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DEMAND PARAMETERS IN RURAL BANGLADESH

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1. SUMMARY

This study estimates a complete demand system for rural Bangladesh, applying the Almost Ideal Demand System (AIDS) model. The estimates of demand parameters are based on primary data from the rural household survey conducted by IFPRI in 1991/92.

The estimates of income elasticity of demand suggest that rural households in general are highly responsive to changes in income in adjusting their consumption patterns. There is a tendency for the higher-priced foods, such as meat and milk, to have higher income elasticities.

Demands for commodities are also quite responsive to changes in their own prices, with the exception of salt. The estimates of cross-price elasticities indicate that substitution effects are strong, and therefore have important implications for price policies.

Disaggregated by income groups, the estimates of demand parameters of rice and wheat suggest that low-income households are more price and income responsive than high-income households. Differences in elasticities in absolute values between the two groups are quite striking.

The estimates conform with the findings of other studies that wheat is an inferior commodity in rural Bangladesh. This attribute makes wheat a self-targeting commodity for targeted food intervention programs.

The study contends that government price interventions may lead to serious price repercussions in the economy. Particularly, rice price stabilization programs are likely to skew producer incentives in non-rice crops. In contrast, income generating programs and policies foster higher levels of consumption for all normal commodities, and thus, a steady growth in production by enhancing effective demand.

2. INTRODUCTION

An understanding of consumption patterns is essential for a consistent analysis of domestic food policy. The demand parameters for food as well as nonfood commodities can be used to answer several important policy questions. For example, with the recent trend in falling rice price in Bangladesh, how much more rice will likely be consumed by people in different income groups? What will be the effect on market demand for wheat? How will demand for pulses, potatoes, edible oil, or fish change? Does the falling wheat price have any influence on demand for rice? Is wheat an inferior good? When per capita income rises, how much is market demand for rice likely to increase? If per capita income rises while domestic edible oil production remains static, how many tons of edible oil will have to be imported to keep prices stable? If the price of kerosine fuel rises, how will demand for different food items change in rural areas? Estimates of income, own-price and cross-price elasticities of demand are needed to answer such questions.

Appreciation of consumption implications on agricultural production policies are only beginning to evolve in Bangladesh. Food production and consumption have their influences on each other. An adequate effective demand for food is needed to sustain the growth in food production. The consumption parameters provide necessary information on linkages from food consumption to incentives for agricultural production, through the marketing sector. For instance, the availability of commodity-wise disaggregated food demand parameters are essential in formulating crop diversification policies and programs.

Several studies in Bangladesh provide price and income (expenditure) elasticities for various commodities. These include: elasticities of composite foodgrains (Alamgir and Berlage 1973, Mahmud 1979); foods and nonfood items (Ahmed 1981, Chowdhury 1982, Bouis 1989); and food items (Pitt 1983, Goletti 1993). With the exception of Mahmud (1979), these studies used cross-section data from the Household Expenditure Surveys (HES), periodically conducted by the Bangladesh Bureau of Statistics. Mahmud (1979) used pooled cross-section data from Quarterly Survey of Current Economic Conditions for the years 1964,

1965, 1967 and 1969. The most recent estimates of demand elasticities of food items are based on 1988/89 HES data (Goletti 1993).

Five of the previous studies on demand parameters used the system of demand approach. Among these studies, Chowdhury (1982) used a method developed by Frisch (1959) which is based on additivity or "want independence" assumption. A consumer's preferences are said to be want-independent if the marginal utility of any one good depends on the quantity of that good, and not on the quantity of any other goods. This is an extreme assumption, and therefore, the Frisch methodology can be criticized because of the severe restrictions imposed. Ahmed (1981) used the Linear Expenditure System (LES) for estimating a complete demand system. However, the LES also suffers from the limitations of additive systems mentioned above. The Frisch's method and the LES imply that all goods are substitutes (they cannot be complements) and none are inferior goods (Alderman 1986).

Bouis (1989, 1992) developed a method of estimating a food demand system based on demand for energy, variety, and tastes of foods. A complete matrix of demand elasticities can be derived for all food and one nonfood commodities by specifying utility as an explicit function of these food characterists, which Bouis terms the Food Characteristic Demand System (FCDS). In contrast to Frisch's method, the FCDS assumes that marginal utility from consumption of any food depends on the level of consumption of all other foods. Bouis's method, however, requires prior knowledge of any four elasticities to generate the matrix of demand elasticities. Bouis (1989) applied his FCDS method to derive demand elasticities for food and nonfood commodities in Bangladesh using the 1973/74 HES data.

The other two studies by Pitt (1983) and Goletti (1993) used a method called Tobin's probit or tobit to estimate the food demand system. The basic reason for using the tobit method to estimate the demand system was to overcome the econometric problems that arise due to nonconsumption or zero-value observations. The Tobit model permits a positive probability of observing nonconsumption. However, Pitt (1983) showed that it is inappropriate to use tobit in demand analysis for models that have expenditures or budget shares as

dependent variables. This immediately rules out some of the most popular and relatively recently developed demand systems, such as the Rotterdam model, and the Almost Ideal Demand System (AIDS).

The present study of demand parameters in rural Bangladesh differs from the previous studies mainly in two respects. First, the parameter estimates are based on the most recent primary data from three rounds of the household consumption and nutrition survey conducted in Bangladesh by International Food Policy Research Institute (IFPRI), over the period from September of 1991 to November of 1992. Next, for the first time in Bangladesh, the study applies the Almost Ideal Demand System (AIDS) to estimate a complete demand system.

3. MODEL SPECIFICATIOIN, ESTIMATION, AND DATA

The AIDS Model and Elasticities

The Almost Ideal Demand System (AIDS) was introduced by Deaton and Muellbauer (1980a, 1980b). The AIDS model has been widely adopted by economists in recent years. Its popularity can be attributed to its properties which are consistent with the theory of demand, and its relatively simplistic estimation procedure. Although a few other models (such as the Rotterdam or translog models) possess many of these desirable properties, none possesses all of them simultaneously.

