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"HETEROGENEITY OF FAMILY AND HIRED LABOR IN AGRICULTURE:
A Test Using Farm-Level Data From India and Malaysia"

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HETEROGENEITY OF FAMILY AND HIRED LABOR IN AGRICULTURE: A Test Using Farm-Level Data From India and Malaysia*

I. INTRODUCTION

While a number of studies have attempted to fit agricultural production functions to data from developing countries (Heady and Dillon, 1961; Rao, 1965; Yotopoulos, Lau and Somel, 1970; Bardhan, 1973; Barnum and Squire, 1979 and others), most have failed to distinguish between family and hired labor inputs, thus implicitly maintaining the questionable assumption of homogeneity of the two types of labor in agricultural production. Since hired labor often performs different agricultural tasks than family labor, it is unlikely that the two are homogeneous and perfect substitutes for each other. If the two types of labor are imperfect substitutes, it is important to know the sign and magnitude of the elasticity of substitution between them, since this has important bearing on such diverse things as the labor supply and fertility of farm households and the effect of rural-urban migration on rural employment and poverty.

In this paper, we test the hypothesis that family and hired labor are perfect substitutes in agricultural production, and estimate the elasticity of substitution between the two kinds of labor, using household-level data from two very different regions: India and Malaysia. The estimated production function is general enough to allow a variable elasticity of substitution between hired and family labor. Nested within this model are two restrictive models, one of which treats family and hired labor as perfectly substitutable and symmetric (in terms of

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output effects) inputs and another which treats them as perfectly substitutable but asymmetric inputs. This makes it possible to test the general model against the conventional production functions commonly found in the literature.

To anticipate our findings, we reject the hypotheses of symmetry and perfect substitution between the two types of labor. When calculated at the mean levels of inputs, the elasticity of substitution between hired and family labor is generally observed to be close to unity. We should note, however, that this result does not justify estimation of a Cobb-Douglas production function having family and hired labor as separate inputs: such a specification assumes that all farms use both kinds of labor. A large number of farms in both the Indian and the Malaysian sample used either family or hired labor but not both.

The empirical results further indicate that hired labor has a larger marginal product than family labor, with the ratio between the two marginal products, at the mean input levels, being close to 2 in the case of Malaysian farms and 17 in the case of Indian farms. Such a result may be obtained because hired labor often performs specialized tasks that are more critical to output (such as operation of bullocks or tractors, transplanting, etc.) than tasks performed by family labor (such as weeding or supervision), or because outside labor is generally hired in seasons such as harvesting when the marginal product of labor is large owing to heavy time pressure. Furthermore, the large literature on agricultural dualism in developing countries also argues that, because of limited alternative employment opportunities for family labor, the shadow price and hence the marginal product of family labor is lower than the casual wage rate or the marginal product of hired labor.

II. HOMOGENEITY VERSUS HETEROGENEITY OF LABOR IN PREVIOUS RESEARCH

Previous researchers have typically estimated Cobb-Douglas production functions having total (hired plus family) labor as a single input. The assumptions underlying such a production function are (i) family and hired labor are symmetric in terms of their effect on output, and (ii) family and hired labor are perfect substitutes (in the sense of having an infinite elasticity of substitution between them) in agricultural production. To see this, let the agricultural production function be:

$$(1) \quad Y = C\, L^{\beta} \prod_{i=1}^{n} X_i^{\beta_i},$$

where i indexes non-labor inputs, Y = output, and L = labor services. C, β, and β_i are parameters to be estimated. Labor services are assumed to be "produced" according to a linear production function:

$$(2) \quad L = L_f + L_h$$

where L_f and L_h are quantities of family and hired labor used. As is obvious from equation (2), the coefficients on hired and family labor are identical (and equal to one), implying equal effects of the two inputs on output. Further, since the elasticity of substitution is infinite in a linear production function, the relationship between family and hired labor in equation (2) is that of perfect substitutability.

