FARM HOUSEHOLD MODELS IN DEVELOPING COUNTRIES

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INTRODUCTION

In a wide range of disciplines, including anthropology, sociology, psychology and economics, substantial academic attention has been directed to identification and specification of stimuli and inhibitors of technical change. However, analyses of the adoption process have not, as judged from the literature, generated information of the kind and quality that is adequate for policy makers. The deficiencies in these analyses are twofold. First, empirical investigations which impinge on this area have been confined largely to dichotomous treatment of adopters and non-adopters or to the use of a subset of arbitrarily chosen discriminants with tenuous relevance as modifiers of economic behaviour. Secondly, the most significant deficiency in most of these analyses is the absence of linkages between the adoption process and the relevant economic entities, the farm household, the farm firm, and the policy and market environment in which economic decisions are made. While progress has been made, principally by Strauss (1984), Hardaker, *et al.* (1985), Lopez (1984), Barnum and Squire (1979), the defects of these analyses persist because of weaknesses in the theory which purports to explain the behaviour of subsistence and semi-subsistence farmers.

In recent years some of the gaps in the theory have been partially filled by the development of integrated models which accommodate explicitly the activities of households and firms (Becker, 1965; Nakajima, 1986). But empirical implementation of suitable models to reflect the theory has been rare. Often the models do not account for simultaneity in production, consumption and trading activities with respect to agricultural inputs and outputs. These deficiencies can be remedied, and the proposition advanced here is that, with appropriate adjustments, the adoption behaviour of farmers can be better understood within a theoretical structure which allows for joint production and consumption decisions than in a research mode which treats them in isolation. The spirit of this proposal is embodied in a recent study of 'tastes' by Stigler and Becker (1977).

In this paper an integrated agricultural household model in the genus ‘ modern household economics' is developed to achieve an implementable model of semi-subsistence farming in developing countries. The aim is to reflect adequately the features of market imperfections that beset most developing countries' agriculture. The model is then applied to a rice growing semi-subsistence area in Orissa, India.

There is some theoretical contribution in this study but it is largely empirical with the focus on policy analysis. The study addresses directly the simple yet important issues of whether or not the policy to promote new technology is directed to worthwhile and achievable goals and to what extent the target variables are capable of manipulation by commonly pursued policy measures. In addition, the issue of consistency in the choice of policy instruments and the variety of individual policy targets is addressed.

THEORETICAL MODEL

In the traditional analysis of farm househould behaviour the possibility of wage-price differentials and market segmentation is generally ruled out by the assumption of perfect competition in both factor and product markets. The consequence of this assumption was that a common wage rate applied for family labour and hired labour use in production and also for on-farm and off-farm labour supply decisions. The same real wage, $\frac{w}{p}$, was considered relevant for the determination of production and consumption optima. There is, however, widespread evidence that market imperfections, especially in developing countries, are pervasive leading to differential buying and selling prices and wages for similar products and inputs (Stiglitz and Weiss 1981, Nerlove, 1979). One way to handle the problems of market imperfections is to recognise the existence of segmented markets and incorporate the price differentials in the models. In this paper, a farm household model is developed to account for a segmented labour market. The on-farm wage rate is defined as the rate at which labour can be hired (purchased) from the market. The off-farm wage rate is the rate at which the farm household sells its labour in the market. Clearly, if the on-farm wage rate is more than the off-farm wage rate, commodity price remaining the same, the farm household's total labour demand l_t is equal to its on-farm labour supply l_{fs}, market (hired) labour demand $l_{md} = l_h = 0$ and market (off-farm) labour supply $l_{ms} = 0$. This case is somewhat trivial. Hence we consider the more general and interesting case of a higher off-farm wage. In this paper we allow for the possibility of commodity price variability and define buying and selling prices of the subsistence good, q, as p_b and p_s. The real wage rate relevant for the market demand for labour is $\frac{w_f}{p_s}$ and that for the market labour supply is $\frac{w_m}{p_b}$, where w_f and w_m are the on-farm and off-farm labour market wage rates. By assumption $\left(\frac{w_m}{p_b}\right) > \left(\frac{w_f}{p_s}\right)$. The farm household would decide, in these circumstances, the production optimum by equating the marginal product of labour with the on-farm wage rate, $\frac{w_f}{p_s}$, for this would maximise its rental income and consumption decisions by equating its MRS between the subsistence good and leisure with the off-farm wage rate, $\frac{w_m}{p_b}$. The production and consumption decisions are nonetheless interconnected through the decision on on-farm labour supply, which is determined by the equality of $MRS_{s,q} = \frac{w_m}{p_b} = MP_{l_{fs}}$, the marginal product of family labour, and has a bearing on how much hired labour is used in the production process. Market segmentation and differential wages and prices thus may account for concurrent purchase and sale of labour by the farm household.

The overall optimisation problem of the agricultural household can be described in the following manner. The farm household maximises its utility function,

$$U = U(q,s) \tag{1}$$

subject to its production function defined on total labour demand, l_{td},

$$q_p = f(l_{td}) \tag{2}$$

where $q_p = q + q_m$, $l_{td} = l_{fs} + l_{md}$, q_p is total farm produce, q is family consumption demand, q_m is market supply q_{ms} of the subsistence good, if positive, and market demand q_{md}, if negative, and other terms are as defined before. The farm household also faces the time constraint,

$$T = l_{fs} + l_{ms} + s \ , \tag{3}$$

as well as a market constraint expressed in real terms as:

$$q_m + \frac{y_n}{p_b} + \frac{w_m}{p_b} l_{ms} = \frac{w_f}{p_s} l_{md} \ , \tag{4}$$

where the terms are as defined before.

The farm household's behaviour as represented by the equations (1) through (4) are illustrated graphically in Figure 1. In the figure, q_nq_n represents the non-labour real income, Tq represents the production function. The on-farm real wage line is shown as $T\hat{q}$. Given this farm wage, the farm household would wish to use labour Tl_{td} at point e_p on the production function to produce q_p amount of subsistence good and earn a rental income equal to Tq_R. The sum of rental income and non-labour income is represented by q_Nq_N which may be viewed as the real income that the farm household can earn without sacrificing any of its time endowment. Given the off-farm real wage, $\frac{w_m}{p_b}$, however, the agricultural household can augment its income q_Nq_N by market wage income, $T\bar{q}$, so that at its full income the farm household chooses the commodity bundle e_c to maximise its utility by consuming q_c and s_c amounts of subsistence and leisure goods. At the equilibrium point, e_c, $MRS_{s,q} = \frac{w_m}{p_b}$ where the farm household's total supply of labour is Ol_{ts} of which Tl_f is supplied to the farm-firm and the balance $l_{ts}l_{fs} = (Tl_{ts} - Tl_{fs})$ to the market. The market demand for labour by the farm household is equal to $l_{td}l_{fs} = (Tl_{td} - Tl_{fs})$. The reason why the utility maximising agricultural household does not sell all its labour to the market but reduces hired labour demand is that by doing so it is able to save payments for labour to the extent of HH[1]. Another way of explaining the labour supply behaviour is that at the initial levels of labour use in production (to the right of e_f in Figure 1) returns to labour are higher than the fixed real wage $\frac{w_m}{p_b}$ that may be obtained by selling labour in the external market.