The AIDS model is usually specified as

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

where X is total household expenditure on the group of goods being analyzed, P is the price index for the group, P_j is the price of the jth good, w_i is the budget share of the ith good (i.e. $w_i = P_iQ_i/X$), and the price index (P) is defined as

$$\ln P = \alpha_0 + \sum_j \alpha_j \ln P_j + \frac{1}{2} \sum_j \sum_i \gamma_{ij} \ln P_i \ln P_j \qquad (2)$$

Consumer theory implies four general restrictions that must be satisfied by any estimated demand system for theoretical consistency. These restrictions are: adding-up, homogeneity, symmetry of the cross-substitution effects, and negativity of the own substitution effect. Explanations of these restrictions of demand theory are beyond the scope of this study. The AIDS model automatically satisfies the adding-up condition, and is capable of satisfying the three other restrictions, but does not necessarily do so. In terms of the parameters in equation (1) the adding-up condition implies

$$\sum_i \alpha_i = 1, \sum_i \beta_i = 0, \sum_j \gamma_{ij} = 0 \qquad (3)$$

Homogeneity is satisfied if

$$\sum_j \gamma_{ij} = 0 \qquad (4)$$

while symmetry is satisfied provided

$$\gamma_{ij} = \gamma_{ji} \qquad (5)$$

The negativity conditions have no obvious parametric representation in the AIDS model. Except for the adding-up condition, the AIDS does not have the restrictive implications such as that of the Linear Expenditure System (LES) which automatically satisfies all the theoretical restrictions. Thus, the AIDS offers the opportunity of testing homogeneity and symmetry restrictions.

The price index from equation (2) makes equation (1) a non-linear system of equations, raising estimation difficulties. To avoid non-linear estimation, most of the empirical studies used the Stone (1953) price index (P^*) instead of P, as suggested by Deaton and Muellbauer (1980):

$$lnP^* = \sum_j w_j lnP_j \qquad (6)$$

The model that uses stone's geometric price index is called the "Linear Approximate AIDS" (LA/AIDS) following Blanciforti and Green (1983). It can be shown that if prices are highly collinear, then the LA/AIDS model can be used to estimate the parameters of the AIDS model because the factor of proportionality of P to P^* is incorporated in the intercept term (Green and Alston 1990).

Household demand for goods not only depends on prices and income but also on other socioeconomic and demographic factors. Ray (1979) explicitly

incorporated family size (m) in the AIDS model. The resulting LA verson of the AIDS is

$$w_i = \alpha_i + \sum_j \gamma_{ij} \ln P_j + \beta_i \ln \left(\frac{X}{P^*} \right) + \theta_i \ln m \qquad (7)$$

where x (= X/m) is per capita household expenditure and θ_i denotes the effect of family size on budget share in addition to the effect of per capita real household expenditure (x/P^*).

From the micro-model in equation (7), the following formulas are obtained (see Appendix 1 for derivation) for expenditure elasticity ϵ_i and uncompensated own and cross-price elasticity ϵ_{ij}:

$$\epsilon_i = 1 + \left(\frac{\beta_i}{w_i} \right) \qquad (8)$$

$$\epsilon_{ij} = w_i^{-1} (\gamma_{ij} - \beta_i w_j) - \delta_{ij} \qquad (9)$$

where δ_{ij} is Kronecker delta which takes the value of one for own price elasticity and zero for cross-price elasticity. The budget share of the jth commodity, w_j, is used as weight in Stone's price index in equation (6). Once the expenditure and the uncompensated price elasticities are estimated, compensated own and cross-price elasticities can be computed using the Slutsky equation in elasticity form:

$$\epsilon_{ij} = \epsilon^H_{ij} - w_j \epsilon_i \qquad (10)$$

where ϵ^H_{ij} is the compensated (Hicksian) price elasticity.

Estimation

Besides income, the most important factor affecting household consumption is its size and composition. Although family size is incorporated in equation (7), calculation of expenditure per capita may be misleading because it

does not take into account the age and sex composition of different households. Therefore, expenditures per adult equivalent unit (AEU) are calculated in this study to adjust for the differences in age and sex composition of households. Nutritional scales seem to be appropriate to compute adult equivalents, because food constitutes the major share of household expenditure. Each family member is indicated as a fraction of an adult male equivalent consumption unit based on the calorie requirements recommended by James and Schofield (1990) for the less developed countries' rural population. The AEU approach used in this study is a refinement to the per capita expenditure approach, and is similar to the food-based scales proposed by Prais and Houthakker (1971). Table 1 presents the estimated adult equivalent consumption units. In equation (7), per capita expenditure (x) is replaced by per adult equivalent expenditure, and family size m is replaced by adult equivalent family size.

The Stone's geometric price index (P^*) in equation (6) is used to deflate the expenditure of the ith household. The analysis in this study is based on three rounds of survey data collected over one year. The price index is constructed for each household by multiplying the log of price of the jth good faced by the household with the average budget share of the jth good for all households in that round. The price index (P^*) is obtained by summing the product over all commodity groups.

Adjusting for adult equivalency, equation (7) is estimated for each commodity groups using the Ordinary Least Squares (OLS) method. The demand elasticities are estimated from the estimated parameters using the elasticity formulas in equations (8), (9), and (10). F-tests are carried out to investigate the hypotheses.

