Bangladesh J. Agric. Econ. XIV, 2 (December 1991) 1-26

FOOD PREFERENCE AND CALORIE INTAKE BEHAVIOUR IN BANGLADESH

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ABSTRACT

Food-specific and total calorie intake functions were estimated with respect to six selected food items - rice, wheat, potato, pulses, fish and edible oil- using the 1981-82 Bangladesh Household Expenditure Survey data. All the food-specific calorie price coefficients had expected sign except for pulses in the case of urban households. While calories from all other food items were normal goods, those from wheat were inferior goods for all the classes of households. Rice price had greater impact on total calorie intake for urban than for rural households. The income elasticity of demand for total calorie was higher for rural than for urban households. An account of quality preference revealed that people would substitute high-cost for low-cost-calorie foods with rising income even at the lower level income.

I. INTRODUCTION

Bangladesh, like many other less developed countries, is characterized by widespread malnutrition of the large segment of the population. Although total availability of food roughly corresponds to the minimum nutritional needs (1800 calories per capita per day)[1], the distribution of calorie intake points to a wide range of variation in intake among different social and economic classes of people. According to the 1983-84 Household Expenditure Survey, per capita daily calorie intake ranged from as low as 829 to 2112 calories among the lower 75 per cent of the expenditure group and 2278 to 2850 calories among the upper 25 per cent of the expenditure group of households (Shahabuddin 1989). If 1800 calories are taken as the minimum nutritional requirement, more than 40 per cent people in Bangladesh consume calories below this requirement (BBS 1986).

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National goals are often set to alleviate nutritional deficiencies of the masses of people. The attainment of such goals through selective price and/or income policies requires information on peoples' food preference pattern. A particular food is demanded not only for its nutrient content, but also for other characteristics such as taste, colour, odor and social value attached to its consumption.

The pattern of preference for nutritional and non-nutritional characteristics of food is not unique for societies with respect to their state of social and economic development. While Silberberg (1985) identified considerable weight being attached to non-nutritional characteristics in comparison with nutritional characteristics of food in the context of highincome people of the United States, Shah (1983), and Greer and Thorbecke (1984) conjectured similar evidence in the context of low-income people of India and Kenya. In a situation where non-nutritional characteristics weigh heavily in the demand for a particular food item, food demand parameter can not be a reliable proxy for nutrient consumption parameter, and the former can represent a gross overestimation of the latter. In order that the impact of price and/or income changes on consumption of a particular nutrient is to be fairly accurately determined, the analysis of policy has to be based on the relevant nutrient consumption parameters.

This paper uses the 1981-82 Bangladesh Household Expenditure Survey data to estimate both food-specific and total calorie intake response with respect to changes in relative prices and incomes of different social and economic classes of households in Bangladesh. An appropriate demand model for estimation of the relevant parameters is presented in section II. The special characteristics of the data are also discussed in this section. In section III the parameter estimates are presented and their implications for policy are discussed. Some conclusions are drawn in the final section of the paper.

II. SPECIFICATION OF THE DEMAND MODEL

Estimation of nutrient consumption parameters can be done in two ways: (i) derivation of the parameters indirectly from the food demand equations by using a fixed food-nutrient conversion factors'(Murty and Radhakrishna 1981, Strauss 1982, Pitt 1983), and (ii) estimation of the relevant parameters from

directly specified nutrient demand functions (Timmer and Alderman 1979, Ward and Sanders 1980, Gray 1982, Behrman and Wolfe 1984, Behrman and Deolalikar 1987).

Pitt (1983) estimated nutrient elasticities from Bangladesh data using food expenditure system models and argued that a separate equation with nutrient as dependent variable is not necessary since all the parameters of the true nutrient-price "relationships are completely identified from the individual demand equations" (Pitt 1983,p.110). His contention is valid when quantities of food and their nutrient contents are proportional in their price and quantity relationships which implies that foods with higher prices contain higher nutritive values. However, it is possible for the price of a food item to vary according to shape, colour, taste or other subjective characteristics even if the nutrient content remains constant. Also, with broad range of items, consumers are found to substitute high-cost-nutrient foods for low-cost-nutrient ones as their incomes rise (Shah 1980, 1983; Behrman and Wolfe 1984; Chaudhri and Timmer 1986).

Thus the use of constant food-nutrient conversion factor is likely to overestimate the true nutrient income elasticity. Such outcomes are likely to have stronger manifestation within the broader food groups. As Behrman and Deolalikar (1987) observe, at the level of aggregation at which it is typically applied, the fixed food-nutrient conversion approach "tends to result in higher estimates of nutrient elasticities with respect to expenditure than the direct estimates" (p. 496).

In this study, direct estimation method is applied where commodity-specific and total calorie consumption figures are used as dependent variables, to be explained by calorie price, income and other socio-demographic factors. The general specification of the food-specific and total calorie demand functions are expressed as:

$$C_i = f(P_{ci}, P_{cj}, Y, Y^2, H, \pi) \quad \ldots \quad \ldots (1)$$

$$C_t = f(P_{ci}, Y, Y^2, H, \pi) \quad \ldots \quad \ldots (2)$$

where,

C_i = per capita calorie consumed from the ith food item,

C_t = per capita total calorie consumed from all (six) food items,

P_{ci} = price per unit of calorie from the ith food item,

P_{cj} = price per unit of calorie from the jth food item,

Y = per capita income of the households,

Y^2 = square term of per capita income,

H = size (number of persons) of the households,

π = composition (proportion of adult members) of the households.

Food-specific calorie equations were estimated for six food items namely rice, wheat, potato, pulses, fish and edible oil. These six food items accounted for 90 per cent of total calorie intake of the average households in Bangladesh (Talukder 1990, p. 281). In addition, a separate function for foodgrain-calorie was also estimated where foodgrain-calorie represented calories from rice and wheat. The calorie consumption figures represented per capita daily calorie from individual and all selected food items. Price of calorie was obtained by dividing the total expenditure on the food items by total units of calorie from the respective food items. The income variable represented per capita monthly total expenditure on all food and non-food items. The influence of the demographic factors was accounted for in the model by including size (number of members) and composition (proportion of adult members) of the household[2].

