Analysis of the Household Demand for Dairy Products in Sri Lanka: An Almost Ideal Estimation with a Censored Regression

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Abstract *— Being the leading segment in the livestock sector in Sri Lanka, the dairy sector still is incapable of meeting at least half of the domestic requirement. Moreover, the annual per capita consumption of milk remains lower than the recommended level for an average Sri Lankan. Hence, this study intends to present price and expenditure elasticities, in order to discover the consumption behaviour of five types of dairy products. Further, this aims to determine the impact of demographic factors which influence the dietary choices of those dairy produce. This paper employed the Linear Approximation of the Almost Ideal Demand System (LA/AIDS) to estimate price and expenditure elasticities, by utilizing the Household Income and Expenditure Survey, 2006/07. The infrequency of purchases, a typical problem encountered in LA/AIDS estimation is circumvented by using a probit regression in the first stage, to capture the effect of demographic factors, in consumption choice. Results reveal that, Sri Lankans consume these milk produce regardless of the area they live, size of the household, gender of the household head, education level of the head and spouse, prevalence of heart diseases and diabetes, while incidence of having young children and blood pressure will have a significant impact. All milk products except milk powder are highly responsive to their own prices. Fresh milk, milk powder and infant milk powder are identified as necessities whereas, the rest show luxurious behavior, with the income. However, demand for dairy products will be more influenced by price related policies than income oriented policies. Because milk powder is both price and income inelastic, and most are imported, any restriction would massively affect the demand for milk powder. Moreover, while identifying consumers' needs and wants through various research studies, domestic production should be promoted to meet the current demand.*

Keywords— AIDS model, censoring, dairy products

I. INTRODUCTION

Dairy sector has been identified as the leading sector amid other livestock sub sectors in Sri Lanka, where the contribution of livestock sector to the national GDP in 2011 was approximately one percent (Department of Animal Production and Health, 2011). However, only about 15-20% of the domestic requirement has been realized at present by the dairy industry, whereas achieving 50% self-sufficiency in milk products by 2015 remains confronting to the government (Ranaweera, 2009).

Conversely, out of milk and milk products available for consumption, 71.2% have been imported into the country, mostly in the form of powdered milk (Department of Animal Production and Health, 2011), which has been become controversial due to the existence of toxic chemical dicyandiamide (DCD).

Additionally, the annual per capita consumption of milk has been recorded as much lower than the recommended level for an average Sri Lankan. Consequently, increasing the consumption of milk and/or milk products in the country has become critical in order to meet the nutrient requirement (Bogahawatte and Herath, 2006).

In identifying the most appropriate policy interventions, food demand patterns of a particular country enormously support to improve the nutritional status of individuals and households. Hence, the knowledge of the food consumption behaviour is essential for sectoral and macroeconomic policy analysis where estimation of price and income elasticities of food is the key to the analysis of food demand behaviour (Weliwita *et al*., 2003).

Thus, this study intends to estimate price and expenditure elasticities by incorporating an economic framework to households in Sri Lanka, in

order to discover the consumption behaviour of dairy products which are more commonly consumed in the form of powder or liquid. Moreover, this intends to determine the impact of demographic factors which influence the dietary choices of these dairy produce.

II. METHODOLOGY

A. Model Specification

The Almost Ideal Demand System (AIDS) proposed by Deaton & Muellbauer(1980) was employed in our study, since it has considerable advantages over both the Rotterdam and Translog models which have been frequently used in the past to analyze consumption patterns because 'The AIDS, gives an arbitrary first-order approximation to any demand system; satisfies the axioms of choice exactly; aggregates perfectly over consumers without invoking parallel linear Engel curves; has a functional form which is consistent with known household-budget data; is simple to estimate, largely avoiding the need for nonlinear estimation; and can be used to test the restrictions of homogeneity and symmetry through linear restrictions on fixed parameters' (Deaton & Muellbauer, 1980).

