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Agricultural Household Models: A Survey of Recent Findings and Their Policy Implications

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ABSTRACT

Semicommercial farms that produce multiple crops make up a large part of the agricultural sector in developing countries. These farms or agricultural households combine two fundamental units of microeconomic analysis: the household and the firm. Traditional economic theory has dealt with these units separately, but, in developing countries in which peasant farms dominate, their interdependence is of crucial importance. Researchers at the Food Research Institute, Stanford University, and the World Bank have developed models of agricultural households that combine producer and consumer behavior in a theoretically consistent fashion. Recent empirical applications of these models have extended them in various ways and expanded the range of policy issues which can be investigated using this general framework.

This paper reports the results of empirical applications of this model in India, Indonesia, Japan, Korea, Malaysia, Nigeria, Senegal, Sierra Leone, Taiwan and Thailand. It provides a comparative analysis of the policy implications of the approach for such matters as the welfare of farm households, marketed surplus, the demand for nonagricultural goods and services, the demand for hired labor, budget revenues and foreign exchange.

I. INTRODUCTION

In most developing countries, agriculture remains a major source of income for the majority of the population, an important earner of foreign exchange, and a focal point for government policy. Efforts to predict the consequences of agricultural policies, however, are often confounded by the complex, behavioral interactions characteristic of semi-commercialized, rural economies. Most households in agricultural areas produce partly for sale and partly for own-consumption. They also purchase some of their inputs -- fertilizer and labor, for example — and provide some inputs -- family labor -- from their own resources. Any change in the policies governing agricultural activities will, therefore, affect, not only production, but also consumption and labor supply.

Agricultural household models are designed to capture these interactions in a theoretically consistent fashion and in a manner that allows empirical application so that the consequences of policy interventions can be illuminated. The existence of such models would enable the analyst to examine the consequences of policy in three dimensions. First one could examine the effects of alternative policies on the well-being of representative agricultural households. Well being may be interpreted here to mean household income or some other measure such as nutritional status. For example, in examining the effect of a policy designed to provide cheap food for urban consumers, an agricultural household model would allow the analyst to assess the costs to farmers of depressed producer prices. The nutritional benefits

to the urban population may be more than offset by the reduced nutritional status of the rural population resulting from lower farm incomes.

Second, an understanding of the behavior of agricultural household models would shed light on the "spillover" effects of government policies on other segments of the rural population. For example, since most investment strategies are designed to increase production, their primary impact is on the incomes of agricultural households. As a result, rural investment strategies may not reach landless households or households engaged in nonagricultural activities. A model that incorporates, total labor demand and family labor supply, however, would allow the analyst to explore the effects of policy on the demand for hired labor and hence on the rural labor market and the incomes of landless households. Similarly, a model that incorporates consumer behavior would allow the analyst to explore the consequences of increased profits for agricultural households on the demand for products and services provided by nonagricultural, rural households. Since the demand for nonagricultural commodities is often thought to be much more responsive to an increase in income than the demand for agricultural staples, this spillover effect may well be important.

Third, governments are interested in the performance of the agricultural sector from a more macroeconomic perspective. For example, agriculture is often an important source of revenue for the public budget and a major earner of foreign exchange. In assessing the effects of pricing policy on the budget or the balance of payments, the government is obliged to consider the quantitative responses of agricultural households. Reducing export taxes, for example, may increase earnings of foreign exchange and

budget revenues provided households market enough additional production. Since agricultural household models capture both consumption and production behavior, they are a natural vehicle for examining the effect of pricing policy on marketed surplus and hence foreign exchange earnings and budget revenues.

The importance of agricultural households in the total population and the significance of sector policies combine to make the behavior of agricultural households an area warranting thorough theoretical and empirical investigation. Many different approaches to the analysis of agricultural households have been followed, each with its own relevance and its own advantages and disadvantages. This paper reports the results of a large body of work that has followed a similar basic approach to the analysis of agricultural household models. It is claimed that the approach adopted here offers important policy insights that differ significantly from the results of more traditional approaches.

Section 2 outlines the theoretical properties of a general model of producer, consumer and labor supply decision-making. In truly subsistence households these decisions are made simultaneously. Without access to trade, a household can consume only what it produces and must rely exclusively on its own labor. A large part of agriculture, however, comprises semi-commercial farms in which some inputs are purchased and some outputs are sold. In these circumstances, producer, consumer and labor supply decisions are no longer made simultaneously although they are obviously connected because the market value of consumption cannot exceed the market value of production less the market value of inputs. Section 2 clarifies the circumstances in which these

decisions must be treated simultaneously and those in which they can be treated separately albeit consistently. In particular, it demonstrates the basic proposition underlying much of the empirical work -- namely, that production decisions are made with reference to market prices but are independent of other decisions, whereas consumption and labor supply decisions depend crucially on the income derived from the household's production.

Section 3 summarizes the major conclusions from this body of applied studies. First, it reconfirms the empirical importance of the approach for the analysis of agricultural policy. Using the results of comparable studies, the quantitative significance of treating the main household decisions in a consistent manner is demonstrated for such policy-relevant magnitudes as the welfare of farm-households, marketed surplus, the demand for non-agricultural goods and services, the rural labor market, budget revenues and foreign exchange earnings. Comparative results on selected elasticities are presented for a range of countries — Japan, Korea, Malaysia, Nigeria, Sierra Leone, Taiwan and Thailand. The section also demonstrates the empirical significance of the approach by comparing the results of models that treat production and consumption decisions separately and those emerging from models in which the decision-making process is recursive.

Section 4 summarizes the implications of agricultural pricing policy for the welfare of farm-households, marketed surplus, the demand for non-agricultural goods and services and the rural labor market using the results from Section 3. This section also draws out the policy conclusions of the extensions to the basic model. It is shown that the model can be extended to allow an exploration of the effects of government policy on nutritional

status, health, saving and investment, and budget deficits. Studies of India, Indonesia, Korea, Senegal and Sierra Leone are drawn upon to illustrate these extensions.

II. THEORETICAL FRAMEWORK

In general any analysis examining the consumption or labor supply of agricultural households has to account for the interdependency of household production and consumption. Agricultural household modeling combines these two fundamental units of microeconomic analysis -- the household and the firm. The two units are linked since farm enterprise activities contribute to household income, and therefore affect household consumption.

Under certain circumstances the only interdependence between the household and firm activities of an agricultural household comes through income. In this case the production activities of the household can be analyzed separately from the consumption activities, the model becoming split into profit maximizing and utility maximizing components. The traditional analysis of farm output supply and input demand using the theory of the firm is then valid. Empirical analysis of both household consumption and production becomes considerably more tractable, and as a result most of the emprical analyses to date have used such separable models. In a static model, the key assumption needed to obtain separation of the household's production and consumption decisions is that the household be a price taker for every

commodity, including family labor, which is both consumed and produced, and that commodities be homogeneous.

In this section a prototype static model is developed. For any production cycle, the household is assumed to maximize a utility function:

$$U = U(X_a, X_m, X_\ell) \qquad (1)$$

where the commodities are an agricultural staple (X_a), a market-purchased good (X_m) and leisure (X_ℓ). Utility is maximized subject to a cash income constraint:

$$p_m X_m = p_a (Q_a - X_a) - p_\ell (L - F) - q_v V + E$$

where p_m and p_a are the prices of the market-purchased commodity and the staple respectively, Q_a is the household's production of the staple (so that $Q_a - X_a$ is its marketed surplus), p_ℓ is the market wage, L is total labor input, F is family labor input (so that L - F, if positive, is hired labor and is off-farm labor supply if negative), V is a variable input (e.g. fartilizer), and q_v is its market price. Finally, E is any non-labor, non-farm income.

The household also faces a time constraint -- it cannot allocate more time to leisure, on-farm production or off-farm employment than the total time available to the household:

$$X_\ell + F = T$$

where T is the total stock of household time. It also faces a production constraint or production technology that depicts the relationship between inputs and farm output.

$$Q_a = Q(L,V,A,K)$$

where A is the household's fixed quantity of land, and K is its fixed stock of capital.