Bardhan (1973) is among the first researchers to have statistically tested for the heterogeneity of family and hired labor in an agricultural production function. However, his test was neither rigorous nor complete. His specification of the production function was

$$(3) \quad Y = C\,L^{\beta} \prod_{i=1}^{n} X_i^{\beta_i} \left(\frac{L_h}{L}\right)^{\gamma}$$

where L = total labor used on the farm (equation (2)) and L_h/L = the proportion of total labor that is hired. Equation (3) can be rewritten as:

$$(4) \quad \ln Y = \ln C + (\beta - \gamma) \ln L + \gamma \ln L_h + \sum_{i=1}^{n} \beta_i \ln X_i$$

In this specification, the effect of L_h on Y is allowed to differ from that of L_f. The importance of this difference is measured by the statistical significance of the parameter γ. However, the direction of the differential effect is rather systematic and therefore restrictive.[1/] Moreover, since heterogeneity consists of a differential effect of the

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[1/] Production function (4) has some undesirable characteristics. If γ is negative, the production function is not everywhere concave, and when L_h approaches zero, output approaches infinity. If γ is positive, no production occurs without hired labor (i.e., Y = o for L_h = o). Thus it would seem more likely that a positive estimate of γ results. In addition, if L_h rises relative to L_f the productivity difference between family and hired labor decreases, for any value of γ. The direction of a possible bias caused by all these assumptions is uncertain. Finally, if one uses micro-level farm data, the specification in (4)), as well as Cobb-Douglas or CES specifications is not flexible enough to deal with zero hired labor or family labor inputs.

two inputs on output and/or imperfect subsitutability between the inputs, the specification given in (4) is not focused directly on the heterogeneity issue. So, Bardhan's finding (1973, p. 138), that for all but two of his samples of Indian farms the estimates of γ were not significantly different from zero,[2/] cannot be accepted as conclusive evidence against the hypothesis of heterogeneous labor.

Other evidence on this issue is rather sketchy. Huang (1971) includes family and hired labor as separate inputs in an agricultural production function (Cobb-Douglas). Using farm data from Malaysia he observes a simultaneous occurrence of overuse of family labor and underuse of hired labor, with the latter being more productive. Substitutability is not further investigated.

Brown and Salkin (1974) also find, using farm data from South Vietnam, that hired labor is more productive than hired labor. Not all evidence presented by them is convincing however. Some of it is obtained by comparing the labor coefficients of two subsamples separated according to whether hired labor constitutes more or less than twenty percent of total labor used. This selection criterion is an endogenous aspect of the heterogeneity issue and this biases the result. This criticism can also be leveled against the same finding by Desai and Mazumdar (1970). They separate the sample of (Indian) farms according to whether labor is hired, and then compare estimated labor coefficients.

A recent study by Deolalikar and Vijverberg (1982) found evidence of labor heterogeneity in a sample of Indian district-level data, where

[2/] For those two samples, a positive γ was found, indicating that hired labor was more productive than family labor.

family (hired) labor was measured as the number of cultivators (agricultural laborers) per operational holding in a district. The aggregation problem inherent in using such data was not addressed however. Microeconomic farm data are needed to answer the heterogeneity issue conclusively.

Frequently the productivity gap between family and hired labor is explained with dual labor market arguments. Nath (1974) provides another insight as to why family labor may be less productive. He distinguishes a busy season and a slack season, and assumes that all casual labor is employed during the busy season in addition to a certain fraction of permanent labor (which is estimable in principle, although Nath only tries certain values). Among Indian farms, the productivity of busy season labor is positive, while the productivity of slack season labor is zero. Aggregating all labor together in the production function yields an estimated productivity equal to zero as well. Therefore failing to distinguish the contribution of family labor during the various seasons may have led to underestimating the marginal product of family labor and, as a consequence, to overestimating the marginal product of hired labor.

In this context a finding by Ahmed (1981) is interesting as well. One usually assumes that all farmers employ the same production technology, although at a different scale. Ahmed found that small farmers in Bangladesh produce more labor-intensive crops than large farmers. Estimates of labor productivity based on the assumption of identical production technology over the full scale of operation will be biased downward. Since smaller farms are more family-oriented, this downward bias will be expressed mainly through the coefficient on family labor. Viewing the results reported above, this prediction is borne out quite well.

