Ind. Jn. of Agri. Econ.
Vol. 50, No. 4, Oct.-Dec. 1995

Do Farm Households Use the Labour Market as a Hedge against Revenue Risk? Evidence from Female Labour Supply

I
INTRODUCTION

It is a trite observation that farmers have always had to make decisions under various conceivable risky conditions. The production process itself is extremely susceptible to the caprices of the weather. The paucity of rainfall, or else its superabundance, its lack of proper correspondence with the various stages of production, blight, frost, pestilence and other such factors contribute greatly to an uncertain yield. Add to this the fact that product prices at the end of the cropping season may be quite different from what they were at the time the sowing decisions were made. All these reasons may make for a considerable amount of revenue uncertainty. In the absence of well-developed insurance and capital markets in less developed agriculture, producers often use diverse mechanisms to mitigate the impact of this revenue uncertainty that they are confronted with. One such possibility open to them is to use the casual labour market as a hedge. Thus, if at the time of planting their crops the rains fail or are sub-optimal, thereby increasing the riskiness of production, the farmers could 'move out' to the local casual labour market. Of course, the extent to which the farmers can do so effectively will also depend on the uncertainty attaching to labour market employment.

This paper addresses the question whether *female* household labour adjusts to revenue uncertainty through variations in its wage labour effort. Interest in this group of labour suppliers is more than a matter of mere detail. A host of reasons have contributed to focus attention on this particular sub-group within the household. Their respect in society has tended to be coloured, *inter alia*, by their income-earning effort. Second, even when family prestige has been equated with womenfolk *not* working outside the household, sheer economic necessity often drives them into the labour market. Third, during certain stages in the agricultural cycle, such as harvest time, there is additional demand for prompt and efficient labour, so that female labour supply assumes more importance.

Block and Heineke (1973) find that "Arguments concerning the 'disincentive effects' of uncertainty are .... not .... unambiguously supported by theory". And this within a rather simple model framework. Sumner (1982), Rosenzweig (1980), Huffman (1980), Barnum and Squire (1979) and Bardhan (1979) estimate their models assuming certainty, so that their models are subject to specification bias. Roe and Graham-Tomasi (1986) incorporate yield risk in their model, but their simulation results are contingent on *assumed parameter values* for the utility and production functions specified in their models.

A static decision-theoretic model is outlined in the next section. The data set and computed variables are discussed in Section III. Finally, Sections IV and V present the estimation results and conclusions.

II
THE MODEL

Given our interest in the cultivators' off-farm labour supply, the appropriate framework would be the household production model. The household (head) is assumed to maximise a well-behaved utility function $U = U(a,m,1;Z_1)$, where 'a' is the consumption of the agricultural staple, 'm' is the consumption of the market purchased good, '1' is the consumption of leisure time, and 'Z_1' is a vector exogenous variables that are discussed later.

Expenditure on the market purchased good is constrained by (and, in equilibrium, will equal) the household's total income (comprising profits, wage income and exogenous income) $p_m m = p_a(Q-a)-w^h L^h+w^M F_2^M+w^F F_2^F+I$, where p_a is the price of a, p_m is the price of m, w^h is the nominal wage rate for hired labour, w^M is the nominal wage rate for male labour, w^F is the nominal wage rate for female labour, Q is the household production of the staple, L^h is hired labour, F_2^M is off-farm labour supply of males, F_2^F is the off-farm labour supply of females and I is exogenous income.

The well-behaved production function for the household staple is $Q = g(L; Z_2)\epsilon = g(L^h + F_1^M + F_1^F; Z_2)\epsilon$, where F_1^M is male on-farm labour supply, F_1^F is female on-farm labour supply, Z_2 represents exogenous variables that are discussed later, and ϵ represents multiplicative yield risk,[1] such that $E(\epsilon) = \bar{\epsilon}$ and $V\epsilon = \sigma^2$.

Given the possibility of unemployment/under-employment in the labour market, off-farm employment may be uncertain; the wage rates may then be thought of as expected wage rates [derived as the product of the (estimated) wage rate and the probability of finding employment]. But it could happen that the probability of finding employment is correlated with revenue risk. However, there is evidence to the contrary (see Kanwar, 1994), which simplifies the model. Further, the estimated wage rates have been computed as functions of the human capital and other characteristics of the household member in question (for details, see the following section). This is the usual practice adopted in the labour supply literature (see Rosenzweig, 1980 and the references cited therein).

