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Consumption, Family Size, Schooling and Labor Supply Decisions:

Estimates of a Linear Expenditure System for Bangladesh

Shahidur R. Khandker*
and
David W. Butterfield

A linear expenditure system is estimated in order to quantify the consumption decisions of rural households in Bangladesh. These decisions include household demands for farm goods, non-farm goods, and child investment goods (the number of children and level of schooling per child); and household supplies of adult male, adult female and minor labour. The impact of the productive role of children on family size and schooling decisions is incorporated explicitly. The empirical results indicate the degree to which these decisions respond to changes in income, prices and wages, and the degree to which they are affected by household characteristics.

I. Introduction

The recent shift toward emphasis on rural development in the developing countries has generated an increased need for understanding rural institutions and the underlying decision-making processes of farm households in these countries. This is essential for evaluation of the potential impacts of alternate policy measures aimed at fostering economic growth in the developing

* World Bank, and Associate Professor in the Department of Economics, McMaster University, Canada.

nations. Most recent studies relating to farm households concentrate exclusively on resource allocation decisions without paying attention to consumption decisions. To the extent that farm households are consumers as well as producers their responses regarding consumption are as important as their responses regarding production.

Very few studies have explored the consumption behaviour of farm households in the developing areas. The two studies known to the authors were done for Taiwan (Lau, et al.), and Malaysia (Barnum and Squire). However, these two studies explore the income-leisure choices of farm households taking household resources, including family labour endowment, as given. These studies observed that family labour endowment was an important determinant of farm household resource allocation in income earning activities. Thus, the consumption decisions concerning child quantity and child quality (schooling) are important for labour supply and other consumption decisions. It is important, therefore, to analyze farm household consumption decisions in a framework where family labour is endogenously determined through family size and child schooling decisions. This analysis is also required to examine the responses of farm households to policy measures such as family planning and the provision of rural health and education services.

This paper uses a linear expenditure system in order to quantify the consumption decisions of rural households in Bangladesh. The linear expenditure system (LES) contains household demand functions for the consumption of farm goods, market purchased non-farm goods, child investment goods (including the number of children and their education level) and supply functions for family labour of different categories. This system is estimated by the Full-information Maximum Likelihood (FIML) method with survey data from two villages of rural Bangladesh. The results provide a variety of insights into the decisions of farm households in an agrarian economy.

Following earlier work by Rosenzweig and Evenson, this paper utilizes the new consumer theory developed by Becker in which non-traditional goods, such as children and schooling are regarded as household produced consumption goods. The explicit introduction of heterogeneous family labour services in terms of adult male, adult female and minor child labour incorporates the productive role of child labour into the farm household decision problem.

We present the model and discuss the estimation procedures used in section II. In section III, we present the estimates of the LES demand functions for commodities, child quantity and schooling, and labour supply functions for different categories of family labour. In section IV, in order to highlight the significance of the model and its estimated parameters, we present some of the elasticities calculated for the household commodity demand and labour supply functions with respect to some selected variables. Finally, in section V we summarize the major results and discuss policy implications of the model.

II. A Linear Expenditure System for Farm Households

A. Introduction

The data set includes (and the model allows) both nuclear and extended families, where the number of adult males and females in the household is greater than two. The labour supply functions apply only to income earning activities in agriculture, although non-agricultural activities are important as well in both of the villages which were surveyed. However, the two types of activities are not perfect substitutes to the extent that employment in non-agricultural activities requires very specific types of labour, which may be different from those used in agriculture. We treat non-agricultural employment and income as exogenous in the expectation that the exclusion of non-agricultural activities from the labour supply consideration will not seriously affect our conclusions. In addition to the labour supply functions the model contains demand functions for agricultural and non-agricultural consumption bundles and for child quantity and education.

B. The Linear Expenditure System

Households are assumed to maximize the objective function given by (1.1) subject to the constraints (1.2) through (1.8):

$$(1.1)\ U = U(C,Q,N,E,l_3,L_1,L_2)$$

$$(1.2)\ F = F(D_1, D_2, D_3, d_j; \overline{LA}, \overline{KA})$$

$$(1.3)\ N = N(X_N, T_{NW})$$

$$(1.4)\ E = E(X_E, T_{EC})$$

$$(1.5)\ N_1\Omega_M = H_1 + D_1 + L_1$$

$$(1.6)\ N_2\Omega_W = H_2 + D_2 + L_2 + T_{NW}$$

$$(1.7)\ N\Omega_C = H_3 + D_3 + NT_{EC} + Nl_3$$

$$(1.8)\ P_N X_N + P_E X_E + rQ = W_M H_1 + W_W H_2 + W_C H_3 + G + P(F-C) - \Sigma p_j d_j$$

where

C	:	consumption of farm goods
P	:	price of farm goods
Q	:	consumption of non-farm goods
r	:	price of non-farm goods
N	:	number of minor children (under the age of 15) in the family
N_1	:	number of adult males in the household
N_2	:	number of adult females in the household
E	:	schooling per minor child
L_1	:	total leisure consumed by adult males
L_2	:	total leisure consumed by adult females
l_3	:	leisure per minor child
G	:	non-farm income
F	:	agricultural production
D_1	:	total person-days of adult males in crop production
D_2	:	total person-days of adult females in crop production
D_3	:	total person-days of minor children in crop production
d_j	:	other variable inputs used in crop production
P_j	:	the prices of other variable inputs used in crop production
H_1	:	total adult male person-days hired out ($H_1 > 0$) or hired in ($H_1 < 0$)

H_2	: total adult female person-days hired out ($H_2>0$) or hired in ($H_2<0$)
H_3	: total minor child person-days hired out ($H_3>0$) or hired in ($H_3<0$)
W_M	: wage rate of adult male labour
W_W	: wage rate of adult female labour
W_C	: wage rate of minor children
X_i	: aggregate purchased goods from markets for production of household commodities, N and E
P_i	: price of X_i, i = N,E
T_{NW}	: total female time involved in raising children
T_{EC}	: time devoted to schooling per minor child
$\overline{LA}, \overline{KA}$	: land and capital inputs (fixed)
$\Omega_M, \Omega_W, \Omega_C$	: total days available to each member of each group in the household.

