Econometric Estimation of Engel Curve in Household Demand Analysis: A case stndy of household food demand in Dhaka Metropolitau City.

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Abstract

This paper examines the Engel's law (that household food expenditure at constant price increases less than proportionately with increase in household income level) for the samples of middle and upper middle class households dwelling in two popular suburbs of Dhaka Metropolitan City. Data on monthly household food expenditure, monthly household average income, household size and composition based on age, and some other household characteristics of 625 households dwelling in suburb Shiddeshwari and 348 households dwelling in suburb Moghbazar were collected from a survey conducted in September 1999. With commonly used specifications of Engel curves, estimates of income effect and income elasticity of food have been obtained using Ordinary Least Squares (OLS) estimation technique. Then, the household food demand model for two suburbs was again estimated incorporating some interesting household characteristics. In all estimations, food is found to be significantly income inelastic, and economies of scale is found to be working for both samples.

Introduction

One of the oldest and most important uses of econometrics is its application to households in the estimation of demand relationships and consumer behavior. Virtually, all econometric studies involve some aspects of structural analysis, particularly the estimation of the impacts of prices and income on demand, as measured by elasticities of demand. Some are oriented towards forecasting, in particular forecasting quantities and/or prices of particular commodities in either the short or long range future. Others are oriented toward policy evaluation, in particular, impacts of policies that may affect markets for consumer goods, such as taxes or (de) regulation.

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With the theoretical idea that individual (and household) expenditure on any particular good at constant prices depend on individual (and household) income, it is possible to analyze individual (and household) demand for that particular good, and make empirical conclusions regarding the comparative static effects for changes in the parameters of the model (Intrilligator: 1971). A popular way to do this practically is to estimate individual (and household) demand and/or expenditure (at constant prices) functions with cross-sectional data (for many individuals or households) using ordinary least squares, calculate price and/or income elasticity of demand for that particular good, and comment on the estimated elasticities. Studies of similar kinds are found in literature with Allan and Bowley (1926), Prais and Houthakker (1938), Stone (1954), Houthakker (1960), Barten (1977) and Deaton (1986).

This paper estimates Engel curves for food demand in Dhaka city using simple ordinary least squares estimation technique, and thus makes an attempt to compare the structural differences of food demand taking food as a composite commodity. For the purpose of this study, a sample of 625 households from a popular middle and upper-middle class suburb of Dhaka City, namely Shiddeshwari, is chosen. For the purpose of a comparison, a sample of 348 households from another popular middle and upper-middle class suburb of Dhaka City, namely Moghbazar, is chosen. Data are collected from a "walk in" and telephone survey, so the data collected are primary.

Household demand in theory

The problem of the household (or consumer), from a formal point of view, is that of choosing levels of consumption of goods (including services) so as to maximize a utility function subject to a given budget constraint. Basic references for the theory of the household include Intrilligator (1971), Barten and Bohm (1982), Phlips (1983), Deaton (1986), Kreps (1990) and Varian (1990). Considering the simplest case of two goods, in which purchases by a single household are measured by x_1 and x_2, respectively, the problem of the household can be stated as

$$\max_{x_1, x_2} U(x_1, x_2) \text{ subject to } p_1x_1 + p_2x_2 = I \quad \ldots\ldots (1)$$

Here $U(x_1, x_2)$ is the utility function, p_1 and p_2 are the prices of the two goods, and I is the level of income of the household. Evidently, income and both prices are assumed to be positive constants. The utility function is an ordinal representation of tastes in that the household prefers a bundle of goods **x** = (x_1, x_2) with a higher value of utility to a bundle with a lower value of utility. The budget constraint requires that total expenditure, obtained by totaling expenditures on each of the goods, equal income. The household thus chooses among bundles that satisfy the budget constraint so as to attain the highest available level of utility.

In principle, the solution to this problem using Kuhn Tucker optimality conditions (and with the assumption of strict quasiconcavity of the utility function) is a pair of (optimal) demand correspondence, or functions. The demand functions give the dependence of the (optimal) quantities demanded on all parameters of problem (1), namely both prices and income:

$$x_j = x_j(p_1, p_2, I),\ j = 1, 2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1.1)$$

These functions indicate the amount demanded of each of the goods at alternative combinations of prices and income.