Finally, on-farm labour, off-farm labour and leisure time are constrained by the total time available to the household (T). Assuming the household to maximise its expected utility, the above relations give us the maximand:

$$\text{Max EU}\ \{a, [p_a(Q\epsilon - a) - w^h L^h + w^M F_2^M + w^F F_2^F + I]/p_m, T-F_1^M-F_1^F-F_2^M-F_2^F \qquad \text{....(1)}$$

Differentiating the maximand with respect to a, F_1^M, F_1^F, F_2^M, F_2^F and L^h in turn,[2] we may write the optimising conditions as:

$$E\{U_a - U_m\, p_a/p_m\} = 0$$
$$E\{U_m\, g_{F_1^i}\, \epsilon p_a/p_m - U_l\} = 0; \qquad i = M,F$$
$$E\{U_m\, w^i/p_m - U_l\} = 0; \qquad i = M,F$$
$$E\{U_m\, g_L{}^h\, \epsilon\, p_a/p_m - w^h\} = 0$$

which, using the rule $E(x,y) = E(x)E(y) + Cov(x,y)$ for random variables x and y, may be re-written as (Horowitz, 1970):

$$E(U_a)/E(U_m) = p_a/p_m \qquad \text{....(1a)}$$

$$\bar{\epsilon}\, g_{F_1^i}\, p_a/p_m - E(U_l)/E(U_m) = -\left[Cov\,(U_m, \epsilon\, g_{F_1^i})/E(U_m)\right](p_a/p_m) \qquad i = M,F \qquad \text{....(1b)}$$

$$E(U_l)/E(U_m) = w^i/p_m \qquad i = M,F \qquad ....(1c)$$

$$\overline{\in} g_{L^h} p_a - w^h = - [Cov (U_m, \in g_{L^h})] p_m \qquad ....(1d)$$

According to equation (la), goods are consumed so as to equate the expected marginal rate of substitution to their price ratio, as in the certainty case. According to equation (lb), the difference between the expected marginal rate of substitution between leisure and the consumption of market purchased good and the expected value of the marginal product of on-farm labour is proportional to the risk premium associated with the covariance term on the right hand side. Given that on-farm labour, off-farm labour and leisure are tied together via the time constraint, note that risk considerations also affect the determination of off-farm labour supply in equation (lc). Finally, equation (ld) says that the difference between the expected value of the marginal product of hired labour and the wage rate is proportional to the risk premium. Following Fabella (1989), note that $\delta g_{L^h}/\delta \in > 0$, so that when $\in$ increases so does $\in g_{L^h}$. But this also increases (expected) profits and so decreases U_m given risk aversion[3] (i.e., $U_m < 0$). Thus Cov ($U_m, \in g_{L^h}$) < 0. From equation (ld), therefore, $\in g_{L^h} p_a - w \neq 0$, so that this system is non-separable. However, we may characterise the problem as if the household sought to maximise its certainty-equivalent income and then to choose the levels of consumption of goods and leisure (see Roe and Graham-Tomasi, 1986). The off-farm labour supply of the household members is then residually determined. Tentatively capturing revenue risk by its conditional expectation (r^e) and its standard deviation (σ_r), the unconditional *reduced form* off-farm labour supply equation for females is then:

$$F_2^F = F_2 (p_a/p_m, w^F/p_m, w^M/p_m, I, Z_1, Z_2, r^e, \sigma_r)$$

(Given no cogent reason for dropping any of the regressors from the similar equation for males, even if the error terms of the male and female equations are correlated there is no gain in efficiency in estimating them simultaneously.)

III

DATA AND VARIABLES

The study uses farm-household data from ICRISAT's (International Crops Research Institute for the Semi-Arid Tropics) village level studies pertaining to three villages - Aurepalle, Shirapur and Kanzara - in the Indian semi-arid tropics. These villages were, in general, characterised by low and variable rainfall and poor quality soils, although there was some variation (for instance, some deep black soils in Shirapur and relatively assured rainfall in Kanzara). On the whole, these regions tended to be susceptible to high risk. The sample comprised 40 households[4] surveyed over the period 1975-1984.