In this presentation, various complexities have been omitted. For example the possibility of more than one crop has been ignored. In addition, it has been assumed that family labor and hired labor are perfect substitutes and can be added directly. Production is also assumed to be riskless. These assumptions can be relaxed and have been in the literature. 1/ Finally, and perhaps most importantly, it will be assumed that the three prices in the model -- p_a, p_m, and p_ℓ -- are not affected by actions of the household. That is, the household is assumed to be a price-taker in the three markets and, as seen below, this will result in a recursive model.

The three constraints on household behavior can be collapsed into a single constraint. Substituting the production constraint into the cash income constraint for Q_a and substituting the time constraint into the cash income constraint for F yields a single constraint of the form:

$$p_m X_m + p_a X_a + p_\ell X_\ell = p_\ell T + \pi + E \qquad (2)$$

where $\pi = p_a Q_a(L, V, A, K) - p_\ell - q_v V$

and is a measure of farm profits. In this equation, the left-hand side shows total household "expenditure" on three items -- the market-purchased commodity, the household's "purchase" of its own output, and the household's "purchase" of its own time in the form of leisure. The right-hand side is a development of Becker's concept of full income in which the value of the stock of time $p_\ell T$) owned by the household is explicitly recorded as is any non-labor income. The extension for agricultural households is the inclusion of a measure of farm profits $(p_a Q_a - p_\ell L - q_v V)$ with all labor valued at the market wage, this being a consequence of the assumption of price-taking behavior in the labor market. Equations 1 and 2 are the core of all the studies of agricultural households reported in this survey.

A glance at Equations 1 and 2 reveals that the household can choose the levels of consumption for the three commodities, the total labor input and the fertilizer input into agricultural production. If the first order conditions for the farm production inputs, labor and fertilizer, are considered, the household will equate the marginal revenue products to the market prices. An important attribute of these two equations is that they contain only two endogenous variables -- L and V. The other endogenous variables -- X_m, X_a, X_ℓ -- do not appear and do not, therefore, influence the household's choice of L or V (provided second order conditions are met). Accordingly, farm labor and fertilizer demand can be solved for as a function of prices (p_a, p_ℓ and q_v), the technological parameters of the production function, and the fixed area of land and quantity of capital. The solutions can be substituted into the right-hand side of the constraint (equation 2) to

obtain the value of full-income when farm profits have been maximized through an appropriate choice of variable inputs. Equation 2 can therefore, be rewritten as:

$$p_m X_m + p_a X_a + p_\ell X_\ell = Y^* \qquad (3)$$

where Y^* is the value of full income associated with profit maximizing behavior. Maximizing utility subject to this new version of the constraint, yields the demand equations for X_m, X_a, and X_ℓ as functions of prices (p_m, p_a, p_ℓ) and full income (Y^*). This demonstrates, given the assumptions made about markets, that even though the household's production and consumption decisions are simultaneous in time, they can be modeled as separate (Nakajima, 1969; Jorgenson and Lau, 1969).

Separation notwithstanding, the presence of farm profits in equation (3) demonstrates the principal message of the farm household literature, that farm technology, quantities of fixed inputs, and prices of variable inputs and of outputs do affect consumption decisions. Given separation, however, the reverse is not true. Preferences, prices of consumption commodities. and income do not affect production decisions. Output supply responds positively to own price at all times due to the quasi-convexity assumption on the production function. For commodities (X_a) which are also produced by the household, (Q_a) own price effects are

$$\frac{dX_a}{dp_a} = \frac{\partial X_a}{\partial p_a}\bigg|_{Y^*} + \frac{\partial X_a}{\partial Y^*} + \frac{\partial Y^*}{\partial p_a} \qquad (4)$$

The first term on the right-hand side is the standard result of consumer demand theory and, for a normal good, is negative. The second term captures the profit effect. A change in the price of the staple increases farm profits and hence full income. From equation 4,

$$\frac{\partial Y^*}{\partial p_a} dp_a = \frac{\partial \pi}{\partial p_a} dp_a = Q_a dp_a \qquad (5)$$

that is, the profit effect equals output times the change in price and is, therefore, unambiguously positive. As noted, the positive effect of an increase in profits, an effect that is totally ignored in traditional models of demand, will definitely dampen and may outweigh the negative effect of standard consumer demand theory.

To explore the consequences of making prices endogenous to the household it will be convenient to use duality results to express the equilibrium of the household. We can define the full income function as the maximization of full income with respect to outputs and variable inputs subject to the farm production function. Clearly the full income function can be written as the sum of the value of endowed time, a restricted (or short run) profits function and exogenous income. For the expenditure side of full income we can define an expenditure function as the minimum expenditure (equation 3) required to meet a specified level of utility, $e(p_\ell, p_m, p_a, \bar{U})$.

Now we are in a position to relax our assumption that prices are fixed. The household's equilibrium is characterized by equality between the household's full income function, and its expenditure function, $e(\cdot)$, where the expenditure function is evaluated at the utility level achieved at the

household's optimum. This condition will hold whether or not households face given market prices. Now suppose that a household is constrained to equate consumption with production for some commodity(ies). One possible reason for this would be nonexistence of a market. Another reason might be heterogeneous commodites, say that family and hired labor are imperfect substitutes, with the household choosing to sell no family labor off the farm. Alternatively sales and purchase prices might differ for an identical commodity. Consequently the household's equilibrium will be characterized by a set of additional conditions -- equality of household demand and household supply for each such commodity. This second set of equilibrium conditions implicitly defines a set of virtual prices -- or shadow prices (Neary and Roberts, 1980; Deaton and Muellbauer, 1980) -- which if they existed would induce the household to equate supply and demand for these commodities.

These virtual prices are not fixed for the household as market prices are assumed to be. Rather they are determined by the household's choices. From the household's equilibrium it can be seen that they will be a function of market prices, time endowment, fixed inputs, and utility. Consequently these prices depend on both the household's preferences and its production technology. Changes in market prices will now affect behavior directly, as before, and indirectly through changes in the virtual prices.

The consequences of this additional affect can be shown provided one is willing to assume that commodities are substitutes or complements in consumption or production. If for instance the price of the farm good rises, the demand schedule for labor should shift upwards. If leisure and food consumption are substitutes the compensated labor supply will also shift

upwards. Given that other market prices, fixed inputs, and utility are constant, the virtual wage has to rise in order to reequate compensated labor supply with demand. The rise in the virtual wage will impact on the household's choices, for example farm output will rise less than otherwise in response to a rise in its price when the virtual wage rises. Indeed it is possible for the virtual wage to rise so much that farm output could actually fall consequent to its price rising.

As should be clear, whether prices are exogenous for commodities which are both consumed and produced by the household affects the type of interdependency between the household's consumption and production choices. For such commodities the virtual prices are functions of both household preferences and production technology. Because these prices help to determine both consumption and production choices — they belong in both the expenditure and the full income functions -- the household commodity demands will depend on production technology both through the virtual price and through full income. Output supplies and input demands will depend on preferences through the virtual price. If, however, the household faces only market prices, or if it faces a virtual price for a commodity which is consumed but not produced (or vice versa), then production choices will not depend on household preferences, but consumption choices will depend on production technology through full income. The model is then separable.

A. Estimation Issues

Separable models are much easier to estimate empirically, since in that case all prices can be taken as exogenous to the household. Given that the model is separable, one can derive from the household's equilibrium a set

of commodity demand equations (including leisure or labor supply) and a set of output supply and variable input demand functions (or equivalently a production function). The commodity demands are functions of commodity prices, full income and possibly household characteristics. Holding full income constant they satisfy the usual constraints of demand theory: adding up to total expenditure; zero homogeneity with respect to prices and exogenous income; symmetry and negative semi-definiteness of the Slutsky-substitution matrix. The output supplies and input demands are functions of input and output prices and of farm characteristics (including fixed inputs). They are derived from a profit function which obeys the usual constraints from the theory of the firm: homogeneity of degree one in prices, and convex with respect to prices. These results can be used as a guide when specifying the model for estimation.