Assuming that the production functions for N and E in equations (1.3) and (1.4) are subject to constant returns to scale and fixed proportions, we can substitute (1.2) - (1.7) into (1.8) to get a single budget constraint:

$$(1.9)\ N(\pi_N + E\pi_E + W_C l_3) + rQ + pC + W_M L_1 + W_W L_2 = \Pi + G + W_M N_1 \Omega_M + W_W N_2 \Omega_W = I$$

where $\Pi = pF(\cdots) - W_M D_1 - W_W D_2 - W_C D_3 - \Sigma p_j d_j$

is income from agricultural activity under profit maximizing conditions,

$\pi_N = (P_N x_N + t_{NW} W_W - W_C \Omega_C)$ is net cost per minor child per year,

$\pi_E = (P_E x_E + t_{EC} W_C)$ is the cost of schooling per child per year,

and X_N, t_{NW}, X_E and t_{EC} are the marginal (= average) fixed coefficients associated with the production functions for N and E, respectively.

The symbol I in the budget constraint (1.9) represents augmented "full income" according to Becker's terminology.

To derive a set of demand functions corresponding to the arguments in the utility function (1.1) for estimation purposes, we have chosen to represent the household's preferences by an "augmented" Stone-Geary utility function.[1]

$$(2)\ U = \beta_C \ln(C-\bar{C}) + \beta_Q \ln(Q-\bar{Q}) + \beta_N \ln(N-\bar{N}) + \beta_E \ln(E-\bar{E}) + \beta_{L1} \ln(L_1-\bar{L}_1) + \beta_{L2} \ln(L_2-\bar{L}_2) + \beta_{l3} \ln(l_3-\bar{l}_3)$$

We assume that $\bar{N} = 0$, i.e., that there is no social norm regarding the minimum number of children the family should have.[2]

Maximization of (2) subject to (1.9) leads to the following demand equations:

$$(3)\ (3.1)\ p(C-\bar{C}) = \beta_C/A\ [I-p\bar{C}-r\bar{Q}-W_M\bar{L}_1-W_W\bar{L}_2]$$

$$(3.2)\ r(Q-\bar{Q}) = \beta_Q/A\ [I-p\bar{C}-r\bar{Q}-W_M\bar{L}_1-W_W\bar{L}_2]$$

$$(3.3)\ N(\pi_N + \bar{E}\pi_E + \bar{l}_3 W_C) = (\beta_N-\beta_E-\beta_{l3})/A\ [I-p\bar{C}-r\bar{Q}-W_M\bar{L}_1-W_W\bar{L}_2]$$

$$(3.4)\ N\pi_E(E-\bar{E}) = \beta_E/A\ [I-p\bar{C}-r\bar{Q}-W_M\bar{L}_1-W_W\bar{L}_2]$$

$$(3.5)\ NW_C(l_3-\bar{l}_3) = \beta_{l3}/A\ [I-p\bar{C}-r\bar{Q}-W_M\bar{L}_1-W_W\bar{L}_2]$$

$$(3.6)\ W_M(L_1-\bar{L}_1) = \beta_{L1}/A\ [I-p\bar{C}-r\bar{Q}-W_M\bar{L}_1-W_W\bar{L}_2]$$

[1] This choice is not entirely arbitrary. The Stone-Geary direct utility function (which yields the linear expenditure system, LES) is the only utility function consistent with linear expenditure and labour earnings functions (see Abbott and Ashenfelter). Moreover, on an empirical basis with farm household data, Barnum and Squire (1979b) found LES to perform better than its log-linear counterpart LLES.

[2] We can derive similar demand equations assuming $\bar{N} > 0$. This involves, however, non-linearity both in the parameters and in the variables, which leads to substantial computational problems. To the extent that $\bar{N} > 0$ may be important for policy implications, the estimation of the demand system with $\bar{N} > 0$ remains as an exercise for future research.

$$(3.7)\ W_W(L_2-\bar{L}_2) = \beta_{l2}/A\,[I-p\bar{C}-r\bar{Q}-W_M\bar{L}_1-W_W\bar{L}_2]$$

where $A = (\beta_N + \beta_Q + \beta_C + \beta_{L1} + \beta_{L2})$

and $Z = I-p\bar{C}-r\bar{Q}-W_M\bar{L}_1-W_W\bar{L}_2$ repesents "discretionary" augmented full income available to the household for the consumption of household commodities.

Note that in equations (3.4) and (3.5) we have taken total "discretionary" expenditure on child schooling and child leisure as the dependent variables.

For the purposes of estimation, the demand equations in (3) seem to require explicit measures of leisure of different categories, which can only be obtained by making arbitrary assumptions about the total time available to each group of household members. These assumptions involve potential specification errors, as observed by Barnum and Squire (1979b).