We now briefly discuss some of the key computed variables used in the estimation. The regressand is supposed to be the *desired* supply of female labour, for we are considering the issue of female labour supply from the viewpoint of the supplier. This is derived as the sum of the actual number of labour days worked by the females in the household and the number of days they are involuntarily unemployed.[5]

To construct the expected wage rate variable we need estimates of the probability of finding employment in the labour market. These are defined as the ratio of the actual labour supply to the desired labour supply. Further, the estimated wage rates for males and females are derived by regressing their actual wage rates on the individual's characteristics such as age, (age^2), education, caste and village dummies.

To derive estimates of the conditional expectation and standard deviation of the (net) revenue distribution, we begin by hypothesising that the change in output is related to the previous period's output (see Dandekar, 1980). Allowing for variation in the rate of change of output over time, the relation would be $\log q_t = \alpha + \beta t + \gamma t^2$. Now if the harvest fails making net revenue negative (as is true for some observations in our sample), we would be unable to estimate this model. However, note that the above expression implies the second-order differential equation ($dq/dt = (\beta + 2\gamma t)q$. Treating time as a discrete variable we may state this, instead, as a difference equation yielding the relation $q_t = z(q_{t-1}, t)$. Further, if a household draws on its savings to purchase draught animals at the end of period t-1, a better predictor of its revenues in period t would account for this change in assets. Accordingly, we use 'change in assets' as an additional regressor. Finally, the assumption of a normally distributed error process for the above model seems appropriate as a first approximation (see Walker and Subbarao, 1982 on this score). Estimating this model, we then derive joint estimates of the conditional expectation (r^e) and the associated standard deviation (σ_r) for each of the sample households.

IV

RESULTS

We estimate the model using the Heckman two-step procedure (see Heckman, 1979; Greene, 1981). In the first step we estimate a probit maximum likelihood model (where y=1 for positive female off-farm labour supply, and y=0 otherwise), which tells us how the labour force participation decision is impacted by the different exogenous variables (Table I). It is found that a higher real expected female wage rate (EXPRWF) increases their likelihood of off-farm work significantly. Higher female education (EDUF) is significant in inducing female labour force participation. Education levels may be taken as proxies for skill levels and hence the level of wages that workers can command. Also, wage labour supply becomes one way in which the returns to investment in education may be realised. Therefore, higher female education may be expected to evoke higher female labour participation. The reverse strongly holds for female age (AGEF). This may simply be on account of the debilitating effects of a higher age. The household caste (CASTE) - which perhaps signals the education and skill levels of the workers - works positively. Similarly, a higher expected real male wage rate (EXPRWM) significantly increases the likelihood of female participation in the labour force. Perhaps a higher expected male wage also implies a higher expected female wage. Higher male formal education (EDUM) has a strong negative effect. The number of working members (WRKMEM) is negatively related to the regressand. Thus, assuming that a greater number of working members implies a greater number of males in the households (as also females), the need for females to supply their labour for off-farm activities will be that much smaller. However, this result is not statistically significant. A higher number of dependent members in the household (DEPMEM) also has a negative but insignificant influence on the regressand. In so far as the burden of rearing children is seen as a female responsibility, a larger number of dependents will decrease the probability of female off-farm labour supply. The coefficient of gross cropped area (GCA) turns out to be insignificant. Greater non-land assets (NLASS) greatly reduce the probability of female off-farm labour. The availability of alternative productive work on-farm - animal husbandry, handicrafts, spinning, weaving, etc., - would serve to absorb significant amounts of female labour time, decreasing their likelihood of doing off-farm work. The expected net revenue (EXPNR) and its standard deviation have an insignificant impact on the probability of labour force participation. Finally, a likelihood ratio test for the joint significance of the village dummies (D_1, D_2 and D_3) supports their inclusion. Thus the different agro-climatic and edaphic characteristics of the villages make for different probabilities of off-farm work. The estimated model correctly predicts about 79 per cent of the observations, and a likelihood ratio test strongly rejects the hypothesis that the regressors are all zero.