In summary, heterogeneity of labor consists of two elements. Evidence of the first, a differential effect of family and hired labor on agricultural output exists, but the tests have not been clean and should be performed more accurately in view of seasonality (Nath) and potential supply responses (Ahmed; see also Brown and Salkin, and Desai and Mazumder). Evidence of the second element of heterogeneity -- imperfect substitutability between family and hired labor -- is only implied by use of Cobb-Douglas production functions. Imperfect substitutability has not been tested as such. Therefore we will proceed in section 4 with a test of the heterogeneity of labor, after we view the labor heterogeneity issue in a broader context.

III. IMPLICATIONS OF LABOR HETEROGENEITY

The most immediate implication of heterogeneous family and hired labor is for the growing literature on empirical applications of the 'theory' of the farm household (Lau, Lin and Yotopoulos, 1978; Barnum and Squire, 1979). These models have typically involved separate estimation of consumption and production models of a farm household and subsequent 'integration' of the estimated models to calculate the net (final) impact of prices, wage rates, and policy variables on a representative farm household. Separate estimation of consumption and production decisions has generally been justified on the grounds that there is a perfectly competitive market for labor in LDCs and that family and hired labor are homogeneous. Farm households are thus assumed to make their family labor supply decisions independently of the demand for on-farm labor, since the competitive market and homogeneous labor assumptions imply that excess family labor can always be sold in the casual labor market, or excess demand can be met by hiring in casual labor from the market, at a fixed wage rate.

If family and hired labor are heterogeneous, the labor demand and labor supply decisions of farm households cannot be so easily separated. To take an extreme example, if the elasticity of substitution between family and hired labor is zero, the supply of labor by family members cannot be determined independently of the onfarm demand for managerial and supervisory tasks, since the latter can never be performed by hired labor. Even for more plausible elasticities of substitution (i.e., greater than zero but less than infinity), the conventional models of the farm household, which assume separability of the household's production and consumption decisions, will have to be substantially revised.

A second implication of the imperfect substitutability between family and hired labor is at the labor market level and relates to rural-urban migration. Abstracting from household consumption decisions, if family and hired labor are perfect substitutes and if the former migrates to the city, the demand for hired labor will go up by the amount of family labor migrated.[3/] As a result, one would expect wages paid to hired labor to rise. Thus migration would benefit the population that stays behind in the agricultural sector. However, this conclusion is not so clear when family and hired labor are imperfect substitutes. Taking the extreme case in which substitutability is zero, the demand for hired labor may decrease when family labor migrates, depending on the substitutability with other inputs. Therefore, the landless agricultural population may actually be improverished due to the migration and its effect on rural poverty and income distribution.

A third implication, especially over a longer run, of the imperfect substitution between family and hired labor is that variables such as farm size, irrigation, or technical change, which increase the demand for family labor on the farm, may be expressed to affect fertility rates among farm households. If family and

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[3/] When one would integrate this implication with the existence of household consumption decisions, one has to make assumptions about the nature of migration: does the migrant remit part of his earnings; does the household now consist of two units and how does that affect consumption. Alternatively one might assume that the migrant leaves permanently and therefore that the family size decreases. Each of these assumptions affects the implications of migration somewhat.

hired labor are identifal and perfect substitutes for each other, fertility among farm families should not be related to these factors[4/], since the greater demand for family labor on large or irrigated farms can always be met by hiring in casual agricultural labor at a fixed wage rate.

Our central argument is that the conventional concept of 'labor demand' is invalid if family and hired labor are heterogeneous in the sense of having different efficiencies and being imperfect substitutes for each other. Instead, we need to talk about a demand function for family labor and a demand function for hired labor arising out of constrained profit maximization by farm households. In general, the wage rate paid to hired labor will not be the correct price of family labor. The latter will be the wage rate received by family workers while working away from the family farm. Hardly any study has bothered to check whether the wage rate paid by cultivators to hired workers is different from that received by themselves when working on other farms, although such information is generally available from most household surveys. Instead, most studies have simply assumed that the two wates are equal.