Since from a policy point of view it is the supply curve of labour rather than the demand curve for leisure that is important, it is desirable to obtain direct estimates of the labour supply functions. Fortunately, following Abbott and Ashenfelter, the LES does allow us to obtain a direct estimate of the supply function for each category of labour once we recognize that it is the maximum "feasible" hours out of total available hours that is crucial for deriving the labour supply function. We define

$$\bar{\Upsilon}_1 = N_1\Omega_M-\bar{L}_1$$

$$\bar{\Upsilon}_2 = N_2\Omega_W-\bar{L}_2$$

$$\bar{\Upsilon}_3 = N\Omega_C-\bar{L}_3 = N\Omega_C-N\bar{l}_3$$

as the maximum "feasible" working person-days in a year available for allocation to different activities by adult males, adult females, and minor children, respectively.

We can, therefore, substitute $N_1\Omega_M-\bar{\Upsilon}_1$ for $\bar{L}_1$, $N_2\Omega_W-\bar{\Upsilon}_2$ for $\bar{L}_2$, $N\Omega_C-\bar{\Upsilon}_3$ for $\bar{L}_3$ as well as $N_1\Omega_M-L_1 = S_1$, $N_2\Omega_W-L_2 = S_2 + Nt_{NW}$, $N\Omega_C-L_3 = S_3 + NEt_{EC}$ (from the time constraints (1.5)-(1.7)) into the demand system (3). Here S_1 is the labour supply of adult males, S_2 is the labour supply of adult females, and S_3 is the labour supply of minor children. We also define $NE = e$ as the total schooling of minor children in the household and $N\bar{E} = \bar{e}$ as the minimum required total schooling of minor children in the household.

These substitutions yield:

$$(4)\ (4.1)\ pC = p\bar{C} + \beta_C/A\,[Y + W_M\bar{\Upsilon}_1 + W_W\bar{\Upsilon}_2 - p\bar{C} - r\bar{Q}]$$

$$(4.2)\ rQ = r\bar{Q} + \beta_Q/A\,[Y + W_M\bar{\Upsilon}_1 + W_W\bar{\Upsilon}_2 - p\bar{C} - r\bar{Q}]$$

$$(4.3)\ N(P_N x_N + W_W t_{NW}) = -\pi_E\bar{e} + W_C\bar{\Upsilon}_3 + (\beta_N - \beta_E - \beta_{l3})/A \cdots [Y + W_M\bar{\Upsilon}_1 + W_W\bar{\Upsilon}_2 - p\bar{C} - r\bar{Q}]$$

$$(4.4)\ \pi_E e = \pi_E\bar{e} + \beta_E/A\,[Y + W_M\bar{\Upsilon}_1 + W_W\bar{\Upsilon}_2 - p\bar{C} - r\bar{Q}]$$

$$(4.5)\ W_C(S_3 + et_{EC}) = W_C\bar{\Upsilon}_3 - \beta_{l3}/A\,[Y + W_M\bar{\Upsilon}_1 + W_W\bar{\Upsilon}_2 - p\bar{C} - r\bar{Q}]$$

$$(4.6)\ W_M S_1 = W_M\bar{\Upsilon}_1 - \beta_{L1}/A\,[Y + W_M\bar{\Upsilon}_1 + W_W\bar{\Upsilon}_2 - p\bar{C} - r\bar{Q}]$$

$$(4.7)\ W_W(S_2 + Nt_{NW}) = W_W\bar{\Upsilon}_2 - \beta_{L2}/A\,[Y + W_M\bar{\Upsilon} + W_W\bar{\Upsilon}_2 - p\bar{C} - r\bar{Q}]$$

where $Y = \pi + G = NP_N x_N + NEP_E x_E + pC + rQ - W_M S_1 - W_W S_2 - W_C S_3$ is household income from non-farm activities plus agricultural profit, which equals household expenditure less labour (farm) earnings.

The above equations, after the addition of error terms, can be directly estimated. Following Abbott and Ashenfelter, if we consider $Y + W_M\bar{\Upsilon}_1 + W_W\bar{\Upsilon}_2$ as the "feasible" full income, then in effect equations (4.1) - (4.4) turn full income into an estimable quantity, while (4.5) - (4.7) require that the household as a group set aside the fractions β_{l3}/A, β_{L1}/A, and β_{L2}/A of its "discretionary" income for leisure time. The parameters $\bar{\Upsilon}_1$, $\bar{\Upsilon}_2$, $\bar{C}$, $\bar{Q}$ appear in each equation while parameters $\bar{e}$ and $\bar{\Upsilon}_3$ only appear in the equations ((4.3), (4.4) and (4.5)) that are associated with the quantity and quality of minor children. Moreover, the β parameters are constrained by the relation:

$$(5)\quad \beta_C/A + \beta_Q/A + \beta_N/A + \beta_{L1}/A + \beta_{L2}/A = 1.$$

That is to say, an estimate of β_{L2}/A can be obtained from the estimates of β_C/A, β_Q/A, β_N/A, and β_{L1}/A. We also require β_N/A $(\beta_E/A + \beta_{l3}/A)$ for N to be positive.