Special cases of the demand functions, in which two of the three parameters are held constant, are also widely discussed in the literature on partial equilibrium analysis. This holding p_2 and I constant, for j=1, we can get the demand curve for the first good:

$$x_1 = D_1(p_1) = x_1(p_1, p_2, I) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

where p_2 and I are held constant. Similarly the demand curve for the second good is:

$$x_2 = D_2(p_2) = x_2(p_1, p_2, I) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

These demand curves indicate the effect of a change in the price of a good on the quantity demanded, holding other price(s) and income constant (i.e. the *ceteris paribus* effect of a change in "own" price). If the other price(s) and income change, the result will be a shift in the demand curve.

The Engel curve and Engel's law

A second partial equilibrium approach holds p_1 and p_2 constant, to yield the (commonly known) Engel curves:

$$p_1x_1 = E_1(I) = p_1x_1(p_1, p_2, I) \quad (4)$$
$$p_2x_2 = E_2(I) = p_2x_2(p_1, p_2, I) \quad (5)$$

where both p_1 and p_2 are held constant. (4) and (5) show that expenditure on any particular good x_j, j = 1, 2 at constant prices depend on household income. These Engel curves indicate the effect of a change in income on the expenditure for each good at fixed prices. Engel's law refers to a property of the Engel curve for food. The law states that the proportion of income consumers spend on food decreases as their income increases. Thus if x_j is food, the law simply states that eventually the ratio p_jx_j/I decreases as I increases.

Elasticities of demand can be defined using the Engel curve. These elasticities are convenient summaries of the responsiveness of the quantity demanded to factors influencing it, in part because they are independent of the units of measurement of the good, prices, income and so on. Thus comparisons of elasticities can be made across goods, across households and so on. Since Engel curve is estimated for constant prices, it is justifiable to represent the income elasticity of demand for food by the income elasticity of expenditure on food. The income elasticity of demand for good j is:

$$\eta_j = (\partial x_j / \partial I).(I/x_j) = \partial \ln x_j / \partial \ln I \quad (6)$$

which gives the percentage change in the quantity demanded (or expenditure at constant prices) for a 1% change in income. Usually, the income elasticity, so defined, is positive for normal goods. The elasticity is negative for inferior goods, for those demand falls as income rises. The good is said to be income elastic (inelastic) if $\eta_j > 1$ ($\eta_j < 1$). In terms of elasticities, Engel's law states that food is income inelastic, i.e. the income elasticity of demand for food is less than unity.

Data and variables

The data collected for this research and used in the paper is from a survey conducted in September 1999. To avoid heteroskedasticity in the cross-sectional regression, attempt was made to consider households with household income in the middle and upper-middle class range (with household aggregate monthly income of taka 15,000.00 and above). The chosen households in both suburbs (Shiddeshwari and Moghbazar) varied in size and composition. To account for household characteristics in the estimation, data for household size, composition (based on age), if run by a female head, religious beliefs etc. were collected. The reason to choose these characteristics is to examine if household expenditure on food differs for variations in size and different other characteristics. Among the other characteristics, household composition based on age groups living in the household is important to check which age group spends more on food. It becomes, therefore, important for the market to recognize potential consumer groups based on age. In Bangladesh, and probably around the world, there is a general idea that tastes and expenditure on food differs largely due to differences in religious beliefs. With majority of the population being Muslims, there are however, non-Muslims living in these suburbs. Information on religious beliefs of the households under survey was taken to statistically test the hypothesis.

The samples chosen for this study are appropriate in the sense that these two suburbs represent the standard inhabitants of Dhaka Metropolitan City. The time period considered for the survey is a normal time period, so there is no linkage effects of previous stochastic shocks. To judge the justifiability of the survey data (whether households are responding correctly), and to make sure that only households that maximize utility subject to their budget constraint (well behaved households) are included in the estimation, households who were reported to have food expenditure higher than their real income were eliminated from both the samples. Also, households who were reported to have a zero food expenditure and/or a zero income, were treated as irrational households, and thus were eliminated from the samples. After the elimination, 605 households from the sample of suburb Shiddeshwari and 341 households from suburb Moghbazar were taken for OLS estimation.

The households, in both suburbs, were selected from possibly every locality inside the suburbs, such that the samples represent the aggregate behavior of households dwelling in a particular suburb. Food expenditure data was collected in thousand taka spent on food during August-September 1999 for individual households. The income data was collected in thousand taka earned per month by individual households (including reported salary or business income, earnings from fixed assets or securities, rental earnings, 'donation' earnings), taking the average monthly income for the period July 1999 to September 1999, assuming that prices remained fixed during this period.