Four functional forms - linear, log-linear, linear-log and double-log - were tried. The results were compared following the procedures suggested by Doran and Guise (1984). The double-log was found to be the most preferred functional form. Thus the algebraic specification of the food-specific general model in double-log form was as follows:

$$\begin{aligned} \ln C = \alpha &+ \beta \ln P_{co} + \delta_1 \ln XP_{c1} + \delta_2 \ln XP_{c2} + \delta_3 \ln XP_{c3} \\ &+ \delta_4 \ln XP_{c4} + \delta_5 \ln XP_{c5} + \delta_6 \ln XP_{c6} + \Theta \ln Y \\ &+ \phi \ln^2 Y + \varepsilon \ln H + \sigma \ln \pi \quad \ldots \quad \ldots \quad \ldots \qquad (3) \end{aligned}$$

where ln refers to the natural log of the variables; P_{co} is the own price of calorie from the food item; XP_{c1}, XP_{c2}, XP_{c3}, XP_{c4}, XP_{c5} and XP_{c6} are the cross-price terms representing price per 1000 calorie from rice, wheat, potato, pulses, fish and edible oil respectively; α, β, δ, Θ, ϕ, ε and σ are the parameters to be estimated.

The model was estimated for both pooled rural-urban and separately for rural and urban samples. The conduct of Chow test indicated that the rural and urban parameters were structurally different for most of the equations. Therefore, separate regressions were run for rural and urban samples. The

results of pooled regression are also reported with urban dummy (U) as the intercept.

Description of the Data[3]

The data used in this study were obtained from the nation-wide Household Expenditure Survey (HES) 1981-82, conducted by the Bangladesh Bureau of Statistics (BBS). The data were in processed form and represented the average for each district (previously called subdivision) for both rural and urban areas. Thus a sample household represented the average of households in each district separately for rural and urban locations. Again, for each location data were obtained separately for six income groups.

There were 67 district locations separately for rural and urban areas. Given that each rural and urban locations of 67 districts represented a unit of observation in each of the six income classes, the total number of observations comprising all locations and all income classes would be obtained at 67x2x6=804. However, most of the information corresponding to some observations were missing and a series of regression diagnostics[4] revealed that some of the observations were outliers. Having accounted for these factors, some observations were dropped from the data set. Finally, the total number of observations used in the analysis were 652 of which 380 were rural and 272 were urban (Talukder 1990).

Since data corresponding to an observation represented those for the average of households in a district for each category of households, and since the actual number of households corresponding to each observation were not the same, all regressions were weighted by the square root of the number of households against each observation of all the categories of households[5], as a partial measure against heteroscedasticity.

III. CALORIE CONSUMPTION ANALYSIS

Food-specific Calorie Consumption Behaviour

The coefficient estimates of the food-specific calorie demand models for rural, urban and all households in Bangladesh are presented in the Appendix Tables A-1, A-2 and A-3 respectively. The estimates are from double-log

model and therefore can be directly read as the elasticity values. For a closer look at the coefficients of particular interest, the own-price and income elasticities of calorie intake from different food items for rural, urban and all households are presented in Table 1.

Table 1. Own-Price and Income Elasticities of Calorie from the Selected Food Items for Rural, Urban and All Households in Bangladesh.

Calories from food items	Elasticities by location of households		
	Rural	Urban	All
Own-price Elasticities			
Foodgrain	-0.507	-0.482	-0.525
Rice	-0.781	-0.399	-0.720
Wheat	-0.387	-1.718	-0.859
Potatoes	-1.242	-1.628	-1.268
Pulses	-1.194	+0.449	-1.115
Fish	-0.687	-0.725	-0.699
Oil	-0.750	-1.150	-0.883
Income Elasticities			
Foodgrain	0.402	0.257	0.351
Rice	0.604	0.320	0.502
Wheat	-1.466	-0.364	-1.084
Potatoes	1.438	0.764	1.197
Pulses	1.575	1.248	1.473
Fish	1.366	1.069	1.227
Oil	1.040	0.819	0.949

Both price and income elasticities differed markedly between rural and urban households. The difference was more pronounced for rice- and wheat-

calorie price elasticities. The absolute value of the own-price elasticity of calories from rice of the rural households was twice that of the urban households. For wheat-calories, however, the absolute value of the urban elasticity was four tim9s that of the rural elasticity. Thus for urban consumers, price policy, c6teris paribus, seems to be an effective instrument for augmenting calorie consumption from wheat, one of the lowest-cost sources of calorie.

As can be inferred from the values of income elasticity, while rice calories are a necessity for rural, urban and all households in Bangladesh, calories from wheat are an inferior good for all the above categories of households, the degree of inferiority being much stronger for rural than for urban households. While calories from potato and oil are a luxury for rural households, for urban households they are a necessity.. The sign of the coefficients of these food-specific calorie equations followed the coefficients of the individual food demand models (Talukder 1990), and only the magnitudes varied to some extent.

Parameters were also estimated for some selected disaggregated income groups. As mentioned earlier, data were available for six income groups each for rural and urban households. These groups were rearranged into three categories- low-income, middle-income and high-income. The coefficient estimates of the food-specific calorie consumption functions for low, middle and high-income groups are presented in the Appendix Tables A-4, A-5 and A-6 respectively. Some of the variables included in the overall model were dropped as they were not found significant in the specific contexts. For ready reference of the coefficients of particular interest, the own-price and income elasticities of calories from the selected food items for the three income groups are presented in Table 2.

No systematic order of magnitude was observed in the own-price elasticities of calories across the income groups. The income elasticities of calorie from all the food 'items consistently decreased with rising income levels of the households. Except for wheat, all the food items were superior as indicated by the positive income elasticities of calorie from the food items. For wheat-calorie, the absolute value of the negative income elasticity consistently increased from low-income to the high-income households implying that wheat was an. inferior good more for the high-income than for the low-income households. While calories from potatoes, pulses, fish and oil were luxuries for

the low-income households, they were all necessities for the high-income households.