We can represent the system (4) in matrix form as follows:

$$(6)\ \theta = \beta B + \phi P,$$

where

$$\theta = \begin{bmatrix} p^C \\ r^Q \\ N(P_N x_N + W_W t_{NW} \\ \pi_E{}^e \\ W_C(S_3 + et_{EC}) \\ W_M S_1 \\ W_W(S_2 + Nt_{NW}) \end{bmatrix} \qquad \beta = \begin{bmatrix} \frac{\beta_C}{A} \\ \frac{\beta_Q}{A} \\ \frac{(\beta_N - \beta_E - \beta_{l3})}{A} \\ \frac{\beta_E}{A} \\ \frac{-\beta_{l3}}{A} \\ \frac{-\beta_{L1}}{A} \\ \frac{-\beta_{L2}}{A} \end{bmatrix}$$

$$B = \begin{bmatrix} Y & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & Y & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & Y & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & Y & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & Y & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & Y & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & Y \end{bmatrix}$$

$$\phi = \begin{bmatrix} p(1-\frac{\beta_C}{A}) & -r\frac{\beta_C}{A} & 0 & 0 & W_M\frac{\beta_C}{A} & W_W\frac{\beta_C}{A} \\ -p\frac{\beta_Q}{A} & r(1-\frac{\beta_Q}{A}) & 0 & 0 & W_M\frac{\beta_Q}{A} & W_W\frac{\beta_Q}{A} \\ -p\frac{(\beta_N-\beta_E-\beta_{l3})}{A} & -r\frac{(\beta_N-\beta_E-\beta_{l3})}{A} & -\pi_E & W_C & W_M\frac{(\beta_N-\beta_E-\beta_{l3})}{A} & W_W\frac{(\beta_N-\beta_E-\beta_{l3})}{A} \\ -p\frac{\beta_E}{A} & -r\frac{\beta_E}{A} & \pi_E & 0 & W_M\frac{\beta_E}{A} & W_W\frac{\beta_E}{A} \\ p\frac{\beta_{l3}}{A} & r\frac{\beta_{l3}}{A} & 0 & W_C & -W_M\frac{\beta_{l3}}{A} & -W_W\frac{\beta_{l3}}{A} \\ p\frac{\beta_{L1}}{A} & r\frac{\beta_{L2}}{A} & 0 & 0 & W_M(1-\frac{\beta_{L1}}{A}) & -W_W\frac{\beta_{L1}}{A} \\ p\frac{\beta_{L2}}{A} & r\frac{\beta_{L2}}{A} & 0 & 0 & -W_M\frac{\beta_{L2}}{A} & W_W(1-\frac{\beta_{L2}}{A}) \end{bmatrix}$$

and $$P = \begin{bmatrix} \overline{C} \\ \overline{Q} \\ \overline{e} \\ \overline{\Upsilon}_3 \\ \overline{\Upsilon}_1 \\ \overline{\Upsilon}_2 \end{bmatrix}$$

Since observations on $\overline{C}$, $\overline{Q}$, $\overline{e}$ and the $\overline{\Upsilon}$'s are not directly obtainable, we express these parameters as functions of household characteristics, such as the number of adult males (N_1), number of adult females (N_2), years of schooling of the household head (S), and age of the household head (a). In particular, the matrix P can be rewritten as a function of household characteristics:

$$P = \alpha H,$$

where

$$\alpha = \begin{bmatrix} \delta_1 & \alpha_{11} & \alpha_{12} & \alpha_{13} & \alpha_{14} \\ \delta_2 & \alpha_{21} & \alpha_{22} & \alpha_{23} & \alpha_{24} \\ \delta_3 & \alpha_{31} & \alpha_{32} & \alpha_{33} & \alpha_{34} \\ \delta_4 & \alpha_{41} & \alpha_{42} & \alpha_{43} & \alpha_{44} \\ \delta_5 & \alpha_{51} & \alpha_{52} & \alpha_{53} & \alpha_{54} \\ \delta_6 & \alpha_{61} & \alpha_{62} & \alpha_{63} & \alpha_{64} \end{bmatrix}$$

and

$$H = \begin{bmatrix} 1 \\ N_1 \\ N_2 \\ s \\ a \end{bmatrix}$$

Thus, the final estimating equations can be written as:

$$(7)\ \theta = \beta B + \Psi' \alpha H$$

III. Estimation of the Linear Expenditure System

We have estimated the LES system separately for each of the villages. The estimates were calculated using the FIML method under the assumption that the error terms of the equations in (7) are described by a multivariate normal distribution with mean zero.[3] The data used to estimate these equations are described in

[3] Since equation system (7) is a simultaneous equations system and is non-linear in parameters, FIML, is chosen to estimate the model. It is the only known asymptotically efficient method for models that are non-linear in their parameters. However, the FIML, estimator has small sample bias (see, e.g., Maddala). In our equation system we have 36 parameters in 7 equations and use 100 observations for each village. Thus, for each village we have 700 observations on the endogenous variables from which to estimate 36 parameters. Thus, small sample bias may not be important.

detail in the Appendix.

Computation of the maximum likelihood estimates of the structural parameters in system (7) requires initial values of those parameters. To this end, our estimation strategy proceeded as follows. Recognizing that $\Psi\alpha$ is the matrix of the reduced-form parameters of the demand system (7), Ordinary Least Squares (OLS) was applied separately to each equation of (7) to obtain initial values of the $\Psi\alpha$ matrix under the assumption that the disturbance terms in each equation are independent and have zero means. Then the system (7), written in terms of the reduced-form parameters, was estimated by the FIML method with restriction (5) imposed, using the initial values obtained by OLS. The FIML estimates of these reduced-form parameters may be obtained from the authors. In a second step we obtained initial values of the structural parameters, such as the δ's and the α's in (7) from the FIML estimates of the reduced-form parameters. Using these initial values, we wrote the β and $\Psi\alpha$ matrices in terms of the structural parameters and estimated the system (7) by the FIML method, again imposing (5), in order to obtain direct estimates of the structural parameters.

