CHAPTER - III

AGRICULTURAL HOUSEHOLD MODEL: THEORY AND ESTIMATION ISSUES

3.1 Introduction

Based on the work on time allocation model by Becker (1965), a number of household models have been developed to analyse not only the market activities such as consumption, labour supply etc., but also the non-market activities namely, fertility, child schooling, health etc. In the household production models, utility of the household is assumed to depend upon the composite commodity and other choice variables. The demand functions for the choice variables are derived and estimated. On the other hand, farm production decision has been analysed independently based on the neoclassical production theory.

Barnum and Squire (1979) are the first to derive an agricultural household model, incorporating the own-farm produced and market-purchased commodities as choice variables along with other choice variables in the utility function, where as these commodities are aggregated into a single commodity known as composite commodity in the case of household production models. A farm production constraint is also specified along with the other constraints in the model. However, farm and household decisions are treated as separable and analysed independently in the study.
Singh, Squire and Strauss (1986) derived a common consistent framework to analyse jointly the farm and household decisions. A considerable number of empirical studies have appeared based on the agricultural household models. Pitt and Rosenzweig (1986) flexibly modified the agricultural household models to analyse the health decision of household members simultaneously with other household decisions and farm production decision. The theoretical model used in the present study is based on Singh, Squire and Strauss (1986) and Pitt and Rosenzweig (1986).

This chapter is organised as follows. The theoretical model is presented in section 3.2. The comparative statics of the model is discussed in section 3.3. Specification and estimation issues are discussed in section 3.4.

3.2 The Model

The utility of the farm household is assumed to depend upon the consumption of own-farm produced and market-purchased food commodities, health status and leisure of household members.

The utility function of the household can be written as

\[ U = U(X_o, X_m, L_o, L_t, H_o, H_t) \]  

(3.1)

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1 The econometric works analysed the farm and household decisions using agricultural household model for various developing countries are reviewed in a relevant section of the Chapter II.
where \( X_o \) is the own-farm produced commodity, \( X_m \) is the market-purchased commodity\(^2\), \( L_m \) and \( L_r \) are the leisure time of the adult male and female members in the farm household, and \( H_m \) and \( H_r \) are the health status of adult male and female members.\(^3\)

The health of the adult male and female household members is assumed to be influenced by own-farm produced and market purchased commodities, health inputs, time inputs of the adult members, and environmental factors given the individual's initial \( \mu \)th endowment.

The health production function can be written as

\[
H_j = H_j (X_o, X_m, X_r, L_m, L_r, \mu_j) \quad j = m, f
\]

(3.2)

where \( X_j \) is the vector of health inputs, which yield no direct utility and \( \mu_j \) is a vector of individual's health endowment and environmental factors which are beyond the control of the household but which affect the health status of the household members. It is also assumed that the own-farm produced and

\(^2\) Generally, household production models include a composite consumption good, which includes all goods irrespective of whether it is own-produced or market purchased [See Rosenzweig and Evenson (1977), Duraisamy (1988, 1995)]. However, the agricultural household models distinguish the composite good into own-farm produced and market-purchased food commodities in order to study jointly the production relation of own-farm goods and other household issues.

\(^3\) It is possible to include child labour (leisure) and health in the model and derive the demand functions for their leisure and health. We had very few working children in our sample and find it difficult to empirically estimate the labour supply and health demand functions for children. Hence the study is confined to adult members' labour supply and health behaviour.
market-purchased food commodities and health inputs and leisure time of adult members increase the health status of the household members.

The farm output production conventionally depends on a set of variable and fixed factors. In addition to these factors, the human capital of the farm household members are assumed to influence the farm production [See Jamison and Lau (1982), Evenson (1973), Duraisamy (1990, 1992)]. That is, education, farming experience, extension contact and health status of the adult members of the farm household are assumed to influence the farm output through farm inputs.

The farm production function for the own-farm produced food commodity can be specified as

$$Q = Q(B, G, V, F; H_m, H_f, E_m, E_f)$$  \hspace{1cm} (3.3)

where $Q$ is the value of farm output, which is the sum of the commodities used for own-consumption ($X_w$) and marketable surplus ($N$), $B$ is the labour input of adult family members, $G$ is the hired male and female labour inputs, $V$ is the vector of other variable inputs such as fertilizer, seeds, bullock labour etc. $F$ is the vector of fixed inputs namely area of land, capital etc. $H_m$ and $H_f$ are the health status of male and female adult members and $E_m$ and $E_f$ are the vector of other human capital variables namely education, extension contact, farming experience etc. of male and female members in the household.
Health and other human capital variables are assumed to affect the farm productivity through farm inputs but not directly the output. For instance, education and extension contacts could increase the knowledge and information and thus influence the output through "worker effect", "allocative effect" and "innovative effect", [See Schultz (1975), Chaudhri (1979), Welch (1970, 1978)]. Better health can influence the output through the quantity and quality of the labour input such as supervision etc.