Data

The data used for the estimation are taken from the household consumption and nutrition survey conducted by IFPRI in rural Bangladesh. The objective of the survey was to assess the consumption and nutritional effects of the two targeted food intervention programs--the Rural Rationing (RR) and the Vulnerable Group Development (VGD) programs. The survey was repeated

Table 1—Adult equivalent consumption units according to age and sex

Age	Male	Female
(years)	(adult equivalent consumption units)	
0+	0.25	0.25
1+	0.37	0.36
2+	0.42	0.40
3+	0.46	0.43
4+	0.49	0.46
5+	0.53	0.48
6+	0.56	0.49
7+	0.58	0.49
8+	0.58	0.49
9+	0.58	0.49
10+	0.70	0.64
11+	0.71	0.64
12+	0.73	0.66
13+	0.77	0.68
14+	0.81	0.70
15+	0.85	0.70
16+	0.89	0.72
17+	0.92	0.75
18-29+	1.03	0.82
30-59+	1.03	0.83
>60	0.68	0.61
Adult	1.00	0.81

Source: Computed from IFPRI's Consumption and Nutrition Survey data, using the method of estimating calorie requirement in James, W.P.T. and E.C. Schofield, "Human Energy Requirements": A Manual for Planners and Nutritionists", published for FAO by Oxford University Press (Oxford 1990).

seasonally to obtain three observations over one year. The first survey round was conducted in 1991 during October-November; the second, January-March 1992; and the third, September-November 1992.

The survey was conducted in eight villages, two in each of the four divisions of the country. In selecting the sample villages, the focus was on achieving adequate variation in the factors, such as distress-proneness, and developed and un-developed areas, that might affect household consumption patterns.

The first part of the household survey consisted of a census (100 percent of the households) of the eight selected village. A total of 3,194 households were surveyed in the census. The basic purpose of the census was to select sample households. A sample of 553 households (consisting 200 RR, 117 VGD, and 236 control households) was chosen in the first round, using standard sampling procedure based on statistical theory. The first survey round included only low-income households. The sample size was enlarged from 553 households in the first round to 737 households in the second and third survey rounds to include households from the higher income groups.

The RR program was suspended in December of 1991, and was finally abolished in May of 1992. therefore, only the first survey round included RR beneficiary household. A recent IFPRI study found that the RR program did not produce any measurable food consumption benefits for the beneficiaries (Ahmed 1993). Thus, the inclusion of RR beneficiary households in the analysis should not have any significant impact of the program on the consumption patterns of the sample household. In contrast, the IFPRI study suggested a significant positive effect of the VGD program on food consumption and nutrition of the VGD beneficiaries. Moreover, since the VGD program distributed a large quantity of free wheat ration among the beneficiaries, the presence of VGD households in the sample could bias the estimates of demand parameters. Therefore, data on VGD households are excluded from the data set used in this analysis. Combining the three rounds of survey data, a total of 1,740 observations are retained for this analysis. Household-level data on prices and expenditures are used in the analysis.

4. RESULTS AND INTERPRETATIONS

The estimated aggregate demand parameters for the entire sample of rural households are presented in Tables 2 through 5, while Table 6 provides the parameters of foodgrain demand disaggregated by low-income and high-income groups. In interpreting the results, a rather simplistic approach is used here in view of the diversity of audience involved in food policy analysis. The common terminologies used by economists are briefly explained when they are introduced. The main findings and their interpretations are highlighted as follows:

How Does Income Affect Consumption Patterns?

Table 2 provides the shares of household expenditures spent on consumption items, and the estimated relationships between income and consumption. Although household income data are available from the IFPRI survey, household consumption expenditures are used in the analysis as a proxy for income for two reasons. First, based on the permanent income hypothesis, Friedman (1957) argues that expenditures are likely to reflect permanent income and hence a better determinant of consumption behavior. Second, data on expenditures are generally more reliable than income data.

For the entire sample, about 69 percent of total household expenditures are spent on food. The estimates show the overwhelming dominance of expenditure on rice in the total household expenditures. On the average, foodgrains (rice and wheat) account for about 67 percent of total food expenditures, implying a very little diversity in diet. Low-income households spend relatively greater share of their income on food, particularly on rice, than that of the high-income households.

A household will usually spend only a portion of an additional income on purchasing a certain commodity. Economists refer to this pattern as the marginal propensity to consume (MPC), or the marginal budget share. If, say, 55 paisa out of one additional taka income is spent on food, then the value of the MPC of food is 0.55. In Table 2, the estimates of marginal budget shares (multiplied by 100) suggest if income of a household increases by one taka, then that household will increase its spending on rice by 30 paisa.

Table 2—Pattern of household consumption expenditures in rural Bangladesh, 1991/92

Commodity	Average Budget Share	Marginal Budget Share	Expenditure Elasticity
	(percent)		
Rice	44.1	29.9	0.68[a]
Wheat	2.3	-0.5	-0.22[b]
Pulses	1.1	1.4	1.31[a]
Fruits and Vegetables	4.5	4.7	1.05[a]
Potatoes	1.2	1.4	1.15[a]
Fish	3.9	5.8	1.48[a]
Meat and Eggs	1.5	3.6	2.47[a]
Milk	0.6	1.2	1.94[a]
Edible oils	2.4	2.2	0.91[a]
Onion	0.8	0.9	1.14[a]
Spices	2.9	2.5	0.88[a]
Sugar	1.4	2.2	1.56[a]
Salt	1.3	0.7	0.53[a]
Other food	1.0	2.2	2.16[a]
Fuel (Kerosine)	1.8	1.1	0.63[a]
Other nonfood	29.2	42.3	1.45[a]
Total of all expenditures	100.0	100.0	--

Source: Computed by authors based on data from IFPRI's Consumption and Nutrition Survey, 1991/92, Bangladesh.

Note: Totals may not add up exactly to 100.0 due to rounding.

The F-test is used to test the significance levels of the estimated elasticities.
[a] Significant at the 99 percent level.
[b] Significant at the 95 percent level.
[c] Significant at the 90 percent level.