TABLE I. FEMALE OFF-FARM LABOUR SUPPLY: PROBIT ML ESTIMATES

Variable (1)	Regression coefficient (2)	Asymptotic t-values (3)
p_a/p_m	-0.1085	-0.2728
EXPRWF	0.0253	3.2389
EXPRWM	0.1967	2.2152
AGEF	-1.2520	-2.7529
AGEM	-0.0023	-0.2601
EDUF	0.8266	1.8415
EDUM	-0.0567	-2.0577
CASTE	0.1336	3.2771
WRKMEM	-0.0435	-1.3640
DEPMEM	-0.0761	-1.5452
GCA	0.0038	0.6601
NLASS	-0.0001	-4.3922
EXPNR	0.00001	0.6160
SDNR	-0.00001	-0.6097
D1	1.0570	2.2775
D2	0.2695	0.5413
D3	1.0097	2.1745
Log of the likelihood function = -205.94		
Percentage of right predictions = 79 per cent		

In the second step of the Heckman procedure, we estimate the multiple regression of female off-farm labour supply on the regressors *contingent* on the labour force participation decision in the first step (Table II). From Table II, we find that female off-farm labour supply is positively, albeit insignificantly, related to the real price of the consumption staple (p_a/p_m). While the substitution and income effects of an increase in the real price of the staple would cause a movement away from its consumption, the profit effect would work in the opposite direction. The consequent change in the consumption of the staple may be expected to induce off-setting changes in the female wage labour supply. However, for our sample this relation is insignificant. The coefficient of the expected real male wage rate (EXPRWM) is positive but insignificant. It appears that an increase in the real male wage rate, by causing a substitution of labour away from males and towards females, exerts an upward pressure on the real female wage rate. This induces an increase in female off-farm labour supply. The expected real female wage rate (EXPRWF) is negatively significantly related to the dependent variable. Given the secondary nature of the income earned by the females in the household, this would seem in order - the higher the rate of return that female labour gets, the less do they need to work in order to earn a given amount. The female age (AGEF) and education level (EDUF) are insignificantly related to female labour supply.

TABLE II. FEMALE OFF-FARM LABOUR SUPPLY: SELECTION MODEL ESTIMATES

Variable (1)	Regression coefficient (2)	Asymptotic t-values (3)
p_a/p_m	47.7220	0.6630
EXPRWF	-2.7493	-1.8421
EXPRWM	11.5070	0.7055
AGEF	42.0660	0.2801
AGEM	-1.2692	-1.0852
EDUF	-14.9040	-0.1122
EDUM	-9.8653	-1.5876
CASTE	-4.0435	-0.4612
WRKMEM	3.9739	0.6584
DEPMEM	2.8888	0.3214
GCA	-3.2179	-2.5608
NLASS	0.0051	0.9940
EXPNR	0.0011	0.3821
SDNR	-0.0003	-0.0717
LAMBDA	-73.2340	-0.5509
D1	216.9100	2.6779
D2	267.7700	2.6321
D3	281.1200	3.6711
Log of the likelihood function = -2031.04		

The coefficients of the household caste, the number of working members and the number of dependents are statistically insignificant in explaining the magnitude of labour force participation. Gross cropped area (GCA) turns out to have a highly significant negative relation with the dependent variable. Non-land assets (NLASS) have an insignificant relation with the regressand. A likelihood ratio test for the null hypothesis that the village dummies are all zero rejects the null hypothesis.

Finally, both expected net revenue (EXPNR) and the standard deviation of net revenue (SDNR) turn out to be insignificant explanatory variables of female off-farm labour supply. Thus female off-farm labour supply does not appear to be used by the farm households to any significant extent, in hedging against production risk. This can be explained in terms of the secondary nature of female wage income in rural farm households, and the attitude that the household prestige depends on womenfolk not working outside the household. Thus in the event of an increase (or decrease) in the riskiness of on-farm production, female off-farm labour does not exhibit any significant response either way in our sample of farm households.