The AIDS is built upon the minimum cost or expenditure function, which is required to achieve a specific utility level at given prices. The AIDS model in budget share form can be expressed as:

$$W_i = \alpha_i + \beta_i \ln\left(\frac{X}{P}\right) + \sum_j \gamma_{ij} \ln(P_j) \qquad \textbf{(1)}$$

Where, W_i = budget share of i^{th}dairy product; X = the total expenditure on all dairy products per household; P_j = prices of the j^{th}dairy product; P = price index defined as;

$$\ln P = \alpha_0 + \sum_k \alpha_k \ln P_k + \frac{1}{2}\sum_j \sum_k \gamma_{kj} \ln P_k \ln P_j \qquad \textbf{(2)}$$

(Deaton & Muellbauer, 1980)

The α_i parameter is the average budget share when all prices and real expenditure are equal to one. Where, $\beta_i$and γ_{ij} parameters measure the change in the i^{th} budget share for a unit change in the real income and P_j respectively (Weliwita *et al.*, 2003).
Although the true AIDS model possesses many desirable properties, its nonlinearity poses difficulties in estimation (Feng & Chern, 2000). To avoid nonlinearity, P in equation (1) was estimated as the Stone price index:

$$\ln(P^*) = \sum_i \overline{W_i} \ln(P_i) \qquad \textbf{(3)}$$

Where, $\overline{w_i}$stands for the mean budget share of i^{th}dairy product (Bett *et al.*, 2012).

Therefore, the Linear Approximation of the AIDS (LA/AIDS) was used in this study, where the budget shares of various commodities are linearly related to logarithms of real expenditure and relative prices (Deaton & Muellbauer, 1980). Hence, the LA/AIDS can be defined as;

$$W_i = \alpha_i + \beta_i \ln\left(\frac{X}{P^*}\right) + \sum_j \gamma_{ij} \ln(P_j) \qquad \textbf{(4)}$$

B. Data and Estimation Procedure

Data for the analysis were taken from the Household Income and Expenditure Survey (HIES) 2006/07, conducted over a period of 12 monthly rounds, by the Department of Census and Statistics, Sri Lanka. HIES provided information on demographic and socio-economic characteristics, income and expenditure of 18,544 households in Sri Lanka, excluding the Northern province and Trincomalee district in the Eastern province. For our study, weekly consumption of five types of dairy products (fresh milk, pasteurized milk, milk powder, infant milk powder and sterilized milk) was selected.

Because HIES doesn't provide the actual market prices of commodities, a proxy of unit values (expenditure/quantity) was used as prices, since it is the common practice in which literature (Park *et al.*,1996; Weliwita *et al.*, 2003) has followed. However, some households hold zero expenditure due to non-preference, sufficient household inventory, or as responses to market prices. The unit values of those households were replaced by the average values of the nonzero unit values within the most ideal cluster (Weliwita *et al.*, 2003).

A probit regression was carried out for five types of dairy products, to model the dichotomous behaviour of the consumption decision to buy or not to buy. Following extant literature on demand (Bett *et al.*, 2012; Heien & Wessells, 1990; Park *et al.*, 1996; Tiffin & Arnoult, 2010), demographic characteristics in Table 1 were considered in the probit regression, with the intention of capturing tastes and preferences among various households.

Table 1: Demographic variables

Variable	Description
Sector	Two dummy variables urban=1, otherwise=0 rural=1, otherwise=0
Household size	
Gender of the household head	One dummy variable male=1, female=0
Education level of the head	
Education level of the spouse	
Presence of young children up to three years of age	One dummy variable if present=1, otherwise=0
Presence of heart diseases	One dummy variable if present=1, otherwise=0
Presence of blood pressure	One dummy variable if present=1, otherwise=0
Presence of diabetes	One dummy variable if present=1, otherwise=0

Further, to circumvent the infrequent consumption observed in most households, Inverse Mills Ratios (IMRs) for each household for each dairy product were computed using probit parameters, where IMR(Φ_i) = θ (standard normal density)/Θ (cumulative probability function) and then, they were used in the AIDS as an instrumental variable (Weliwita *et al.*, 2003).

Hence, the estimating model is:

$$W_i = \alpha_i + \beta_i \ln\left(\frac{X}{P^*}\right) + \sum_j \gamma_{ij} \ln(P_j) + \omega_i \Phi_i + \varepsilon_i \quad \textbf{(5)}$$

Where,ω_i = coefficient of i^{th} IMR; ε_i = error term of i^{th}dairy product equation (Bett *et al.*, 2012).