The income (expenditure) elasticity of demand may be interpreted as the percentage change in quantity demanded when income changes (roughly) by one percent, other factors held constant. Since the elasticities of demand are independent of the units in which demand is measured, elasticities are more meaningful measures of the responsiveness of demand to changes in income or prices. For example, estimated at the mean level of rice expenditures for the entire sample, the income elasticity of demand for rice is 0.68, suggesting that a 10 percent increase in household income increases the demand for rice by 6.8 percent. All estimates of income elasticity for different commodities are statistically significant.

Wheat (including wheat flour) has a negative income elasticity of demand on the average for entire sample. This indicates that wheat is an "inferior" good (as opposed to a "normal" good, such as rice) in rural Bangladesh.

How Responsive are Demands to Changes in Prices?

Own-Price Elasticity. The own-price elasticity of demand for any commodity is just the percentage change in quantity demanded associated with a given percentage change in the price of that commodity. When the price of a commodity changes, there are two effects on consumption--a substitution effect and an income effect. If, for example, price of rice falls, then consumers may substitute wheat for rice, that is, they may purchase more rice and less wheat. This change in demand due to the trade-off between commodities is called the substitution effect of price change. The substitution effect represents the pure effect of price change on demand. The fall in rice price also means that the purchasing power of money goes up, that is, the real income increases, although the absolute amount of taka income of consumers remains the same. If rice is a "normal" good, then consumers will buy more rice due to the increase in their real income. This change in demand due to having more purchasing power is called the income effect of a price change. The income effect is negative for an "inferior" good.

The own-price elasticity of demand that corresponds to the total effect of price change (that is, the substitution effect plus the income effect) is sometimes

called the uncompensated own-price elasticity, while that corresponds to the substitution or pure price effect is called the compensated own-price elasticity. Although the compensated demand is more sound from the standpoint of demand theory, the substitution effect is not observable, therefore the uncompensated elasticities are generally used for policy analysis.

Table 3 provides the estimated uncompensated and compensated own-price elasticities, and income (expenditure) elasticities for different commodities. The estimates suggest, except for salt, rural households are quite responsive to change in prices in adjusting their consumption of corresponding commodities. The absolute value of own-price elasticity of demand for salt is very small, indeed the estimated elasticity is not statistically different from zero. This indicates that if the salt price falls, households do not increase their salt consumption, and vice versa. In addition to its chemical suitability, this inelastic nature of demand makes salt an ideal vehicle to promote iodine intakes among consumers through iodized salt. Iodine is an essential micro-nutrient, but Bangladeshis in general suffer from serious iodine deficiency.

The estimated own-price elasticities indicate if, for example, the rice price falls by 10 percent then demand for rice would increase by 4.5 percent. Of this total increase in demand, only 1.2 percent is purely due to price effect (i.e. the substitution effect) as the compensated elasticity suggests. The income effect of the price fall accounts for the remaining 3.3 percent (i.e. 4.5 - 1.2) increase in rice demand due to the increase in real income, although the absolute amount of money income remains unchanged. The income effect is relatively large in rice demand because rice has a large share in household budget. If per capita income also increases by 10 percent accompanied by a 10 percent fall in rice price, then demand for rice would increase by 11.3 percent (i.e. 4.5 + 6.8). However, the increase in per capita income represents a shift in the rice demand curve that normally leads to an increase in rice price. The estimation of resulting equilibrium level of rice consumption will require the information on the supply elasticity of rice.

The estimates of own-price elasticities in Table 3 reveal that except for rice, the income effect of change in prices is very little for other food items. This is so

Table 3—Own price and expenditure elasticities of all commodity groups

Commodity	Own Price Elasticities		Expenditure Elasticities
	Uncompensated	Compensated	
Rice	-0.45[a]	-0.12	0.68[a]
Wheat	-1.29[c]	-1.30	-0.22[b]
Pulses	-0.49[a]	-0.48	1.31[a]
Fruits & Vegetables	-0.77[a]	-0.72	1.05[a]
Potatoes	-1.27[a]	-1.26	1.15[a]
Fish	-0.71[a]	-0.66	1.48[a]
Meat & Eggs	-2.21[a]	-2.19	2.47[a]
Milk	-1.71[a]	-1.71	1.94[a]
Edible oils	-0.66[a]	-0.64	0.91[a]
Onion	-0.61[a]	-0.60	1.14[a]
Spices	-0.65[a]	-0.63	0.88[a]
Sugar	-1.15[a]	-1.13	1.56[a]
Salt	-0.08	-0.07	0.53[a]
Other food	-1.10[a]	-1.09	2.16[a]
Fuel (Kerosine)	-0.32[a]	-0.30	0.63[a]
Other nonfood	-0.94[a]	-0.57	1.45[a]

Source: Computed by authors based on data from IFPRI's Consumption and Nutrition Survey, 1991/92, Bangladesh.

Note: The F-test is used to test the significance levels of the estimated elasticities.
[a] Significant at the 99 percent level.
[b] Significant at the 95 percent level.
[c] Significant at the 90 percent level.

because most food items have very small shares in household income (Table 2), hence their price changes have only minimal effects on real income. Moreover, since wheat is an inferior good, the negative income effect offsets the total effects of price change, as reflected in the uncompensated elasticity.

Cross-Price Elasticities. Cross-price elasticities of demand are measures of how the quantity demanded of one commodity responds to changes in the price of another commodity. Like the own-price effects, the cross-price effects also have the substitution and the income effects, and hence the terms uncompensated and compensated cross-price elasticities.

Generally, there are two types of cross relationships: the commodities may be substitutes or complements. If, for example, the price of rice decreases, then the consumers will increase their rice consumption. However, they would probably decrease their wheat consumption, since wheat becomes relatively more expensive. That is, they would substitute rice for wheat. Thus, for substitute commodities, the price of one commodity and demand for the other move in the same direction, giving a positive relationship.