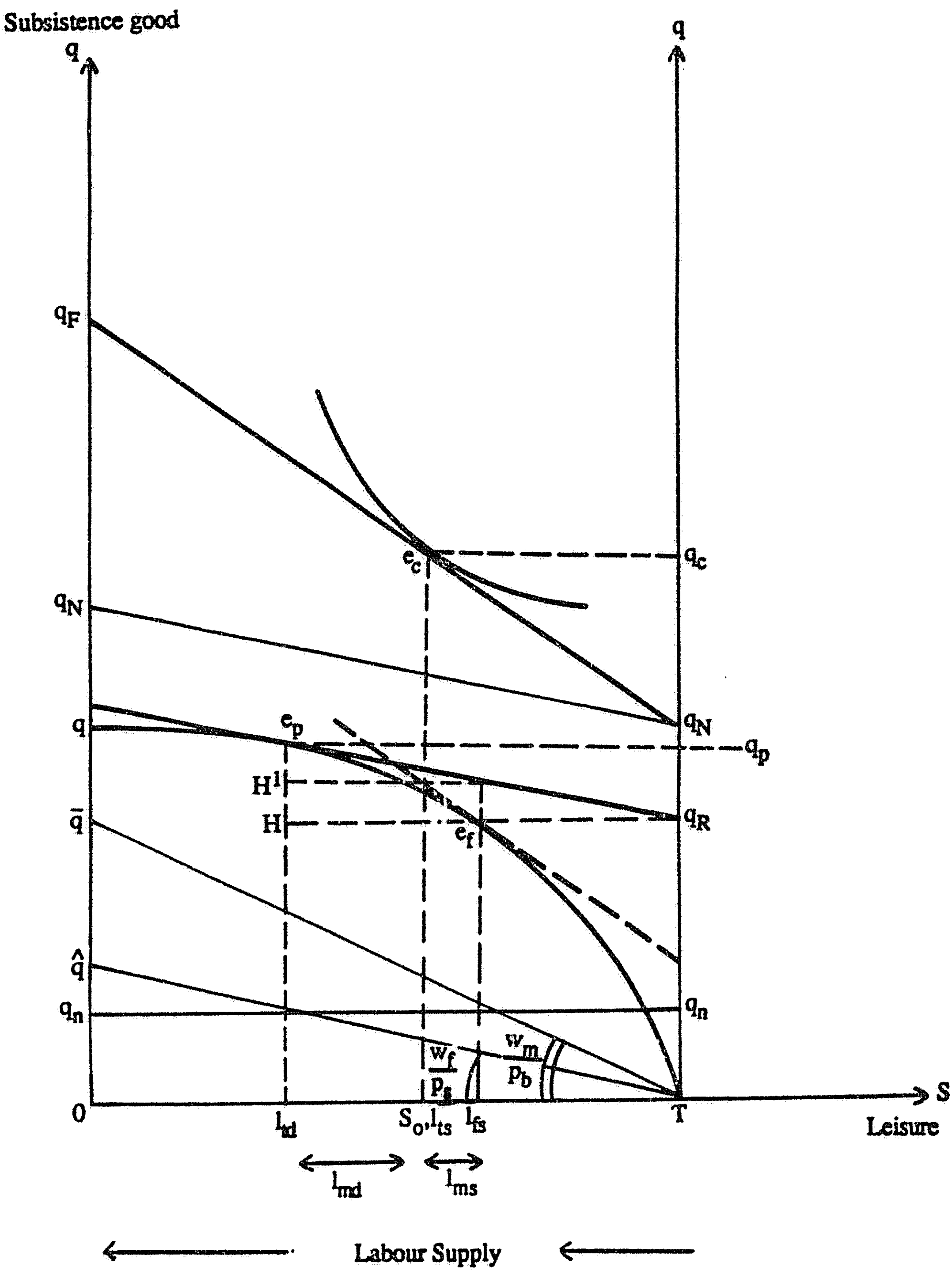

Figure 1 . Farm Household Behaviour in a Segmented Labour Market

FARM HOUSEHOLD BEHAVIOUR WITH IMPERFECT FACTOR AND COMMODITY SUBSTITUTION

The discussion of agricultural household behaviour in segmented markets was confined to the case of perfect factor and commodity substitution. In particular, it was assumed that family and hired labour are perfect substitutes in production. Similarly, on-farm and off-farm labour supply were assumed to be perfect substitutes in consumption. The result was that the production function could be defined on total labour demand by the farm-firm and the utility function could be defined on total labour supply (conversely leisure). The implication was that on-farm and off-farm labour had no effect on preferences except for reducing leisure by the same magnitude at the margin. In other words, the drudgery (discomfort) involved with on-farm and off-farm work were ignored altogether.

Similarly, the marginal efficiencies of hired and family labour as reflected in their productivities were assumed to be identically distributed. No allowance was made for the possible compositional effects of labour demand on production. However, both these assumptions are very restrictive. On the labour demand side, there is a growing and compelling view that hired and family labour may not be treated as identical inputs to be summed together to a single input. Although put in somewhat different terminology, the main reason is that there are sufficiently different motivational incentives for the two kinds of labour. For hired labour a fixed wage rate is paid irrespective of the realisation of its productivity. The wage earner has no incentive to apply his labour efficiently which is indeed counter to his objective of utility maximisation. The reward for family labour, on the contrary, is critically dependent on the level of final output since it is not paid normally at the time of its use. Hence there is sufficient incentive for family labour to apply itself to its full potential. The treatment of on-farm and off-farm labour as equivalent is even more questionable for it denies the obvious association of varying degrees of pleasure and pain with different types of work. For these reasons it is suggested that at least in empirical investigations compositional effects of labour demand and supply should not be neglected.

The recognition and incorporation of imperfect substitution between different kinds of labour in production and consumption increase the scope and complexity of farm household models. Specifically, the production and utility functions become multidimensional in character, which render geometric representation of farm household behaviour non-illuminating. For this reason a mathematical approach is found suitable to describe the farm household optimisation problem involving multiple factors and commodities.

To elucidate how one might allow for compositional effects of total labour supply and demand on preferences and production respectively we re-define the optimisation problem. The utility function as usual may be given by:

$$U = U(q,s) \tag{5}$$

which is maximised subject to a production function,

$$q_p = f(l_{fd}, l_{md}) \ , \tag{6}$$

a time endowment constraint,

$$T = s + g(l_{fs}) + h(l_{ms}) \ , \tag{7}$$

and a market (real balance) constraint,

$$q_m + \frac{y_n}{p_b} + \frac{w_m}{p_b} l_{fs} - \frac{w_f}{p_s} l_{md} = 0 \ , \tag{8}$$

where family labour supply is equal to family labour demand so that

$$l_{fs} = l_{fd} \ , \tag{9}$$

$$q_p = q + q_m \ , \tag{10}$$

and g and h are the discomfort functions associated with the farm and market work respectively. All other terms are as defined before. Note that equation (7) is a significant variation from the previously defined time constraint in that it is now non-linear to allow for increasing pain (disutility) over and above the reduction of leisure with higher levels of on-farm and off-farm labour supplies, i.e., $g'(l_{fs})$ and $h'(l_{ms})$ are greater than zero.

The farm household model in this version is highly non-linear and interdependent. The usual practice of merging all constraints and equilibrium conditions into a single constraint as is suggested by the proponents of the new household economics and used in the earlier models in this study, is possible, but would lack a proper interpretation of the production function. In order to preserve the usual meaning of the production function it may be proper to maintain the distinction between the production function and the real balance constraint. For the same reason, the time constraint may now be used to eliminate s in equation (5) to define the utility function as:

$$U = U(q,s) = U\left[q,\ T - g(f_{ls}) - h(l_{ms})\right] \qquad (11)$$

which is maximised subject to the production function,

$$q_p = q + q_m = f(l_{fs}, l_{hd}) \ , \qquad (12)$$

and

$$q_m + \frac{y_n}{p_b} + \frac{w_m}{p_b} l_{ms} = \frac{w_f}{p_s} l_{hd} \ , \qquad (13)$$

where hired labour demand l_{hd} replaces the market labour demand l_{md} which by definition is equal to l_{hd}. Clearly equations (9) and (10) are used in the derivation of (12). From the system of equations, (11) through (13), it is obvious that the consumption and production decisions of the farm household cannot be isolated and estimated separately. Imperfect factor and commodity substitution which is assumed in this model is judged to be pervasive in third world agriculture. Notwithstanding this stark reality in semi-subsistence agriculture, applied and policy oriented farm household models continue to impose the assumptions and predictions of perfect competition to suggest an isolation of production decisions from consumption behaviour. This, may well be the major failing of most research endeavours on farm household modelling.

In order to redress this problem it is suggested that farm household models should be constructed in a way which allows for simultaneous production and consumption decisions so that factor demand and supply as well as commodity demand and supply behaviour are jointly determined rather than in isolation. This is not to say that economic theory must incorporate simultaneity and an accurate representation of economic phenomena. Theoretical prediction would indeed be impossible without simplifying assumptions and abstractions. There is, and perhaps there will always remain, a gap between theory and empirics for their objectives are different. What is stressed is that, while theory and its predictions derived from simple models aid model specification and its testing, they may not be used indiscriminately in the construction of empirical models.

Due attention must be paid as well to the generality and empirical plausibility of the model. Failure to recognise such details in practice and imposition of inappropriate restrictions would not only lead to specification error but also to bias in estimation and policy predictions in an unforeseeable direction. It may therefore be advisable to be as general as possible in applied work and incorporate most essential elements of the phenomenon under investigation. Hence simultaneity and joint production and consumption must be allowed for in the case of agricultural household behaviour.

In addition, it is necessary to include other relevant inputs such as land, capital, fertilizer and irrigation water in production and market purchased goods such as clothing, salt, sugar, tobacco and oil, to name but a few, in consumption. The utility and production functions as defined in this chapter are unrealistic and limited in scope. They were adopted only for the purpose of elucidation. Theoretical extensions and detailed specification of the empirical model which is used to analyse and evaluate the effect of technology adoption on farm household behaviour is described in following sections of the paper.

EXTENSIONS AND MODIFICATIONS OF THE THEORETICAL MODEL

The consequences of introducing multiple commodities, resources and technologies into the farm household model are significant changes in the dimensions of the three fundamental relationships of chapter four. They are the utility function (equation 11), the production function (equation 12) and the real balance constraint (identity 13).

In the first place, the production function undergoes changes as a result of introducing a new technology which may be used concurrently with the existing technology. Given that two technologies - the high yielding and traditional varieties of rice considered in this study - produce an identical commodity and they compete for the fixed amount of land resource, the two production functions can be combined to derive a farm's total output equation (Pradhan and Quilkey, 1985). The farm output function may be written as:

$$q_p = q + q_m = F\,(l_{fs}, l_{hd}, C_f, \pi, x_i) \ , \qquad (14)$$

where l_{fs}, l_{hd} are labour supply and hired labour demand, C_f represents the cash inputs, π is the extent of new technology adoption as measured by the proportion of land allocated to the new technology and x_i are other relevant exogenous variables. Note that the output function, F, is different from the production function, f, referred to earlier. This is because f refers to a given technology while F is a result of combining two separate technologies.

The other significant endogenous variables which appear in equation (14) are the cash inputs. Strictly speaking 'cash inputs' are a misnomer for a variety of sundry inputs used in the production process which are difficult to measure precisely in physical units. Such inputs include land rent, water charges and even the cost of fertilizers which are purchased in complex compound forms. The problem encountered in the interpretation of cash inputs is similar to that in capital theory where capital refers to a wide range of plant and equipment of different vintages.

Despite the above conceptual difficulty, the use of cash inputs as a measurable variable has certain advantages in the context of agricultural household modelling. First of all, it is implied that cash in a farm household may have alternative uses apart from its use as an input in production. Just as in the case of labour, a time constraint provided the linkage between the production, consumption and market dimensions of farm household behaviour, a similar constraint may be operative connecting the different uses of cash in the farm firm and the farm household. Akin to the concept of a reservation wage, a reservation interest rate for cash inputs may be an appropriate concept in decision making. Thus, the cash-resource endowment of the farm household may be handled on an equal footing with the time endowment.

Parallel to the time constraint (3), a cash endowment constraint may be invoked as:

$$\bar{C} = C_u + C_f + C_l \ , \tag{15}$$

where $\bar{C}$ is the total endowment of cash available to the farm household, C_u is the cash that is used to yield utility directly through purchase of consumption commodities, C_f is the cash used in the farm firm for the production of q and C_l is the cash lent in the market. C_u is the residual cash endowment which plays a role similar to that of leisure in determining the utility function. The utility function may now be written as:

$$U = U(q,s,C_u) = U[q, T - g(l_{fs}) - h(l_{ms}), \bar{C} - C_f - C_l] \ , \tag{16}$$

which makes use of (15) by replacing C_u with its empirically measurable components.