To examine the variation in food expenditure for variations in household size and age composition, data on how many members live in a particular household and their age were collected. To categorize household composition for age groups, proportion of the total household members belonging to age groups 0-11 years, 12-17 years, 18-34 years, 18-50 years, 35-59 years, 51 years and above and 60 years and above were computed. Households run by a female head were assigned a value 1 for the dummy variable "female head", and 0 otherwise (run by a male head). Non Muslim households were assigned a value 1 for the dummy variable "non Muslims", and 0 otherwise (if Muslim household). The variables used in different OLS estimation of Engel curve in the following sections of this paper (for which information have been collected) are reported in table 1.

Table 1: List and description of variables used in OLS estimation of Engel curve.

Variable Name	Type of variable	Description of variable
Food Expenditure (fexp)	Dependent variable	Monthly food expenditure of a particular household in thousand taka during August-September 1999.
Income (Inc)	Explanatory variable	Monthly income earned by individual households, taking the average monthly income for the period July to September, 1999.
HH	Explanatory variable / scaling variable	Size of household in number of members, i.e. how many members live in a particular household
Non-Muslims	Dummy variable (characteristics variable)	A dummy variable that takes the value 1 if the household is a non-Muslim household, 0 otherwise (Muslim household).
Female Head	Dummy variable (characteristics variable)	A dummy variable that takes the value 1 if the household is run by a female head, 0 otherwise (run by a male head)

HH011	Characteristics explanatory variable	Proportion of household belonging to the age group 0 years to 11 years (children)
HH1217	Characteristics explanatory variable	Proportion of household belonging to the age group 12 years to 17 years (teenagers)
HH1834	Characteristics explanatory variable	Proportion of household belonging to the age group 18 years to 34 years (young)
HH1850	Characteristics explanatory variable	Proportion of household belonging to the age group 18 years to 50 years (young and middle age)
HH3559	Characteristics explanatory variable	Proportion of household belonging to the age group 35 years to 59 years (middle age)
HH51P	Characteristics explanatory variable	Proportion of household belonging to the age group 51 years and above (old)
HH60P	Characteristics explanatory variable	Proportion of household belonging to the age group 60 years and above(old)

Table 1.1 represents a summary of statistics for the data on food expenditure (in thousand taka) and income (in thousand taka) for both samples, which will be helpful in different calculations.

Table 1.1: Summary of statistics of food expenditure and income for suburbs Shiddesbwari and Moghbazar.

Sample	Variable	Mean	Standard Deviation	Minimum	Maximum
Shiddeshwari	Food Expenditure	64.51	33.9	0.7	263.17
	Income	233.7	122.06	22.84	1415.1
Moghbazar	Food Expenditure	70.82	38.43	9.98	287.19
	Income	238.9	125.82	16.61	1098.9

As mentioned earlier, to capture the food demand behavior of middle and upper middle class households, data was collected for households who have aggregate monthly income of 15000 taka and above. Variation in household income is more in suburb Moghbazar as compared to suburb Shiddeshwari (a larger standard deviation of income for suburb Moghbazar indicating a larger variance). However, on an average, the 341 households in suburb Moghbazar earn more and spend more on food as compared to 605 households in suburb Shiddeshwari (larger arithmetic mean of both food expenditure and income for suburb Moghbazar).

The household food demand model

Important work on the theory of household food demand within a cross sectional framework was done in estimating Engel curve. For example, Allan and Bowley estimated a linear Engel curve from cross sectional data on 112 British City families in 1926. Prais and Houthakker in their study of budgets of British middle class families in 1938 estimated Engel curve using a semi logarithmic specification. Houthakker in 1950 estimated Engel curve for U.S. urban households using a double logarithmic specification. Other cross sectional estimation of Engel curve involve the study by Stone in 1954 for United Kingdom, Wold and Jureen in 1953 for United Kingdom, both using log linear specifications. However, the study of household food demand evolved from single equation demand estimation to estimation of system of demand equations using time series data during the 1970s and 1980s, with Powell (1974), Barten (1977), Phlips (1983) and Deaton (1986) contributing to the literature.