Two commodities are complements if the price of one commodity and demand for the other move in the opposite direction. The consumption relationship between betel leaves and betel nuts may be a good example of complementary commodities in rural Bangladesh. If the price of betel leaves increases, then consumers will decrease their consumption of betel leaves. Since betel leaves are eaten with betel nuts, the demand for betel nuts is also likely to decrease. In this case there is a negative relationship between the price of betel leaves and the demand for betel nuts.

Tables 4 and 5 provide, respectively, the entire uncompensated and compensated price elasticity matrices. The uncompensated cross-price elasticities provide the "gross" cross effects that include both the substitution effect and the income effect. The compensated cross-price elasticities represent the pure price effects (that is, only the substitution effect) or the "net" effects of price change on demand.

Table 4—Uncompensated own and cross-price elasticities of all commodity groups

Commodities	Demand for: Rice	Wheat	Pulses	Fruits & Veg.	Potatoes	Fish	Meat & Eggs	Milk	Edible oils	Onion	Spices	Sugar	Salt	Other food	Fuel (Kerosine)	Other nonfood
Price of																
Rice	-0.45[a]	1.77[b]	-0.55[c]	-0.84[a]	0.72[c]	-1.02[a]	-2.96[a]	-0.08	-0.20	0.08	0.54[b]	-0.37	0.37[b]	-0.15	0.01	-0.45[a]
Wheat	0.07	-1.29[c]	0.80	-0.82[a]	1.89[a]	0.16	1.13	-3.81[a]	0.76[b]	1.35[a]	1.29[a]	2.15[a]	0.26	-0.84	0.89[a]	-0.52[a]
Pulses	-0.08[a]	0.11	-0.49[a]	-0.11	0.39[a]	0.26[b]	-0.26	0.83[a]	0.19[c]	0.23[a]	0.16[c]	0.33[b]	0.01	-1.07[b]	0.24[a]	0.08[c]
Fruits & Vegetables	-0.01	-0.05	0.08	-0.77[a]	0.11	-0.06	-0.25[c]	0.17	0.07	0.14[a]	-0.03	-0.02	-0.01	-0.55[a]	0.06[b]	-0.01
Potatoes	-0.07[a]	-0.09	0.62[a]	-0.50[a]	-1.27[a]	0.62[a]	-0.29	-0.18	0.07	0.44[a]	0.77[a]	0.15	-0.04	-0.51	0.15[a]	0.13[a]
Fish	-0.10[a]	-0.19	0.35[a]	0.15[a]	-0.15[c]	-0.71[a]	0.47[a]	-0.002	0.14[a]	0.09[c]	-0.13[a]	0.04	-0.002	0.45[b]	0.05	0.12[a]
Meat & Eggs	-0.06	0.20	0.37[c]	0.28[b]	-1.48[a]	-0.01	-2.21[a]	0.73	0.27[b]	-0.10	-0.46[a]	0.19	-0.04	1.33[b]	0.15[c]	0.05
Milk	0.16[a]	-0.35	-0.56[a]	-0.35[a]	0.43[b]	0.64[a]	-0.02	-1.71[a]	-0.19	-0.31[b]	-0.27[a]	-0.43[b]	-0.10	-0.71	-0.17[b]	-0.13[b]
Edible oils	-0.02	0.21	-0.52[b]	0.26[c]	-0.26	-0.24	0.45	-1.41[a]	-0.66[a]	-0.26[c]	-0.31[a]	-0.46[b]	-0.11	1.06[c]	-0.14	0.09
Onion	-0.07	0.29	0.17	-0.13	-0.77[a]	-0.04	-0.01	-0.59[b]	0.23[a]	-0.61[a]	0.46[a]	-0.001	-0.06	1.54[a]	0.07	-0.02
Spices	0.001	-0.54[a]	-0.21[a]	0.18[a]	0.47[b]	-0.08	0.34[a]	0.10	0.09[c]	0.12[a]	-0.65[a]	0.17[b]	-0.04	0.36[c]	0.05[c]	-0.001
Sugar	0.03	0.24	0.26	-0.29[a]	-0.37[b]	-0.06	-0.33	1.19[a]	-0.10	0.02	0.05	-1.15[a]	-0.11[b]	-0.75[c]	-0.04	0.05
Salt	-0.16	1.09[a]	-0.56[c]	-0.43[b]	0.48[c]	-1.07[a]	1.06[b]	0.98	-0.21	-0.45[b]	0.48[a]	-0.13	-0.08	-0.35	-0.05	0.22[a]
Other food	0.003[a]	-0.15[c]	0.10[c]	0.08[b]	-0.29[a]	0.11[a]	-0.03	-0.11	-0.11[a]	-0.05	0.01	0.07	-0.05[a]	-1.10[a]	-0.03	0.02
Fuel (Kerosine)	-0.08	-0.65	-0.22	0.33[c]	-0.17	0.52[b]	0.71	0.09	0.68[a]	-0.30	-0.29[c]	-0.14	-0.22[b]	-2.03[b]	-0.32[a]	0.13
Other nonfood	-0.03	0.07	0.01	-0.08	-0.18[b]	-0.08	0.19	-0.07	0.06	-0.03	0.06	0.13	0.01	0.16	0.02	-0.94[a]

Source: Computed by authors based on data from IFPRI's Consumption and Nutrition Survey, 1991/92, Bangladesh.

Note: The F-test is used to test the significance levels of the estimated elasticities.
[a] Significant at the 99 percent level.
[b] Significant at the 95 percent level.
[c] Significant at the 90 percent level.