In principle it is possible to modify the utility function (16) and the production function (14) further by introducing borrowed cash (like hired labour) and risk perception functions $\Phi(C_f)$ and $\psi(C_l)$ for C_f and C_l in the same vein as $g(l_{fs})$ and $h(l_{ms})$. In practice, however, there are problems of measurement and interpretation. The risk perception functions, Φ and ψ, and discomfort functions, g and h, are hard to quantify and their properties are not known clearly. Segregated data on lending, borrowing and use of cash in the farm are hard to obtain with any degree of reliability.

The time and cash endowment of resources vary significantly across households in cross-sectional studies and are also difficult to measure precisely.

To overcome the above difficulties the complex utility function (16) is respecified for the empirical study as follows:

$$U = U[q, M, l_{fs}(s_i), l_{ms}(s_j), C_f(s_k)] \quad , \tag{17}$$

where an additional commodity M is incorporated to take account of all other consumption goods besides the subsistence good which is produced and consumed by the farm households, and s_i, s_j and s_k are i,j and k specification of variables associated with on-farm labour supply l_{fs}, off-farm (market) labour supply l_{ms}, and cash input C_f used in farm activities. No distinction is made as to the sources of C_f which may be funded by borrowing or 'own cash' generated from liquid assets. Lending activities are assumed to be not very important in the empirical context so that $C_l = 0$.

The specification variables, in effect, represent the sources of resource endowments, their allocations and product characteristics of relevant endogenous variables. By definition, these are exogenous variables which determine the values of their respective endogenous variables by mechanisms other than those explained by the current model. One can, however, identify reasonably well what these specification variables are in particular contexts.

In the present model, it is obvious that s_i and s_j may stand for such factors as family size and composition which largely account for variation in the time endowments among farm households. Family size and compositional factors are to be considered as exogenous variables since they determine, without themselves being determined by, current decision related variables such as on-farm and off-farm labour supply. Similarly, specification variables s_k accompanying cash inputs are likely to be asset and liquidity related variables such as income and wealth, and credit market related variables such as credit-acquisition-time, interest rates and sources of credit.

As a result of the above respecification and for empirical convenience, the real balance constraints (11) also need restatement. The market value of other consumption commodities M is to be included. Although for analytical exposition as well as actual decision making, real prices and income as defined in (11) may be relevant, at an empirical level the constraint facing the farm households is a cash-flow problem which is defined in nominal terms. The real balance constraint may thus be redefined as a cash-flow equation in the form:

$$p_s q_m + y_n + w_m l_{ms} - w_f l_{hd} - M - C_f - V = 0 \ , \qquad (18)$$

where p_s is the price at which marketed surplus q_m of farm produce, rice is sold, w_f and w_m are the on-farm and off-farm wage rates, y_n is non-rice non-wage income, M is the market value of non-rice consumption commodities, C_f is the use of cash inputs in the farm-firm, and V is the saving of cash that may be carried over from year to year.

THE EMPIRICAL MODEL

At an empirical level, the optimisation problem of a semi-subsistence agricultural household in developing countries may be stated as maximising the utility function (17) subject to the production function (14) and the cash-flow identity (18).

To derive the empirical model, the familiar constrained optimisation technique of model solution may be applied to the problem defined in the previous section. Instead of the usual case of a single linear constraint which is so often encountered in economics texts, here there are two constraints, one of which is non-linear. The general methodology, however, applies yielding the Lagrangian function:

$$\begin{aligned} L = {} & U[q, M, l_{fs}(s_i), (l_{ms}(s_j), C_f(s_k)] - \\ & \lambda_1[q + q_m - F(l_{fs}, l_{hd}, C_f, \pi; X)] - \\ & \lambda_2(p_s q_m + y_n + w_m l_{ms} - w_f l_{hd} - M - C_f - V) \ , \end{aligned} \qquad (19)$$

where λ_1 and λ_2 are Lagrangian unknowns.

Differentiating (19) partially with respect to the unknown variables q, M, l_{fs}, l_{ms}, C_f, q_m, l_{hd}, π, λ_1 and λ_2, the following first order conditions can be obtained. Thus:

$$L_q = U_q - \lambda_1 = 0 \ , \qquad (20)$$

$$L_M = U_M - \lambda_2 = 0 \ , \qquad (21)$$

$$L_{l_{fs}} = U_{l_{fs}} + \lambda_1 F_{l_{fs}} = 0 \ , \qquad (22)$$

$$L_{l_{ms}} = U_{l_{ms}} - \lambda_2 w_m = 0 \ , \qquad (23)$$

$$L_{C_f} = U_{C_f} + \lambda_1 F_{C_f} + \lambda_2 = 0 \ , \tag{24}$$

$$L_{l_{hd}} = \lambda_1 F_{l_{hd}} + \lambda_2 w_f = 0 \ , \tag{25}$$

$$L_\pi = \lambda_1 F_\pi = 0 \ , \tag{26}$$

$$L_{q_m} = -\lambda_1 - \lambda_2 p_s = 0 \ , \tag{27}$$

$$L_{\lambda_1} = -(q + q_m) + F(l_{fs}, l_{hd}, C_f, \pi; X) = 0 \ , \tag{28}$$

and

$$L_{\lambda_2} = -(p_s q_m + y_n + w_m l_{ms} - w_f l_{hd} - M - C_f - V) = 0 \ . \tag{29}$$

where the subscripted L's, U's and F's are partial derivatives of the relevant functions with respect to the indicated subscript variables.

In principle, the solution of the first order conditions (20) through (29) would yield the relevant behavioural equations and the equilibrium values of λ_1 and λ_2 in reduced form. In practice, however, a general analysis of the reduced form behavioural equations through their derivation from (19) poses formidable difficulties (Deaton and Muelbauer, 1980) for two reasons. The utility and production functions involved in equations (20) through (29) are typically very nonlinear in nature, at least in variables if not in parameters. Moreover, accurate specification of U and F with respect to the variables to be included and the functional forms to be used is essential to the derivation of sensible reduced form equations.

To overcome these difficulties a simple and linear utility function is generally assumed to exist in applied work (Stone, 1954). Methodologically, this approach has problems. First of all, errors in specification of the unknown U and F, extend to the derived reduced form equations. Second, the errors may be exacerbated particularly when U and F are nonlinear so that application of a Taylor's series approximation would almost always be required for the solution of the first order conditions.

In view of the above problems the methodology of prior specification and reduced form equations, despite its immense value in theoretical analysis, is not followed here. As a matter of practical significance, attention is paid to the specification of structural relations directly rather than the solution of first order conditions. These structural relations are likely to retain more economic meaning than the reduced form equations. This is so because the structural form provides more information than the reduced form.

Structural relations of interest may be derived from the first order conditions in the following way. The values of λ_1 and λ_2 are defined in terms of marginal utilities of the subsistence good and all other consumption goods in equations (20) and (21). These can also be interpreted as the prices of the two goods concerned. While λ_1 refers to the utility value of a physical entity, the subsistence good produced and consumed at home, λ_2 is the utility value of a monetary unit, the rupee value of other consumption goods. Although in principle either λ_1 or λ_2 could be chosen as a numeraire, the study λ_1 has been selected. This is because (1) by definition, supply (production) of and demand for (consumption of) q are equal, so that λ_1 represents the equilibrium value and (2) the study is concerned with the behaviour of subsistence and semi-subsistence farmers rather than commercial units.

From equation (20) which provides the linkage between the consumption sector (the farm family) and the production sector (the farm-firm) of the farm household,

$$\lambda_1 = U_q \quad . \tag{30}$$

Using the value of the numeraire λ_1 from (30), the relative prices of other consumption goods can be obtained from the linkage equation (31) between the real and nominal sectors as:

$$\lambda_2 = -\frac{\lambda_1}{P_s} = -\frac{U_q}{P_s} \quad . \tag{31}$$

The Lagrangian unknowns can now be removed from the rest of the first order system of equations by using their values from (30) and (31). The resulting system of equations defined in implicit form may be treated as the structural relations of the farm household model.

There is an identification problem with regard to the equations. However, it seems natural to name the transformed first order conditions after the variables with respect to which the Lagrangian function is differentiated. Thus, the transformed first order condition (21) written as:

$$U_m + \frac{U_q}{P_s} = 0 \ , \tag{32}$$

may be called the 'other consumption goods function' since its origin can be traced back to partial differentiation of L with respect to other consumption goods, M. Similarly, equations (22) through (23) may be transformed into the implicit family labour supply equation:

$$L_{l_{fs}} + U_q F_{l_{fs}} = 0 \ , \tag{33}$$

The off-farm labour supply equation:

$$L_{l_{ms}} + \frac{U_q}{P_s} w_m = 0 \ , \tag{34}$$

a cash-input function:

$$U_{C_f} + U_q F_{C_f} - \frac{U_q}{P_s} = 0 \ , \tag{35}$$

a hired labour demand equation:

$$U_q F_{l_{hd}} - \frac{U_q}{P_s} w_f = 0 \ , \tag{36}$$

and a rice-technology adoption equation:

$$U_q F_{\pi} = 0 \tag{37}$$

respectively. To measure the output equation (28), the variable representing total production q_p is used in place of $(q + q_m)$ so that it becomes:

$$q_p = F(l_{fs}, l_{hd}, C_f, \pi; X) \ . \tag{38}$$

The equations (6.19) through (6.25) along with the identities:

$$q_p = q + q_m, \tag{39}$$

and

$$p_s q_m + y_n + w_m l_{ms} - w_f l_{hd} - M - C_f - V = 0 \tag{40}$$

constitute the structural farm household model consisting of a system of nine equations in nine endogenous variables.

To specify the behaviourial equations (32) through (38) in explicit form, the standard normalization rule is applied. Each equation is normalized with respect to the endogenous variable which it is designed to explain. For example, the farm output function (38) is normalized with respect to the output variable; the family labour supply equation (33) is normalized with respect to the family labour supply variable and so on.

Some econometricians agree on the existence of such normalization rules but also on their existence naturally (Fisher, 1970).