The application of econometrics to the theory of the household requires, in addition to data, a specific formal econometric model. In considering an econometric model for estimating Engel curve, the following four specifications were considered for both samples (irrespective of household characteristics):

1. **Linear Model:**

$$fexp = \alpha + \beta Inc \text{ .... (E1)}$$

Where fexp = food expenditure (in thousand taka)

Inc = Household income (in thousand taka)

Such that effect of small change in income on food expenditure,

$$\partial fexp/\partial Inc = \beta$$

And Income elasticity, $\eta_1 = \beta.(Inc/fexp)$ .... (E1.1)

2. **Semi logarithmic Model:**

$$fexp = \alpha + \beta \ln(Inc) \text{ .... (E2)}$$

Where fexp = food expenditure (in thousand taka)

Inc = Household income (In thousand taka)

ln = natural logarithm

Such that effect of small change in income on food expenditure,

$\partial fexp/\partial Inc = \beta/Inc$

And Income elasticity, $\eta_2 = \beta.(1/fexp)$ .... (E2.1)

3. **Double logarithmic Model:**

$\ln(fexp) = \alpha + \beta \ln(Inc)$ .... (E3)

Where fexp = food expenditure (in thousand taka)

Inc = Household income (in thousand taka)

ln = natural logarithm

Such that effect of small change in income on food expenditure,

$\partial fexp/\partial Inc = \beta(fexp/Inc)$

And Income elasticity, $\eta_3 = \beta$ ....(E3.1)

4. **Log reciprocal Model:**

$\ln(fexp) = \alpha + \beta(1/Inc)$ .... (E4)

Where fexp = food expenditure (in thousand taka)

Inc = Household income (in thousand taka)

ln = natural logarithm

Such that effect of small change in income on food expenditure,

$\partial fexp/\partial Inc = -\beta(1/Inc^2)$

And Income elasticity, $\eta_4 = -\beta.(1/Inc)$ .... (E4.1)

The approach made to model household food demand in this paper is basically two fold. In the first step, both samples are used to estimate specification (E1), (E2), (E3) and (E4), and thus estimate the income elasticity for food demand. Then, in the second step, a (arguably) complete household food demand model is estimated choosing one of the four specifications and incorporating some important household characteristics, size and composition that are hypothesized to affect household demand for food. The choice of specification is made by statistical significance of coefficient estimates, high R^2 and low σ^2 values from the estimation.

The parameters of the four specification (E1), (E2), (E3) and (E4) for both samples of Shiddeshwari and Moghbazar, were estimated using ordinary least squares (OLS) technique with the help of computer software Shazam 8.0. Using these results and equation (E1.1), (E2.1), (E3.1) and (E4.1), income elasticities of food were estimated for both samples. These results and their analysis are presented in tables 2, 3, 4 and 5.

Results of OLS estimation

Table 2 presents the summary of the OLS estimates for suburb Shiddeshwari, and table 3 presents the same for suburb Moghbazar. For both samples, all four specifications provide satisfactory fit in terms of R^2 values. The estimations were checked for (general) heteroskedasticity, and all hypotheses of homoskedasticity were accepted.

Tahle 2: OLS estimates of four Engel curve specifications for 605 households of Suhurh Shiddeshwari.

Model	Coefficient estimate (standard error)	t-ratio [p-value]	Statistical significance	R^2	σ^2
Linear (E1)	0.1215 (0.0101)	11.95 [0.000]	Significant at 1% level	0.191	30.51
Semi logarithmic (E2)	37.051 (2.749)	13.48 [0.000]	Significant at 1% level	0.231	884.76
Double logarithmic (E3)	0.612 (0.0466)	13.13 [0.000]	Significant at 1% level	0.222	0.254
Log reciprocal (E4)	- 90.38 (7.829)	- 11.54 [0.000]	Significant at 1% level	0.181	0.268

Tahle 3: OLS estimates of four Engel curve specifications for 341 households of Suhurb Moghbazar.

Model	Coefficient estimate (standard error)	t-ratio [p-value]	Statistical significance	R^2	σ^2
Linear (E1)	0.1428 (0.0146)	9.742 [0.000]	Significant at 1% level	0.218	1157.7
Semi logarithmic (E2)	40.506 (3.976)	10.21 [0.000]	Significant at 1% level	0.235	1133.4
Double logarithmic (E3)	0.598 (0.0542)	11.04 [0.000]	Significant at 1% level	0.264	0.212
Log reciprocal (E4)	- 62.604 (7.148)	- 8.759 [0.000]	Significant at 1% level	0.184	0.235