[4/] Of course, the positive relationship between fertility and farm size or irrigation may well be due to a positive income effect of the latter variables on fertility. The positive income effect would imply that children are normal goods.

IV: THE MODEL

We assume that the agricultural production function facing farms is of the Cobb-Douglas type:

$$(5) \quad Y = C\, L^{\beta_1} A^{\beta_2} \prod_{i=3}^{n} X_i^{\beta_i} e^{u},$$

where Y = output, L = labor services, A = services from land, X_i = quantity of i^{th} input, and u = i.i.d. error term. We assume that labor services, L, are produced using family labor, L_f and hired labor, L_h, according to the following generalized quadratic production function:

$$(6) \quad L = \alpha_1 L_f + (1 - \alpha_1)\, L_h + \delta_{11} L_f^2 + \delta_{22} L_h^2 + \delta_{12} L_f L_h .$$

The production function in (6) is general enough to allow any elasticity of substitution between family and hired labor. Furthermore, this elasticity of substitution will vary from observation to observation. A requirement for the overall production function (i.e. (5) and (6) combined) to be concave is that (6) is concave. Necessary conditions for this are that δ_{11} and δ_{22} are non-positive and that the marginal products of L_f and L_h is (6) (i.e. $\partial L/\partial L_f$ and $\partial L/\partial L_h$) are non-negative. If so desired, these requirements can be imposed when estimating (5) and (6). It should also be noted that, unlike the Cobb-Douglas and the CES production functions, the production function in (6) allows zero inputs of family or hired labor.

If $\delta_{11} = \delta_{22} = \delta_{12} = 0$ equation (6) reduces to:

(7) $L = \alpha_1 L_f + (1 - \alpha_1) L_h$,

which is the linear production function which allows for asymmetry of family and hired labor but still imposes perfect substitutability between them. The ratio of productivity is simply $\alpha_1/(1 - \alpha_1)$, and is the same for all levels of labor inputs. If in addition α_1 equals .5, (7) essentially simplifies to (2), which imposes symmetry as well. As said, this is the most commonly assumed specification in the literature.

Since there are two parts, (5) and (6), in the overall production function, one may define two different measures of the Allen-Uzawa elasticity of substitution between family and hired labor. The first measures substitution possibilities within the context of the labor services production function (6), and will be indicated by $\sigma^L_{L_f L_h}$. The second, indicated by $\sigma^Y_{L_f L_h}$, measures substitution possibilities within the context of the overall production function, (5) and (6) combined. The relationship between the two elasticities is not obvious -- $\sigma^L_{L_f L_h}$ assumes L constant, while $\sigma^Y_{L_f L_h}$ assumes Y constant, so due to the broader range of inputs which may vary, one would expect that $\sigma^Y_{L_f L_h}$ exceeds $\sigma^L_{L_f L_h}$, but a mathematical relationship cannot be found.

The heterogeneity in land - viz, between irrigated and unirrigated land - has been treated somewhat similarly, although not as elaborately. _A priori_ there is good reason to believe that irrigated and unirrigated land are perfect substitutes for each other. However, they are certainly not symmetric in terms of their effects on output. As such, we have assumed A in equation (5) to be:

$$(11) \quad A = rA_i + (1 - r)\, A_u,$$

where A_i = acres of irrigated land and A_u = acres of unirrigated land.

V. DATA AND ESTIMATION

We have estimated the agricultural production function in (5) and (6) with household-level data from two very different regions: Malaysia and Matar taluka in India. The purpose of selecting such widely different samples is to examine the robustness of our empirical results.

Matar taluka is a small, well-irrigated taluka (development block) in the Western Indian state of Gujarat. A stratified random sample survey of 1,111 rural households was conducted in 1974-75 by Vimal Shah and C.H. Shah. Of these 1,111 households, 572 are farm households, whose cropping pattern consists mostly (although not entirely) of paddy in the summer and wheat in the winter. Data availability restricted the sample to 476 households.