Table 5—Compensated own and cross-price elasticities of all commodity groups

Commodities	Demand for: Rice	Wheat	Pulses	Fruits & Veg.	Potatoes	Fish	Meat & Eggs	Milk	Edible oils	Onion	Spices	Sugar	Salt	Other food	Fuel (Kerosine)	Other nonfood
Price of:																
Rice	-0.12	1.67	0.03	-0.38	1 23	-0.37	-1.87	0.78	0.20	0.59	0.93	0.32	0.60	0.80	0.28	0.19
Wheat	0.08	-1.30	0.83	-0.80	1.91	0.19	1.18	-3.77	0.78	1.37	1.31	2.19	0.27	-0.79	0.90	-0.49
Pulses	-0.07	0.11	-0.48	-0.10	0.41	0.27	-0.23	0.85	0.20	0.24	0.17	0.35	0.02	-1.05	0.24	0.10
Fruits & Vegetables	0.02	-0.06	0.14	-0.72	0.16	-0.00	-0.14	0.26	0.11	0.19	0.01	0.05	0.01	-0.46	0.09	0.05
Potatoes	-0.06	-0.09	0.64	-0.48	-1.26	0.64	-0.26	-0.16	0.08	0.45	0.78	0.16	-0.03	-0.48	0.16	0.15
Fish	-0.07	-0.20	0.40	0.19	-0.10	-0.66	0.57	0.07	0.17	0.13	-0.09	0.10	0.02	0.54	0.07	0.17
Meat & Eggs	-0.05	0.19	0.39	0.30	-1.46	0.01	-2.19	0.75	0.29	-0.09	-0.45	0.21	-0.04	1.36	0.15	0.07
Milk	0.16	-0.36	-0.55	-0.34	0.43	0.65	0.00	-1.71	-0.18	-0.31	-0.27	-0.43	-0.10	-0.70	-0.17	-0.12
Edible oils	-0.01	0.21	-0.49	0.28	-0.24	-0.20	0.51	-1.36	-0.64	-0.23	-0.29	-0.43	-0.10	1.11	-0.12	0.12
Onion	-0.06	0.29	0.18	-0.12	-0.76	-0.03	0.01	-0.58	0.24	-0.60	0.47	0.01	-0.06	1.56	0.08	-0.01
Spices	0.02	-0.54	-0.17	0.21	0.51	-0.03	0.41	0.15	0.11	0.16	-0.63	0.21	-0.02	0.42	0.07	0.04
Sugar	0.04	0.24	0.28	-0.28	-0.35	-0.04	-0.29	1.22	-0.09	0.04	0.06	-1.13	-0.11	-0.72	-0.03	0.08
Salt	-0.15	1.09	-0.54	-0.42	0.49	-1.05	1.09	1.00	-0.20	-0.43	0.49	-0.11	-0.07	-0.32	-0.04	0.24
Other food	0.01	-0.15	0.11	0.09	-0.28	0.12	0.00	-0.09	-0.10	-0.04	0.02	0.09	-0.05	-1.09	-0.03	0.04
Fuel (Kerosine)	-0.07	-0.65	-0.19	0.35	-0.15	0.55	0.76	0.13	0.70	-0.28	-0.28	-0.11	-0.21	-1.99	-0.30	0.16
Other nonfood	0.17	0.00	0.39	-0.22	0.15	0.35	0.91	-0.50	0.32	0.30	0.31	0.58	0.17	0.79	0.21	-0.57

Source: Computed by authors.

The results of the F-test suggest that 189 out of 240 (78.8 percent) cross-price elasticities have statistically significant relationships. The estimates indicate that the change in rice price has a strong and statistically significant effect on wheat demand, but wheat price has no significant effect on rice demand. If, for example, the price of rice falls by 10 percent, then the households would decrease their demand for wheat by 17.7 percent (Table 4). The rice-to-wheat cross-price elasticity is positive because the price of rice and the demand for wheat move in the same direction. The pure price effect of this fall in rice price results in a 16.7 percent decrease in wheat demand (Table 5). Since wheat is an inferior good, the increase in real income due to the fall in rice price (the income effect) induces the consumers to decrease their wheat demand by 1 percent (i.e. 17.7 - 16.7).

Rice and fish have complementary relationships with each other, and these relationships (in elasticity forms) are statistically significant. A ten percent fall in rice price would result in a 10.2 percent increased demand for fish. The increase in real income due to the lower rice price is the main contributor (6.5 percent) to this increased demand for fish. The cross-price elasticity representing the effect of change in fish price on rice demand indicates that a 10 percent fall in fish price is associated with a one percent increase in rice demand.

Some cross-price elasticities change signs between their uncompensated and compensated forms. For example, the total effect of a change in rice price on demand for pulses suggests that rice and pulses are "gross" complements (Table 4). However, the compensated cross-price elasticity is positive, indicating rice and pulses are "net" substitutes (Table 5). Since pulses have a relatively high income elasticity of demand (Table 3), an increase in real income due to a fall in rice price results in an increased demand for pulses. The income effect in this case outweighs the substitution effect, which suggests that the pure price effect of a fall in rice price is a decrease in demand for pulses.

Foodgrain Elasticities of Poor and Rich Consumers

Table 6 presents the estimates of demand elasticities of rice and wheat, disaggregated by income groups. The estimates of price elasticities suggest that

Table 6—Price and expenditure elasticities of rice and wheat

	Demand for:				
	Rice		Wheat		
	Uncompensated	Compensated	Uncompensated	Compensated	Expenditure Elasticity
Quartile 1					
Price of:					
Rice	-0.83[a]	-0.25	1.93[b]	1.62	1.05[a]
Wheat	0.09	0.15	-1.94[b]	-1.97	-0.58[c]
Quartile 4					
Price of:					
Rice	-0.17	-0.003	0.74	0.79	0.48[a]
Wheat	-0.05	-0.04	-0.18	-0.17	0.11
All Households					
Price of:					
Rice	-0.45[a]	-0.12	1.77[b]	1.67	0.68[a]
Wheat	0.07	0.08	-1.29[c]	-1.30	-0.22[b]

Source: Computed by authors based on data from IFPRI's Consumption and Nutrition Survey, 1991/92, Bangladesh.