From table 2 and 3, it is evident that both samples fit the model specifications E1, E2, E3 and E4 satisfactorily. For suburb Shiddeshwari for all four specifications (table 2), the coefficient estimates are all statistically significant at 1% level, and all of them have their expected signs (the constants of these specifications are also estimated and found statistically significant. For parsimony, they are not reported). All coefficient estimates exhibit that household food expenditure tends to increase significantly for increases in household income. This conclusion includes the log reciprocal model (E4) as the coefficient estimate for this specification for this sample is significantly negative, such that the marginal effect on food expenditure for a small increase in income, is positive. All four estimated models have satisfactory R^2 values, and exhibit on an average 20% goodness of fit. The rest 80% unexplained variation in food expenditure for this sample is (probably) due to omitted variables like household characteristics, size and compositions etc. In terms of relatively high R^2 (=0.22) and low σ^2 (=0.254) values, the double logarithmic model can be chosen for further estimation using all household characteristics.

Table 3 represents the results from Engel curve estimation for 341 households of suburb Moghbazar. This estimation also provided consistent results for all four specifications of Engel curve. All four coefficient estimates are statistically significant at 1% level indicating the precision of the estimation (once again the constants of these specifications are also estimated and found statistically significant. For parsimony, they are not reported). The coefficient estimates also have their expected signs. The R^2 values are better for this sample as compared to the other one, indicating that this sample, on an average, fits the models better than the other one. Once again, the double logarithmic model can be chosen for further estimations as it has a relatively high R^2 value (=0.26) and a relatively low σ^2 (=0.212) value.

The estimated income effects on food expenditure and income elasticity of food demand for both samples are reported in tables 4 and 5. These tables will prove helpful for justifying Engel's law. Table 4 presents the income effect on food expenditure and income elasticity of food demand for the sample of suburb Shiddeshwari.

Table 4: Income effect and income elasticity estimates for four Engel curve specifications for 605 households of suburb Shiddesbwari.

Model	Income Effect	Income Elasticity (η) (standard error)	Statistical Significance	Comments on income elasticity
Linear	0.121	0.44 (0.036)	Significant at 1% levei	Inelastic
Semi logarithmic	0.158	0.574 (0.042)	Significant at 1% level	Inelastic
Double logarithmic	0.168	0.612 (0.04)	Significant at 1% level	Inelastic
Log reciprocal	0.0016	0.386 (0.033)	Significant at 1% level	Inelastic

Table 4 illustrates that food as a commodity is income inelastic for suburb Shiddeshwari. This is because, in all four specifications, the estimated income elasticity of food is significantly less than 1, indicating that household expenditure on food increases less than proportionately with increase in household income. The estimated income effects on food demand (expenditure at constant prices) are very low, indicating a low income elasticity of food demand. Overall the estimated income elasticities show consistency in magnitude irrespective of specifications used, and they are statistically significant at 5% level. Similar consequences are found for the sample of suburb Moghbazar, and results are reported in table 5.

Tahle 5: Income effect and income elasticity estimates for four Engel curve specifications for 341 households of suhurb Moghhazar.

Model	Income Effect	Income Elasticity (η) (standard error)	Statistical Significance	Comments on income elasticity
Linear	0.142	0.479 (0.047)	Significant at 1% level	Inelastic
Semi logarithmic	0.169	0.571 (0.056)	Significant at 1% level	Inelastic
Double logarithmic	0.162	0.548 (0.05)	Significant at 1% level	Inelastic
Log reciprocal	0.0010	0.262 (0.029)	Significant at 1% level	Inelastic

Table 5 reports the estimated income effects on food demand and income elasticity of food demand for the sample of suburb Moghbazar.

Consistency in estimation is again established in this estimation. The estimated income effects are low, and that resulted in income inelastic food demand for this suburb. All estimated income elasticities of food demand are statistically significant at 5% level, with the log reciprocal model generating the lowest estimate of income elasticity of food demand. Thus, both samples strengthen the point that food is income inelastic, so that food demand for households in Dhaka Metropolitan City do not increase proportionately as household income increases. Thus, Engel's law holds. This does not mean that food demand falls with increase in household income, but surely means that less than proportionate increase in food demand is recorded for increase in income for the samples chosen.

Engel Curve with household characteristics

With a range of household characteristics affecting the demand for food, it is important to incorporate household characteristics in estimating Engel curve using econometric models. The estimations conducted so far resulted in a relatively better fit for the double-logarithmic model (E3), although that estimation did not take into account the difference in household size and composition. In reality, larger households are supposed to spend proportionately lesser amount of their income on food. This is due to the concept of economies of scale, i.e. when household size gets large, household food expenditure falls proportionately due to economies of scale. Hence it requires a scaling of the model on household size. Besides, composition and characteristics of household may also have important effects on household food expenditure, as articulated by Powell (1974) and Deaton (1986). This is reflected by a relatively low R^2 value for estimation of double logarithmic model E3 for both the samples. This indicates that some more variables need to be added to the specification to improve the explanatory power of the model.