To conform to the demand theory, adding up (6), homogeneity (7) and symmetry (8) restrictions were imposed on the equation (5) as:

$$\sum_i \alpha_i = 1, \sum_i \beta_i = 0, \sum_i \gamma_{ij} = 0, \sum_i \omega_i = 0, j = 1,\ldots,n. \quad \textbf{(6)}$$

$$\sum_j \gamma_{ij} = 0, i = 1,\ldots,n. \quad \textbf{(7)}$$

$$\gamma_{ij} = \gamma_{ji}, i, j = 1,\ldots, n. \quad \textbf{(8)}$$

C. Elasticities

The expenditure elasticity of i^{th} dairy product was estimated as;

$$\eta_i = 1 + \frac{\beta_i}{\overline{W_i}} \quad \textbf{(9)}$$

According to the equations 10 and 11, both Marshallian (uncompensated) and Hicksian (compensated) price elasticities were calculated, respectively as:

$$\varepsilon_{ij} = -\delta_{ij} + \frac{\{\gamma_{ij} - \beta_i \overline{W_j}\}}{\overline{W_i}} \quad \textbf{(10)}$$

$$\varepsilon_{ij} = -\delta_{ij} + \frac{\gamma_{ij}}{\overline{W_i}} + \overline{W_j} \quad \textbf{(11)}$$

Where, δ_{ij} = Kronecker delta, which is equal to one for $i = j$ and zero for $i \neq j$ (Taljaard *et al.*, 2004).

Since, adding up restrictions ensure that $\sum W_i = 1$, one equation (sterilized milk) was dropped from the system. A Seemingly Unrelated Regression (SUR) technique was employed to avoid possible error correlations of each equation. Under the constrained Iterated SUR (ITSUR) procedure, the estimation was carried out in Stata 11.2.

III. RESULTS AND DISCUSSION

A. Empirical Results

Results obtained from the probit model highlights that the model is significant for all milk products at 1% level. Model significance in SUR models is usually checked through Chi-square tests. Here, Chi-squares for all equations are significant at 1% level (Table 2).

Table 2: Model significance in probit and SUR

Variables	Probit	SUR	
	Prob> chi 2	Chi-square value	P value
Fresh milk	0.0000	106.56	0.0000
Pasteurized milk	0.0000	57.42	0.0000
Milk powder	0.0000	330.01	0.0000
Infant milk powder	0.0000	623.88	0.0000
Sterilized milk	0.0002	-	-

Moreover, revealing that ignorance of zero budget shares when estimating the system would generate biased and inconsistent parameter estimates; most of the IMR coefficients are significant at 1% level (Table 5).

B. Demographic Effects

Tables 3 and 4 show the impacts of prices (Table 3) and demographic factors (Table 4) on the selection probability of the five types of milk products under study. Table 4 reveal that Sri Lankans consume most of these milk products regardless of the area they live, size of the household, gender of the household head, education level of the head and spouse, prevalence of heart diseases and diabetes.

Conversely, reflecting the variations in lifestyle patterns, availability and access to the dairy products in different areas, estimates highlight that urban households tend to consume pasteurized milk, while there is a significant probability that the estate community is more likely to go for fresh milk. Besides, not surprisingly, households where young children are present reveal a significant positive relationship with the consumption of infant milk powder. Moreover, it is quite clear that milk powder is more favoured by households with blood pressure patients than other dairy produce, as they are frequently encouraged to consume low-fat milk in order to obtain the nutrients which lower the blood pressure.

C. Price Effects and Price Elasticities

Of the outcome obtained from the probit model, own-price coefficients are significantly negative for all dairy products except milk powder and sterilized milk (Table 3). However, corroborating the usual consumer behavior of reducing the consumption when prices increase, SUR estimates for own-price coefficients of almost all milk products carry a negative sign (Table 5).

Marshallian or uncompensated price elasticity contains both the income effect and substitution effect while Hicksian or compensated price elasticity reflects only the substitution effect. As expected, the Marshallian own price elasticities of all dairy produce are negative and hence, consistent with the utility theory (Table 6). The values denoted that only milk powder is less responsive to its own price changes, while all others are more responsive. It infers that, in case of a general price increase, consumption of all dairy products except milk powder would drop by a larger proportion. The price inelasticity of milk powder depicts its status of being prominent among all other dairy products, symbolizing the trend to purchase milk powder whatever the prices it holds.