Table 2. Own-Price and Income Elasticities of Demand for Calories from Selected Food Items by Income Classes of Households in Bangladesh.

Calories from food	Elasticities by income classes		
	Low income	Middle income	High income
	Own-price Elasticities		
Foodgrain	-0.440	-0.605	-0.477
Rice	-0.979	-0.621	-0.477
Wheat	0.214[a]	-0.646[a]	-1.984
Potatoes	-1.517	-0.871	-1.204
Pulses	-1.188	-0.979	-1.283
Fish	-0.880	-0.665	-0.451
Oil	-0.664	-1.276	-0.567
	Income Elasticities		
Foodgrain	0.585[b]	0.372	0.232
Rice	0.792[b]	0.536[b]	0.288
Wheat	-0.910	-0.861	-1.173
Potatoes	1.775	1.300	0.837
Pulses	1.496	1.475	0.689
Fish	1.731[b]	1.282	0.743
Oil	1.001[b]	0.908	0.781

a. The coefficients were not statistically significant at 0.05 level

b. The elasticities were derived by using the quadratic term of the income variable as it was statistically significant in the respective equations.

Some implications for policy emerge from the cross-price coefficients across equations of different income classes of households. The cross-price elasticities can be directly read from the Appendix Tables A-1 through A-6. As indicated by the signs and magnitudes of the cross-price terms, while wheat-calorie is a poor substitute in the rice-calorie equation for urban as well as all

households, it is a weak complement in the corresponding equation for rural households in Bangladesh (Tables A-1, A-2, A-3). In the wheat-calorie equation, however, rice is a strong substitute for all the above categories of households, the degree of substitutability being much stronger for rural than for urban households. Thus wheat-calorie intake can be significantly increased in rural areas by raising rice prices. Since price per unit of calorie from wheat is lower than that from rice, such a policy would be more cost-effective. However, since the negative own-price elasticity for rice-calorie is quite high, and rice constitutes the major component in the diet, the net effect of such a policy on calorie intake may be negative.

Among the other features of cross-price coefficients, rice is a strong complement of potato for rural, urban and all households in Bangladesh. Such preference pattern seems to be in contrast with food preference pattern in Western countries where potatoes and rice would be mutually substitutes. In a related preference pattern, potato appears to be a complement in the fish-calorie equation. Fish is eaten in the form of curry in which potato is a popular ingredient. Thus different own and cross-price effects interact in such a complex manner that the net effects of relative price changes on calorie intake become difficult to be identified.

Total Calorie Intake Behaviour

One way of ascertaining the net impact of own and cross-price effects on overall calorie intake is to estimate a function which would determine the effect of change in the price of calorie from individual foods on total calorie intake. The general specification of such a function was given in equation (2). The algebraic specification in a double -log form is as follows:

$$\begin{aligned} \ln C_t = \alpha &+ \beta_1 \ln P_{C1} + \beta_2 \ln P_2 + \beta_3 \ln P_{C3} \\ &+ \beta_4 \ln P_{C4} + \beta_5 \ln P_{C5} + \beta_6 \ln P_{C6} + \delta \ln Y \\ &+ \Theta \ln^2 Y + \phi \ln H + \sigma \ln \pi \quad \ldots \quad \ldots \quad \ldots \qquad (4) \end{aligned}$$

where P_{c1}, P_{c2}, P_{c3}, P_{c4}, P_{c5} and P_{c6} represent price per (1000) unit of calorie from rice, wheat, potato, pulses, fish and oil respectively. Other variables and parameters are as described earlier.

The coefficient estimates of the model for both rural and urban households are presented in Table 3. Except for rice in the rural and urban samples, and pulses in the urban sample, no other single price had any remarkable impact on total calorie intake. Also, rice price had greater impact on total calorie intake for urban than for rural households, although the absolute value of the own-price elasticity of rice-calorie for rural households was twice that of the urban households (Table 1). The greater value of the own-price elasticity for rural households implies that lower price of rice would cause substitution of rice for other calorie-rich foods in greater proportion for rural than for urban households. Thus, although as a result of fall in the price of rice, total calorie intake of both will increase, the increase will be greater for urban than for rural households.

The results of Table 3 indicate that the prospect of an income induced change in total calorie intake would be greater for rural than for urban households. Again, the positive and statistically significant coefficient of the household size variable is an indication that there were economies of size with respect to total calorie intake and that such an effect was stronger for rural than for urban households. Also, the household composition variable was positive and statistically significant for both rural and urban households implying that the presence of adult members contributed positively to per capita total calorie intake of the households.

The estimated coefficients of total calorie intake function of the three income classes of households are presented in Table 4. As with the rural and urban estimates, among the price variables, rice price was the single major determinant of total calorie intake for all. the income groups. The net impact of rice price change on total calorie intake was lowest for the low-income group, although the own-price elasticity of rice-calorie was the highest for the group (Tables A-4, A-5, A-6). The positive rice price coefficient in the wheat equation was highest for the low-income group. Thus the higher (negative) own-price and (positive) cross-price effects for rice may have been instrumental in effecting greater substitution of rice for wheat and, other

Table 3. Coefficient Estimates of Total Calorie Demand Models for Rural and Urban Households.