As to the identification of right hand side explanatory variables in each structural equation, such knowledge is generally imperfect. The well known fact that each endogenous variable in a simultaneous equation system is jointly determined by all predetermined variables provides little help in the specification of structural equations. One has to turn to intuition, experience and the structural linkages in the model to specify the explanatory variables in each structural equation.

It may be noted that such specification is not entirely ad hoc. The structural linkages and the specification variables referred to earlier hold the key to a great deal of correct specification. For example, the family labour supply equation by virtue of the structural linkage equation (33) is likely to be affected by other variables which appear in the utility function and the production function. Similarly, specification variables such as family size and composition through their effect on time endowment are most likely to explain family labour supply behaviour.

Applying similar reasoning, the behaviourial equations of the model are specified in terms of the mnemonics used in the empirics for the relevant variables. The farm output equation is specified as:

$$TRO = (FLKR, HLKR, PMVRA, POIA, VDAN, CCER, APU) \quad , \qquad (41)$$

where TRO is the total farm output of the farm-firm in quintals (Qt) ;

FLKR is the amount of family labour supplied to the farm-firm for rice cultivation and is measured in man-days of eight hours;

HLKR is the amount of hired labour demand in the farm-firm for rice production and is measured in man-days;

PMVRA is the ratio of the area of MV (modern varieties) to the total rice area of the farm-firm;

POIA is the ratio of the area of irrigated rice area of the farm to the total rice area of the farm;

VDAN is the value in Rupees (Rs) of bullock services used on the farm;

CCER is the value of the cash-inputs used in the production of the rice crop on the farm over one year; and

APU is the amount of fertilizer applied to rice crop(s) on the farm and is measured in quintals.

The model contains two family labour supply equations - representing the supply of labour to the farm-firm and to the off-farm labour market facing the agricultural household. The general form of the on-farm labour supply equation is given by:

FLKR=G(OKRA,HLKR,CCER,PMVRA,VMSC,TNFB,PDA,POIA,PRFR,OFFWR), (42)

where OKRA is the amount of rice land in the farm in acres;

VMSC is the value of the modern stock of capital (such as pump set, thresher, iron plough, tube-well) used in the farm and is measured in Rs;

TNFB is the total number of members of the farm family; PDA is the ratio of dependants (children up to 14 years of age) to the total number of family members;

PRFR is the ratio of the price of fertilizer to the selling price of rice, and

OFFWR is the imputed off-farm wage rate received by the farm-family and is measured in Rs per man-day of 8 hours work.

Other variables of the equation are as defined previously.

The off-farm labour supply equation of the farm household is determined on the one hand, by the opportunities available to the farm-family both on the farm and in the external labour market and on the other hand, by the composition and needs of the farm family. Its general form is as follows:

OFLS = H (CCER,TMRS,HRC,TNFB,PDA,VHMA,OTI,DC1,OFFWR,PSPR), (43)

where OFLS is the amount of off-farm labour supply by the farm-family in man-days;

HRC is the amount of rice consumed at home and is measured in quintals (Qt);

TMRS is the amount of rice sold in the market (positive) or purchased from the market (negative). It is also measured in quintals;

VHMA is the value of home assets of the farm household in Rs;

OTI is the non-rice-crop-non-wage income of the farm household in Rs;

DC1 is a dummy variable to represent the caste difference among respondents. DC1 takes a value of zero if the farmer belongs to any of the lower castes including untouchables and one if he belongs to a higher caste, and

PSPR is the selling price of rice in Rs/Qt.

Other variables are as previously defined.

In addition to the two labour supply equations the model includes a hired labour demand function for the farm-firm. The quantity of hired labour demanded by the farm is dependent on farm size, the extent of adoption of new technology, consumption levels of the farm-family, and the conditions prevailing in the exogenous factor-product markets. In general, the hired labour demand function is represented by the following equation:

HLKR = h (FLKR,PMVRA,TNFC,HRC,CCER,OFLS,OKRA,CNFMW,PSPR), (44)

where TNFC is the value of market goods consumed by the farm family (Rs);

and

CNFMW is the on-farm wage rate for the hired labour in Rs/man-day.

The model of the farm household also contains a demand function for cash inputs. Demand for these inputs depends on the conditions prevailing in the credit market facing the agricultural household, the wealth and liquidity position of the family farm, its assets, income and consumption levels including other factor supply and demand conditions. Formally, the cash-input demand equation is written as follows:

CCER = C (FLKR,HLKR,OFLS,HRC,PMVRA,RI,CAT,OTI,WLTH,LLFF,ANU), (45)

where RI is the borrowing rate of interest per annum (the rate applicable to the major source of credit);

CAT is the credit acquisition time measured as the time taken for a single loan transaction (the acquisition time for loans from the major source of credit);

WLTH is the wealth position of the farm-household in thousand Rs (the farmer's valuation of total assets by the summation of individually valued items);

LLFF is the liquidity position of the agricultural household in Rs (the cash which the household can generate from assets in one week), and

ANU is the amount of nitrogen fertilizer applied to the rice crop. This is measured in Qt.

Besides the factor demand and supply equations, the model of the agricultural household includes a commodity demand function for the consumption of market goods at home. This is largely determined by the wealth and income of the farm household and its marketing surplus of rice and consumption levels. The commodity demand function for market goods is reflected in the following equation.

TNFC = T (FLKR,CCER,HRC,TMRS,OTI,WLTH,OFFWR,PBPR) , (46)

where PBPR is the buying price of rice in rupees per quintal and all other variables are defined earlier.

Finally, the model of the agricultural household explains the adoption behaviour of the farmer with respect to the new rice varieties. The behavoural equation for adoption is crucially dependent on input supply and demand conditions as well as information regarding the new technology. Apart from these variables, factor and product prices and other facilitating variables, such as irrigated area and level of education, are useful in explaining the rates of adoption of technology among farmers. Therefore, the adoption equation is formalised below as:

PMVRA = P(FLKR,HLKR,CCER,RYD,RSDD,EXMV,POIA,EDLDM,PON,
PBPR,PSPR) , (47)

where RYD is the ratio of yield of MV to that of TV (traditional varieties);

RSDD is the ratio of standard deviation of MV to that of TV;

EXMV is the level of experience in MV on the part of the farmer and measured as the number of years MV has been grown in the farm;

EDLDM is the level of education of the decision makers on the farm (or in the farm-firm) and is measured as the average years of formal schooling of the decision makers, and

PON is the price of nitrogen fertilizer in Rs/Qt (in terms of the price of Calcium Ammonium Nitrate).

The above seven equations describe the behaviour of the farm household in less monetised economies of developing countries. The model is closed by two additional equilibrium conditions to ensure that total expenditure in any planning period, including savings, just exhausts the income of the farm household. The two identities defining respectively the money-income-expenditure and farm output clearance equilibria are as stated below:

OTI + (PSPR x TMRS) + (OFFWR x OFLS) - (CNFMW x HLKR) - TNFC - CCER

SAV = 0 , (48)

and HRC = TRO - TMRS , (49)

All the variables of these two identities except one, have been defined previously. The variable not defined before is SAV which is savings, if positive, or dis-savings, if negative, of the farm family. Savings in this model is assumed to be exogenously determined, by such factors as target saving, debt obligations or by forced borrowing, in case of negative savings, for survival. Nevertheless, the farm household must distribute its farm produce (TRO) between home consumption (HRC) and market supply of farm output in such a way that both the money receipts and expenditure, and farm output production and distribution equilibrium conditions are satisfied.

Equation (49) is a statement that, in general, part of the total farm output will be consumed at home and the rest will be sold in the market. Equation (48) states that the aggregate money receipts from asset income (OTI), marketed surplus and market supply of labour will be identically equal to aggregate expenditure on hired labour payments, consumption of market goods, use of cash inputs, and savings.

ESTIMATION AND APPLICATION OF THE MODEL

Consistent with the above theory a system of simultaneous equations with seven stochastic equations and two identities were estimated by using primary cross-sectional data obtained from 280 farmers in Orissa, India. The estimates of the model are presented in Tables 1-7. The technique of simulation was then applied to the model to evaluate the policies that have largely been employed to promote the HYV technology in India.

A. MONOPOLICY SOLUTIONS

The monopolicy solutions are shown in Table 8 and Table 9. Table 8 contains the solutions for price-income policies, while Table 9 contains solutions for structural and institutional policies.

1. Interest Rate Policy

To evaluate the effectiveness of interest rate policy in agriculture, the model was simulated with a 10 per cent decrease in the borrowing rate for credit to farmers. The consequences of this policy which are shown in Table 8 indicate that it would achieve a number of desirable goals. The policy would increase the total production of rice (TRO) by a small margin of 0.13 per cent, generate surplus food for the industrial labour force (TMRS) by 0.76 per cent, enhance the adoption rate of technology (PMVRA) by about a third of one per cent, and at the same time generate additional employment opportunities in the agricultural sector (HLKR) for landless rural families by 0.44 per cent.

TABLE 8: Percentage Changes in Farm Household Responses to Price-Income Policies

Farm Households Response Variables (Policy goals)	Actual Values	Predicted Values from Basic Sim-ulation	Price-Income Policies					
			10% Decrease in Interest Rate	20% Increase in Selling Price	20% Decrease in Fertilizer Price	20% Decrease in On-farm Wage Rate	20% Decrease in Buying Price	10% Increase in Non-Farm Income
On-farm Family Labour Supply FLKR 1	122.86	122.43	0.12	0.36	10.12	-2.81	-2.38	-2.07
Hired Labour Demand.HLKR 1	96.44	96.71	0.44	4.81	-3.74	2.81	1.50	2.86
Total on-farm Labour Demand TLD 1	219.30	219.14	0.26	2.32	3.00	-0.33	-0.68	0.11
Off-farm Labour Labour Supply OFLS 1	309.19	307.84	0.38	-6.51	-3.83	-0.86	1.29	-1.14
Total Family Labour Supply TLS 1	1132.05	430.27	0.31	-0.56	0.11	-1.41	0.25	-1.40
Farm Rice Output TRO 2	28.90	28.87	+0.13	1.24	6.15	-0.98	0.59	-0.97
Cash-Input Use CCER 3	1672.05	1668.71	1.31	0.91	1.24	0.46	1.38	1.31
Non-food Consumption TNFC 3	2852.23	2854.73	0.57	1.42	2.43	0.23	3.93	2.48
Per Cent of Adoption PMVRA	34.74	34.76	0.03	1.38	3.20	0.16	3.56	0.17
Marketed Supply of Rice TMRS 2	8.16	8.01	0.76	-0.84	9.24	-6.38	6.41	-7.32
Home Consumption HRC 2	20.74	20.86	-0.48	2.03	4.96	1.10	-1.64	1.47

1 Man Days 2 Qt (Quintals) 3 Rs (Rupees)

The farm family would increase its work effort both on the farm as well as in off-farm activities which may generate further employment opportunities in the rural sector. Off-farm labour supply emanating from farm-families would rise more (0.38 per cent) than the increase in on-farm labour (0.12 per cent). Agricultural households, as a result of this policy, would use more of both labour (TLD = 0.26 per cent) and cash-inputs (CCER = 0.43 per cent). The utility maximising agricultural household would prefer to consume more market purchased goods (TNFC = 0.57 per cent) and reduce its rice consumption by about half of one per cent.