Taking these into consideration, this study makes an attempt to incorporate household characteristics into the model and scales the food expenditure and income of a particular household by its size. In selecting the characteristics that may affect the household food expenditure, a few specifications were considered depending on the information collected from the survey. In general, to scale household food expenditure and income for household size, data for both household food expenditure in thousand taka and household income in thousand taka were deflated by household size (no. of members in a household). This was done for both samples, such that the processed variables to be used in econometric estimation are:

$$lnSfexp_{jk} = \ln(fexp_{jk} / householdsize_{jk}) \quad \text{(E5)}$$

where,

$lnSfexp_{jk}$ = Scaled food expenditure of household j,

j = 1, 2, ..., 605 for k = Shiddeshwari;

j = 1, 2, ...341 for k = Moghbazar,

of sample k, k = Shiddeshwari, Moghbazar.

And, $$lnSInc_{jk} = \ln(Inc_{jk} / householdsize_{jk}) \quad \text{(E6)}$$

where, $lnSInc_{jk}$ = Scaled income of household j,

j = 1, 2, ..., 605 for k = Shiddeshwari;

j = 1, 2, ...341 for k = Moghbazar,

of sample k, k = Shiddeshwari, Moghbazar.

To be used as an explanatory variable, the natural logarithm of household size was created, with

$$lnHH_{jk} = \ln(householdsize_{jk}) \quad \text{(E7)}$$

where,

$lnHH_{jk}$ = Natural logarithm of household size of household j,

j = 1, 2, ..., 605 for k = Shiddeshwari;

j = 1, 2, ...341 for k = Moghbazar,

of sample k, k = Shiddeshwari, Moghbazar.

Household characteristics, such as, if household is run by a female head, if household is a non-Muslim household, and age compositions in a particular household were considered as explanatory variables in the model. Different combinations of these characteristics were chosen for estimation for both samples, and best specifications for both samples were chosen using likelihood ratio test. The chosen specification (for both samples) is:

$$lnSfexp_{jk} = \beta_0 + \beta_1\, lnSInc_{jk} + \beta_2\, lnHH_{jk} + \beta_3 Nonmuslim_{jk} + \beta_4 Femalehead_{jk} + \beta_5 HH011_{jk} + \beta_6 HH1217_{jk} + \beta_7 HH51P_{jk} \quad \text{(E8)}$$

Besides, whether or not it is necessary at all to include all these characteristics was tested using a likelihood ratio test. The OLS estimation results of chosen specification (E8) for both samples are reported in tables 6 and 7.

Table 6: Results from OLS estimation of Engel Curve scaled by bousehold size aud incorporating housebold cbaracteristics for 605 bouseholds in suhurh Shiddeshwari.

Dependent variable: lnSfexp

Variable Name	Estimated Coefficient (Standard Error)	t-ratio [p-value]	Statistical significance
lnSInc	0.321 (0.054)	5.85 [0.000]	Significant at 1% level
lnHH	- 0.393 (0.061)	- 6.409 [0.000]	Significant at 1% level
Non-Muslim	- 0.0079 (0.041)	- 0.189 [0.850]	Not Significant
Female Head	- 0.232 (0.052)	- 4.447 [0.000]	Significant at 1% level
HH011	0.471 (0.140)	3.359 [0.000]	Significant at 1% level
HH1217	0.610 (0.158)	3.852 [0.000]	Significant at 1% level
HH51P	0.295 (0.141)	2.092 [0.037]	Significant at 5% level
Constant	1.861 (0.268)	6.943 [0.000]	Significant at 1% level

$R^2 = 0.31$ Adjusted $R^2 = 0.30$ SSE = 133.75 $\sigma^2 = 0.224$
Log of the likelihood function = - 401.899