The effective family adult labour input day, \( B_e_j \), depends upon the actual family labour input\(^4 \) days \( B_j \) and health status of the adult members, which can be specified as

\[
B_{e_j} = \theta (B_j, H_j)
\]

for \( j = m, f \)  

(3.4)

Any change in actual labour input (man days) and health status of adult members are assumed to increase their effective labour input.

For farm production activities, the labour days of household members are hired at a constant wage rate \( W \), and each hired labour days in the farm production provides \( \delta \) effective units of labour days. Then the actual labour input of adult male and female members in terms of efficiency units can be measured as \( B_{e_j} + \delta G_j \) where \( G_j \) is the hired labour input of household

In the farm production analysis, the usual practice is to aggregate male, female and child labour days into man days by taking the weighted sum of these three categories of labour input. The weights are 1 for male, 0.66 for female and 0.33 for children. The family labour input is the weighted sum of adult male and female work days in own-farm.
members for wage. The price of effective labour input days is \( w_i = W/\delta \) and \( wB \) is the household members labour costs of production on the farm.\(^5\)

The health status of farm family members may be expected to increase the quantity of healthy days available for work or leisure [See Grossman (1972)]. The total available healthy days can be used for own-farm production as labour input, for wage work and for leisure.

The time constraint can be written as

\[
B_j + M_j + L_j = T(H_j) \quad j = m,f \tag{3.5}
\]

where \( M_j \) is the total wage-work days of adult members of the farm household and \( T(H_j) \) is the total available healthy days.

Using (3.5), equation (3.4) can be written as

\[
B_{kj} = \theta[T(H_j) - M_j - L_j, H_j] \quad j = m,f \tag{3.6}
\]

The budget constraint of the farm household is

\[
P_a X_a + P_m X_m + P_X X_x = \pi + \Sigma_j W_j B_{kj} + A \quad j = m,f \tag{3.7}
\]

Incorporating equation (3.6), equation (3.7) becomes

\[
P_a X_a + P_m X_m + P_X X_x = \pi + \Sigma_j W_j \theta[T(H_j) - M_j - L_j, H_j] + A \tag{3.8}
\]

\[
P_a X_a + P_m X_m + P_X X_x = Y^*
\]

\(^5\) The efficiency wage \( w \) can be estimated based on the efficiency wage models first developed by Leibenstein (1957), and subsequently extended by others [Rodgers (1975), Mirrlees (1976), Stiglitz (1976), Bliss and Stern (1978a,b) etc.].
where \( P_a, P_m \) and \( P_z \) are respectively the prices of \( X_a, X_m \) and \( X_z \), \( W \) is the market wage rate, \( Y^* \) is the full-income of the farm household and \( \pi = P_a Q - \sum W_j B_j - \sum \phi_i V_i \) is the farm profits. Where \( \phi \) is the vector of price of other variable inputs, \( A \) is the non-farm, non-wage income of the household.

The household is assumed to maximise the utility function (3.1) Subject to the health (3.2), farm production (3.3), time (3.6) and budget (3.8) constraints.

The Lagrangian function can be written as

\[
\mathcal{L} = U(X_a, X_m, L_m, L_f, H_m, H_f) + \lambda \left[ P_a X_a + P_m X_m + P_z X_z - \pi \right] \\
- \sum_{j} W_j \theta_j (T(H_j) - M_j - L_j, H_j) + A] \\
j = m, f
\]

(3.9)

Mathematical optimization process to the above utility maximization framework leads to a set of first-order conditions.