2. Fertilizer Price Policy

In order to be able to evaluate the consequences of subsidised fertilizer, an important input in the new technology, the fertilizer price was decreased by 20 per cent. As the results show, the effects of this policy were to promote adoption of the new technology by a substantial magnitude of 3.2 per cent and increase farm output by 6.15 per cent. The agricultural policy goal of generating food surplus for industrial development would be enhanced by a rise in marketed surplus of rice by 9.24 per cent. The goal of generating rural employment would not be realised given the reduction of labour hired by farm-families of 5.74 per cent.

It appears that a subsidy for fertilizer and the ensuing higher level of fertilizer use would increase agricultural labour productivity and restrain family labour from off-farm activities (OFLS = -3.83 per cent) and induce more work effort in the family labour force.

As a result of a policy to reduce the price of fertilizer, the agricultural household would increase its consumption of both farm produce (rice) and market purchased goods by 4.96 and 2.43 per cent respectively.

3. Agricultural Wage Policy

To evaluate agricultural wage policy, the model was simulated with a 20 per cent decrease in the on-farm wage rate. A consequence of this policy, as reflected in the agricultural household response variables, was to increase rural agricultural employment opportunities by 2.81 per cent and to reduce, proportionately, family labour use on the farm to the same extent. Farm output and marketed surplus, however, declined by about one and over six percentage points respectively. Thus, a policy designed to reduced agricultural wages may on these ground be less attractive to the government when account is taken of the effects on output and marketed surplus.

It appears that farm-households experience a strong income effect as a result of this policy. The increase of income that results from a low wage bill induce the farmer to consume more of both farm and non-farm goods and take more leisure. This was reflected in the reduction of total labour supply by 1.4 per cent which came about as a result of about 2.81 per cent reduction in on-farm labour and 1.14 per cent fall in off-farm labour. The decrease in on-farm labour supply outweighed the increase in hired labour demand of 2.81 per cent in absolute number of mandays.

4. Agricultural Product Price Policies

Two product price policies were considered. The first policy - a 20 per cent increase in the selling price of rice resulted in an 0.84 per cent reduction in marketed surplus, a 1.38 per cent increase in technology adoption, a 1.24 per cent increase in production and a 4.81 per cent increase in hired labour. This meant that a price incentive policy for farmers would achieve most goals but would reduce the food surplus available for industrial development.

Total labour demand in agricultural households would increase by 2.3 per cent while total labour supply would decrease by 4.56 per cent. The consumption of both rice and other goods would increase by 2.03 and 1.42 percentage points respectively. The policy would lead to increased use of total labour (2.32 per cent) and cash-input use (1.91 per cent) in the form of purchased inputs of fertilizers and chemicals.

The second rice price policy - a twenty per cent decrease in the purchase price of rice on the other hand, resulted in increased levels of production, technology adoption, marketed surplus and rural employment which are usually regarded as desirable from a macropolicy perspective. However, farm family's consumption of rice decreased by 1.64 per cent. The policy also led to a 0.25 per cent increase in labour (work hours) which meant that the welfare of farm households would diminish as a result of the price reduction.

The above two price policies indicate that efforts to bridge the gap between producer price and purchase price may lead to the achievement of both micro and macro policy goals.

5. Income Policy Effects

To assess the impact of income policy, the model was simulated with a 10 per cent increase in non-farm income (income derived from assets, businesses and service sectors). It was observed that on-farm family labour supply would decrease by about 2 per cent, off-farm labour supply would also fall by 1.14 per cent. Despite increases in cash-input use (1.31 per cent), total labour (0.11 per cent) and new technology adoption (0.17 per cent), farm output would decrease by about one percentage point. This may result from lack of supervision for efficient resource use in agriculture as family labour is withdrawn from farming. The increased income resulted in greater consumption of both farm and non-farm goods in the family and less off-farm work. This policy, like the selling price of rice, reduced the agricultural surplus for industrial development.

6. Structural and Institutional Policies

In this category, four policies of interest were incorporated. One was the effect of increasing irrigation facilities on farms. A twenty per cent increase in irrigation facilities available was envisaged. The second policy was to increase the experience of farmers with HYV by two years, perhaps through introduction of a field-demonstration scheme by an agricultural extension agency. Under the third policy, the formal education level of the farm-household's decision-maker was increased by five years. One way in which this might be achieved is to undertake an extensive adult education programme in rural communities. Finally, a twenty per cent decrease in dependants in farm families was incorporated. Testing of this policy was aimed at evaluating the consequences of family planning.

7. Irrigation Policy Effects

According to the results in Table 9, a 20 per cent increase in irrigation potential would generate agricultural surplus by about 13 per cent through an increase in technology adoption and output by about 4 per cent and 7.5 per cent respectively. The policy would, however, displace agricultural hired labour by approximately 2 per cent despite an increase in overall employment opportunities in farming. The increase in total labour demand by 1.24 per cent would be met by an on-farm labour increase of 3.81 per cent. The agricultural household reduces its total work effort by 1.87 per cent which was solely due to a decrease in market labour supply of 4.11 per cent. The policy would induce a marginal increase in cash-input use in farming but a substantial increase in consumption of food and non-food goods in the family. As a result of reduced work effort and increased consumption family welfare is likely to improve as a result of this policy.

9. Agricultural Extension Policy

It should be mentioned that an increase in experience in the new technology as defined here may come about as a result of self-motivation or through imposed demonstration schemes. The effect of these two approaches on household behaviour may be different. In this study, it is assumed that on-farm demonstration of the HYV performance would induce similar responses to those which might emerge in a self-motivated adoption process.

The consequences of a 2 year increase in experience in HYV on the part of the farmers would result in an increase in marketed surplus (6.72 per cent), adoption rate (8.81 per cent), farm output (2.97 per cent), family's food consumption (6.72 per cent) non-food consumption (8.81 per cent) but would reduce total labour supply

TABLE 9: Percentage Change in Farm Household Response to Structural/Institutiona. Policies in Orissa, India

Farm Household's Response Variables (Policy Goals)	Actual Values	Predicted Values from Basic Simu-lation	Infrastructural/Institutional Policies			
			20 per cent Increase in Irrigation Area	Increase in Exper-ience by 2 Years	5 Years Increase in Education	20 per cent Decrease in Depen-dants
On-farm Family Labour Supply FLKR 1	122.86	122.43	3.81	-2.91	-0.95	3.19
Hired Labour Demand HLKR 1	96.44	96.71	-2.02	-0.46	-0.16	-1.80
Total On-farm Labour Demand TLD 1	219.30	219.14	1.24	-1.83	-0.60	0.99
Off-farm Labour Labour Supply OFLS 1	309.19	307.84	-4.11	-1.17	-0.36	1.71
Total Family Labour Supply TLS 1	1132.05	430.27	-1.87	-1.67	-0.53	2.13
Farm Rice Output TRO 2	28.90	28.87	7.48	2.97	0.99	1.40
Cash Input Use CCER 3	1672.05	1668.71	0.43	1.70	0.57	-0.38
Non-food Consumption TNFC 3	2852.23	2854.73	3.14	2.51	0.83	0.64
Per cent of Adoption PMVRA	34.74	34.76	3.99	8.81	2.92	-0.27
Marked Supply of Rice TMRS 2	8.16	8.01	13.08	6.72	2.29	-2.62
Home Consumption HRC 2	20.74	20.86	5.33	1.53	0.49	2.95

1 Man Days 2 Qt (Quintals) 3 Rs (Rupees)

(1.67 per cent) and demand (1.83 per cent) in agriculture. Both hired labour and family labour would be withdrawn from farming and capital intensive technology in the form of higher cash-input use (1.7 per cent) would be employed. The result is not surprising in view of the learning process involved in the use of the capital intensive technology, HYV rice. Farm households increased consumption of both leisure and goods and services as a result of increased farm produce (income effect), a result consistent with the theory derived earlier in the paper.

9. Education Policy Consequences

Simulation incorporating 5 years of increased formal education indicated that the farm households would consume more of both food (0.49 per cent) and non-food (0.83 per cent), use less labour intensive (0.60 per cent) and more capital intensive (0.57 per cent) technology as a result of allocating an increased proportion (2.92 per cent) of land to HYV rice and reduce both on-farm and off-farm labour supply. Consequently, as in the agricultural extension policy, the farm household's welfare is likely to rise. There would be displacement of labour (0.6 per cent) from agriculture of which 0.16 per cent would come about in the form of hired labour withdrawal. Hence landless rural families may be worse off as a result of this policy due to reduced job opportunities. Although the reduction in the farm family's off-farm labour supply (0.36 per cent) was found to be more than the reduction in hired labour (0.16 per cent) in agriculture, it is unlikely that the redundant agricultural labour force can take on the job vacancies created in the non-farm sector. Similar analysis also applies to the irrigation and agricultural extension policy solutions.