Note: First quartile represents the lowest income and fourth, the highest income households.

The F-test is used to test the significance levels of the estimated elasticities.
[a] Significant at the 99 percent level.
[b] Significant at the 95 percent level.
[c] Significant at the 90 percent level.

low-income households are more price responsive than high-income households. Differences in elasticities between the two groups are quite striking.

In the case of rice, low-income households are highly responsive to own-price and income. In contrast, high-income households (mostly medium to large farmers) moderately respond to income, but their own-price elasticity of demand for rice is not statistically different from zero. This indicates that the demand for rice by high-income rural households is insensitive to market price of rice, probably because these households normally meet their rice consumption from their own production. For both the low-income and high-income households, wheat price has no statistically significant effect on demand for rice, as the cross-price elasticities suggest.

The demand for wheat by low-income households is highly responsive to its own-price as well as to the price of rice, and the elasticities are statistically significant. On the contrary, both the own and cross-price elasticities of demand for wheat of high-income households are not statistically different from zero. The estimates of income elasticity of demand for wheat suggest, if income of the poorest 25 percent of all rural households increases by 10 percent, they would reduce their wheat consumption by 5.8 percent. However, the absolute value of the income elasticity tends to become smaller (that is, the income elasticity becomes less negative) for relatively higher income households. For the richest 25 percent of all rural households, the income elasticity of demand for wheat is positive, but not statistically different from zero. This suggests that high-income households' demand for wheat is not responsive to changes in their income.

A Comparison with Results from Other Studies

Disaggregated demand parameters of rice and wheat probably have the most important use by the food policy analysts in Bangladesh. Although a number of previous studies estimated the elasticities of composite foodgrains, only a few provide disaggregated estimates of rice and wheat elasticities. Table 7 presents a comparison of rice and wheat elasticity estimates between studies.

Estimates of demand parameters in other studies conform with the estimates in this studies in indicating that own-price and income elasticities of rice

Table 7—A comparison of own-price and income elasticities of rice and wheat in rural Bangladesh

Author(s)	Data Source and Year	Estimating Model	Description	Rice Elasticity		Wheat Elasticity	
				Own-price	Income	Own-price	Income
Pitt (1983)	HES 1973/74	Tobit demand system	Low-income	-1.30	1.19	-0.72	-0.10
			High-income	-0.83	0.94	-0.06	-0.24
Bouis (1989)	HES 1973/74	Food characteristic demand system	First quartile	-0.96	0.83	-1.00	0.19
			Fourtn quartile	-0.53	0.64	-0.82	-0.29
Ahmed and Hossain (1990)	IFPRI/BIDS 1982	Working-Leser Engel function, modified by Hazell and Roel	Underdeveloped villages	--	0.94	--	-0.06
			Developed villages	--	0.76	--	-0.14
Goletti (1993)	HES 1989/90	Tobit demand system	First quartile	-0.89	0.80	-1.23	-1.37
			Fourth quartile	-0.39	0.03	-0.21	-0.19
Ahmed and Shams (1993) (present study)	IFPRI 1991/92	AIDS	First quartile	-0.83	1.05	-1.94	-0.58
			Fourth quartile	-0.17	0.48	-0.18	0.11

Source : Studies mentioned in the first column of the table.

decline (in absolute values) with increase in income. That is, low-income households are more responsive to prices and income than higher income households. However, differences in elasticity estimates among the studies are quite substantial. Using the same data set from the Household Expenditure Survey (HES) of 1973/74, Pitt (1983) and Bouis (1989) obtained different estimates of elasticities, probably due to difference in the estimation procedures followed.

Out of 10 estimates of income elasticity of wheat, eight have the negative sign, suggesting wheat is an inferior good in rural Bangladesh. Furthermore, estimates based on the two most recent data sets (Goletti 1993, and this study) indicate that income elasticities of wheat decline (in absolute value) as income rises.

5. CONCLUSION

Estimates of demand parameters in Bangladesh are available from a number of studies. However, there is a wide range of variations in the level of aggregation (by commodities and income classifications), and methodological approaches. A few of these studies used methodologies that are computationally simple but often based on very restrictive assumptions. Elasticity estimates in the previous studies are mostly based on secondary data from the 1973/74 Household Expenditure Survey (HES). The most recent estimates of demand parameters are based on 1988/89 HES data.

The present study is the pioneer in Bangladesh in the application of the AIDS model in estimating a complete demand system. The estimates of demand parameters are based on primary data from IFPRI's own rural household survey, conducted in 1991/92.

The estimates in this study find wheat to have a negative income elasticity of demand, suggesting it is an inferior commodity in rural Bangladesh. This attribute makes wheat a self-targeting commodity for targeted food intervention programs, and thus has the potential to increase cost-effectiveness of such programs.

The estimates of cross-price elasticities indicate that substitution effects of price changes are quite strong. Therefore, government price interventions may lead to serious price repercussions in the economy. Particularly, rice price stabilization programs are likely to skew producer incentives in non-rice crops. Moreover, price interventions have the undesirable allocative inefficiency effects.

In contrast, the high income elasticities of demand for most food as well as nonfood commodities suggest that income-generating policies foster higher levels of consumption for normal commodities, and thus, a steady growth in production by enhancing effective demand. Short-run targeted income transfer programs, and longer-term income-generating programs (such as, labor-intensive infrastructure development, and investments in irrigation and agricultural research) have the potentials to activate a sustainable development process.