Table 1 presents the maximum likelihood estimates of the structural parameters of the system (7). As one can see from this table, a large number of parameters (about 50%) are significantly different from zero at a 90 percent confidence level. There is some variation in coefficient signs as well as in the significance levels of structural parameters across the two villages in our sample survey. All but a few marginal budget shares (β_i/A) of commodities and of labour supply in both villages have significant coefficients. Plausible interpretation can be offered for some of the signs of the α coefficients, which measure the effects of household characteristics on minimum consumption needs for commodities and maximum "feasible" working days for different categories of labour. For instance, in both villages it appears that an increase in the number of adult males in the household may lead to an increase in the minimum consumption needs for farm goods, schooling and/or maximum feasible working days of adult and minor workers in the household. On the contrary, it seems to be true for both villages that an increase in the number of adult females increases the maximum feasible working days but reduces minimum consumption needs for child schooling. In order to show the importance of the estimates in Table 1 for commodity demand and labour supply functions, we calculate the elasticities of the endogenous variables with respect to some selected variables and present them in the next section.

IV. Household Response Elasticities with Total Expenditure Net of Labour Earnings Treated as an Exogenous Variable

The response elasticities of all seven endogenous variables, C, Q, N, e, S_3, S_1, and S_2 with respect to the price of farm goods (p),

Table 1

MAXIMUM LIKELIHOOD ESTIMATES OF LINEAR EXPENDITURE SYSTEM (7)

Coefficients	Estimates		T-Statistic	
	Hamsadi	Khilgati	Hamsadi	Khilgati
β_C/A	0.25	0.57	53.24*	80.54*
β_q/A	0.75	0.43	156.11*	59.87*
β_N/A	0.11	0.11	2.28*	3.69*
β_E/A	0.01	0.004	1.28*	0.44
β_{l3}/A	-0.04	-0.07	-2.53*	-4.21*
β_{L1}/A	-0.03	-0.07	-0.43	-3.72*
β_{L2}/A	-0.06	-0.01	-2.11*	-0.72
δ_1	-4,392.63	15,028.6	-0.98	1.56*
δ_2	-18,906.0	-10,935.5	-1.19	-1.31*
δ_3	-458.37	-339.49	-1.28*	-0.77
δ_4	249.58	1,779.03	0.28	1.29*
δ_5	2,926.96	107.4	2.03*	0.17
δ_6	-2,926.96	-107.4	-2.03*	-0.17
α_{11}	752.51	1,662.57	0.48	1.23*
α_{12}	-678.85	-2,305.52	-0.39	-1.33*
α_{13}	367.44	845.10	2.56*	1.70*
α_{14}	91.95	-1.64	1.04	-0.02
α_{21}	-8,305.92	1,006.64	-1.58*	0.72
α_{22}	-8,634.37	-3,023.23	-1.54*	-1.75*

Table 1 (continued)

Coefficients	Estimates		T-Statistic	
	Hamsadi	Khilgati	Hamsadi	Khilgati
α_{23}	573.09	557.24	0.68	1.21*
α_{24}	186.15	-57.02	0.49	-0.42
α_{31}	50.19	263.19	0.57	3.27*
α_{32}	-273.84	-27.88	-1.99*	-0.27
α_{33}	43.72	21.86	3.02*	0.77
α_{34}	8.19	0.05	1.17	0.006
α_{41}	302.4	57.44	1.04	0.22
α_{42}	-950.99	-423.72	-2.55*	-1.15
α_{43}	95.27	207.9	2.36*	2.62*
α_{44}	13.97	-1.68	0.93	-0.063
α_{51}	84.67	-65.49	0.14	0.76
α_{52}	-678.01	-343.53	-0.90	-2.53*
α_{53}	-195.52	4.01	-4.66*	0.14
α_{54}	-18.10	0.78	-1.31*	0.09
α_{61}	-84.67	65.49	-0.14	0.76
α_{62}	678.0	343.53	0.91	2.53*
α_{63}	195.52	-4.01	4.66*	-0.14
α_{64}	18.10	-0.78	1.31*	-0.09

The asterisk identifies estimates that are significantly different from zero at a 90 percent confidence level.

the price of non-farm goods (r), the wage rates (W_M, W_W, W_C), the number of adult males (N_1) and adult females (N_2), and the education (s) and age (a) of the household head are presented in Table 2. The formulas for these elasticities may be obtained from the authors. All elasticities are computed at the arithmetic mean of variables under the assumption that total expenditure on all consumption items less farm labour earnings, Y, remains constant. In other words, here we are presenting elasticities which include the conventional substitution and income effects and also the "endowment" effects in a labour supply problem, but hold farm profit and non-farm income constant. Our analysis of these household response elasticities will follow, with occasional

Table 2

ELASTICITIES OF HOUSEHOLD RESPONSE WITH RESPECT TO EXOGENOUS VARIABLES WITH TOTAL EXPENDITURE LESS LABOUR EARNINGS ASSUMED CONSTANT

