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Consumption, Family Size, Schooling and Labor Supply Decisions:

Estimates of a Linear Expenditure System for Bangladesh

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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

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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):

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

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.

$$(3.7)\quad W_W(L_2-\bar{L}_2) = \beta_{I2}/A\,[I-p\bar{C}-r\bar{Q}-W_M\bar{L}_1-W_W\bar{L}_2]$$

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

$$\bar{Y}_1 = N_1\Omega_M-\bar{L}_1$$
$$\bar{Y}_2 = N_2\Omega_W-\bar{L}_2$$
$$\bar{Y}_3 = N\Omega_C-\bar{L}_3 = N\Omega_C-N\bar{l}_3$$

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 $N_1\Omega_M-\bar{Y}_1$ for $\bar{L}_1$, $N_2\Omega_W-\bar{Y}_2$ for $\bar{L}_2$, $N\Omega_C-\bar{Y}_3$ 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

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

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

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

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.

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 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	—	—

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.

-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 sup-

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

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 × number of children enrolled in primary schools + 10 × 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.

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