From table 6, it is certain that the precision of the estimation of Engel curve has improved for the inclusion of the household characteristics and for scaling the model with household size. There has been a considerable improvement in R^2 and σ^2, and the estimated model has very low sum of squared errors. The estimated income elasticity of food demand (=0.321) is statistically significant at 1% level, and again food is income inelastic. The positive sign of income elasticity indicates food is a normal good, which is an expected conclusion. The coefficient estimate of log of household size is statistically significant at 1% level and negative, indicating that economies of scale is working for this sample. This means that larger households spend proportionately lesser amount of money of food. The coefficient estimate of characteristic dummy variable Non Muslim is statistically insignificant, indicating that household food expenditure for this sample does not vary for different religious beliefs. The coefficient estimate of characteristic dummy variable Female Head is significantly negative, indicating that families with female head spend lesser on food. This is an interesting hypothesis from the social point of view, as it proves women are less enthusiastic about spending much on food. All three age groups have significant positive effects on food expenditure, with teenagers (HH1217) adding the most to basic food expenditure (=0.610). Adjusted $R^2 = 0.30$ indicates that approximately 30% variation in scaled food expenditure is explained by the model, while the rest 70% is still unexplained. This may be a prospective area for further study.

Table 7: Results from OLS estimation of Engel Curve scaled by bousebold size and incorporating household characteristics for 341 bouseholds in suburb Moghbazar.

Dependent variable: lnSfexp

Variable Name	Estimated Coefficient (Standard Error)	t-ratio [p-value]	Statistical significance
lnSlnc	0.389 (0.062)	6.279 [0.000]	Significant at 1% level
lnHH	- 0.341 (0.072)	- 4.686 [0.000]	Significant at 1% level
Non-Muslim	0.0208 (0.0522)	0.398 [0.690]	Not significant
Female Head	- 0.161 (0.0611)	- 2.64 [0.009]	Significant at 1% level
HH011	0.211 (0.163)	1.297 [0.196]	Not significant
HH1217	0.333 (0.194)	1.710 [0.088]	Significant at 10% level
HH51P	- 0.196 (0.189)	- 1.036 [0.301]	Not significant
Constant	1.689 (0.314)	5.373 [0.000]	Significant at 1% level

$R^2 = 0.37$ Adjusted $R^2 = 0.35$ SSE = 63.127 $\sigma^2 = 0.189$
Log of the likelihood function = - 196.269

Results from OLS estimation for the sample of suburb Moghbazar are reported in table 7. These results again establish that food is income inelastic, and economies of scale is working for this sample. The coefficient estimate for characteristic dummy variable Non-Muslim is statistically insignificant, drawing a similar conclusion as found for the other sample. This result establishes the point that food demand in Dhaka Metropolitan city is unaffected by religious beliefs. The coefficient estimate of characteristic dummy variable Female Head is significantly negative, once again establishing that households with women as the head spend less on food. This sample establishes that households with more teenagers spend more on food. However the other two age dummy variables are found statistically insignificant. The precision of the estimation has improved significantly, evident from a high R^2 (and adjusted R^2) and low σ^2 value.

Tests of Hypotheses

The estimations lead us towards testing some interesting hypotheses to justify this research. The overall significance of estimated specification E8 for both samples is a matter of major concern. The individual significance of hypothesized household characteristics are already tested in analyzing tables 6 and 7. It is also interesting to test whether household characteristics should be included in estimating Engel curve. To test these hypotheses, likelihood ratio test and F-test were used. The likelihood ratio statistic (λ) is defined as:

$$\lambda = -2\,\{\ln(\text{likelihood } H_0) - \ln(\text{likelihood } H_1)\} \qquad \text{(E9)}$$

with H_0 being the null hypothesis to be tested, and H_1 being the alternative. The F statistic is computed using the following formula:

$$F = [(SSE_R - SSE_U)/j] \div [SSE_U/(T-k)] \qquad \text{(E10)}$$

With SSE_R and SSE_U being the sum of squared errors for restricted and unrestricted models respectively, j being the number of restrictions imposed, T being the sample size and k being the number of parameters in the unrestricted model. The tests and summary of results are reported in tables 8 and 9 for the samples of suburbs Shiddeshwari and Moghbazar, respectively.

Table 8: Statistical tests summary of hypothesis testing for sample of suburb Shiddeshwari.