If estimation is to be by econometric means, errors have to be added to the model. The issues involved in sensibly specifying an error structure are outside the scope of this paper. For simplicity, suppose the errors are added to the demand and output supply equation. If for a given household the errors on the input demand and output supply equations are uncorrelated with the errors on the commodity demand equations, the entire system of equations is statistically block recursive. In this case profits will be uncorrelated with the commodity demand disturbances so that the latter equations may be consistently estimated as a system independent from the output supply and input demand equations. The practical advantage which results from separate estimation of the demand and production sides of the model is that far fewer parameters need to be estimated for each side separately. This is potentially

important if the equations are nonlinear in parameters and have to be estimated using numerical algorithms, since expense is greatly reduced and tractability increased. Thus models with greater detail can be estimated.

On the other hand if production and consumption side errors are correlated, then profit is correlated with the demand side errors, and its endogeneity must be accounted for to estimate the demand equations consistently, whether or not the deterministic model is separable.

Estimation doesn't have to be of a system of equations, since single equations can be consistently estimated as well. This will be advantageous when the underlying model is not separable. In that case virtual prices and hence farm profits are endogenous so that the commodity demand, output supply and input demand equations are not in reduced form. To estimate the full set of "structural" equations is expensive (see Lopez, 1984, for such a study). At the other extreme one can specify the reduced form equations. The disadvantage of that approach is that it is usually not possible to solve for the reduced form analytically. Consequently one can't take full advantage of economic theory in imposing (or testing) parameter restrictions, though some of the restrictions may be readily apparent. Nevertheless one can specify what variables belong in the reduced form, and so can estimate a least squares approximation to it. Several of the studies included in this survey are of this type. As a compromise, a subset of the structural equations might be estimated, while accounting for the endogeneity of any choice variables. In this way some economic structure can be imposed (tested) on the data.

III. SUMMARY OF RECENT EMPIRICAL FINDINGS

What can be learned about the economic response of rural, mainly farming households, from these empirical studies which use an integrated approach to modeling the behavior of agricultural households? Does the new agricultural household modeling approach matter empirically both in terms of predicting economic behavior as well as in terms of the policy implications that follow from it? Although the studies summarized in this paper differ in the details of the applied methods, the characteristics of the sampled households and the focus of their policy interest, nonetheless they share the view that integrating production and consumption decisions is not only the proper approach to modelling economic behavior of agricultural households but that the empirical results and their policy implications are sufficiently different to justify the effort.

A. The Surveyed Studies

Table 1 lists some essential characteristics of the different partial equilibrium studies which are summarized in this paper. The first empirical studies giving estimates of agricultural household models where conducted at Stanford by Lau, Yotopoulos, and their collaborators (Lau, Lin and Yotopoulos, 1978; Kuroda and Yotopoulos, 1980; Yotopoulos, Adulavidhaya, Kuroda and Lau, 1976), and at the World Bank by Barnum and Squire, (1979a, 1979b). These are all econometric studies which specify separable models, and estimate commodity demands and either output supply and input demands, or a production function.

Subsequent studies have extended the basic methodology in various ways. Three studies have disaggregated commodities on both the production and

consumption sides of the model (Ahn, Singh and Squire, 1981: Strauss, 1984b: Singh and Subramanian, 1985). Disaggregation of produced commodities allows explicit treatment of the crop-composition decision, while disaggregation of consumed commodities allows a more careful accounting of caloric intake. One paper extends the model to endogenize saving and investment decisions (Iqbal, 1984), and another looks at determinants of health within a farm household framework (Pitt and Rosenzweig, 1984). In addition, the paper reviews several recent attempts to embed agricultural household models in a multi-market framework. This allows a more comprehensive analysis of agricultural policies since it allows explicitly for important interactions that are neglected in partial equilibrium models (Braverman and Hammer, 1984).

B. Main Results

Table 2 presents a subset of elasticities calculated from the seven studies which estimate the full system of commodity demand equations. The table reports the response of consumption of the agricultural commodity, consumption of market-purchased goods, marketed surplus, and labor supply to changes in the price of the agricultural commodity.

For consumption of the agricultural commodity, the studies show an almost even split between those which report a positive own-price elasticity and those reporting a negative one. The magnitudes of both positive and negative elasticities are small. The positive response indicates that the profit effect has more than offset the traditional negative effect predicted by standard consumer demand theory. For consumption of market-purchased goods, the most important result is the strongly positive cross-price elasticities. This result also attests to the strength of the profit effect

in increasing total expenditure. The reported elasticities suggest that the level of farm incomes and the availability of non-farm goods are important determinants of responsiveness. Sierra Leone, for example, has a much lower elasticity than those of the East Asian countries.

Elasticities of marketed surplus are strongly positive whereas those for labor supply are negative. The positive elasticities of marketed surplus indicate that, even where the profit effect is strong enough to make consumption response positive, the total output response is always large enough to offset increased household consumption. The negative responses for labor supply suggest a strong profit effect and reflect the empirical fact that leisure is a normal good. Other results are summarized in Tables A1 to A4 appended to this paper.

Do Agricultural Household Models Matter?

Agricultural household models integrate production and consumption decisions in rural farm-households. This requires a more complex theoretical structure as well as considerably more data for empirical estimation. Is the additional effort justified? Can practitioners make do with far simpler techniques that have been traditionally used to model farm behavior — that is, with the demand and supply sides separated? The answer lies at two levels. First at the empirical level we must ask whether these models, which account for the interdependence of production and consumption decisions, provide estimates of elasticities that could not have been obtained otherwise. Second, at the policy level, we must ascertain whether the resulting differences in these elasticity estimates lead to a different policy implications from those that would have been arrived at from traditional

methods. This section addresses the first issue — that of the empirical significance of agricultural household models.

In assessing the empirical significance of agricultural household models, it is useful to recall that their distinguishing characteristic is the inclusion of the profit effect. Table 3 compares two sets of elasticities -- those with and those without the profit effect. The results clearly establish the empirical significance of agricultural household models. The estimates of the elasticity of demand with respect to own-price not only differ significantly in the cases of Japan, Thailand and Sierra Leone, but change sign in the case of Taiwan, Malaysia, Korea and Northern Nigeria. Thus, whereas traditional models of demand, as we would expect, predict a decline in own-consumption in response to an increase in agricultural commodity prices, for three cases, the agricultural household models predict an increase. This is because the "profit effect" -- resulting from an increase in income when crop prices are raised--offsets the negative price effects. Farm households end up increasing their own-consmption as prices are raised. Whether or not this would reduce the amounts they offer on the market will depend on the elasticity of output. We know that this marketed surplus elasticity remains positive in these cases (Table 2). The response, however, is dampened by the "profit effect".

The differences in the elasticity of demand for non-agricultural goods with respect to the price of agricultural goods are also striking. The elasticities change sign in four cases, and in the other three cases the magnitudes are much larger when the profit effect is included. Whereas cross-price elasticities estimated using traditional demand models tend to be low or

negative because of negative income effects, the agricultural household model estimates are positive and large because of the positive profit effect. The elasticities of household labor supply with respect to the price of the agricultural good also differ dramatically. In the traditional demand models, an increase in the price of the agricultural good reduces not only the consumption of that good, but also that of leisure, implying an increase in the family work effort (Table 3). In contrast, agricultural household models predict a negative response of household labor supply to increased output prices because households are willing to take a part of their increased incomes in increased leisure, thereby reducing their work effort.

While fewer signs change when responses to agricultural wage rates are examined, the magnitudes do. In traditional demand models an increase in the wage rate implies an increase in real household incomes resulting in a positive demand response for agricultural and non-agricultural goods and a negative or inelastic response of household labor supply. These effects are partially offset in agricultural household models because an increase in wages also affects the production side and reduces total farm incomes. As a result, demand responses for both the agricultural and non-agricultural goods are either dampened or totally offset (Taiwan, Malaysia), while labor supply response becomes positive and/or more elastic.