Variables	Village	Elasticities						
		Consumption of Farm Products	Consumption of Non-Farm Products	Number of Minor Children	Level of Child Schooling	Minor Labour Supply	Adult Male Labour Supply	Adult Female Labour Supply
Price of agricultural products (p)	Hamsadi	-0.88	-0.27	-0.04	-0.06	-0.10	-0.03	-0.36
	Khilgati	-0.57	-1.04	-0.44	-0.13	-2.58	-0.43	2.64
Price of non-farm goods (r)	Hamsadi	0.65	-2.43	0.68	0.91	1.60	0.49	5.37
	Khilgati	0.51	-2.22	0.39	0.12	2.28	0.38	-2.33
Adult Male wage rate (W_M)	Hamsadi	0.01	0.04	0.01	0.01	0.002	-0.86	0.02
	Khilgati	-0.02	-0.04	-0.02	-0.005	-0.09	-1.25	0.13
Adult Female wage rate (W_W)	Hamsadi	-0.01	-0.04	-0.28	-0.01	-0.002	-0.004	-6.47
	Khilgati	0.02	0.04	0.02	0.005	0.09	0.02	-5.20
Minor Labour wage rate (W_C)	Hamsadi	—	—	0.09	-0.44	-1.30	—	—
	Khilgati	—	—	0.22	-0.11	0.16	—	—

Table 2 (continued)

Variables	Village	Elasticities						
		Consumption of Farm Products	Consumption of Non-Farm Products	Number of Minor Children	Level of Child Schooling	Minor Labour Supply	Adult Male Labour Supply	Adult Female Labour Supply
Number of adult males (N_1)	Hamsadi	0.18	-0.39	0.20	0.75	-2.85	0.30	2.24
	Khilgati	0.0004	-0.01	-0.19	1.27	-5.06	-0.12	2.02
Number of adult females (N_2)	Hamsadi	0.21	-0.46	0.21	-0.74	0.93	-0.09	6.80
	Khilgati	0.08	-0.19	0.11	-0.08	0.02	0.06	4.08
Education of the household head (s)	Hamsadi	0.01	-0.03	-0.04	0.36	-0.65	-0.31	1.09
	Khilgati	0.01	-0.02	-0.01	0.11	0.39	-0.11	-0.24
Age of the household head (a)	Hamsadi	0.05	-0.11	-0.22	0.67	-2.70	-0.58	0.93
	Khilgati	0.11	-0.27	0.09	-0.03	0.47	0.08	1.26
Total Expenditure (Y)	Hamsadi	0.36	2.40	0.38	0.51	0.89	0.28	3.01
	Khilgati	0.81	1.46	0.62	0.18	3.66	0.60	-3.70

Note: Using parameter values from Table 1, all elasticities are computed at the arithmetic mean of variables and under the assumption that Y is independent of all prices and wages.

reference to some similar analyses done for other countries.[4]

We consider first the expenditure elasticities for different consumption commodities. For both villages, the expenditure elasticity for consumption of farm goods (0.36 in Hamsadi and 0.81 in Khilgati) is positive but less than one; whereas, the elasticity for non-farm goods with respect to income (2.40 in Hamsadi and 1.46 in Khilgati) is greater than one. These results are consistent with the results obtained by Barnum and Squire for Malaysia.

The expenditure elasticity of the adult male labour supply to agricultural activities in both villages is positive but less than one (0.28 in Hamsadi and 0.60 in Khilgati) which may indicate that the implied income elasticity of leisure is negative and hence that adult male leisure is an inferior good.

The expenditure elasticities for the number of minor children and for the level of child schooling in both villages are positive but less than one (0.38 and 0.51 respectively for Hamsadi, 0.62 and 0.18 respectively for Khilgati) indicating that expenditure for child investment goods is income inelastic. One interesting relationship between these two elasticities for each village is worth noting: where the expenditure elasticity of minor children is high, the corresponding expenditure elasticity of child schooling is low and vice versa. A similar relationship occurs between child schooling and minor labour supply. Apart from leisure and income earning activity, minor children may also pursue schooling which competes with income earning activities (see the budget constraint for child time, (1.7)). Therefore, it follows that the larger is the expenditure elasticity of child schooling, the lower is the expenditure elasticity of minor labour supply. Thus, the fact that the expenditure elasticity of child schooling is higher in Hamsadi (0.51) than in Khilgati (0.18) is consistent with a lower expenditure elasticity of minor labour supply in Hamsadi (0.89) than in Khilgati (3.66).

4 Application of the LES to farm-level data is rare. The only LES application known to the authors is the Barnum and Squire study of Malaysia. Another study of farm-level consumption data which uses the LLES is the study of Taiwan by Lau, et al. To the extent that our model introduces different categories of labour supply as well as demand functions for child investment goods, it is difficult to compare our results with the findings of Barnum and Squire. However, whenever possible, we shall try to refer to similar findings.

Similarly, since female members of the household bear the major burden for raising minor children, the expenditure elasticity of female labour supply is inversely related to the expenditure elasticity of minor children. Thus low values of the expenditure elasticity of female labour supply are consistent with high values of the expenditure elasticity of minor children. A case in point is in Khilgati which may, in part, be due to the high expenditure elasticity of minor children.