When Marshallian cross price elasticity is considered, they suggest that milk products can be more of substitutes than they are complements. However, Hicksian price elasticity is a better measure of substitutability between two goods, since it measures only the substitution effect leaving the income effect out (Weliwita *et al*., 2003). Hicksian cross-price elasticities indicate that all dairy produce are having substitutable relationships with each other (Table 7). Cross price elasticities suggest that there is a strong substitutable relationship between infant milk powder and fresh milk, whereas both of them can be substituted with milk powder. While highlighting the strong substitutable relationship of infant milk powder and fresh milk with milk powder (1.0427 and 0.9531 respectively), estimates also suggest that households would alter consumption between fresh milk and infant milk powder according to the price changes, implying that parents would however manage price fluctuations so as to avoid the risk and incidence of becoming their children undernourished.

Variables	Fresh milk	Pasteurized milk	Milk powder	Infant milk powder	Sterilized milk
Fresh milk price	-0.7612 [a]	0.4611 [a]	0.7364 [a]	0.9065 [a]	0.7747 [a]
Pasteurized milk price	-0.4771	-1.2355 [a]	0.9490 [a]	-0.0281	0.3479
Milk powder price	0.4861 [c]	-0.2067	-0.2990	0.8616 [a]	0.3218
Infant milk powder price	-0.0807	0.2898	3.0127 [a]	-0.7075 [a]	0.0079
Sterilized milk price	0.1261	0.6093 [a]	-0.1356	0.7318 [a]	0.2793
Real income	0.3059 [a]	0.4499 [a]	0.5566 [a]	1.3719 [a]	0.2985 [a]
Constant	-7.6156 [a]	-6.9098 [a]	2.1451 [c]	-10.4584 [a]	-4.0166

Table 3: Parameter estimates of the Probit model

Note: Superscripts a, b, and c denote statistical significance at 1, 5, and 10 percent level, respectively.

Table 4: Parameter estimates of the Probit model - demographic variables

Note: Superscripts a, b, and c denote statistical significance at 1, 5, and 10 percent level, respectively.

Variables	Fresh milk	Pasteurized milk	Milk powder	Infant milk powder	Sterilized milk
Urban sector	-0.0556	0.6427[b]	-0.0529	0.0802	3.1032
Rural sector	-0.2842[b]	0.2801	0.0484	0.0563	2.9123
Household size	0.0018	0.0083	-0.0095	-0.0987[a]	-0.0026
Gender of the head	0.1123	0.2177	0.0387	-0.1634	-0.0420
Education level of the head	-0.0105	0.0183	0.0232	-0.0154	-0.0009
Education level of the spouse	0.0194	0.0124	0.0230	-0.0159	-0.0159
Presence of children	-0.2651[a]	-0.2510[a]	-0.7137[a]	1.9629[a]	-0.1566
Presence of heart diseases	-0.0961	-0.1618	-0.0653	0.0003	0.2026
Presence of blood pressure	-0.1684	-0.2302[b]	0.3572[b]	-0.1366	0.1582
Presence of diabetes	0.1431	0.0881	-0.0664	-0.0806	0.2767[b]

Table 5: Parameter estimates of the AIDS

Variables	Fresh milk	Pasteurized milk	Milk powder	Infant milk powder	Sterilized milk
Fresh milk price	-0.0186[a]	0.0096[a]	-0.0041	0.0174[a]	-0.0043
Pasteurized milk price	0.0096[a]	-0.0207[a]	-0.0015	0.0101[b]	0.0025
Milk powder price	-0.0041	-0.0015	-0.0467[a]	0.0544[a]	-0.0021
Infant milk powder price	0.0174[a]	0.0101[b]	0.0544[a]	-0.0849[a]	0.0030
Sterilized milk price	-0.0043[c]	0.0025	-0.0021	0.0030	0.0009
Real income	-0.0053[b]	-0.0037[b]	-0.0731[a]	0.0724[a]	0.0097
IMR	-0.0153[a]	0.0032[c]	-0.0322[a]	-0.0056[a]	0.0499
Constant	0.0611[b]	0.0286	1.6089[a]	-0.5539[a]	-0.1447

Note: Superscripts a, b, and c denote statistical significance at 1, 5, and 10 percent level, respectively.

Moreover, conveying that income effect outweighs the substitution effect, some of the cross price elasticities are negative for the Marshallian demand, while being positive for the Hicksian demand.