Variables	Equations: Per capita total calorie[a]	
	Rural households	Urban households
Constant	0.092[c]	3.837
	(0.102)	(4.208)
$\ln\pi$	0.160	0.103
	(3.417)	(2.063)
$\ln P_{c1}$	-0.231	-0.329
	(-2.904)	(-2.959)
$\ln P_{c2}$	-0.034[c]	-0.020[c]
	(-637)	(-0.334)
$\ln P_{c3}$	-0.003[c]	-0.028[c]
	(-0.116)	(0.619)
$\ln P_{c4}$	-0.039	-0.223
	(-1.693)	(-2.719)
$\ln P_{c5}$	0.052	-0.086
	(2.159)	(-2.330)
$\ln P_{c6}$	-0.051[c]	0.022[c]
	(-1.180)	(0.526)
$\ln Y$	2.466 0.401[b]	1.267 0.319[b]
	(6.981)	(3.862)
$\ln^2 Y$	-0.202	-0.088
	(-5.966)	(-3.001)
$\ln H$	0.130	0.069
	(5.590)	(3.190)
R^2	0.713	0.502
R^{-2}	0.705	0.483
F	91.910	26.310

Note : The figures in parentheses are t-values.

a. Per capita daily total calorie from the six selected food items.

b. Income elasticities for total calorie intake at the mean value of the variable.

c. The coefficients were not significant at 0.05 level.

calorie-rich foods leading to a smaller impact of a change in rice prices on total calorie intake for this group of households.

The positive relationship of the price of fish with total calorie intake, as observed for rural households, was found to hold for all income groups. The positive oil price coefficient of total calorie intake of the high-income group may be interpreted as the urban influence, possibly of substituting oil for other calorie-rich foods in response to a lower price of oil. The income elasticity of total calorie intake was highest for the low-income and lowest for the high-income group. Thus the efficacy of income policy, ceteris paribus, to augment overall calorie consumption seems to be greater among the low-income households.

Accounting for Quality Preference in Food Consumption

One possibility was raised in the introduction section that people could substitute high-cost items for low-cost ones within a specified food or food group with rising income. Thus they could be paying more for the same amount of nutrient,reflecting preference for subjective characteristics of foods. An attempt is made here to capture the degree of such preference, if any, by estimating calorie price equations.

The average calorie price from different foods can be taken as an index of dietary quality or variety. If such a calorie price is regressed on per capita income, the income coefficient from a double-log model represents the 'quality' or 'prices-paid' elasticity. This elasticity value indicates the extent to which people prefer quality of food to quantity of calories in their purchase decisions. In order to examine such preference patterns, the following simplified food-specific and total calorie price functions were specified:

$$\ln P_{ci} = \alpha + \beta \ln Y + \delta \ln H \quad \ldots \quad (5)$$

$$\ln P_{ca} = \alpha + \beta \ln Y + \delta \ln H \quad \ldots \quad (6)$$

where,

P_{ci} = price per unit of calorie from individual food,

P_{ca} = price per unit of calorie from all (six) foods.

The estimated coefficients for rural-urban and income classes of households are presented in the Appendix Tables A-7 and A-8 respectively. As

Table 4. Coefficient Estimates of Total Calorie Demand Models for Different Income Classes of Households.

Variables	Equations: Per capita total calorie		
	Low-income	Middle-income	High-income
Constant	-2.227 (-1.608)	5.386 (19.947)	5.861 (22.503)
$\ln Pc_1$	-0.186 (-1.778)	-0.267 (-2.703)	-0.247 (-1.852)
$\ln Pc_2$	-0.024[a] (-0.303)	-0.069[a] (-1.290)	0.003[a] (0.043)
$\ln Pc_3$	-0.007[a] (-0.420)	0.050 (-2.153)	-0.104 (-2.791)
$\ln Pc_4$	-0.050[a] (-1.606)	-0.024[a] (0.821)	-0.043[a] (-0.868)
$\ln Pc_5$	0.056 (1.928)	0.030[a] (1.003)	0.011[a] (0.243)
$\ln Pc_6$	-0.040[a] (-0.778)	-0.021[a] (-0.462)	0.020[a] (0.305)
$\ln Y$	3.332 0.576[c] (5.946)	0.374 (8.382)	0.275 (7.229)
$\ln^2 Y$[b]	-0.282 (-4.999)	– –	– –
$\ln H$	0.063 (2.012)	0.116 (2.779)	0.206 (4.080)
U	-0.057 (-2.124)	-0.092 (-3.751)	-0.056 (-1.726)
R^2	0.584	0.286	0.291
R^{-2}	0.563	0.257	0.260
F	27.480	9.890	9.320

Note : The figures in parentheses are t-values

a. The coefficients were not significant at 0.05 level.

b. Coefficients of the variable for middle and high-income groups were not statistically significant and as such were dropped from the respective equations.

c. Income elasticity for total calorie intake at the means of the variables.

is evident from the coefficient estimates, R^2 and F values, except for a few equations the food-specific calorie price functions did not yield good results in most of the groups of households. However, the total calorie price equations performed consistently well for all the classes of households.

The income elasticities of 'prices-paid' for food-specific and total calories for rural, urban and income classes of households are presented in Table 5. Except for potatoes in the middle-income group and oil in the urban as well as in the middle-income group, 'prices-paid' elasticities were positive for both food-specific and total calorie intakes.

The extent of 'prices-paid' elasticities for food-specific calories were not that high, except for fish-calorie elasticity. However, the 'prices-paid' elasticities of calorie from all foods were of substantial magnitude for all the classes of households. The elasticity of fish-calorie was exceptionally high among the food-specific elasticities and this might have had considerable influence on the higher value of 'prices-paid' elasticity of calorie from all foods.

Table 5. Elasticity of Prices-paid for Calorie by Rural, Urban Locations and Income Classes of Households.

Calorie Source	Prices-paid elasticities by types of households				
	Location		Income classes		
	Rural	Urban	Low	Middle	High
Foodgrain	0.096	0.096	0.103	0.121	0.084
Rice	0.055	0.090	0.069	0.086	0.072
Wheat	0.037	0.015	0.038	0.028	0.040
Potatoes	0.102	0.055	0.089	-0.013	0.083
Pulses	0.055	0.034	0.033	0.145	-0.034
Fish	0.264	0.219	0.302	0.246	0.264
Oil	0.065	-0.041	0.047	-0.012	-0.019
All foods	0.192	0.201	0.201	0.218	0.187

The results of the estimates indicate that while quality elasticity is minimal within the individual food items, it increases and reaches a substantial magnitude for the total food intake. Thus people, in choosing from among the broad range of food items, substitute high-cost items for low-cost ones as their incomes rise. More interestingly, the magnitude of such preference for the low-income households is one of the highest among the classes of households, as is evident from Table 5. The results corroborate the evidence provided by Shah (1983) from India that even at low levels of income, taste dominates the decision to allocate income to different foods.