Null Hypothesis (H_0)	Test Statistic	Critical Value at 10% level	Decision
$\beta_1 = \beta_2 = \ldots\ldots\ldots = \beta_7 = 0$	F = 2713.547	$F_{(7, 597)0.10} = 1.73$	Reject H_0
$\beta_3 = \beta_4 = \ldots\ldots\ldots = \beta_7 = 0$	$\lambda = 28.922$	$\chi^2_{(5)0.10} = 9.23$	Reject H_0

The first null hypothesis is the one for overall significance for the estimation of E8. For the suburb Shiddeshwari, the null hypothesis that the specification E8 is unnecessary is strongly rejected at 10% level using the F-test. The second null hypothesis states that it is unnecessary to include all household characteristic variables in estimating Engel curve (i.e. the household characteristics included in E8 are jointly insignificant). This null hypothesis is also strongly rejected at 10% level using a likelihood ratio test. The test results for suburb Moghbazar is reported in table 9.

Table 9: Statistical tests summary of hypothesis testing for sample of suburb Moghbazar.

Null Hypothesis (H_0)	Test Statistic	Critical Value at 10% level	Decision
$\beta_1 = \beta_2 = \ldots\ldots\ldots = \beta_7 = 0$	F = 1870.404	$F_{(7, 333)0.10} = 1.74$	Reject H_0
$\beta_3 = \beta_4 = \ldots\ldots\ldots = \beta_7 = 0$	$\lambda = 10.554$	$\chi^2_{(5)0.10} = 9.23$	Reject H_0

Similar test results are found for the estimation of the sample of suburb Moghbazar. Both null hypotheses are strongly rejected at 10% level. These test results establish the justification of using E8 as a specification of Engel curve estimation and including household characteristics in estimating Engel curve.

Implications

This study and the estimated results leave us with some interesting and robust findings regarding the household behavior towards food expenditure in Dhaka Metropolitan City. For both samples, before and after including household characteristics, food is found to be income inelastic. In real sense, it is understandable that an increase in household income (e.g. an income tax cut or a cash subsidy) does not facilitate (increase the income of) food business and food store-owners proportionately. The considerably low magnitude of income elasticity of food demand indicate that households spend a bulk proportion of their increased income on other things than food. This in turn, can be interpreted as a psychological negligence of Dhaka Metropolitan City households towards food, or a high degree of unaffordability of other things for middle class household, or a combination of the two.

Another robust finding of this study is that households run by female heads spend less on food, indicating that women in general, if leading a household, are less enthusiastic about spending more on food. This is a strong market signal for food store owners, as they can be sure that males are potential customers for sales of food items. For both suburbs, economies of scale works, indicating that as households get larger in size, food expenditure at constant prices rises less than proportionately. This implies that household food expenditure at constant price increases at a decreasing rate with increase in number of members in the household. Thus, food buyers heading a relatively smaller household are more potential as a customer for food store-owners. The hypothesis that households with more teenagers as members spend more on food is reestablished in this study. At a growing age, these teenagers require nourishing and healthy food. Besides, this age group is also the most enthusiastic part of the population for fast foods and eating out, which is real world evidence. It is also found that religious beliefs do not significantly vary household food expenditure in Dhaka Metropolitan City.

Concluding Remarks

To analyze household behavior towards food expenditure, different conventional specifications of Engel curves for food demand in Dhaka Metropolitan City were estimated using simple ordinary least squares estimation technique. An attempt was made to compare the structural differences of food demand taking food as a composite commodity. Engel curves were estimated for a sample of 605 households from a popular middle and upper-middle class suburb of Dhaka City, namely Shiddeshwari. For the purpose of a comparison, a sample of 341 households from another popular middle and upper-middle class suburb of Dhaka City, namely Moghbazar, was chosen. For both suburbs, it was found that food is income inelastic, and that household characteristics should be incorporated for more precise estimation of Engel curve.

Different household characteristics, such as household size and composition based on age, if household run by a female head, if household is non-Muslim were incorporated and household food expenditure and income were scaled for household size. Engel curves for both suburbs were estimated using the extended specification, and a few interesting hypotheses were tested. Once again, food was found to be income inelastic, and economies of scale was found to be working for both samples. The finding that food is income inelastic, is robust from the study. A probable area of future research can be estimating a specification incorporating, with household income, other basic household expenditures (such as clothing, transport etc.) as explanatory variables to test the joint and cross effects of income increase and/or other basic expenditure increase in household food expenditures. Besides, evaluating variation in household food expenditure at variable prices (using time series or panel data) can also be interesting from marketing research point of view. In policy evaluation, this study has found that a food subsidy (from the government) in the form of cash, or any other fiscal device that generates more real income for households (e.g. an income tax cut or a higher income tax return), will not result in proportionately increased purchase or proportionately increased consumption of food in Dhaka Metropolitan City. It has also been established that larger households spend proportionately lesser amount for food from their income.

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