We now turn to the own-price elasticities of different goods. The own-price elasticities of farm goods in both villages (-0.88 in Hamsadi and -0.57 in Khilgati) are low compared to the own-price elasticities of non-farm goods (-2.43 in Hamsadi, -2.22 in Khilgati) indicating that farm goods are necessary items of consumption while non-farm goods are not. Evidence from Malaysia reinforces this conclusion (Barnum and Squire 1979a). The own-price elasticities of labour supply appear to be quite different for the two villages. For instance, the own-price elasticity of adult male labour supply is -0.86 in Hamsadi and -1.25 in Khilgati. These values imply that, taking into account the "endowment" effects, the supply curve for adult male labour is backward bending.[5] On the other hand, the own-price elasticity of minor labour supply is -1.30 in Hamsadi and 0.16 in Khilgati. Finally, the own-price elasticity of female labour supply is -6.47 in Hamsadi and -5.20 in Khilgati, respectively.

The linear expenditure system imposes the restriction that all own-price elasticities bear an approximate linear relationship to expenditure elasticities (see Deaton 1974). To test this alleged proportionality rule, we calculate the ratios of the own-price to the expenditure elasticities for C, Q, S_3, S_1 and S_2, which are -2.44, -1.01, -1.46, -3.07, -2.15 for Hamsadi and -0.70, -1.52, 0.04,

[5] This result appears inconsistent with the negative income elasticity of leisure reported earlier. This apparent inconsistency is resolved if we examine the formula for the elasticity of adult male labour supply with respect to the male wage rate. If the income elasticity of leisure is negative, this formula can still lead to a negative value if the maximum labour supply, $\bar{\gamma}_1$, is sufficiently smaller than the actual labour supply, S_1. Since $\bar{\gamma}_1$ is estimated indirectly as a function of household characteristics, its estimated value need not exceed that of S_1. When γ_1 is less the S_1 the "endowment" effect is smaller than the "income" effect and a backward bending supply curve of labour is possible when leisure is an inferior good.

-2.08, 1.41 for Khilgati respectively. These calculations indicate that the own-price and expenditure elasticities are not related by a constant proportion. A similar finding is reported by Barnum and Squire (1979a) for Malaysian farm household data.

Our next concern is with the cross-price elasticities and the elasticities with respect to household characteristics. Since we do not have any *a priori* information about the sign or magnitude of these elasticities, it is difficult to make any conjectures about their effects. However, one result of particular interest lies in the cross-price elasticities of child quantity (N) and child schooling (e) with respect to the minor labour wage rate (W_C) and the female labour wage rate (W_W). For both villages, an increase in the minor wage rate (W_C) can lead to an increase in the quantity (N) but a decrease in the quality (e) of minor children. This conforms to theoretical expectation and other evidence (see Rosenzweig and Evenson for India). On the other hand, the cross-price elasticities of child investment goods with respect to the female wage rate (W_W) differ across villages. In Hamsadi an increase in W_W reduces both quantity and quality while in Khilgati it has negligible effects.

The effects of increased number of adult males or females can be given reasonable interpretations. For example, an increased number of adult males in the household, which can be viewed as an increase in the family labour force, causes the family to restructure its consumption pattern away from non-farm goods (0.18 in Hamsadi, 0.0004 in Khilgati), and to increase the adult male labour supply (2.24 in Hamsadi, 2.02 in Khilgati), thereby reducing minor labour supply to farm activity (-2.85 in Hamsadi, -5.06 in Khilgati) and increasing child schooling (0.75 in Hamsadi and 1.27 in Khilgati). By similar reasoning, an increase in the number of adult females appears to increase the number of minor children, decrease child schooling and increase female labour supply (see the relevant elasticities in Table 2).

As for the effects of the household head's education level, the results for the two villages are very similar. An increase in the level of education of the household head decreases the number of minor children, while increasing child schooling and reducing minor labour supply. At the same time, an increase in the level of education of the household head reduces adult male labour supply to agricultural activities while increasing female labour supply to such activities.

The age of the household head appears to have some predictable impacts in contrast to the findings of no effect for Malaysia and Taiwan (Barnum and Squire; Lau, Lin and Yotopoulos).[6] In Khilgati, an increase in the age of the household head appears to increase the consumption of farm goods and reduce the consumption of non-farm goods, increase the number of minor children in the family, and reduce consumption on child schooling. Also, as a result of a larger family base, it increases both adult male and female labour supply. Opposite effects are found in Hamsadi, where an increase in the age of the household head appears to imply a reduction in family size, possibly because adult male sons may leave the old parental house and form a new family base (demographic transition), which also leads to a reduction in the number of minor children. There is also a reduction in minor labour supply, an increase in child schooling, and an increase in adult male labour supply. Adult female labour supply increases with the age of the household head in both villages.

V. Conclusions

A linear expenditure system (LES) containing demand function for farm and non-farm goods and child investment goods, and labour supply functions has been estimated by the Full-

6 The coefficient values for the age of the household head in the demand for minor children equation may reflect two quite different phenomenon. On the one hand, in a *nuclear* family, one might expect the number of minor children to be small at low ages, to rise to a peak, and then to decline as the household head grows older. On the other hand, in an *extended* family, the number of minor children might be expected to increase or stay constant as the age of the household head increases, because it may include grandchildren, great grandchildren, nephews, nieces, etc. The linear relationship which is assumed here may combine both effects.

An alternative approach to accounting for the age of the household head is to "normalize" the family size variable to a common age, thus removing the effect of the age of the household head from the variable before estimation. Since the data used here includes many extended families with different numbers of adults, this normalization procedure would be extremely complex. In addition, there should also be a normalization of other endogenous variables to completely control for the age of the household head. Here, the more convenient procedure of controlling by including a variable for the age of the household head among the explanatory variable has been adopted.

information Maximum Likelihood (FIML) method with survey data from two villages in Bangladesh (The LES was estimated separately for each village). The household response elasticities with respect to selected exogenous variables in the system were not always similar across the two villages. Since there is limited empirical evidence from other countries for models similar to ours, a complete comparison of the Bangladesh results with other findings cannot be made. However, for some variables, Barnum's and Squire's reported LES elasticities for Malaysia are similar to our findings.