IV. CONCLUSIONS

The consumption parameters obtained from this study indicate the differential impacts of a particular policy choice on different classes of people. Besides, different own and cross-price effects interact in such a complex manner that the net impact of a policy choice on nutritional intake becomes difficult to be determined.

The disaggregated estimation of parameters reveals that while rural and urban parameters were structurally different, the source of difference was the high-income households. Thus implications of price and/or income policies for the low-income households could be taken as invariant with respect to their rural-urban locations.

The negative income and positive price coefficients of wheat-calorie for the low-income households pose a real problem for policy especially in view of the fact that the national policy goal seeks to divert preference from rice and other food items to wheat, the low-cost source of calorie and protein. The additional concern for policy is the overall food preference pattern of different classes of households, especially the low-income households. An assesment of quality preference revealed that even the low-income households placed considerable weight on subjective taste-related characteristics in allocating their incomes to different food items.

Such preference patterns would place severe restrictions for policy planners contemplating to alleviate nutritional problems through selective price and/or income policies. Solution to the problems relate, to some extent, to

technological aspects of production and processing of foods, such as imparting taste and other subjective characteristics to low-cost nutritious foods or reducing the cost of 'palate-pleasing' foods. Finally, promotional measures such as dissemination of information pertaining to the merits of low-cost calorie-intensive foods can also play an important role in moulding peoples' preference to the coveted direction.

Notes

1. Literature on nutritional requirement for human body almost fails to provide any consensus on minimum calorie requirement for a given population. However, in order to assess the quantitative magnitude of undernutrition and poverty, some cut-off point of requirement becomes necessary. Attempts have been made in Bangladesh to determine some alternative levels of calorie requirement following the FAO/WHO guidelines. For justification of taking 1800 as the minimum calorie requirement in the specific context of Bangladesh, see BBS 1986 and Talukder 1990.

2. The details of the rationale for choice of the variables can be seen in Talukder 1990.

3. The information presented in this section have been obtained from Talukder 1990.

4. The diagnostic measures employed were, among others, 'condition index', 'variance decomposition proportion', 'studentized residual', 'covariance ratio', 'Cook's distance' and 'DFFIT'. See Talukder 1990 for details.

5. See Timmer and Alderman 1979, and Gray 1982 for similar treatment.

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Table A-1. Coefficient Estimates of Commodity-Specific Calorie Demand Models (Rural Households: N = 380).

Variables	Equations: Per capita calories from food						
	Food-grain	Rice	Wheat	Potato	Pulses	Fish	Oil
Constant	-0.428*	-4.557	2.229*	-19.129	-24.888	-15.661	-3.795*
	(-0.459)	(-4.370)	(0.293)	(-3.382)	(-3.875)	(-5.108)	(-1.348)
$\ln P_{c0}$	-0.507	-0.781	-0.387*	-1.242	-1.194	-0.687	-0.750
	(-5.668)	(-8.616)	(-0.863)	(-12.621)	(-7.417)	(-8.368)	(-5.576)
$\ln XP_{c1}$			3.658	-1.137		0.465	
			(5.477)	(-2.365)		(1.787)	
$\ln XP_{c2}$		-0.033*					
		(-0.548)					
$\ln XP_{c3}$					0.275	-0.134	0.147
					(2.444)	(-2.512)	(2.998)
$\ln XP_{c4}$	-0.016*		-0.345				
	(-0.702)		(-1.802)				
$\ln XP_{c5}$				0.208*	0.352		0.065*
				(1.374)	(2.048)		(0.869)
$\ln XP_{c6}$	-0.034*	0.076	-1.274				
	(-0.782)	(1.578)	(-3.507)				
$\ln Y$	2.692	4.090	2.367*	7.848	9.089	6.733	2.196
	(7.462)	(10.131)	(8.802)	(3.589)	(3.649)	(5.681)	(2.012)
$\ln^2 Y$	-0.224	-0.341	-0.375*	-0.627	-0.735	-0.525	-0.113*
	(-6.441)	(-8.802)	(-1.324)	(-2.991)	(-3.079)	(-4.616)	(-1.081)
$\ln H$	0.153	0.098	0.385	-0.146*	0.297	-0.246	-0.229
	(6.491)	(3.729)	(2.003)	(-1.006)	(1.798)	(-3.121)	(-3.151)
$\ln \pi$	0.157	0.132	0.010*	-0.001*	-0.011*	-0.140*	-0.032*
	(3.246)	(2.456)	(0.026)	(-0.006)	(-0.034)	(0.884)	(-0.224)
R^2	0.682	0.757	0.245	0.395	0.481	0.495	0.494
$\bar{R}^2$	0.676	0.753	0.228	0.374	0.471	0.486	0.484
F	114.23	116.17	15.06	34.81	49.28	52.28	51.89

Note: Figures in the parentheses are t-values
*The coefficients were not significant at 0.05 level.

Table A-2. Coefficient Estimates of Commodity-Specific Calorie Demand Models (Urban Households: N = 272).

