	-.5596	.06039	-.11110
Cards	-.1560	-.7102	.0096	-.0076	-.15694	-.05557	-.03941	.00661
Sweets	-.0825	.0268	.1591	-.0962	.05625	.02853	-.11595	-.33497
Tea/coffee	-.0873	.2992	-.0847	-.9182	.36995	.34445	.00116	.06491

Milk and butter, on the other hand, have complementary relationships with each other. For example, a 10 % fall in milk price would result in a 3.2% increased demand for butter. The cross-price elasticity representing the effect of change in butter price on milk demand indicates that a 10% fall in butter price is associated with a 2% increase in milk demand.

It is evident from Table 3 that the absolute expenditure elasticities for the items- eggs, milk, sweets and tea/coffee are less than unity implying them as necessary food items suggesting that the budget share for each of these items rise with higher expenditure. On the other hand, meat, butter, ghee and cards are considered as luxurious food items by the consumers of Bangladesh.

Table 3 also reveals that the size elasticities for the items milk, cards, sweets and tea/coffee are less than unity implying that as the family size increases, the budget shares for these items will decrease. On the other hand, size elasticities for the items meat, butter and ghee exceed unity suggesting that with the increase in family size, the budget shares for these commodities will also increase.

Table 3. Expenditure and size elasticities

Items	Expenditure Elasticity	Size Elasticity
Meat	1.0194	1.16108
Eggs	.56043	-.65184
Milk	.20697	.43291
Butter	1 .14569	-1.2368
Ghee	1.2284	1.4459
Cards	1.44598	.70037
Sweets	.2361	.5669
Tea/coffee	.0125	.1273

However, for the items eggs and ghee, the size coefficients are found to be insignificant and hence comments on size elasticities computed from these estimates are meaningless.

Conclusion

In the present study, a variation of the Almost Ideal Demand System (AIDS) model, suggested by Deaton and Muellbauer (1980), is adopted in order to present the estimates of demand structure for dairy products in Bangladesh. On the basis of the empirical results, the AIDS model was a useful instrument for this analysis. The budget shares are generally more responsive to per capita total expenditure than to prices. However, with regard to demographic variables, the empirical results have considerable importance for food industries. Food industry analysts can use this information in planning marketing program strategies. Furthermore, the results of this analysis can also be used in a wide range of applied works in the relevant areas. For instance, nutritional analysis, assessment of agricultural price intervention policies- all require prior estimates of demand elasticities. The study is thus likely to contribute in public policy research of Bangladesh.

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