D. Expenditure Effects and Elasticities

Probit estimates for the real expenditure are significant at 1% level and positive for all dairy products, and it suggests that increase of real income would encourage the preference of consuming any type of milk product (Table 3). Amid the SUR estimates for the real expenditure (Table 5), the positive coefficients denote that consumers would spend more on infant milk powder and sterilized milk, when income rises. Negative coefficients of the budget shares of fresh milk, pasteurized milk and milk powder infer that, when income rises their consumption would increase less proportionately. It may be because of the consumers' willingness to purchase pasteurized milk so often during their hectic working hours, regardless of their status of income. With respect to fresh milk and milk powder, it can be due to the habitual preference of Sri Lankans who are used to consume either fresh milk or powdered milk at least once for a day and hence, they become so demanded despite the income of consumers Implying that all dairy products are normal and therefore, increase in income would lead to higher consumption, all expenditure elasticities carry a positive sign (Table 6). Corroborating the usual dietary patterns which can be seen in most households in Sri Lanka and the trend to purchase infant milk powder when young children are present, the elasticity estimates of fresh milk, powdered milk and infant milk powder reveal them as necessities. Alternatively, pasteurized milk and sterilized milk are identified as luxuries signifying that higher income households spend proportionately more on them.

Table 6: Marshallian/uncompensated elasticities

$\boldsymbol{\varepsilon_{ij}}$	Fresh milk	Pasteurized milk	Milk powder	Infant milk powder	Sterilized milk
Fresh milk	**-1.0263**	0.0185	0.0407	-0.0473	-0.0232
Pasteurized milk	0.0118	**-1.0808**	0.0171	-0.0168	-0.0054
Milk powder	0.0045	0.0129	**-0.9755**	-0.0511	-0.0329
Infant milk powder	0.0233	0.0200	0.1046	**-1.2012**	-0.0182
Sterilized milk	-0.0016	0.0070	0.0208	-0.0301	**-1.0067**
$\boldsymbol{\eta_i}$	0.9910	1.0321	0.9850	0.9238	1.1099

Note: ε_{ij} : diagonal values = own price elasticities, off diagonal values = cross price elasticities, η_i= expenditure elasticities

Table 7: Hicksian/compensated elasticities

$\boldsymbol{\varepsilon_{ij}}$	Fresh milk	Pasteurized milk	Milk powder	Infant milk powder	Sterilized milk
Fresh milk	**-0.4428**	0.6281	0.5844	0.6151	0.5746
Pasteurized milk	0.2613	**-0.8395**	0.2433	0.2602	0.2531
Milk powder	0.9531	0.9540	**-0.0884**	1.0427	0.9532
Infant milk powder	0.6889	0.7007	0.7161	**-0.4693**	0.6694
Sterilized milk	0.2939	0.3113	0.2990	0.3057	**-0.6958**

Note:ε_{ij}: diagonal values = own price elasticities, off diagonal values = cross price elasticities

IV. CONCLUSIONS AND RECOMMENDATIONS

The demand for dairy products which are more often consumed by Sri Lankans in the form of liquid or powder was analyzed by employing the LA/AIDS, while paying the particular attention to the zero expenditure problem. The demographic factors which influence the buying decision of these milk products were captured through a Probit regression.

Among the demographic factors we considered, consumption choice of most of the dairy produce will be decisively affected from presence of young children and prevalence of blood pressure. Nevertheless, preferences across households to purchase milk products will be insignificantly influenced by the area, household size, gender of the household head, education level, existence of heart diseases and diabetes.

As infant milk powder which is more preferred by the households where young children are present, being price elastic, government should be more careful when establishing policies in order to ensure adequate nutritional status of the younger generation in Sri Lanka.

Furthermore, all dairy products except milk powder are quite responsive to their own prices, while pasteurized milk and sterilized milk respond similarly for the income variations as well. However, demand for dairy products will be more influenced by price related policies than income oriented policies.

Being a necessity and a price inelastic commodity, milk powder holds the most prominent choice among all other alternatives. As most of the powdered milk available in the local market is being imported; any restriction would massively affect the demand for milk powder. Therefore, any action imposed on powdered milk will have a significant impact on Sri Lankans' dietary choices with respect to the dairy products. Additionally, various research studies should be conducted to capture consumers' needs and wants properly and also, domestic production should be encouraged in order to maintain a continuous supply.

ACKNOWLEDGEMENT

Authors wish to express their gratitude to the Department of Census and Statistics for providing data for the research.

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