Variables	Equations: Per Capita Calories from Food						
	Food-grain	Rice	Wheat	Potato	Pulses	Fish	Oil
Constant	3.185	0.421*	18.448	-4.311*	-17.027	-8.892	-3.534*
	(3.227)	(0.363)	(2.792)	(-0.985)	(-3.916)	(-3.194)	(-1.374)
$\ln P_{co}$	-0.482	-0.399	-1.718	-1.628	0.449*	-0.725	-1.150
	(-4.178)	(-2.839)	(-3.930)	(-7.337)	(1.157)	(-6.345)	(-9.444)
$\ln XP_{c1}$			1.497	-0.640*		0.103*	
			(1.862)	(-1.197)		(0.305)	
$\ln XP_{c2}$		0.113*					
		(1.480)					
$\ln XP_{c3}$						0.231*	-0.231
						(1.639)	(-1.797)
$\ln XP_{c4}$	-0.197		-1.966				
	(-2.201)		(-3.298)				
$\ln XP_{c5}$				0.684			0.284
				(3.805)			(2.721)
$\ln XP_{c6}$	0.112	0.216	-1.328				
	(2.387)	(3.924)	(-4.239)				
$\ln Y$	1.409	2.150	-3.163*	2.357*	5.908	3.997	2.337
	(3.986)	(5.115)	(-1.332)	(1.476)	(3.750)	(3.936)	(2.509)
$\ln^2 Y$	-0.107	-0.170	0.260*	-0.148*	-0.433	-0.272	-0.141
	(-3.382)	(-4.485)	(1.213)	(-1.028)	(-3.040)	(-2.967)	(-1.683)
$\ln H$	0.074	0.077	0.004*	0.040*	0.073*	-0.063*	-0.060*
	(3.213)	(2.[illegible]92)	(0.030)	(0.381)	(0.704)	(-0.936)	(-0.983)
$\ln \pi$	0.112	0.117*	0.387*	0.357*	0.052*	-0.176*	-0.110*
	(2.080)	(1.840)	(1.065)	(1.482)	(0.216)	(-1.147)	(-0.789)
R^2	0.375	0.422	0.164	0.373	0.464	0.530	0.614
$\bar{R}^2$	0.359	0.407	0.138	0.356	0.449	0.517	0.604
F	22.71	27.62	6.45	22.46	32.66	42.57	60.17

Note: Figures in the parentheses are t-values
*The coefficients were not significant at 0.05 level.

Table A-3. Coefficient Estimates of Commodity-Specific Calorie Demand Models (All Households: N = 652).

Variables	Equations: Per Capita Calories from Food						
	Food-grain	Rice	Wheat	Potato	Pulses	Fish	Oil
Constant	0.105*	-3.434	16.101	-14.750	-22.359	-12.482	-4.539
	(0.173)	(-4.969)	(3.396)	(-4.324)	(-5.903)	(-6.521)	(-2.574)
lnP_{co}	-0.525	-0.720	-0.859	-1.264	-1.115	-0.699	-0.883
	(-7.480)	(-9.616)	(-2.590)	(-15.737)	(08.555)	(-10.762)	(-9.275)
$lnXP_{c1}$			3.287	-1.102		0.403	
			(6.330)	(-3.049)		(1.989)	
$lnXP_{c2}$		0.010*					
		(0.216)					
$lnXP_{c3}$					0.287	-0.119	0.119
					(3.195)	(-2.650)	(2.874)
$lnXP_{c4}$	-0.019*		-0.365				
	(-0.909)		(-2.219)				
$lnXP_{c5}$				0.297	0.319		0.104
				(2.565)	(2.483)		(1.746)
$inXP_{c6}$	0.030*	0.144	-1.359				
	(0.941)	(3.842)	(-5.286)				
lnY	2.472	3.637	-3.143	6.150	8.118	5.501	2.527
	(10.707)	(13.867)	(-1.742)	(4.750)	(5.625)	(7.572)	(3.767)
ln^2Y	-0.203	-0.300	0.197*	-0.474	-0.636	-0.409	-0.151
	(-9.389)	(-12.198)	(1.169)	(-3.909)	(-4.710)	(-6.019)	(-2.407)
lnH	0.132	0.102	0.148*	-0.065*	0.204	-0.175	-0.163
	(7.819)	(5.302)	(1.122)	(-0.675)	(1.902)	(-3.226)	(-3.258)
$ln\pi$	0.137	0.135	-0.015*	0.111*	0.034*	-0.146*	-0.057*
	(3.753)	(3.240)	(-0.055)	(0.543)	(0.150)	(-1.278)	(-0.547)
U	-0.078	-0.150	0.536	0.252	0.345	-0.020	0.147
	(-5.703)	(-0.896)	(4.937)	(2.925)	(3.488)	(-0.432)	(3.256)
R^2	0.616	0.696	0.213	0.384	0.527	0.501	0.640
$\bar{R}^2$	0.612	0.692	0.202	0.376	0.521	0.495	0.636
F	129.28	184.64	19.37	50.10	89.66	80.80	143.42

Note: Figures in the parentheses are t-values

*The coefficients were not statistically significant at 0.05 level.

Table A-4. Coefficient Estimates of Commodity-Specific Calorie Demand Models (Low Income Group : N = 206).

Variables	Equations: Per Capita Calories from Food						
	Food-grain	Rice	Wheat	Potato	Pulses	Fish	Oil
Constant	-2.298	-5.511	8.960	-4.888	-4.625	-17.800	-11.690
	(-1.539)	(-2.928)	(6.354)	(-3.192)	(-2.824)	(-3.302)	(-2.566)
$\ln P_{co}$	-0.440	-0.979	-0.214*	-1.517	-1.188	-0.880	-0.664
	(-3.462)	(-6.939)	(-0.373)	(-10.435)	(-4.524)	(-7.6653)	(-3.886)
$\ln XP_{c1}$			4.116	-1.105*		-0.494*	
			(5.582)	(-1.415)		(-1.284)	
$\ln XP_{c2}$		0.039*					
		(0.361)					
$\ln XP_{c3}$					0.325	-0.107	0.159
					(2.067)	(-1.510)	(2.645)
$\ln XP_{c4}$	-0.034*		-0.324*				
	(-1.060)		(-1.502)				
$\ln XP_{c5}$				0.336*	0.112*		-0.045*
				(1.424)	(0.448)		(-0.046)
$\ln XP_{c6}$	-0.021*	0.122	-1.050				
	(-0.391)	(1.729)	(-2.852)				
$\ln Y$	3.371	4.447	-0.910	1.775	1.496	7.663	5.543
	(5.575)	(5.853)	(-3.504)	(5.870)	(4.743)	(3.510)	(3.007)
$\ln^2 Y$	-0.285	-0.374				-0.607	-0.464
	(-4.675)	(-4.873)				(-2.757)	(-2.499)
$\ln H$	0.096	0.049*	0.290*	0.099*	0.013*	0.073*	-0.233
	(2.888)	(1.188)	(1.396)	(0.414)	(0.054)	(0.600)	(-2.244)
R^2	0.511	0.603	0.253	0.411	0.331	0.479	0.516
$\bar{R}^2$	0.494	0.589	0.227	0.393	0.311	0.460	0.499
F	29.63	43.09	9.62	23.13	16.46	26.03	30.20

Note: Figures in the parentheses are t-values
*The coefficients were not significant at 0.05 level.