The other set of data are from the Malaysian Family Life Survey, carried out during 1976-1977 in Peninsular Malaysia (Butz and DaVanzo, 1978). Using area probability sampling methods, a total of 1,262 households were selected, in which at least one ever-married woman aged less than 50 years was present. While the main focus of the survey was to gather information on fertility behavior and related topics, if the household owned a farm, data were collected on inputs and outputs of this farm. There were more than 300 farm households in the sample, but only 100 of them were used for this study, due to lack of data on capital stock and especially value of production. Most farm households are engaged in year-round paddy (two or three crops), but some also produce fruits (coconut and other) and vegetables.

The definitions of the variables used from these surveys are given in Table 1. The list of non-labor, non-land inputs in the two samples is different because of different designs and scopes of the two surveys. The Indian survey has more detail because it was specifically designed to examine agricultural and rural development issues. Table 1 also shows that Malaysian farms rely more on family labor relative to hired labor than Indian farms, and use relatively less irrigation. Total farm size is about equal in the two countries. We have stressed in previous sections that the generalized quadratic labor services production function (6) is more suitable for farm-level empirical analysis than Cobb-Douglas or CES specifications, due to zero labor inputs that may occur. In the Indian sample, 2.5 percent of the households did not use family labor, and 2.9 percent did not use hired labor. These numbers corresponds with those of Rosenzweig (1978) from another Indian data set. The same statistics for the Malaysian sample are 0 and 49 percent respectively.

These variables are used to obtain estimates of the production function. Direct estimation of production functions has been critized on the grounds that the estimates so obtained are subject to simultaneous equations bias. However, Hoch (1962) and Zellner, Kmenta and Dreze (1966) have argued that, because of the time lag between input decisions and output in agriculture, OLS estimation of agricultural production functions is valid. At any rate, the alternative of estimating the reduced-form system of input demand, output supply, and restricted profit functions is not possible here either because of the absence of price variation (as in the case of Matar taluka, which is a small and homogenous region) or because of the unavailability of prices from the survey (as in the case of Malaysia).

The study of labor heterogeneity further demands that we have data on both wage rates paid to hired labor and wage rates earned by family labor in alternative employment. As explained earlier, such data are hard to come by in surveys.

The production function in (5) and (6) has been estimated using non-linear least squares. The results of the estimation are reported in Table 2. The production functions are estimated in both the cases with a fair degree of precision. Only two out of a total of 12 parameters estimated in the Indian production function are not significant at the 0.10 level. In the case of the Malaysian production function, one parameter out of the nine actually estimated is not significant at the same level.

The sum of the output elasticities is 1.027 in Matar taluka and 1.049 in Malaysia, indicating approximately constant returns to scale. The magnitudes of the individual output elasticities are, however, different in the two samples: while land has a larger output elasticity than labor in the Indian production function, the opposite is true in the Malaysian production function.

An F-test for the joint significance of the terms δ_{11}, δ_{12}, and δ_{22} indicated that, in both the Indian and the Malaysian samples, the hypothesis that $\delta_{11} = \delta_{22} = \delta_{12} = 0$ (i.e., the labor services production function is non-symmetric but perfectly substitutable in family and hired labor) can be rejected at the 0.10 level. The hypothesis that $\beta_1 = 0.5$ <u>and</u> $\delta_{11} = \delta_{22} = \delta_{12} = 0$ (i.e., the labor services production function is symmetric and perfectly substitutable in family and hired labor) can also be rejected at the same level of significance. The generalized quadratic production function for labor serviecs is thus the best model among the three models considered.

Any quadratic form has a satiation point. The labor services production function has a satiation point at $L_f = 1682$ and $L_h < 0$ in the Indian sample (measured as days per year), and $L_f = 189$ and $L_h = 432$ (hours per week) in the Malaysian sample. In both samples are farms that use too much labor: more labor services can be produced with less family and/or hired labor.