Looking at the market (or off-farm) labor supply responses of landed and landless households in rural India, Rosenzweig (1980) provides a different type of evidence that agricultural household models matter. After separately estimating market supply equations for landless and agricultural households, Rosenzweig compares coefficients between the two groups and finds that twenty-

one out of twenty-two comparisons conform to the predictions of the agricultural household framework. For instance the male off-farm labor response of landless households to increases in the market male wage is less than for agricultural households, as would be predicted because of the negative profit effect of raising male wages.

In addition to differences between elasticities estimated from traditional models and those estimated from agricultural household models, there are other elasticities provided by the latter which are not even defined for models that focus exclusively on consumption behavior. These are the elasticities of demand with respect to non-labor input prices, stocks of fixed factors of production, including land and farm technology. A selection of these elasticities is shown in Table 4. While the absolute magnitudes are small in most cases, the point to recall is that they have no counterpart in models that do not integrate production and consumption. Thus, while traditional demand models can predict demand responses to output prices, they tell us nothing about such responses to input prices or changes in the fixed factors of production or technology. Similarly, traditional supply models can predict supply responses to changes in output and input prices, fixed factors of production and technology, but they fail to tell us anything about the demand responses to these exogenous factors. Agricultural household models therefore provide a vital link between the demand and supply side responses to exogenous policy changes. While these links can be established informally between traditional supply and demand models, in agricultural household models they are handled directly within a consistent theory and framework of estimation.

The results of Tables 3 and 4 allow us to identify when the use of a full agricultural household model is likely to be important. Since the profit effect is the distinguishing feature of these models, this amounts to identifying when the profit effect is likely to be important. The first point to note is that changes in some exogenous prices have a small effect on farm profits. For example, the profit effect is much more important in Malaysia than in Sierra Leone (Table 3) partly because the effect of a price change on profits is much larger in the Malaysian case. In Malaysia, a ten percent increase in output price results in a sixteen percent increase in profits. In Sierra Leone, the same percentage increase in output price increases profits by only two percent.

Second, even if profits are affected by an exogenous price increase, profits may be only a small part of full income (equation 2) and it is full income that appears in the demand equations. For our sample of countries, the share of profits in full income ranges from 0.5 in Malaysia to only 0.2 in Thailand. It follows that a given percentage increase in profits will have a much bigger impact on total income in Malaysia than in Thailand.

Finally, the effect of full income on demand varies among commodities. It is much more important, for example, in the case of non-agricultural commodities than agricultural ones since demand in the latter tends to be inelastic with respect to income. In Malaysia, the elasticity of demand for rice with respect to full income is only 0.52 conpared with 2.74 for market-purchased goods. As a result, the profit effect is much more significant in the case of non-agricultural goods than in that of agricultural goods (Table 3).

These remarks suggest that, if profits are relatively insensitive to producer prices and constitute a relatively small part of full income, and if consumption of a particular item is relatively insensitive to full income, than couching the analysis in the context of an agricultural household model will not yield much gain in accuracy. This proves to be the case, for example, with the elasticity of demand for agricultural goods with respect to changes in producer prices in Sierra Leone (although it is not true for low-income households in that study (Strauss, 1984b)). If, on the other hand, these three conditions are reversed, then, as the example of the elasticity of demand for non-agricultural goods with respect to producer prices in Malaysia reveals, a full agricultural household model is of critical importance.

IV. POLICY RESULTS

A. Results from the Basic Model

Agricultural household models provide policy insights in three broad areas. These are the welfare or real incomes of agricultural households, the spillover effects of agricultural policies on to the rural, non-agricultural economy, and, at a more aggregate level, the interaction between agricultural policy and international trade or fiscal policy. To illustrate the potential role of agricultural household models, this section draws the policy conclusions in each of these three dimensions for a "typical" agricultural policy. The policy chosen is that of taxing output (either through export taxes or marketing boards) in order to generate revenue for the central exchequer and simultaneously subsidizing a major input (usually fertilizer) in order to restore, at least partially, producer incentives. Other policies can be examined with the use of agricultural household models, but this particular combination is a common characteristic of agriculture in developing countries and illustrates well the type of issue that can be analyzed in this framework.

Consider first the effect of pricing policy on the welfare or real full income of a representative agricultural household. For some price changes -- for example, a change in the price of fertilizer -- the resulting change in nominal full income is an accurate measure of the change in real income since the prices of all consumer goods have remained unchanged. In other cases, however, the commodity in question may be both a consumption good and a farm output or input. For example, if the price of an agricultural staple is increased, the household will benefit as a producer but lose as a

consumer. As long as the household is a net producer of the commodity, its net benefit will be positive (see Strauss 1984a). Nevertheless, if one wishes to quantify the net gain to the household, allowance must be made for both the positive effect coming through farm profits and the negative effect coming through an increase in the price of a major consumption item.

Table 5 presents estimates of the elasticities of real full income with respect to changes in output price and fertilizer price for the seven studies examined earlier. For marginal changes, the decrease in real income following an increase in the price of the agricultural output equals marketed surplus times the price increase while the increase following a reduction in the price of an input equals the quantity of the input times the price reduction. Thus, knowing prices, marketed surplus and full income, these elasticities can be calculated without reference to price and income elasticities. However, for non-marginal changes, it would be necessary to use information on the underlying structure of preferences to calculate equivalent or compensating variation.

The table reveals that the percentage change in real income is less than the percentage change in either the output price or the fertilizer price. In addition, the table suggests that the loss in real income arising from a given percentage reduction in the output price can be offset only if the price of fertilizer is reduced by a much larger percentage. In Malaysia, for example, a ten percent reduction in output price would reduce real income by almost seven percent whereas a ten percent reduction in the price of fertilizer would only increase real income by about one percent. This result arises from the relative magnitudes of marketed surplus and fertilizer use and

indicates that, if policy makers are interested primarily in the welfare of agricultural households, intervention in output markets is likely to be much more important than intervention in the markets for variable, non-labor inputs.

Policy makers are also concerned with the welfare of rural households that do not own or rent land for cultivation. Landless households either sell their labor to land-operating households or else engage in non-farm activities (see, for example, Anderson and Leiserson, 1980). Governments, however, have very few policy instruments that affect the welfare of these households directly. Policy -- price interventions and investment programs — directed at land-operating households, nevertheless, have spillover effects which may or may not be beneficial for these households. What can agricultural household models tell us about these effects?

An increase in the price of a major agricultural staple will obviously hurt households that are net consumers of that item. The direct effect of a price increase, therefore, will be unambiguously negative for landless households and nonfarm households. The policy maker thus faces a dilemma: if he wants to improve incentives, and increase the incomes of agricultural households, he does so at the expense of other rural households. There are, however, offsetting indirect effects. For example, Table 6 reveals that, if the price of the agricultural commodity is increased, agricultural households increase their demand for total — hired and family -- farm labor and reduce the supply of family labor (i.e., increase their leisure time). As a result, the demand for hired labor can be expected to increase substantially to the benefit of landless households. In Malaysia, the

reported elasticities of labor demand (1.61) and labor supply (0.57) imply an elasticity of demand for hired labor of 10.9. While this result in part reflects the initial small percentage of hired labor in total labor (19 percent), it, nevertheless, implies a substantial change in labor market conditions and would undoubtedly exert upward pressure on rural wage rates thereby offsetting, at least to some extent, the negative consequences for landless households of higher prices of agricultural commodities.

The policy implications of these findings are very significant because they also shed light on the extent to which the positive gains from technological improvements "trickle down" via the labor market to the rural landless. It is now widely accepted that technological innovations associated with the "green revolution" (improved seeds, increased use of fertilizers and pesticides, increased irrigation and cropping intensity) have had a dramatic impact on the demand for total labor, but the concern has been whether this increased demand could be translated into an equal impact on hired labor, most of which comes from the smallest farms and the landless. The empirical findings show that it can be. When an increase, either in the fixed factors of production or technologies, boosts incomes on the farm, they tend to reduce the amount of family (household's own) labor effort (Table 4). Any increase in the demand for total labor, therefore, results in an even larger increase in the demand for hired labor. The labor supply and demand elasticities emerging from empirical applications of agricultural household models provide strong support for the view that trickle down effects are both positive and significant.