APPENDIX 1: DERIVATION OF ELASTICITIES

Derivation of Price Elasticity

In the linear approximate AIDS model, the demand function for the ith commodity is

$$w_i = \alpha_i + \beta_i\left(lnx - \sum_j w_j lnP_j\right) + \sum_j \gamma_{ij} lnP_j + \theta_i lnm \quad (11)$$

The left hand side of (11) gives the expenditure share of ith commodity ($w_i = P_i q_i/x$). Expressing (11) in expenditure form and differentiating with respect to price of jth commodity gives

$$\frac{\delta e_i}{\delta P_j} = -\frac{\beta_i x w_j}{P_j} + \frac{x\gamma_{ij}}{P_j} \quad (12)$$

where e_i is the per capita household expenditure on ith commodity. Multiplying (12) by P_j/e_i gives the price elasticity of demand in expenditure form

$$\begin{aligned} \epsilon_{ij} &= -\beta_i \frac{x w_j}{e_i} + \gamma_{ij} \frac{x}{e_i} \\ &= w_i^{-1}(\gamma_{ij} - \beta_i W_j) \end{aligned} \quad (13)$$

With the log transformation, e_i ($=P_i \times q_i$) becomes

$$lne_i = lnP_i + lnq_i \quad (14)$$

Differentiating (14) with respect to lnP_j gives

$$\epsilon_{ij} = \frac{\delta lne_i}{\delta lnP_j} = \frac{\delta lnP_i}{\delta lnP_j} + \frac{\delta lnq_i}{\delta lnP_j} \quad (15)$$

From (13) and (15) the price elasticity of demand for the ith commodity is derived as

$$\frac{\delta lnq_i}{\delta lnP_j} = w_i^{-1}(\gamma_{ij} - \beta_i w_j) - \delta_{ij} \qquad (16)$$

where δ_{ij} ($= \delta \ln P_i / \delta \ln P_j$) is the Kronecker delta which takes the value of one when i=j and zero when i#j.

Derivation of Expenditure Elasticity

Expressing the demand function of the ith commodity in expenditure form and differentiating with household expenditure gives

$$\begin{aligned} MBS_i = \frac{\delta e_i}{\delta x} &= \alpha_i + \beta_i + \beta_i \left(lnx - \sum_j \gamma_{ij} lnP_j \right) \\ &\quad + \sum_j \gamma_{ij} lnP_j + \theta_i lnm \\ &= \beta_i + w_i \end{aligned} \qquad (17)$$

where MBS_i is the marginal budget share spent on the ith commodity.

Since the average budget share of the ith commodity (ABS_i) is simply the left hand side of the demand function for the ith commodity, i.e.,

$$ABS_i = w_i \qquad (18)$$

the expenditure elasticity of the ith commodity can be derived as on

$$e_i = \frac{MBS_i}{ABS_i} = 1 + \frac{\beta_i}{w_i} \qquad (19)$$

APPENDIX 2: TEST OF DEMAND RESTRICTIONS

Consumer theory implies four general restrictions that must hold for theoretical consistency of any estimated demand system. These restrictions are: adding up, homogeneity, symmetry, and negativity. The AIDS model automatically satisfies the adding up condition, and is capable of satisfying three other conditions. However, the negativity condition has no parametric representation in the AIDS model. Thus, the AIDS offers the opportunity of testing homogeneity and symmetry restrictions.

Test of Homogeneity Condition

Demand functions are homogenous of degree zero in prices and income. This means, if a consumer's income, and prices of all commodities purchased are changed by the same proportion, then the consumer's demand remains unchanged. This implies that only relative prices and income matter to consumers, not absolute prices or absolute money-income levels. Thus, money illusion is discarded in demand theory. The homogeneity condition is represented parametrically in the AIDS model from equation (11) as

$$\sum_j \gamma_{ij} = 0 \ , \ \theta_i = 0 \qquad (20)$$

Following is the procedure for testing whether the homogeneity condition holds for the demand function estimated for each commodities in this study. First, the unrestricted model is estimated, and then the linear parametric restriction implied by (20) is imposed in the model. The restricted model is then estimated. The null hypothesis of homogeneity is rejected if the computed value of F-statistic falls outside the critical value at most at the 10 percent level of significance.

The test results suggest that the homogeneity condition in the estimated demand system holds only for wheat, milk, and the "other foods" group. These results indicate that available data for all other commodities may be inconsistent

with demand theory, and money illusion may be present among the consumers. The results, however, do not imply that consumer theory is rejected on the basis of these findings. Several other empirical studies, including that of Deaton and Muellbauer, find that the homogeneity condition does not hold for many commodities. Complex estimation problems are possibly responsible for such findings.

Test of Symmetry Condition

The symmetry condition in consumer's demand function states that the compensated cross-price effects on demand are equal. In the AIDS model this restriction is implied by the equation

$$\gamma_{ij}=\gamma_{ji} \qquad (21)$$

which can be represented and tested parametrically. The Slutsky equation for ith commodity is

$$\frac{\delta q_i}{\delta P_j}=K_{ij}-q_j\frac{\delta q_i}{\delta x} \qquad (22)$$

where K_{ij} is the substitution effect. The symmetry is between the substitution effects of the two partial derivatives, that is,

$$K_{ij}=K_{ji} \qquad (23)$$

Using (22) and (23) the following expression (Tomek and Robinson 1981) is arrived at:

$$\epsilon_{ij} = \left(\frac{w_j}{w_i}\right)\epsilon_{ji} + w_j(\epsilon_j-\epsilon_i) \qquad (24)$$

In the AIDS model, this expression becomes

$$\gamma_{ij} = \epsilon_{ji} w_j + \epsilon_j w_i w_j - w_i w_j \qquad (25)$$

The linear restriction on parameter of the unrestricted model implied in (25) then can be tested by running the restricted model, using the F-test.

In this study, the symmetry condition has been tested only for the cross-substitution between rice and wheat. The test results suggest that the symmetry condition holds for the estimated demand parameters of these two commodities.

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