At the mean level of labor inputs, the implied labor services production functions are concave. The coefficients of the quadratic terms are negative, and the marginal products of hired and family labor are positive. The marginal product of family labor is M$6.90 and of hired labor is M$13.67 in the Malaysian sample, while the corresponding figures are Rs.1.28 and Rs.21.41, respectively, in the the Indian sample. It is interesting to note that the marginal product of hired labor is greater than that of family labor in both the samples. This could be attributed to the fact that labor is often hired to perform specialized tasks, such as tractor or bullock operation and transplanting, that are more critical to output than tasks traditionally performed by family labor, such as weeding and supervision. Furthermore, outside labor is generally hired in seasons (such as sowing or harvesting times) when there is a severe time constraint (i.e., a large amount of work needs to be done in a limited amount of time). At the margin, any labor used during these seasons will be more productive than labor used at other times of the year (see also Nath (1974)).

There is, of course, another explanation. There is a large literature on agricultural dualism in developing countries which argues that, because of limited alternative employment opportunities, the shadow prices of time is low for family workers (Sen, 1966; Mazumdar, 1975). Casual labor, however, has to be paid the going wage rate. As such, there would be a tendency for the profit-maximizing farmer to depress the marginal product of family labor to a lower level than that of hired labor.

The derived elasticity of substitution between family and hired labor in the labor services production function, $\sigma^{L}_{L_f L_h}$, comes out to be 0.68 in the Indian case and 1.16 in the Malaysian case, when calculated at the mean labor input levels (see Table 3). Neither is significantly different from unity, according to the standard deviations obtained by means of Taylor series expansion.[5/]

The accuracy of this approximation of the standard deviation was also checked by simulation. A set of 500 random parameters of the production function was generated according to the estimated covariance matrix, with mean values equal to the estimates reported in Table 2. Eaeh set yielded one value of the elasticity of substitution. The 95% cofidence interval reported in Table 3 excludes both 2.5% tails of the frequency distribution. The results show that the Taylor expansion approximation of the variance is much larger than the simulated spread in the distribution of the estimated value of $\sigma^{L}_{L_f L_h}$. Simulation results lead to a rejection of a unitary elasticity of substitution in the Malaysian case but not in the Indian case.

[5/] Let $\sigma = \sigma(\beta)$ be the relation between the elasticity σ and the parameters of the production function β. Let $\hat{\beta}$ be the estimate of β, with estimated covariance matrix $\hat{\Omega}$ Then the estimated elasticity $\hat{\sigma} = \sigma(\hat{\beta})$ has an asymptotic variance equal to

$$\text{var}\ (\hat{\sigma}) = \left[\frac{\partial\sigma}{\partial\beta}\ (\hat{\beta})\right]' \hat{\Omega} \left[\frac{\partial\sigma}{\partial\beta}\ (\hat{\beta})\right]$$

The Allen-Uzawa elasticity of substitution in the context of the overall agricultural production function, $\sigma^{Y}_{L_f L_h}$, is higher than $\sigma^{L}_{L_f L_h}$, as speculated in Section 4. It is calculated at 1.67 in the Malaysian case and 8.05 in the Indian case. We see again large standard deviations of these estimates when calculated by Taylor series expansion, but narrow ranges when considering simulation results.

Non-rejection of a unitary elasticity of substitution does not imply that family and hired labor can be entered as separate inputs in a conventional Cobb-Douglas production function, as the latter is not consistent with the zero input values for hired (and family) labor often observed in subsistence agriculture. The high elasticities found in the Indian sample with respect to the overall production function should not be interpreted as "nearly infinite," so that one might just add different types of labor together into one labor input. Such hypothesis is nested within our specification, and was rejected as reported above.

As a final note, the Malaysian survey distinguishes hours of the head of the household (L_{fh}) from hours of other family members (L_{fo}). The analysis so far assumed: $L_f = L_{fh} + L_{fo}$. According to the same methodology as above, one may test for heterogeneity among the three types of labor L_{fh}, L_{fo} and L_h, implying four additional parameters in the labor services production functions -- the two-labor case with L_f and L_h becomes a special case of the three-labor case. The latter specification is preferred at the 10 percent significance level, but the resulting production function is not concave at the mean input levels. When restrictions were imposed to make it concave, three restrictions were active and not statistically significant. Thus we obtained a specification with fourteen parameters, three of which were restricted by concavity (at mean) restrictions, which was preferred to the two-labor case at the 5 percent significance level. Estimation results showed that labor of other family members is a complement to hired labor (in the sense that $\partial^2 L/\partial L_{fo}\partial L_h$ is positive), and a substitute for the head's (manager's) labor, which tends to support the idea that family labor is more involved in supervisory and managerial tasks.