Table 6 identifies a second indirect effect of increased output prices -- a significant increase in the demand for non-agricultural goods. The response elasticity is positive and greater than one in two countries -- Taiwan and Malaysia -- and positive and greater than 0.5 in all countries except Sierra Leone (though for low-income households in Sierra Leone it is also high -- 0.9). Some of this demand will be for imports and urban-produced commodities, but a large part will be for rurally produced goods and services and will, therefore, increase demand for the output of non-farm, rural households. Any increase in farm profits, whether caused by a price change or a technological improvement, can be expected to lead to a substantial increase in the demand for goods and services produced by non-agricultural households. Thus, spillover effects through output markets will, at least partially, offset the negative effects on nonfarm households of an increase in agricultural prices and will ensure that the benefits of technological improvements are dispensed throughout the rural community.

Table 6 also traces through the effects of a change in the price of fertilizer. As noted in the discussion of the effects on the welfare of agricultural households, changes in the price of fertilizer have only a minor impact. The results suggest that changes in fertilizer prices can be made without generating large negative or positive spillover effects.

As mentioned earlier, governments often tax agricultural output in order to generate revenue and simultaneously subsidize key inputs such as fertilizer in order to restore production incentives in the hope of achieving self-sufficiency or earning foreign exchange. Can agricultural household models shed light on these issues? Because agricultural household models

provide information on the effect of pricing policy on marketed surplus and fertilizer demand, they can be used as inputs into calculations of self-sufficiency, balance-of-payment effects and budgetary effects.

If the primary interest is in self-sufficiency, governments need to know the marketed surplus available for procurement. Table 7 reproduces elasticity estimates for agricultural production, consumption and marketed surplus. The results illustrate two points. First, even where consumption responds positively to an increase in the price of the agricultural commodity because of the profit effect, marketed surplus still responds positively. Where the consumption response is negative, the elasticities of marketed surplus are positive and large (see, for example, the case of Thailand). Governments can, therefore, use pricing policy in the output market to increase marketed surplus even when it is unable to set the prices facing consumers and producers independently. Second, efforts to offset disincentives in output markets through fertilizer subsidies will not be effective unless the percentage reduction in the fertilizer price is much larger than that in the output price.

The analyst can also derive from Table 7 rough estimates of the effect of pricing policies on budget revenues and foreign exchange. Forexample, assume that the output is exported and that fertilizer is imported. Table 7 reveals that an increase in output price will induce an increase in marketed surplus available for export but only at the expense of icnreased use of fertilizer. The net foreign exchange effect, therefore, is given by the difference between the additional revenues from exporting and the costs of importing additional fertilizer. Similarly, if the output is taxed

and fertilizer is subsidized, one can perform a similar calculation to arrive at a rough estimate of the net impact on the budget.

The policy issues analyzed above illustrate the uses that can be made of the basic framework of the agricultural household model. The framework, however, is very flexible and can be adapted in may ways to fit particular circumstances and issues. In the next section, we discuss the main policy conclusions of these extensions but note that at present these conclusions remain somewhat more tentative than those emerging from the well-researched basic model because replications of the extensions have not yet been performed.

B. Some Extensions

The implications of price and other interventions on the nutritional and health status of target groups specially the rural poor are of special interest to international agencies and national governments. What do the agricultural household models add to the debate? Strauss (1984b) demonstrates how the basic model can be elaborated to allow an investigation of the effect of pricing policy on caloric intake. In his model, the utility function (see Equation 1) becomes

$$U = U(X)$$

where X is a vector of consumer goods including food items, nonfood items and leisure. Calorie intake (K) can then be calculated from:

$$K = \Sigma_i a_i X_i \qquad i = 1...m$$

where a_i is the calorie content of a unit of the i^{th} food and X_i, i = 1...m, are quantities of different food items.

With this extension, Strauss is able to show that price changes exert a considerable effect on caloric intake with the profit effect playing an important role. One might expect that an increase in the price of a major food item would probably have a negative impact on caloric intake. Table 8 however, reveals that in the majority of cases, an increased price results in increased caloric intake because of an increase in profits. Thus, even if consumption of the commodity whose price is increased declines, the extra profits allow the purchase of increased quantities of other foodstuffs so that overall caloric intake responds positively. This result is also found by Ahn, Singh and Squire (1981) in their Korean study. Both the Korean and Sierra Leone analyses find that increased food prices decreases caloric intake when profits are held constant. For Korea these negative elasticities may be applicable for landless households. Again it is found that the profit effect becomes empirically important. In all cases those calorie price elasticities (with profits varying) which are negative are small. This implies that any negative nutritional impact of higher food prices on agricultural households should be small.

In the particular case of Sierra Leone, Strauss is also able to demonstrate an important point regarding the distribution of calories among income groups. He shows that even if a price increase causes a reduction in the caloric intake of middle-income and high-income households (see the case of rice in Table 8), the intake of low-income households is increased. This suggests that, if policy makers are concerned primarily with the nutritional

status of low-income households, price increases for major food items may prove to be beneficial. Increases in the prices of food items towards, say, world prices may improve the nutritional status of low income households and provide appropriate signals for resource allocation. The usual equity-growth trade-off may be absent in this case. 4/

The Sierra Leone results thus suggest that general pricing policies may be important for the nutritional status of households with the lowest intakes, but not for most other households. This is substantiated by the Korean results, which suggest that pricing policies may be more important for landless laborers, and perhaps marginal farmers, than for others. However, the Korean elasticities are so small as to imply that using general price policies to generate nutritional policy goals must be questioned. 5/

Policy makers are interested in nutritional status presumably because it affects health and may also affect productivity at the individual levels. Pitt and Rosenzweig (1984) take the analysis one step further, therefore, and examine the interaction between prices, health and farm profits in the context of an agricultural household model. Their extension involves incorporation of a health variable directly in the utility function -- people prefer to be healthy -- and in the production function -- a healthy individual is more productive. To complete their model, they introduce a production function for health:

$$H = H(X_a, X_m, X_\ell, Z)$$

which says that health (H) depends on consumption (X_a and X_m) and hence on nutrition, on leisure (or work effort, X_ℓ) and on a vector (Z) of other fac-

tors which affect health, some of which are chosen by the household (boiling water) and some of which are community-level services (well water).

Applying their model to Indonesia data, Pitt and Rosenzweig are able to show that a ten percent increase in the consumption of fish, fruit and vegetables reduces the probability of illness by nine, three and six percent respectively whereas a ten percent increase in the consumption of sugar increases the probability of illness by almost twelve percent. These results suggest that increases in consumption cannot automatically be interpreted as contributing to health since the composition of consumption may also change in a manner detrimental to health.

In addition to estimating the health production function, Pitt and Rosenzweig also estimate a reduced-form equation that provides a direct link between prices and health. They show that a ten percent reduction in the prices of vegetables and vegetable oil will decrease the probability of the household head being ill by four and nine percent respectively whereas the same percentage reduction in the prices of grains and sugar will increase the probability of illness by fifteen and twenty percent respectively, albeit from a very low base. These results, however, are calculated with profits held constant. In principle, when profits are allowed to vary some of the results may be modified. In this particular application, however, the coefficient on farm profits proved statistically insignificant. The results reported above, therefore, are reasonably accurate measures of the total effect of changes in price on health.

Changes in health may also affect productivity and farm profits. Pitt and Rosenzweig, however, are able to demonstrate that behavior can be

represented by a recursive model in which case the effects of ill-health or labor supply are not reflected in reduced farm profits since households have resource to an active labor market. Thus, while family labor supply is significantly reduced by illness, total labor input and hence farm profits remain unaffected. This result indicates that the benefits of improved health (or the costs of a deterioration in health) in agricultural households will be reflected in farm profits, if at all, only through the indirect route of the labor market.