10. Family Planning Policy

Inferences about family planning policy as related to technology adoption and agricultural development can be made from the simulation results for a 20 per cent decrease in dependants. It was found that the policy would reduce the pace of technology adoption by 0.27 per cent, agricultural hired labour demand by 1.8 per cent and marketed surplus by 2.62 per cent. Farm output, consumption levels of food and non-food items in the family would rise by 1.4, 2.95 and 0.64 percentage points respectively. Family labour supply both on- and off-farm activities and hence total labour supply activities would rise by 3.19, 1.71 and 2.13 percentage points respectively. Due to the increased consumption levels and work hours by the farm family, family welfare effect of this policy cannot be easily ascertained.

From the point of view of the policy strategist, the policy would work towards increased agricultural production via the traditional technology at the expense of the new rice technology. The policy would also reduce food surpluses for the industrial workforce and might reduce the income and welfare of the landless in the rural sector.

11. Overview of the Monopolicies

It might be noted that, in general, the price-income policies are much less effective in promoting the adoption of new technology and increasing agricultural production. While, with the exception of interest rate and fertilizer price policies, they were better as policies in creating agricultural employment, they failed in generating increased agricultural surpluses for industrial growth.

Infractural and institutional policies, with the exception of family planning policy, were found to be more effective in enhancing the degree of new technology adoption. These were found to be better, as policy measures, in generating agricultural surpluses but inferior in creating agricultural employment for the landless poor.

The above result is, however, not surprising. As is well known, multiple goals generally require as many policy instruments as there are goals in the objective function. Hence, it may be useful to evaluate the consequences of combined policies which may create both agricultural employment for the landless and agricultural surpluses for the urban sector. The evaluation of combined policies is treated in the following.

B. COMBINED POLICIES

The combined policy solutions are shown in Tables 10 through 12. Three illustrative experiments were conducted with the estimated structural model. The effects of these pol' ;s on farm household behaviour and their implications for agricultural development goals were discussed. Also, the question of whether combined policies reinforced or offset the sum of the effects of individual policies in the package was addressed. To achieve this objective, the combined policy responses were compared with the sum of the individual policy responses of the farm household. The first combined policy experiment consisted of 20 per cent increase in farm output selling price (PSPR) and 20 per cent decrease in fertilizer price (PON). The second was a combination of 20 per cent increase in a structural policy variable, per cent of irrigated land in the farm (POIA) and increase in 2 years of experience (EXMV) in the HYV rice, an institutional policy variable. The third combined policy was composed of a price policy in the form of a 20 per cent decrease in fertilizer price and a structural policy in the form of a 20 per cent increase in irrigated land.

In Tables 10 through 12, the joint effects of combined policies, the sum of the individual policy effects in the package, and the interaction effects of the combined policies are shown. The joint effects of combined policies are simply the policy simulated values expressed as percentages of the basic simulation values of the response variables. The sums of individual policy effects are the total of the effects of monopolicies contained in the respective packages. The interaction effects are the differences between absolute values of the joint effects and sums of the individual policy effects. Positive interaction effects suggest reinforcement of sum of the individual policy effects by the combined policy and negative interaction effects represent offsets to the sum of individual effects.

Combined Policy Experiment 1

(Effect of a 20 Per cent Increase in Selling Price of Rice and 20 Per cent Decrease in Buying Price of Fertilizer)

The combined policy effects in Table 10 indicated that the above policy would induce the farm household to grow more (4.77 per cent) of HYV rice. As a result the farm household's production, consumption, marketed surplus of rice would increase by 6.49, 6.50 and 6.47 per cent respectively.

TABLE 10: Joint and Interaction Effects of 20 Per Cent Increase in Selling Price of Rice and 20 Per cent Decrease in Fertilizer Price

Farm Household's Response Variabes (Policy Goals)	Basic Simulation Values	Policy Simulation Values	Percentage Changes		
			Combined or Joint Policy Effects (a)	Sum of Individual Policy Effects (b)	Interaction Effects = |(a)| - |(b)|
On-farm Family Labour Supply FLKR 1	122.43	132.490	8.22	10.48	-2.26
Hired Labour Demand HLKR 1	96.71	96.919	0.22	0.93	-0.71
Total on-farm Labour Demand TLD1	219.14	229.409	4.67	5.32	-0.65
Off-farm Labour Labour Supply OFLS 1	307.84	277.238	-9.94	-10.34	-0.40
Total Family Labour Supply TLS 1	430.27	409.728	-4.77	-0.45	4.32
Farm Rice Output TRO 2	28.87	30.744	6.49	7.39	-0.90
Cash Input Use CCER 3	1668.71	1701.551	1.96	2.15	-0.19
Non-food Consumption TNFC 3	2854.73	2959.328	3.66	3.85	-0.19
Per Cent of Adoption PMVRA	34.76	39.530	4.77	4.58	0.19
Marketed Supply of Rice TMRS 2	8.01	8.528	6.47	8.44	-1.97
Home Consumption HRC 2	20.86	22.216	6.50	6.99	-0.49

1 Man Days 2 Qt (Quintals) 3 Rs (Rupees)

Cash input use in the farm and non-food consumption in the family would also rise by 1.96 and 3.66 per cent respectively. Of the total increase in labour demand by 4.67 per cent, a large part of this increase came about in the form of increase in on-farm labour supply (8.22 per cent) and only a small proportion (0.22 per cent) was due to higher demand for hired labour in the farm. The biggest impact of this combined policy on the farm household behaviour was to reduce off-farm labour supply by 9.94 per cent which was partly offset by an increase in on-farm labour supply.

In view of the increased levels of leisure hours and consumption of food and non-food items in the family, it may be inferred that the above combined policy is family welfare increasing in nature.

From the point of agricultural development goals, it might be noticed that the combined policy was found to be highly effective in generating agricultural surpluses (6.47 per cent) for the urban population and marginally effective in creating jobs (0.22 per cent) for hired labour in the farm. Unlike monopolicies, the combined policy was thus found to be effective in achieving both the goals simultaneously.

In all but two cases - for rice-technology adoption and total family labour supply, the interaction effects were negative. These offset effects suggest that less than the sum of individual policy effects would be achieved by pursuing combined policies. Planners and policy makers designing combined policies where targets are fixed on the basis of individual policy effects might be frustrated by these offset effects. Multiple policy goals, therefore, need to be pursued, in general, on the basis of combined policy solutions rather than mono-policy outcomes. This particular finding of the study, thus, conforms to conventional theory relating to the problem of aggregating policies that, due to the interdependence of policies, the total effect need not be the sum of individual effects (Tinberger, 1963).

TABLE 11: Joint and Interaction Effects of 20 Per Cent Increase in Irrigated Land and 2 Years Increase in Experience in HYV Rice

Farm Household's Response Variabes (Policy Goals)	Basic Simulation Values	Policy Simulation Values	Percentage Changes		
			Combined or Joint Policy Effects (a)	Sum of Individual Policy Effects (b)	Interaction Effects = |(a)| - |(b)|
On-farm Family Labour Supply FLKR 1	122.43	124.200	1.45	0.90	0.55
Hired Labour Demand HLKR 1	96.71	94.409	-2.38	-2.48	-0.10
Total on-farm Labour Demand TLD 1	219.14	218.609	-0.24	-0.59	-0.35
Off-farm Labour Labour Supply OFLS 1	307.84	292.205	-5.08	-5.28	-0.20
Total Family Labour Supply TLS 1	430.27	416.405	-3.22	-3.54	-0.32
Farm Rice Output TRO 2	28.87	31.727	9.90	10.45	-0.50
Cash Input Use CCER 3	1668.71	1698.585	1.79	2.13	-0.34
Non-food Consumption TNFC 3	2854.73	3002.363	5.17	5.65	-0.48
Per Cent of Adoption PMVRA	34.76	45.870	11.11	12.80	-1.69
Marketed Supply of Rice TMRS 2	8.01	9.488	18.45	19.80	-1.35
Home Consumption HRC 2	20.86	22.239	6.61	6.86	-0.25

1 Man Days 2 Qt (Quintals) 3 Rs (Rupees)

Combined Policy Experiment 2

(Effect of a 20 Per cent Increase in Irrigated Land and 2 Years Increase in Experience in HYV Rice)

Pursuit of the above combined structural/institutional policy would lead to substantial increases in family consumption of rice (6.61 per cent), consumption of non-food items (5.17 per cent), marketed surplus of rice (18.45 per cent), technology adoption (11.11 per cent) and farm output (9.90 per cent). On-farm labour supply and cash-input use in the farm would rise by 1.45 and 1.79 per cent respectively while demand for hired labour would fall by 2.38 per cent. Total labour demand in the farm would also fall which indicating substitution of cash inputs for labour in production.

As in experiment one, family welfare would be improved due to reduced work hours (3.22 per cent) and higher consumption levels. As an agricultural development strategy, this combined policy is likely to be highly effective in promoting the new technology, increasing agricultural production and marketed surplus for industrial growth but ineffective in generating employment opportunities for the landless within agriculture. This suggests that, in certain circumstances, more than two policies may be required to create employment opportunities within agriculture. Like the combined price policy, this combined institutional/infrastructural policy offset the sum of the individual policy effects. This is reflected in the negative interaction effects for all but one (the family's on-farm labour supply) response variables.