VI. CONCLUDING REMARKS

This paper defines labor heterogeneity as a combination of asymmetry of the effect of various types of labor on output and imperfect substitutability between them. Existing literature has not rigorously examined this issue. The methodology put forth in this paper is simple and enables one to distinguish among the two components of heterogeneity. Two data sets were used, from India and Malaysia, that both indicate strong evidence of this heterogeneity. These results suggest two broad conclusions.

First, in data collection and analysis one needs to examine the different components of labor more carefully. More attention must be paid to the detailed application of labor, with respect to source (family, hired), timing (planting, harvesting) and task (specialized, supervisory).[6/] This direction of research will also involve development of econometric tools to deal with the many zero-valued labor inputs, which as corner solutions to the underlying decision-making process carry significant information.

Second, models that assume homogeneous labor must be reexamined. As our discussion in Section 3 indicates, this assumption is wide-spread. One of the first areas to start is the conventional model of the farm household that permits separating the household's production and consumption decisions. Once the implications of labor heterogeneity for this model are well-understood, research in other areas, which implicitly build on this model, should be fruitful.

[6/] Data of this nature are already being collected, e.g. by the International Crops Research Institute for the Semi-Arid Tropics in India.

Table 1

Variable Definition and Descriptive Statistics

	Matar - India		Malaysia	
	Mean	st. dev.	Mean	st. dev.
Output (value of production)[a]	13598	14499	2707.1	3486.5
Family labor[b]	107.19	111.26	62.29	58.58
Hired labor[b]	215.52	289.49	72.17	146.39
Capital (value of fixed assets)[a]			358.16	1251.28
Bullock labor[b]	39.64	36.66		
Fertilizer (kilogram)	50.58	100.33		
High-yielding variety (dummy)	.53	.50		
Irrigated land (acres)	5.20	6.17	2.45	5.03
Unirrigated land (acres)	2.02	3.28	4.64	7.24
Number of observations	476.		100	

Notes: [a]Malaysian dollars (M$) for the Malaysian sample, Rupees (Rs) for the Indian sample.

[b]Hours per week for the Malaysian sample, days per year for the Indian sample.

Table 2

Parameter Estimates[a]

	Matar - India	Malaysia
Const.	6.1608 (19.47)	4.5973 (14.25)
β - labor	.4142 (5.36)	.6122 (6.63)
β - capital		.1140 (4.03)
β - bullock	.0101 (0.58)	
β - fertilizer	.0617 (3.53)	
β - land	.5412 (9.03)	.3228 (6.50)
α_1	.2435 (2.58)	.4375 (3.76)
δ_{11} *1000	-.3013 (-1.68)	-1.9115 (-3.04)
δ_{22} *1000	-.1497 (-1.58)	-.7943 (-3.79)
δ_{12} *1000	-.6581 (-2.16)	.6568 (0.96)
γ	.7852 (16.50)	.2793 (2.31)
high-yielding variety	.1550 (1.87)	
σ^2	.7769 (15.33)	.5434 (6.81)
L	-615.3394	-111.4009
N	476.	100.
SSR	369.8044	54.34

Note: [a]Asymptotic t-statistics in parentheses.

Table 3

Elasticities of Substitution

	Matar - India	Malaysia
$\sigma^{L}_{L_f L_h}$	.677	1.157
St.Dev. - Taylor expansion	1.766	.257
95 % confidence interval from simulation	.116 - 1.347	1.120 - 1.193
$\sigma^{Y}_{L_f L_h}$	8.051	1.667
St.Dev. - Taylor expansion	8.075	.468
95 % confidence interval from simulation	6.771 - 9.283	1.632 - 1.702

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