Most of the policy issues considered so far have been static in nature and have been couched in a single-period framework. Iqbal (1984) provides a major departure from previous work by extending the single-period analysis to incorporate borrowing, saving and investment decisions. Since governments and multinationals agencies devote substantial quantities of funds to rural credit programs, this particular extension offers the possibility of using agricultural household models to address a new set of policy issues of considerable importance in many countries.

Iqbal uses a two-period model. In the first period, the household may borrow and invest in farm improvements. In the second period, the loan must be repaid with interest and the household enjoys higher farm profits as a result of its investment in period one. Accordingly, in Iqbal's model the single full-income constraint is replaced by two full-income constraints, one for each period:

$$\pi(K_1) + w_1 T_1 + B = C_1 + I$$

$$\text{and } \pi(K_1+I) + w_2 T_2 = C_2 + B\,(1 + r(B))$$

where K_1, is capital in period one and I is investment so that K_1+ I is capital in period two. B is borrowing in period one and B (1 + r(B)) is repayment in period two. C is the value of consumption of goods and leisure. Iqbal draws a parallel between his treatment of household savings and borrowing and the treatment of own-consumption and marketed surplus or family labor supply and hired labor in the standard agricultural household model. He notes that the recursive property of the standard model carries over to this two period extension, provided the household can borrow at a fixed rate of interest. In his application to India households, Iqbal argues that the interest rate is influenced by household borrowing decisions (r is a function of B in the second-period constraint) and, therefore, adopts a non-recursive specification.

Iqbal's results reveal that borrowing is significantly reduced by increases in the interest rate, the elasticity being -1.2. These results support the view that interest rate policy can have a marked effect on the level of debt held by farmers. Iqbal also shows that farmers owning more than three hectares are highly sensitive to the interest rate whereas the coefficient on borrowing by farmers owning less than three hectares is statistically insignificant. It follows that the elimination or reduction of subsidies to programs providing agricultural credit may serve the dual purpose of increasing efficiency in the capital market and simultaneously improving equity since the reduction in borrowing by "large" farmers will exceed that by "small" ones.

As noted earlier, governments are also interested in the effects of agricultural pricing policy on more aggregate economic variables such as budget deficits and foreign exchange earnings. For example, in Senegal agricultural products generate 70 percent of total export earnings, and deficits resulting from the government's policy on agricultural pricing amounted to more than 20 percent of government expenditure and 2.0 percent of GDP. Changes in agricultural prices can be expected, therefore, to have a major impact on these aggregates. Indeed, concern with the existing levels of foreign exchange earnings and budget deficit may be the major motivation for changes in pricing policy in many countries. In Senegal, the government has explored ways, including pricing policy, to promote the production and consumption of millet in order to reduce imports of rice and hence improve the country's balance of payments.

The effect of pricing policy on foreign exchange and budget revenues was discussed earlier in the paper. Braverman, Ahn and Hammer (1983) and Braverman and Hammer (1984) however, provide an important extension to the basic model that makes the analysis of these policy issues much more complete. They add market-clearing conditions for the major outputs and inputs to the basic model of an agricultural household. The changes in consumption, production or labor supply at the household level following any change in an exogenous variable can then be aggregated and fed into the market-clearing equations. In some cases, the market is cleared through adjustments in international trade with prices remaining fixed at levels determined by the government, i.e.:

$$Q(\bar{P}_a) = X_a(\bar{P}_a) + E$$

where E represents net exports. In this event, a change in production or consumption has an immediate effect on foreign exchange earnings. Alternatively, the market may clear through adjustments in price, i.e.,

$$Q(P_a) = X_a(P_a)$$

Now a policy-induced change in production or consumption will result in a change in price which will generate second-round effects on production and consumption.

In their application to Senegal, Braverman and Hammer (1984) assume the first form -- quantity adjustment -- of marketing clearing for cotton, groundnuts and rice and the second form -- price adjustment -- for maize and millet. The second-round effects flowing from induced changes in the prices of maize and millet are capture fully in their model. Table 9 provides a sample of their policy results. Compare first the effect of reducing the price of groundnuts or increasing the price of fertilizer on the government's deficit arising from its agricultural pricing policy. Both policies reduce the deficit. The reduction in the price of groundnuts, however, has a relatively small effect on net foreign exchange earnings (mainly because a reduction in rice imports offsets reduced exports) although it reduces the real incomes of farmers in the groundnut basin by almost six percent. An increase in the price of fertilizer, on the other hand, causes a larger fall in net export earnings, a reflection of the fertilizer intensity of export crops, but

only reduces farm incomes by one percent. This example illustrates the policy trade-offs that can be explored within this framework. It also confirms a point made earlier — to be effective, changes in the prices of inputs such as fertilizer must be larger than changes in the prices of the main outputs.

The results in Table 9 also illustrate a quite different point regarding the formulation of policy. The Sengalese government has been anxious to reduce imports of rice and hence save foreign exchange by increasing domestic production of rice and increasing consumption of domestic substitutes such as millet. How can this result be achieved? One possibility is an increase in the producer price of rice. This does indeed reduce rice imports by seven percent but net foreign exchange earnings fall by 4.5 percent because in order to increase rice production farmers switch out of export crops. The desired result -- an increase in net foreign exchange earnings -- fails to materialize because of substitution possibilities in production. In this case, failure to recognize substitution possibilities produces a perverse result. In other situations, however, policy may be designed to take advantage of substitution possibilities. For example, the government may increase the consumer price of rice in the hope that people will change their pattern of consumption in favor of millet. Table 9, however, reveals little impact on net export earnings from this policy so that in this case a reliance on substitution possibilities would have been misplaced.

These examples from the Senegal study of Braverman and Hammer illustrate the importance of placing agricultural household models in a multi-market framework. 6/ This is likely to be especially important if attention is focussed on foreign exchange earnings and government revenues. Because

expansion of one crop is usually at the expense of another crop, changes in the quantities of internationally traded items and in the quantities of taxed or subsidized items will influence the overall impact of policy on foreign exchange and government revenue even if a change in a government-controlled price in one market leaves the prices in all other agricultural markets unchanged. More generally, changes in government-controlled prices will induce changes in other prices so that even measures of output response, labor supply response, consumer response and changes in farm profits will have to allow for general equilibrium effects. These remarks suggest that the multi-market analysis of Braverman and Hammer is likely to emerge as the most useful vehicle for generating operationally relevant policy results from agricultural household models.

V. CONCLUSION

On the basis of the empirical work to date, it seems clear that for certain purposes the agricultural household modeling approach is essential. In particular the interaction of consumption and production decisions through farm profits is essential because it matters empirically. It is less certain whether other interactions, through virtual prices, are important. This is likely to be the subject of future research. To the extent that production and consumption decisions can be treated separately the traditional analysis of the farm-firm will continue to be very useful.

For policy analysis, especially at the aggregate level, accounting for the profit effect on consumption will generally be an imperative. For analysts to continue to assume that peasant household consumption is invariant to economic forces is no longer justifiable. As the Senegal study shows, changes in household consumption stemming from a certain policy can have important ramifications for several different outcomes. That study also highlights the advantages of moving toward general equilibrium in policy analysis, since that allows different production and consumption substitution possibilities to be better captured. However, more household level studies need also be conducted to improve understanding of the decision making process, and to extend the basic model to cover other types of decisions.

Footnotes

1/ For a more general treatment of the static model see Strauss (1984a). Roe and Tomasi (1984) treat the case of production risk.

2/ The labor market was one which was in the past considered nonexistent, e.g., Chayanov (1925).

3/ The compensated and uncompensated virtual prices can be equated by evaluating exogenous non-farm income at the level which results in the reference utility level. Strauss (1984a) gives a detailed derivation of how the comparative statics of the functions relate to each other.

4/ Smith and Strauss (1984) provide similar evidence when they simulate the results at the national level while allowing rural wages to equilibrate the rural labor market.