The first-order conditions for the optimal quantities of own-farm produced and market-purchased commodities \((X_a \text{ and } X_m)\), household production inputs \(X\), and \(L\) and farm labour input \(B\) are given below.

\[
U_a + U_{H_a}H_a = \lambda \left[ P_a - \sum W_j H_{ja} (\theta_j T_{jl} + \theta_{il}) \right] \\
j = m, f
\]

(3.10)

\[
U_m + U_{H_m}H_m = \lambda \left[ P_m - \sum W_j H_{jm} (\theta_j T_{jl} + \theta_{il}) \right] \\
j = m, f
\]

(3.11)

\[
U_{H_j}H_j = \lambda \left[ P_z - \sum W_j H_{ja} (\theta_j T_{jl} + \theta_{il}) \right] \\
j = m, f
\]

(3.12)

\[
U_{L_j} + U_{H_{L_j}}L_j = \lambda \sum W_j (\theta_j - H_j (\theta_j T_{jl} + \theta_{il})) \\
j = m, f
\]

(3.13)
\[ P_n \frac{\partial Q}{\partial B_j} = W_j \quad j = m, f \] (3.14)

where

\[ U_k = \frac{\partial U}{\partial X_k}, \quad k = a, m, l; \quad U_{Il} = \frac{\partial U}{\partial H_j}, \quad H_l = \frac{\partial H_l}{\partial X_l}, \quad l = a, m, l \]

\[ \theta_T = \frac{\partial \theta}{\partial T}, \quad \theta_H = \frac{\partial \theta}{\partial H}, \quad T_{Il} = \frac{\partial T}{\partial H} \]

Equations (3.10), (3.11) and (3.13) indicate that the utility of the farm household are influenced directly by the changes in consumption of own-farm produced and market-purchased commodities and leisure of adult members of the household and indirectly through the changes in the health status of adult members. Changes in the effective labour time and total healthy days available to the farm household members for leisure or work, also indirectly affect their income.

The reduced-form equations for the own-farm produced and market-purchased commodities, leisure and health are written as

\[ k = f_k (P_a, P_m, P_z, \pi, W_a, W_m, W_z, A, \mu_j), \quad k = X_a, X_m, H_j, L_j; \quad j = m, f \] (3.15)

The demand functions are the functions of prices of own-farm produced, market purchased and health inputs, wage-rates of adult male and
female members of the household, farm profit and individual health endowment and environmental factors.

The mirror image of demand for leisure (L) is the labour supply of adult members and the labour supply functions can be written as

\[ M_j = M_j (P_a, P_m, P_r, \pi, W_m, W_p, A, \mu_j), \quad j = m, f \]  

(3.16)

The comparative static properties of the demand functions are presented in the next section.

### 3.3 Comparative Statics of the Model

The demand functions derived in the previous section have all the properties of conventional demand-equations derived from the model without household production (health).

The comparative static analysis examines the effect of changes in exogenous variables (prices of household choice variables, and income in the present case) on the optimum values for the endogenous variables (quantities of household choice variables). The properties of these demand functions are own-compensated price effects are negative, cross-compensated price effects are symmetric etc.

There are two important properties of demand functions, first one is that the demand for any commodity is a single valued function of prices and income which follows from the strict quasi-concavity of the utility function. Secondly, demand functions are homogenous of degree zero in prices and income.
The comparative statics for leisure (or its inverse, namely labour supply) can be analysed using slutsky decomposition equation specified below.

$$\frac{\partial M_j}{\partial W_j} = \frac{\partial M_j}{\partial W_j} \bigg|_U + \left[ T (H_j) - L_j - B_j \right] \frac{\partial M_j}{\partial Y^j} \quad j = m, f \quad (3.20)$$

The first term on the right side of above equation is the compensated own-wage effect and the second term is the income effect. The left hand side of the equation is the uncompensated substitution effect. The income effect of the labour supply function is weighted by household labour minus the labour demand (marketed surplus of labour), not by household labour supply.

Next, let us examine the change in own-produced food commodity on the health status of the adult members. It can be shown that

$$\frac{dH_j}{dP_a} = H_a \frac{dX_a}{dP_a} + H_m \frac{dX_m}{dP_a} + H_z \frac{dX_z}{dP_a} + H_l \frac{dL}{dP_a} \quad (3.20a)$$

The first and second terms on the right hand side are the effects of a own-farm produced commodity price change on own-consumption and marketable goods, third term is the own produced goods price effect on health inputs and the last term is the effect of price of own-farm produced good on leisure (or work time). The net effect of a food price change on health will depend on the magnitudes and signs of the own and cross-price effects in consumption. It also depends on the relative magnitudes of the marginal productivity of the inputs used in producing health.
The comparative statics for own-farm produced good crop (paddy in the present study) is specified as

\[
\frac{\partial X_a}{\partial P_a} = \left. \frac{\partial X_a}{\partial P_a} \right|_u - (Q-X_a) \frac{\partial X_a}{\partial Y^*}
\]  

(3.21)

Any change in the price of an agricultural produced commodity has the usual negative substitution effect and an income effect, weighted by net sales (or marketed surplus) of \(X_n\), not consumption of \(X_a\). The income effect is positive for a net seller and negative for a net buyer. The income effect for a farm household has an additional term \(Q (\partial X_a/\partial Y^*)\) as compared with the pure consuming household. This extra effect is what is known as "profit effect" which comes through changing farm profits. The profit effect equals output times the change in price and is unambiguously positive. The positive effect of an increase in profit which is totally ignored in traditional model of demand, will dampen and may outweigh the negative effect of standard consumer-demand theory.