The reader should be warned that the elasticities reported here are calculated based on the assumption that total "net" expenditure (Y) is exogenous to the system. Y can be defined as $\Pi + G$, which varies with farm profit (Π), which in turn varies with wages, prices and technology. Our treatment of Y as exogenous in the LES estimates is only valid if family and hired labour are perfect substitutes in agricultural production. In this case production decisions are independent of the consumption decisions so that there is no "feedback" from labour supply decisions to Y.

The reader should also be cautioned that the price elasticities presented in Table 2 are only partial elasticities since they do not take into consideration the effects on Y which could occur as a result of changes in production decisions.

Our analysis, however, reveals that farm households in both villages do indeed respond to changes in prices and income in consumption decision-making, but that responses differ according to a number of exogenous household characteristics. In particular, we find that household demand for farm goods is income inelastic while demand for non-farm goods is income elastic, and that the demands for child quantity and child quality (schooling) are income inelastic. This analysis suggests that it should not be surprising to observe that poor farm households in LDCs spend most of their income on food, while also having large families and poorly educated children. These observations would be consistent with efficient household consumption behaviour.

In an agrarian economy, the success of government policy measures to promote growth in the rural sector depends on how farm households respond. Our analysis suggests that the response elasticities for different price variables and income are large, so that the pay-off to correctly designed policy measures may be high. However, response elasticities should be computed from a model that integrates both production and consumption decisions. To the extent that our results are accurate, the analysis suggests that government policy measures may yield significant progress in the rural areas of Bangladesh. For instance, the elasticity of the demand for non-farm goods to an income change is found to be high in both study villages. This implies that a technical improvement in agriculture which results in increased farm income, perhaps in the form of irrigation facilities combined with high yielding crop varieties, would greatly increase the demand for non-farm goods and thus help foster economic growth in the urban sector. This suggests that a "rural-led" growth strategy for a country such as Bangladesh may have a large potential impact on the overall growth of the economy.

Appendix

Definition of Variables and Data

The data used for commodity demand functions and labour earnings functions is taken from 100 households in each village. This data, as described in Khandker, was used to generate the variables needed to estimate the linear expenditure system. These variables are described below. Unless indicated otherwise, all data is based on the survey.

pC : expenditure on agricultural goods.

rQ : expenditure on non-farm goods.

$P_N x_N = (P_N X_N/N)$: total monetary cost per minor child (under age 15), which includes fixed cost associated with birth, and the annual cost of food, medicine, footwear, clothing, etc. No direct data was availabe on this cost. However, based on a study by Khuda in another village, this cost was calculated as TK. 1,640.0 per year per child for our sample households. To the extent that food cost actually dominates these costs, and that daily requirements per child do not vary significantly across households, this annual cost taken for all farm households may not be misleading.

$t_{NW} = T_{NW}/N$: average time involved in raising minor children. Based on the weekly data on baby care for all minors in the household by female members, we calculate the yearly time spent by all females in terms of person-days (7 hours per day).

N : number of minor children (under age 15).

W_W : wage rate of female workers (TK. per person-day).

$N(P_N x_N + W_W t_{NW})$: total expenditure both in terms of monetary cost and opportunity cost for minor children per year in Taka.

$P_E x_E = (P_E X_E/E)$: average monetary expenditure for schooling minor children up to class ten per year.

e : maximum total schooling level of all minor chlldren under age 15 (in years). This is calculated as ($e = 5 \times$ number of children enrolled in primary schools $+ 10 \times$ number of children enrolled in secondary school).

$E = e/N$: maximum per child schooling.

T_{EC} : total time spent by a minor child in schooling in a year. Based on weekly data on time spent in person-days by multiplying the weekly hours by 32 weeks (the maximum number of weeks the school may open in a year) and dividing by 7 hours to reach total person-days.

$t_{EC} = T_{EC}/E$: average yearly time spent in school by a minor child per schooling year.

W_C : wage rate of minor labour (Taka per day).

$\pi_E = (P_E x_E + W_C t_{EC})$: average cost (both monetary and opportunity cost) per schooling year for a minor (calculated on the basis of the discussion above).

$e\pi_E$: total cost of educating minor children in a year in terms of monetary cost and income foregone (Taka per year).

S_3 : total person-days worked by minors in farm activity.

$W_C(S_3 + et_{EC})$: total "possible" earnings by minor children in a year in terms of actual earnings, W_CS_3, and foregone earnings, W_Cet_{EC}, that could have been accrued had these minors not attended school.

S_1 : total labour supply to farm activity by all adult males in the household in a year.

W_M : adult male wage rate (Taka per day).

S_2 : total labour supply to farm activities by all adult females in the household in a year.

$W_W(S_2 + Nt_{NW})$: total "possible" earnings by all females in the household in a year. This includes actual earnings, W_WS_2, and the potential earnings, W_WNt_{NW}, foregone by raising the minors in the household.

N_1 : number of adult males in the household (over 15 years of age).

N_2 : number of adult females in the household (over 15 years of age).

s : the number of years of formal education received by the household head.

a : age of the household head.

Y : total expenditure of the household in a year (Taka per year) less all labour (farm) earnings.

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