5/ This does not mean policies to prevent violent seasonal price swings won't be effective. Even with a small price elasticity, a doubling of prices can have an important impact on caloric intake.

6/ Braverman, Ahn and Hammer (1983) examined the inputs of reducing government budget deficits in Korea incurred through the Grain Management and Fertilizer Funds. Analyses of agricultural pricing policies in Sierra Leone (Braverman, Hammer and Jorgenson, 1983), Cyprus (Braverman, Hammer and Jorgenson (1984), and Malawi (Kirchner, Singh and Squire) all using the same underlying framework have further indicated both the usefulness and the practicability of the approach.

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Table 1

Selected Characteristics of Surveyed Partial Equilibrium Studies

References	Country	Type of Data	No. of Observations	Variation in Prices	Separable or Non-Separable Model	Type of Analysis [a/]	Policy Problems Addressed
1. Lau, Lin and Yotopoulos (1978)	Taiwan	Average by farm size and region for each of two years	80	By region and all prices	Separable	LLES and Cobb-Douglas profit function estimated for three commodities	Consumption of agricultural commodity, marketed surplus and labor supply
2. Barnaum & Squire (1979)	Malaysia	Cross-section household level	207	By region for wages only	Separable	LES and LLES estimates for three commodities along with Cobb-Douglas production function	Rice consumption, labor supply marketed surplus
3. Kuroda & Yotopoulos (1980)	Japan	Cross-section average by farm size and region	72	By region for all prices	Separable	LLES and Cobb-Douglas profit function for four commodities. Leisure disaggregated by farm workers and off-farm workers	Consumption of agricultural commodity, marketed surplus and labor supply
4. Yotopoulos, Adulavidhaya, Kuroda & Lau (1976)	Thailand	Separate Household cross-section data sets used for demand system and input demand system	440 [b/] 480	By region for prices	Separable	LLES and Cobb-Douglas profit function for three commodities	Consumption of agricultural commodity, marketed surplus and labor supply
5. Rosenzweig (1980)	India	Cross-section household level for all India	862	By region for male and female wages off-farm labor supply equations	Separable	Reduced form estimates of male and female	Off-farm labor supply by sex
6. Ahn, Singh and Squire (1981)	Korea	Cross-section household level	443	By region for wages and subset of prices	Separable	Multiple (six) commodities analyzed. Linear Programming used for production side and LES estimated for demand side.	Effects of technological change on consumption of agricultural commodity.

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Table 2 Selected Elasticities
Response to Changes in the Price of the Agricultural Commodity

Country	Agricultural Commodity	Consumption of Agricultural Good	Consumption of Market-Purchased Goods	Marketed Surplus	Labor Supply
Malaysia	Rice	0.38	1.94	0.66	-0.57
Taiwan	Farm Output	0.22	1.18	1.03	-1.54
Korea	Rice	0.01	0.81	1.40	-0.13
Japan	Farm Output	-0.35	0.61	2.97	-1.01
Thailand	Farm Output	-0.37	0.51	8.10	-0.62
Sierra Leone	Rice	-0.66	0.14	0.71	-0.09
Northern Nigeria	Sorghum	0.19	0.57	0.20	-0.06

Table 1 (Cont'd)

Selected Characteristics of Surveyed Partial Equilibrium Studies

References	Country	Type of Data	No. of Observations	Variation in Prices	Separable or Non-Separable Model	Type of Analysis a/	Policy Problems Addressed
7. Strauss (1984)	Sierra Leone	Cross-section household level	138	By region for all prices	Separable	Multiple (seven) commodities analyzed. QES estimated on demand side with Constant Elasticity of Transformation Cobb-Douglas output supply equations.	Price and Income responsiveness of caloric availability.
8. Singh and Subramanian (1985)	Northern Nigeria	Cross-section household level	312	By region	Separable	Multiple commodities analyzed (intercropping). Linear programming used for production side and LES for demand equations.	Production choice among alternative crops. Substitutability of certain crops in consumption.
9. Iqbal (1984)	India	Panel data, household level for all India	1,602	By region for interest rate and wages	Non-Separable	Reduced form estimates of borrowing and interest rate equations.	Determinants of borrowing and interest paid for large and small holding farmers.
10. Pitt and Rosenzweig (1984)	Indonesia	Cross-section household level	2,347	By region for all prices	Both-Separability Tested	Farm profits, male labor supply, reduced form illness, and health input demand equations utility function.	Effects of health on profits and labor supply and determinants of individual health status. Intra family distribution considered.

NOTES FOR TABLE 1:

a/ Demand systems abbreviated are:
- LLES: Linear Logarithmic Expenditure System
- LES : Linear Expenditure System
- ELES: Extended Linear Expenditure System
- QES : Quadratic Expenditure System

b/ Observation numbers for demand side and production side analyses respectively.

Table 4 Selected Response Elasticities With Respect to Variable Input Prices and Fixed Factors

With Respect to Fertilizer Price [a]	Elasticity of Agricultural Commodity	Non-Agricultural Commodity	Marketed Surplus	Labor Supply
Taiwan	-0.11	-0.11	-0.24	0.18
Malaysia	-0.03	-0.18	-0.15	0.05
Korea	-0.05	-0.23	0.34	0.04
Japan	-0.03	-0.03	-0.09	0.07
Thailand	-0.03	-0.03	-0.41	0.05
With Respect to Land				
Taiwan	0.46	0.46	1.00	-0.77
Malaysia	0.26	1.37	1.15	-0.41
Korea	0.10	0.49	0.81	-0.08
Japan	0.19	0.19	0.96	-0.43
Thailand	0.11	0.11	1.48	-0.19
Sierra Leone	0.01	0.02	0.02	-0.01
Northern Nigeria	0.10	0.16	0.06	-0.08

[a] Fertilizer is barely used in the Sierra Leone and Northern Nigeria samples and was not therefore modeled.

Table 3 Selected Response Elasticities with Profit Varying and Profits Constant

With Respect to Agricultural Price	Elasticity of: Agricultural Commodity		Non-Agricultural Commodity		Labor Supply	
	A[a/]	B[b/]	A[a/]	B[b/]	A[a/]	B[b/]
Taiwan	-0.72	0.22	0.13	1.18	0.21	-1.59
Malaysia	-0.04	0.38	-0.27	1.94	0.08	-0.57
Korea	-0.18	0.01	-0.19	0.81	0.03	-0.13
Japan	-0.87	-0.35	0.08	0.61	0.16	-1.00
Thailand	-0.82	-0.37	0.06	0.51	0.18	-0.62
Sierra Leone	-0.74	-0.66	-0.03	0.14	0.01	-0.09
Northern Nigeria	-0.05	0.19	-0.14	0.57	0.03	-0.06
With Respect to Wage Rate						
Taiwan	0.14	-0.03	0.05	-0.12	-0.12	0.17
Malaysia	0.06	-0.08	0.29	-0.35	-0.07	0.11
Korea	0.16	0.01	0.77	0.05	0.00	0.11
Japan	0.29	0.15	0.39	0.25	0.15	0.45
Thailand	0.57	0.47	0.62	0.52	0.08	0.26
Sierra Leone	0.47	0.37	0.78	0.57	0.14	0.26
Northern Nigeria	0.06	0.02	0.04	0.01	0.01	0.10

a/ Holding profits constant.
b/ Allowing profits to vary.

Table 6 Spillover Effects of Changes in Output and Fertilizer Price

	Response of		
	Labor Demand	Labor Supply	Consumption of Non-Agricultural Goods
To Changes in Output Price			
Taiwan	2.25	-1.54	1.18
Malaysia	1.61	-0.57	1.94
Korea	-0.57	-0.13	0.81
Japan	1.98	-1.01	0.61
Thailand	1.90	-0.62	0.51
Sierra Leone	0.14	-0.09	0.14
Northern Nigeria	0.12	-0.06	0.57
To Changes in Fertilizer Price [a/]			
Taiwan	-0.23	0.18	-0.22
Malaysia	-0.12	0.05	-0.18
Korea	-0.12	0.04	-0.23
Japan	-0.13	0.07	-0.03
Thailand	-0.11	0.05	-0.03

a/ Fertilizer is barely used in the Sierra Leone and Northern Nigeria samples and was not, therefore, modeled.