Table A-5. Coefficient Estimates of Commodity-Specific Calorie Demand Models (Middle Income Group: N = 232).

Variables	Equations: Per Capita Calories from Food						
	Food-grain	Rice	Wheat	Potato	Pulses	Fish	Oil
Constant	5.410	-6.067	9.597	-2.829	-5.086	-1.768	0.133*
	(19.611)	(-1.969)	(3.936)	(-1.805)	(-2.967)	(-1.989)	(0.170)
lnP_{co}	-0.605	-0.621	-0.646*	-0.871	-0.979	-0.665	-1.276
	(-5.683)	(-6.003)	(-1.340)	(-6.350)	(-5.315)	(-6.593)	(-9.462)
$lnXP_{c1}$			3.737	-0.983		0.511*	
			(4.176)	(-1.736)		(1.593)	
$lnXP_{c2}$		-0.023*					
		(-0.414)					
$lnXP_{c3}$					0.177*	0.033*	0.157
					(1.185)	(-0.430)	(2.328)
$lnXP_{c4}$	0.029*		-0.458				
	(0.197)		(-1.729)				
$lnXP_{c5}$				0.330	0.381		0.082*
				(1.858)	(1.965)		(0.939)
$lnXP_{c6}$	0.045*	0.144	-1.675				
	(0.976)	(2.900)	(-4.019)				
lnY	0.372	4.646	-0.861	1.300	1.475	1.282	0.908
	(8.125)	(3.868)	(-2.163)	(4.908)	(5.169)	(8.536)	(7.084)
ln^2Y		-0.400					
		(-3.432)					
lnH	0.145	0.092	0.293*	-0.096*	0.161*	-0.140*	-0.087*
	(3.424)	(2.001)	(0.776)	(-0.387)	(0.594)	(-1.059)	(-0.710)
U	-0.072	-0.139	0.420	-0.020*	0.226*	-0.099*	0.100*
	(-3.686)	(-6.728)	(2.408)	(-0.150)	(1.4909)	(-1.276)	(1.450)
R^2	0.280	0.497	0.204	0.271	0.291	0.394	0.591
$\bar{R}^2$	0.261	0.482	0.179	0.251	0.272	0.378	0.580
F	14.63	31.72	8.20	13.95	15.45	24.46	54.28

Note: Figures in the parentheses are t-values
*The coefficients were not significant at 0.05 level.

Table A-6. Coefficient Estimates of Commodity-Specific Calorie Demand Models (High Income Group: N = 214).

Variables	Equations: Per Capita Calories from Food						
	Food-grain	Rice	Wheat	Potato	Pulses	Fish	Oil
Constant	5.952	5.464	12.851	-0.260	-0.860*	0.385*	-0.521*
	(22.207)	(19.070)	(6.107)	(-0.291)	(-0.747)	(0.598)	(-0.714)
$\ln P_{co}$	-0.477	-0.477	-1.984	-1.204	-1.283	-0.451	-0.567
	(-3.567)	(-3.183)	(-2.866)	(-8.686)	(-5.542)	(-3.607)	(-2.928)
$\ln XP_{c1}$			1.369*	-1.184		1.114	
			(1.269)	(-2.422)		(4.021)	
$\ln XP_{c2}$		0.078*					
		(0.811)					
$\ln XP_{c3}$					0.172*	-0.298	-0.067*
					(0.996)	(-2.997)	(-0.642)
$\ln XP_{c4}$	-0.071*		-0.339*				
	(-0.139)		(-0.841)				
$\ln XP_{c5}$				0.189*	0.677		0.414
				(1.091)	(3.091)		(3.111)
$\ln XP_{c6}$	0.069*	0.156	-1.174				
	(0.974)	(2.026)	(-2.111)				
lnY	0.232	0.288	-1.173	0.837	0.689	0.743	0.781
	(6.114)	(7.019)	(-3.965)	(5.946)	(3.982)	(7.337)	(7.399)
lnH	0.197	0.187	-0.240*	0.156*	-0.031*	-0.132*	-0.102*
	(3.846)	(3.358)	(-0.597)	(0.834)	(-0.135)	(-0.980)	(-0.709)
U	-0.117	-0.191	0.915	0.279	0.267	-0.036*	0.197
	(-3.998)	(-6.281)	(3.859)	(2.548)	(1.846)	(-0.462)	(2.287)
R^2	0.275	0.382	0.198	0.372	0.326	0.341	0.519
$\bar{R}^2$	0.254	0.364	0.171	0.354	0.307	0.322	0.505
F	13.08	21.34	7.30	20.47	16.75	17.86	37.25

Note: (1) The quadratic term of the income variable as used in some of the equations in the other two groups, was not significant in any of the equations of this group and as such dropped from the models in this group.

(2) Figures in the parantheses are t-values.

* Some coefficients were not significant at 0.05 level.

Table A-7. Coefficient Estimates of Commodity-Specific and Total Calorie Price Equations for Rural and Urban Households in Bangladesh.