### 3.4 Specification and Estimation Issues

The above theoretical framework integrates the household and farm production decisions. Although the two decisions are simultaneous in time, under certain conditions (assumptions), the two decisions are separable and can be analysed as separate components of a sequence. The most important assumptions are the existence of product and labour markets and that the households are price takers. That is, all prices are exogenous to the
households. Under this circumstance, the production decision is independent of labour supply and other household decisions. Given that, the model is separable, the demand functions for labour supply and health [equations (3.15)] and farm production function (output supply or the dual of production function namely profit function) can be estimated separately.

For econometric estimation, the functional form is assumed and error terms are added. The household labour supply and health are functions of a set of prices and income. These equations are called reduced-form equations and no simultaneity exists. The farm output depends upon a set of traditional farm inputs and human capital variables.

If the error terms in the household labour supply and health equations are not correlated with production function equation errors, each equation can be estimated separately. The single equation estimation methods can be used and the computation burden is considerably reduced.

On the other hand, if the error terms in household labour supply and health demand equations and production functions are correlated, then even if the model is separable, the model cannot be estimated as discussed above. The endogeneity due to error term correlation should be taken into account in the estimation.

Under semi-commercial farming, there are certain imperfections in the product or labour market or market may not exist for certain type of labour or products. In the Indian context, the farms are operated and managed by
individuals/households as self-operating enterprise. There is no labour market for farm management. That is, hired labour cannot be a perfect substitute for supervision and input-output allocation. The knowledge and experience acquired about his farm over a period of time is an important skill for the farm operator, which cannot be sold or purchased in the market. Health is a basic commodity and is produced at the household level and it is not tradeable. Under these conditions, the household and farm production decisions may not be treated as separable. In the non-separable case, the household and farm decisions are interlinked and the labour supply, health and farm income/profit are specified in a simultaneous equation framework. Although, it is not possible to take full advantage of the theoretical restrictions, it is possible to test the implications discussed in the previous section. As Singh et al., (1986) point out, "As a comprise, a subset of the structural equations might be estimated, while accounting for the endogeneity of any choice variable. In this way, some economic structure can be imposed (tested) on the data." Accordingly the estimating structural equations of the model can be specified as

\[ M_j = \alpha_{ij} + \beta_{1ij} H_j + \beta_{13j} \ln Q + \sum_j \beta_{4ij} \ln W_i + \sum_j \beta_{4ij} A + \gamma_{1ij} D_1 + \gamma_{12j} D_2 + u_i \]  \hspace{1cm} (3.17)

\[ H_j = \alpha_{2j} + \beta_{22j} M_j + \beta_{23j} \ln Q + \sum_j \beta_{23j} \ln W_j + \sum_j \beta_{24j} A + \gamma_{21j} D_1 + \lambda_{22j} D_2 + u_2 \]  \hspace{1cm} (3.18)

\[ \ln Q = \alpha_{3j} + \sum_j \beta_{33j} M_j + \sum_j \beta_{33j} H_j + \delta_1 D_4 + \delta_2 E + u_3 \]  \hspace{1cm} (3.19)

where \( j = \) adult males (\( M \)) and adult females (\( H \); \( Q \) are measures of labour supply, health and farm production, \( D_1 \) is a vector of individual and household level variables, \( D_2 \) is a vector of labour market characteristics, \( D_3 \) is a vector of health infrastructure at household and village level, \( D_4 \) is a vector
of conventional fixed and variable inputs used in farm production, $E$ is the vector of human capital variables such as education, extension contact, farming experience etc., $u_1, u_2$ and $u_3$ are the random error terms and $\alpha, \beta, \gamma$ and $\delta$ are the parameters to be estimated.

The database of the study to test the implications of the model is discussed in next chapter. A detailed discussion on the measurement of the endogenous and exogenous variables in the above model and the estimation methods of the equations (3.17) through (3.19) is provided in Chapters V and VI.