Table 5 Effect on Real Income of Changes in Output and Fertilizer Prices

	Response of Income to	
	Output Price	Fertilizer Price
Taiwan	0.90	-0.11
Malaysia	0.67	-0.07
Korea	0.40	-0.10
Japan	0.34	-0.03
Thailand	0.10	-0.03
Sierra Leone	0.09	a/
Northern Nigeria	0.12	a/

a/ Fertilizer is barely used in the Sierra Leone and Northern Nigeria samples and was not, therefore, modeled.

Table 8 Response of Caloric Intake to Price Changes

Change in Price of:	Elasticity of Caloric Intake		
	Low Income	Middle Income	High Income
Rice	0.19	-0.24	-0.20
Root Crops and other Cereals	0.43	0.13	0.11
Oils and Fats	0.27	-0.03	-0.21
Fish and Animal Products	0.48	0.23	0.05
Miscellaneous Foods	0.14	0.01	-0.01

Table 7 Output, Consumption, Marketed Surplus and Input Demand

	Response of:			
	Agricultural Output	Agricultural Consumption	Marketed Surplus	Fertilizer Demand
To: Changes in Output Price:				
Taiwan	1.25	0.22	1.03	2.25
Malaysia	0.61	0.38	0.66	1.61
Korea	1.56	0.01	1.40	1.29
Japan	0.98	-0.35	2.97	1.98
Thailand	0.90	-0.37	8.10	1.90
Sierra Leone	0.11	-0.66	0.71	a/
Northern Nigeria	0.30	0.19	0.20	a/
To: Changes in Fertilizer Price a/				
Taiwan	-0.23	-0.11	-0.23	-1.23
Malaysia	-0.13	-0.03	-0.15	-1.13
Korea	-3.0	-0.05	-0.34	-1.10
Japan	-0.13	-0.03	-0.09	-1.13
Thailand	-0.11	-0.03	-0.41	-1.11

a/ Fertilizer is barely used in the Sierra Leone and Northern Nigeria samples and was not, therefore, modeled.

Table A.1
Elasticities of Agricultural Commodity Consumption
With Respect to

Country	Commodity	Total Expenditure	Commodity Price		Wage	Fertilizer Price	Fixed Factors				Scale Technology Factor
			Own	Non-Farm			Workers	Dependents	Land	Capital	
Taiwan	Farm Goods		.22	.29	-.03	-.11	.84	.43	.46	.04	
Malaysia	Rice		.38	-.15	-.08	-.03	.44	.23	.26		.42
Japan	Farm Goods		-.35	.31	.15[a]	-.03	.07[b]	.14	.19	.07[c]	
Thailand	Farm Goods		-.37	.05	.47	-.03[d]	.70	-.16	.11	.10	
Korea	Rice	.57	.01		.01	-.05			.10[g]		.002[h]
Sierra Leone	Rice	.52	-.66	.13	.37		.26[e]	.13[f]	.01	.04	.11
Northern Nigeria	Sorghum	1.80	.19		.02						

a/ Farm wage
b/ On-farm workers
c/ Machinery
d/ Priced Index for fertilizer, seed and chemicals
e/ Males over 15 years old
f/ Children 10 years and under
g/ Average farm size
h/ With respect to increased tiller capacity

Table 9 Analysis of Agricultural Pricing Policy In Senegal

Policy	Percentage Change in Real Income: in Groundnut Basin	Percent Change In: Export Earnings	Govt. Deficit
1. 15% decrease in producer price of groundnuts	-5.7	-1.9	-18.1
2. 100% increase in price of fertilizer	-1.1	-5.2	-10.4
3. 50% increase in producer price or rice	0.2	-4.5	-0.1
4. 50% increase in consumer price of rice	-4.7	-0.2	-34.8

Table A.3
Elasticities of Agricultural Commodity Marketed Surplus
With Respect to

Country	Commodity	Commodity Price		Wage	Fertilizer Price	Fixed Factors				Scale Technology Factor
		Own	Non-Farm			Workers	Dependents	Land	Capital	
Taiwan	Farm Goods	1.03	-.05	-.95	-.24	-.13	-.07	1.00	.08	
Malaysia	Rice	.66		-.55	-.15	.09	-.50	1.15		1.85
Japan	Farm Goods	2.97	-.13	-.77[a]	-.09	-.03[b]	-.06	.96	.37[c]	
Thailand	Farm Goods	8.10	-.12	-3.62	-.41[d]	-1.72	.39	1.48	1.44	
Korea	Rice	1.40			-.34			.81		
Sierra Leone	Rice	.71	-.12	-.49		-.21[e]	-.12[f]	.02	.11	.32
Northern Nigeria	Sorghum	.20						.08		

a/ Farm wage
b/ On-farm workers
c/ Machinery
d/ Price of index of fertilizer, seed and chemicals
e/ Males over 15 years old
f/ Children 10 and under

Table A.2
Elasticities of Non-Agricultural Commodity Consumption
With Respect to

Country	Total Expenditure	Commodity Price: Own	Commodity Price: Agricultural Commodity	Wage	Fertilizer Price	Fixed Factors: Workers	Fixed Factors: Dependents	Fixed Factors: Land	Fixed Factors: Capital	Scale Technology Factor
Taiwan		-.58	1.18	-.12	-.11	.84	0	.46	.04	
Malaysia		-.77	1.94[a]	-.35	-.18	-.06	-.05	1.37		2.21
Japan		-.97	.61	.26[b]	-.03	-.12[c]	.02	.19	.07[d]	
Thailand		-.89	.51	.52	-.03[e]	.69	-.29	.11	.10	
Korea	2.76	-.87	.81[a]	.05	-.23			.49[h]		.01[i]
Sierra Leone	1.18	-.93	.14[a]	.57		.41[f]	.09[g]	.02	.10	.27
Northern Nigeria	3.30		.57[j]	.01						

a/ Price of rice
b/ Farm wage
c/ On-farm workers
d/ Machinery
e/ Price index of fertilizer, seed and chemicals
f/ Males of 15 years old
g/ Children ten years and younger
h/ Average farm size
i/ With respect to tiller capacity
j/ Price of sorghum

Table A.4
Elasticities of Labor Supply
With Respect to

Country	Type of Labor	Commodity Prices		Farm Wage	Off-farm Wage	Female Off-Farm Wage	Fertilizer Price	Fixed Factors				Scale Technology Factor
		Agricultural Commodity	Non-farm Commodity					Workers	Dependents	Land	Capital	
Taiwan	Total	-1.54	.58	.17			.18	1.27	.20	-.77	-.06	
Malaysia	Total	-.57[a]	.24	.11			.05	.62	.12	-.41		-.65
Japan	Farm	-1.01	.30	.45	-1.97		.07	-.89[b]	.34	-.43	-.17[c]	
Thailand	Farm	-.62	.10	.26			.05[d]	.94	-.28	-.19	-.19	
Korea	Total	-.13[a]		.11			.04			-.08[g]		-.002[h]
Sierra Leone	Total	-.09[a]	-.05	.26				.55[a]	.13[f]	-.01	-.05	
Sierra Leone	Off-Farm	-4.42[g]	-1.85	17.18			14.35[e]	3.78[f]	-.94	-4.90		
India	Male Off-Farm				-.18[i]							
India	Female Off-Farm				-2.0[i]	2.0						
Canada	On-farm	.39		.12	-.11							
Canada	Off-farm	-.85		-.26	.18							
Northern Nigeria	Total	-.06[j]		.10								

a/ Price of rice
b/ On-farm workers
c/ Machinery
d/ Price index of fertilizer, seed and chemicals
e/ Males over 15 years old
f/ Children ten years and younger
g Average farm size
h/ With respect to tiller capacity
i/ Male off-farm wage
j/ Price of sorghum