Variables	Equations: Per Capita Calories from Food							
	Food-grain	Rice	Wheat	Potato	Pulses	Fish	Oil	All foods
				Rural households				
Constant	-0.106	0.113	-0.061*	-0.522	0.770	0.678	-0.844	-0.441
	(-1.970)	(1.883)	(-0.697)	(-1.764)	(3.712)	(3.535)	(7.825)	(-7.530)
lnY	0.096	0.055	0.037	0.102	0.055*	0.264	0.065	0.192
	(7.524)	(3.844)	(1.761)	(2.890)	(1.120)	(5.800)	(2.543)	(13.878)
lnH	-0.004*	0.012*	-0.005*	0.209	0.015*	0.140	-0.019*	-0.621
	(-0.041)	(0.938)	(-0.029)	(3.293)	(0.358)	(3.408)	(-0.853)	(-1.745)
R^2	0.204	0.185	0.117	0.126	0.187	0.245	0.119	0.429
$\bar{R}^2$	0.200	0.180	0.115	0.121	0.164	0.241	0.104	0.426
F	48.57	17.57	12.65	27.27	11.64	61.28	13.78	141.90
				Urban households				
Constant	-0.113	-0.025*	0.012*	1.022	1.162	1.271	1.281	-0.470
	(-2.003)	(-0.482)	(-.236)	(8.132)	(16.251)	(8.246)	(9.619)	(-7.517)
lnY	0.096	0.090	0.015*	0.055	0.034	0.219	-0.041*	0.201
	(9.197)	(9.140)	(0.855)	(2.399)	(2.569)	(7.524)	(-1.638)	(16.957)
lnH	0.014*	0.013*	0.024*	0.047	-0.026	0.078	-0.012*	0.003*
	(1.295)	(1.337)	(1.319)	(1.948)	(-1.873)	(2.602)	(-0.472)	(0.224)
R^2	0.267	0.265	0.119	0.147	0.129	0.224	0.112	0.534
$\bar{R}^2$	0.262	0.260	0.104	0.136	0.122	0.218	0.105	0.531
F	49.19	48.69	11.61	16.14	14.14	38.94	11.75	154.47

Note: Figures in the parentheses are t-values
*The coefficients were not significant at 0.05 level.

Table A-8. Coefficient Estimates of Commodity-Specific and Total Calorie Price Equations for Different Income Classes of Households in Bangladesh.

Variables	Equations: Per Capita Calories from Food							
	Food-grain	Rice	Wheat	Potato	Pulses	Fish	Oil	All foods
				Low income households				
Constant	-0.150*	0.032*	0.096*	0.768*	0.969	0.367*	0.920	-0.509
	(-1.301)	(0.240)	(0.551)	(1.041)	(2.184)	(0.080)	(3.547)	(-4.334)
lnY	0.103	0.069	0.038	0.089	0.033*	0.302	0.047*	0.201
	(4.776)	(2.715)	(0.117)	(2.089)	(0.401)	(3.547)	(0.971)	(9.104)
lnH	0.044*	0.018*	-0.021*	0.078*	-0.049*	0.234	-0.017*	-0.025*
	(0.254)	(0.898)	(-0.810)	(0.695)	(-0.870)	(3.362)	(-0.499)	(-0.141)
U	0.014*	0.038	0.018*	0.563	0.248	0.294	-0.064	0.049
	(1.154)	(2.521)	(0.955)	(6.908)	(5.064)	(5.860)	(-2.250)	(3.786)
R^2	0.166	0.143	0.106	0.280	0.160	0.266	0.125	0.475
$\bar{R}^2$	0.153	0.101	0.081	0.270	0.148	0.255	0.110	0.467
F	13.39	7.84	6.45	26.29	12.90	24.46	11.75	60.93
				Middle income households				
Constant	-0.254*	-0.055*	-0.027	0.776*	0.357*	0.843*	1.279	-0.593
	(-1.482)	(-0.304)	(-0.083)	(1.026)	(0.582)	(1.450)	(3.367)	(-3.312)
lnY	0.121	0.086	0.028*	-0.013*	0.145*	0.246	-0.012*	0.218
	(4.313)	(2.870)	(0.531)	(-0.106)	(1.436)	(2.577)	(-0.192)	(7.419)
lnH	0.015*	0.019*	0.054*	0.104*	-0.024*	0.099*	0.042*	-0.064*
	(0.551)	(0.683)	(0.105)	(0.872)	(-0.025)	(1.076)	(-0.706)	(-0.225)
U	0.089*	0.039	0.016*	0.531	0.173	0.250	-0.121	0.044
	(0.775)	(3.201)	0.765	(10.416)	(4.201)	(6.372)	(-4.754)	(3.646)
R^2	0.124	0.134	0.073	0.372	0.136	0.255	0.111	0.399
$\bar{R}^2$	0.112	0.123	0.058	0.363	0.124	0.246	0.099	0.392
F	10.75	11.82	8.56	45.05	11.98	26.14	9.49	50.65

Table A- 8. Cont.

Variables	Equations: Per Capita Calories from Food							
	Food-grain	Rice	Wheat	Potato	Pulses	Fish	Oil	All foods
				High income households				
Constant	-0.047*	0.044*	-0.136*	-0.039*	1.155	0.097	1.264	-0.392
	(-0.374)	(0.351)	(-0.699)	(-0.088)	(3.490)	(2.754)	(5.257)	(-2.546)
lnY	0.084	0.072	0.040*	0.083*	-0.034*	0.264	-0.019*	0.187
	(4.482)	(3.938)	(1.418)	(1.267)	(-0.705)	(5.087)	(-0.556)	(8.258)
lnH	-0.011*	0.025*	0.023*	0.289	0.064*	0.028*	0.012*	-0.033*
	(-0.040)	(-0.099)	(0.584)	(3.108)	(0.941)	(0.040)	(0.024)	(-1.057)
U	0.037	0.066	0.010*	0.408	0.227	0.199	-0.128	0.075
	(2.894)	(5.302)	(0.524)	(9.115)	(6.863)	(5.644)	(-5.338)	(4.849)
R^2	0.206	0.290	0.126	0.349	0.205	0.351	0.169	0.469
$\bar{R}^2$	0.194	0.280	0.102	0.340	0.193	0.342	0.157	0.462
F	18.18	28.60	11.15	37.67	18.08	37.93	14.25	62.02

Note: Figures in the parentheses are t-values
*The coefficients were not significant at 0.05 level.