Combined Policy Experiment 3

(Effect of a 20 Per Cent Increase in Irrigated Rice Land and 20 Per Cent Decrease in Fertilizer Price)

As shown in Table 12 the farm household would as a result of this policy, increase its technology adoption rate (4.55 per cent), farm output (12.67 per cent), consumption levels of food (9.89 per cent) and non-food (4.83 per cent) items. While both total labour and cash-input use would rise by 1.15 per cent and 4.9 per cent, an increase in

TABLE 12: Joint and Interaction Effects of 20 Per Cent Increase in Irrigated Rice Land and 20 Per Cent Decrease in Fertilizer Price

Farm Household's Response Variabes (Policy Goals)	Basic Simulation Values	Policy Simulation Values	Percentage Changes		
			Combined or Joint Policy Effects (a)	Sum of Individual Policy Effects (b)	Interaction Effects = |(a)| - |(b)|
On-farm Family Labour Supply FLKR 1	122.43	140.533	14.79	13.93	0.86
Hired Labour Demand HLKR 1	96.71	89.353	-7.69	-7.76	-0.07
Total on-farm Labour Demand TLD 1	219.14	229.886	4.90	4.24	0.66
Off-farm Labour Labour Supply OFLS 1	307.84	284.371	-7.62	-7.94	-0.32
Total Family Labour Supply TLS 1	430.27	424.904	-1.25	-1.76	-0.51
Farm Rice Output TRO 2	28.87	32.554	12.67	13.63	-0.96
Cash Input Use CCER 3	1668.71	1687.925	1.15	1.67	-0.52
Non-food Consumption TNFC 3	2854.73	2992.552	4.83	5.57	-0.74
Per Cent of Adoption PMVRA	34.76	39.31	4.55	7.19	-2.64
Marketed Supply of Rice TMRS 2	8.01	9.631	20.24	22.32	-2.08
Home Consumption HRC 2	20.86	22.923	9.89	10.29	-0.40

1 Man Days   2 Qt (Quintals)   3 Rs (Rupees)

on-farm labour supply (14.79 per cent) by the farm family would more than offset the withdrawal of family labour from the external market (7.62 per cent) so that demand for hired labour decreased by 7.69 per cent. The combined price-infrastructural policy, like the two infrastructural/institutional policies, failed to generate employment opportunities within agriculture.

This combined policy was found to be, however, extremely effective in generating agricultural surplus for the industrial urban sector. The consequence of the policy was to to improve family welfare as a result of increased leisure by (1.25 per cent) and increased consumption levels of both food (9.89 per cent) and non-food (4.83 per cent) items.

The interaction effects, like other combined policies, were found to be negative. This indicated that less than the sum of individual policy effects is to be expected for most response variables while following combined price-institutional policies.

Overview of the Combined Policies

Results of the combined policies of two instruments at a time indicated that the goal of generating employment opportunities within agriculture is generally difficult to meet. Technology adoption as a strategy of agricultural development and industrial growth through generation of agricultural surpluses are easier to achieve with combined policies than creating employment opportunities for the landless within agriculture. While appropriate combined price policies (experiment one) may achieve this goal, their effects on family welfare and agricultural development are smaller than other combined policies.

Combined policies in general have less impact than the sum of individual policy effects for most response variables. Setting policy targets on the basis of monopolicy outcomes may, therefore, be misleading. One way to handle this problem is to set the goals and targets before experimentation with the model and attempt to find a set of policy.

Some value judgement is almost always required in setting the targets for policy optimisation. This target-instrument approach to policy evaluation is beyond the scope of this study. Instead, a policy scenario approach was followed and policy outcomes were discussed leaving the choice of policies to the planners and policy makers who may be better equipped to make value judgement about the desirability of different policy goals. This approach has the advantage of providing knowledge of the possible outcomes before value judgements are made and policies implemented.

CONCLUSION

In this paper an agricultural household model depicting the technology adoption behaviour in a segmented labour market is presented and discussed. It was argued that decisions about the technology adoption, production, consumption, marketed surplus, and labour supply and demand are interdependent rather than independent or recursive.

Several monopolicy and combined policy scenarios were presented. It was shown that price-income monopolies were, in general, less effective than structural/institutional monopolicies in promoting the new technology. The only exception to this general conclusion is reduced fertilizer price. While price-income policies were better in creating agricultural employment for the hired labour, these were poor instruments in generating agricultural surpluses for the urban industrial population. In general, the reverse was the case for infrastructural/institutional policies.

Combined policies of two instruments redressed the problem of conflicting goals in some cases. However, the problem seemed to remain in most scenarios. It may thus suggest that an integrated industrial and agricultural policy strategy for employment in the rural sector is required rather than reliance on agricultural development strategies alone.

APPENDIX

TABLES 1 - 7

TABLE 1: Parameter Estimates of the On-farm Family Labour (FLKR) Equation

Descriptive name of explanatary variables	Variable code names and goodness of fit measures	Expected directional effect	Methods of estimation		
			OLS	2SLS	3SLS
Constant term	C	?	65.022*** (2.39)	65.022*** (2.39)	56.604*** (2.36)
Inputed off-farm wage rate	OFFWR	-	-2.455*** (-2.47)	-1.825* (-1.57)	-1.307* (-1.38)
Hired labour demand	HLKR	-	-0.454*** (-7.90)	-0.877*** (-6.17)	-1.138*** (-9.08)
Farm cash input use	CCER	+	0.672** (1.92)	1.690*** (3.15)	3.28*** (6.65)
Intensity of new rice-technology adoption	PMVRA	-	-0.425** (-2.27)	-0.447* (-1.46)	-0.568** (-2.13)
Total number of family members	TNFB	+	8.055*** (4.21)	6.932*** (3.26)	5.587 (2.95)
Ratio of dependents to family members	PDA	-	-14.358 (-1.69)	-13.366* (1.43)	-9.943* (-1.38)
Amount of rice land in the farm	OKRA	+	38.098*** (10.00)	44.407*** (9.35)	46.554*** (10.54)
Square term of farm rice land	OKRA2	?	-0.497*** (-2.49)	0.049 (0.18)	0.277 (1.12)
Value of modern stock of capital	VMSC	-	-0.400* (-1.55)	-0.161 (-0.55)	-0.2441 (-1.08)
Per cent of irrigated area	POIA	+	0.142 (1.22)	0.209* (1.41)	0.223** (1.88)
Fertilizer-rice price ratio	PRFR	-	-28.682** (-1.90)	-26.815* (-1.61)	-25.823** (-1.75)
	Equation fit measures				
	R^2		0.51		
	$\bar{R}^2$		0.50		
	$F_{11,268}$		25.60***		
	D.W.		1.79	1.90	2.01
	Simulation fit measures				
	RMSE		66.83	73.31	84.22
	U		0.23	0.24	0.26
	U^M		0.0	0.0	0.0
	U^S		0.17	0.01	0.0

NOTE: Figures in parentheses are calculated t-values
*** Significant at 1 per cent ** Significant at 5 per cent
* Significant at 10 per cent
RMSE, U, U^M, and U^S stand for root mean square simulation error, Thiel's inequality coefficient, bias and variance respectively

TABLE 2: Parameter Estimates of the Hired Labour Demand (HLKR) Equation

Descriptive name of explanatary variables	Variable code names and goodness of fit measures	Expected directional effect	Methods of estimation		
			OLS	2SLS	3SLS
Constant term	C	?	24.679 (0.87)	10.036 (0.34)	10.928 (0.42)
On-farm family labour supply	FLKR	-	-0.370*** (-7.36)	-0.202*** (-2.93)	-0.504*** (-8.88)
Per cent of new rice-technology adoption	PMVRA	+	0.0431 (0.29)	0.162 (0.79)	0.449*** (2.40)
Market goods consumption	TNFC	+	0.0129*** (5.15)	0.0196*** (4.17)	0.0126*** (3.16)
Farm cash input use (in 100 Rs.)	CCER	+	1.098*** (2.98)	0.566 (0.91)	1.940*** (3.54)
Off-farm labour supply	OFLS	-	-0.0159 (-0.90)	-0.0461***(-1.77)	-0.0490** (-1.91)
Home rice consumption	HRC	+	-0.659* (-1.57)	-0.130 (-0.20)	0.354 (0.60)
Square term of farm rice land	OKRA2	?	0.882*** (4.84)	1.179*** (5.69)	0.811*** (4.39)
Size of farm rice land	OKRA	+	25.040*** (6.23)	14.515*** (3.00)	22.259*** (5.33)
On-farm wage rate	CNFMW	-	-4.098** (-1.70)	-4.91** (-1.88)	-0.670 (-0.33)
Rice selling price	PSPR	+	0.0665 (0.58)	-.132 (1.07)	0.105 (0.95)
	Equation fit measures				
	R^2		0.85		
	$\bar{R}^2$		0.84		
	$F_{10,259}$		148.02***		
	D.W.		1.99	2.00	2.00
	Simulation fit measures				
	RMSE		61.54	64.32	65.02
	U		0.17	0.18	0.18
	U^M		0.0	0.0	0.0
	U^S		0.04	0.03	0.01

NOTE: Figures in parentheses are calculated t-values

*** Significant at 1 per cent ** Significant at 5 per cent

* Significant at 10 per cent

RMSE, U, U^M, and U^S stand for root mean square simulation error, Thiel's inequality coefficient, bias and variance respectively

TABLE 3: Parameter Estimates of the Off-farm Labour Supply (OFLS) Equation

Descriptive name of explanatary variables	Variable code names and goodness of fit measures	Expected directional effect	Methods of estimation					
			OLS		2SLS		3SLS	
Constant term	C	?	294.961***	(3.78)	458.245***	(4.93)	455.211***	(5.06)
Farm cash input use (in 100 Rs)	CCER	+	1.040	(1.05)	0.383	(0.28)	0.141	(0.11)
Market supply of rice	TMRS	+	-2.406***	(-3.25)	0.803	(0.73)	0.0491	(0.05)
Total number of family members	TNFB	+	21.252***	(3.18)	57.176***	(5.99)	50.121***	(5.42)
Asset income of farm	OTI	+	0.0421***	(8.04)	0.0511***	(8.24)	0.0497***	(8.25)
Value of family home	VHMA	-	-0.0009	(-0.91)	-0.0001	(-0.10)	-0.877	(-0.08)
Home rice consumption	HRC	-	-1.858*	(-1.36)	-13.002***	(05.35)	-11.443***	(-4.86)
Off-farm wage rate (imputed)	OFFWR	-	-15.104***	(-5.04)	-14.675***	(-4.31)	-15.246***	(-4.61)
Ratio of dependents to family members	PDA	-	-47.968**	(-2.06)	-65.345***	(-2.45)	-61.528***	(-2.38)
Dummy for caste (low = 0, high = 1)	DC1	-	-102.007***	(-3.69)	-103.424***	(-3.25)	-104.452***	(-3.40)
Rice selling price	PSPR	-	0.433	(1.19)	-0.525	(-1.19)	-0.430	(-1.01)
	Equation fit measures							
	R^2		0.38					
	$\bar{R}^2$		0.35					
	$F_{10,269}$		16.28***					
	D.W.		1.80		1.78		1.78	
	Simulation fit measures							
	RMSE		183.0		207.5		200.8	
	U		0.25		0.28		0.27	
	U^M		0.0		0.0		0.0	
	U^S		0.24		0.08		0.11	

NOTE: Figures in parentheses are calculated t-values

*** Significant at 1 percent ** Significant at 5 percent

* Significant at 10 percent

RMSE, U, U^M, and U^S stand for root mean square simulation error, Thiel's inequality coefficient, bias and variance respectively

TABLE 4: Parameter Estimates of the Cash Input Use (CCER) Equation

Descriptive name of explanatary variables	Variable code names and goodness of fit measures	Expected directional effect	Methods of estimation		
			OLS	2SLS	3SLS
Constant term	C	?	3.553* (1.31)	3.548 (1.07)	2.554 (0.83)
On-farm family labour supply	FLKR	+	0.022*** (2.77)	0.0234** (2.28)	0.0381*** (3.89)
Off-farm family labour supply	OFLS	+	0.0017 (0.51)	0.0048 (0.96)	0.0011 (0.23)
Home consumption of rice	HRC	-	-0.0516 (-0.74)	-0.1796** (-1.84)	-0.2266***(-2.42)
Asset and other income	OTI	+	0.0011*** (4.01)	0.0010*** (3.21)	0.0012*** (3.83)
Per cent of MV rice area	PMVRA	+	0.0293 (1.08)	0.0545* (1.46)	0.0580** (1.66)
Borrowing interest rate	RI	-	-0.1366*** (-2.59)	-0.1274***(-2.33)	-0.0808** (-1.64)
Liquidity level	LLFF	+	0.0012*** (3.60)	0.0010*** (3.09)	0.0009*** (3.07)
Credit acquisition time	CAT	-	-0.0605* (-1.54)	-0.0533* (-1.33)	-0.0615** (-1.71)
Hired labour demand	HLKR	+	0.0191** (2.71)	0.0343*** (3.46)	0.0367*** (3.97)
Wealth position	WLTH	+	0.0896*** (4.87)	0.0877*** (4.59)	0.0838*** (4.73)
Amount of nitrogen fertilizer used	ANU	+	0.0297*** (3.78)	0.0235*** (2.66)	0.0266*** (3.34)
	Equation fit measures				
	R^2		0.65		
	$\bar{R}^2$		0.64		
	$F_{11,268}$		45.86***		
	D.W.		1.88	1.83	1.81
	Simulation fit measures				
	RMSE		11.0	11.16	11.29
	U		0.23	0.23	0.23
	U^M		0.0	0.0	0.0
	U^S		0.11	0.09	0.09

NOTE: Figures in parentheses are calculated t-values

*** Significant at 1 per cent ** Significant at 5 per cent

* Significant at 10 per cent

RMSE, U, U^M, and U^S stand for root mean square simulation error, Thiel's inequality coefficient, bias and variance respectively

TABLE 5: Parameter Estimates of the Farm Output (TRO) Equation

Descriptive name of explanatary variables	Variable code names and goodness of fit measures	Expected directional effect	Methods of estimation		
			OLS	2SLS	3SLS
Constant term	C	?	-0.264 (-0.14)	-4.920** (-2.03)	-7.250*** (-3.08)
On-farm family labour supply	FLKR	+	0.0418*** (3.21)	0.121*** (5.12)	0.122*** (5.37)
Hired labour demand	HLKR	+	0.0294*** (3.47)	0.0261** (1.98)	0.0297*** (2.35)
Percent of MV area	PMVRA	+	0.0095 (0.26)	0.120** (1.88)	0.160*** (2.61)
Cash input use (in 100 Rs)	CCER	+	0.1148 (0.92)	0.337* (1.28)	0.375* (1.49)
Value of animal power	VDAN	+	0.0081*** (6.49)	0.0081*** (5.15)	0.0083*** (5.60)
Amount of fertilizer square	APU2	?	-0.0001 (-2.98)	-0.0001***(-3.02)	-0.0001***(-2.90)
Amount of fertilizer used	APU	+	0.0806*** (8.79)	0.0805*** (7.40)	0.0824*** (8.02)
Square term of on-farm family labour	FLKR2	?	-0.0002*** (-2.38)	-0.0006***(-4.29)	-0.0005***(-3.44)
Percent of irrigated area	POIA	+	0.0582*** (2.51)	0.0615** (2.15)	0.0520** (1.89)
Square term of cash input	CCER2	?	0.0014* (1.39)	0.0049*** (2.51)	0.0046*** (2.45)
	Equation fit measures				
	R^2		0.79		
	$\bar{R}^2$		0.78		
	$F_{10,269}$		99.53***		
	D.W.		1.58	1.61	1.65
	Simulation fit measures				
	RMSE		12.84	13.86	14.11
	U		0.16	0.18	0.18
	U^M		0.0	0.0	0.0
	U^S		0.06	0.03	0.02

NOTE: Figures in parentheses are calculated t-values

*** Significant at 1 percent ** Significant at 5 percent

* Significant at 10 percent

RMSE, U, U^M, and U^S stand for root mean square simulation error, Thiel's inequality coefficient, bias and variance respectively

TABLE 6: Parameter Estimates of the Market Goods Consumption (TNFC) Equation

Descriptive name of explanatary variables	Variable code names and goodness of fit measures	Expected directional effect	Methods of estimation: OLS		2SLS		3SLS	
Constant term	C	?	1175.22**	(1.84)	243.693	(0.33)	46.426	(0.07)
On-farm family labour supply	FLKR	-	-0.114	(-0.13)	-1.245	(-1.11)	-2.894***	(-2.69)
Cash input use (in 100 Rs)	CCER	+	50.546***	(7.82)	77.633***	(9.40)	101.276***	(13.07)
Square term of asset and other income	OTI2	-	-0.0000015	(-0.51)	-0.0000021	(-0.67)	-0.0000012	(-0.42)
Home rice consumption	HRC	+	49.051***	(6.32)	64.666***	(5.78)	66.104***	(6.17)
Marketing supply of rice	TMRS	+	54.349***	(11.66)	31.585***	(5.16)	21.355***	(3.76)
Buying price of rice	PBPR	-	-6.708***	(-2.45)	-3.513	(-1.14)	-2.251	(-0.80)
Off-farm wage rate (imputed)	OFFWR	+	13.571	(-.68)	12.576	(0.59)	3.100	(0.16)
Asset and other income	OTI	+	0.259***	(4.47)	0.206***	(3.29)	0.171***	(3.02)
Interaction term of wealth and other income	OTWL	+	0.00026	(1.23)	0.00007	(0.32)	0.00021	(1.01)
	Equation fit measures							
	R^2		0.84					
	$\bar{R}^2$		0.83					
	$F_{9,270}$		157.46***					
	D.W.		1.82		1.80		1.79	
	Simulation fit measures							
	RMSE		1209.0		1277.0		1377.0	
	U		0.15		0.16		0.167	
	U^M		0.0		0.0		0.0	
	U^S		0.04		0.03		0.003	

NOTE: Figures in parentheses are calculated t-values

*** Significant at 1 percent   ** Significant at 5 percent

* Significant at 10 percent

RMSE, U, U^M, and U^S stand for root mean square simulation error, Thiel's inequality coefficient, bias and variance respectively

TABLE 7: Parameter Estimates of the Technology Adoption (PMVRA) Equation

Descriptive name of explanatary variables	Variable code names and goodness of fit measures	Expected directional effect	Methods of estimation: OLS		Methods of estimation: 2SLS		Methods of estimation: 3SLS	
Constant term	C	?	39.231**	(2.21)	41.473**	(2.32)	45.357***	(2.76)
On-farm labour supply	FLKR	-	-0.0497***	(-4.30)	-0.0604***	(-4.30)	-0.0772***	(-5.94)
Hired labour demand	HLKR	+	0.0333***	(3.69)	0.02**	(2.26)	0.0295***	(2.68)
Cash input use (in 100 Rs)	CCER	+	0.209***	(2.63)	0.170**	(1.82)	0.280***	(3.10)
Yield ratio of MV to TV	RYD	+	1.397	(0.38)	1.457	(0.40)	0.129	(0.04)
Standard deviation ratio of MV to TV	RSDD	-	-2.277*	(-1.47)	-2.362*	(-1.52)	-2.042*	(-1.44)
Price of nitrogen	PON	-	-0.0851*	(-1.33)	-0.0891*	(-1.38)	-0.0891*	(-1.43)
Buying price of rice	PBPR	-	-0.082**	(-1.72)	-0.080**	(-1.67)	-0.081**	(-1.83)
Selling price of rice	PSPR	+	0.048	(1.20)	0.0473	(1.18)	0.043	(1.13)
Percent of irrigated area	POIA	+	0.140***	(3.24)	0.145***	(3.32)	0.127***	(3.11)
Experience in MV	EXMV	+	6.865***	(7.20)	6.832***	(7.14)	6.410***	(7.21)
Education level of farm decision makers	EDLDM	+	0.623**	(1.64)	0.560*	(1.46)	0.560*	(1.58)
Square term of experience in MV	EXMV2	-	-0.334***	(-3.95)	-0.328***	(-3.86)	-0.326***	(-4.18)
Interaction term between experience and irrigated land	EXPO	+	0.0218***	(2.72)	0.0205***	(2.54)	0.0225***	(3.02)
	Estimation fit statistics							
	R^2		0.73					
	$\bar{R}^2$		0.71					
	$F_{13,266}$		54.07***					
	D.W.		1.59		1.60		1.64	
	Simulation fit statistics							
	RMSE		17.13		17.18		17.37	
	U		0.186		0.186		0.188	
	U^M		0.0		0.0		0.0	
	U^S		0.08		0.07		0.07	

NOTE: Figures in parentheses are calculated t-values *** Significant at 1 percent ** Significant at 5 percent * Significant at 10 percent

RMSE, U, U^M, and U^S stand for root mean square simulation error, Thiel's inequality coefficient, bias and variance respectively

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