V

CONCLUSION

In the 'absence' of certain markets - such as insurance, futures and capital - in less developed agriculture, one of the diverse mechanisms that farm households may employ to hedge against the riskiness of on-farm production is the variations in their wage labour supply. For a large sample of observations in certain risk prone villages in the Indian semi-arid tracts, we find that female labour in the farm households is not so utilised. The reasons for this appears to be more of a 'social' than 'economic' nature. A major question this raises, in turn, is whether male household labour (and, therefore, total household labour) is so utilised. Further, by investigating female labour supply behaviour in districts where the above-mentioned social constraints are not binding, the issue raised in this paper, namely, whether the labour market can be used as a hedge against production risk, may be put to a more stringent test.

Sunil Kanwar*

Received December 1994. Revision accepted September 1995.

NOTES

1. While it is unclear whether risk should be included additively or multiplicatively *a priori*, Newbery and Stiglitz (1981) point out that even if it is specified additively at the farm level, at the aggregate level it will turn out to be multiplicative. Moreover, in a model such as outlined here, additive risk will not show up in the first-order conditions, thus making it impossible to distinguish the household model under risk from that under certainty. For these reasons, we prefer to introduce risk multiplicatively in our model.

At the same time, we preferred not to use the Just-Pope multiplicative form (see Just and Pope, 1978), for it can be shown that their production function gives a *negative* marginal product for finite output (see Fabella, 1989 on this point).

2. Land allocation is not treated endogenously since evidence shows leasing-in/leasing-out to be not really important for our sample of households. Further, interlinked transactions were not cited as a significant reason for the little leasing-in/leasing-out that occurred. See Jodha (1984) on this point.

3. The evidence on the risk attitudes of farmers shows them to be overwhelmingly risk averse (see Young, 1979 and the studies cited therein).

4. Only those farm households were retained for this study in which the male head of the household and his spouse were alive and present in these villages for the entire ten-year period of the survey. Also see note 5.

5. While this may lead to a slight over-estimate of labour supply, using actual labour supply alone would lead to a gross under-estimate.

REFERENCES

Bardhan, Pranab (1979), "Labour Supply Functions in a Poor Agrarian Economy", *American Economic Review*, Vol. 69, No. 1, March, pp. 73-83.

Barnum, H.N. and L. Squire (1979), "An Econometric Application of the Theory of the Farm-Household", *Journal of Development Economics*, Vol. 6, No. 1, March, pp. 79-102.

Block, M. and J. Heineke (1973), "The Allocation of Effort under Uncertainty: The Case of Risk Averse Behaviour", *Journal of Political Economy*, Vol. 81, No. 2, March-April, pp. 376-385.

Dandekar, V.M. (1980), "Introduction to Seminar on Data Base and Methodology for the Study of Growth Rates in Agriculture", *Indian Journal of Agricultural Economics*, Vol. 35, No. 2, April-June, pp. 1-12.

Fabella, R.V. (1989), "Separability and Risk in the Static Household Production Model", *Southern Economic Journal*, Vol. 55, No. 4, April, pp. 954-961.

Greene, W. (1981), "Sample Selection Bias as a Specification Error: Comment", *Econometrica*, Vol. 49, No. 3, May, pp. 795-798.

Heckman, J.J. (1979), "Sample Selection Bias as a Specification Error", *Econometrica*, Vol. 47, No. 1, January, pp. 153-161.

Horowitz, I. (1970), *Decision Making and the Theory of the Firm*, Holt, Rinehart and Winston Inc., New York, U.S.A.

Huffman, Wallace (1980), "Farm and Off-Farm Work Decisions: The Role of Human Capital", *Review of Economics and Statistics*, Vol. 62, No. 1, February, pp. 14-23.

* Department of Economics, Delhi School of Economics, University of Delhi, Delhi-110 007.

Jodha, N.S. (1984), "Agricultural Tenancy in Semi-Arid Tropical India", in H.P. Binswanger and M.R. Rosenzweig (Eds.) (1984), *Contractual Arrangements, Employment, and Wages in Rural Labour Markets in Asia*, Yale University Press, New Haven, Connecticut, U.S.A.

Just, R.E. and R.D. Pope (1978), "Stochastic Specification of Production Functions and Economic Implications", *Journal of Econometrics*, Vol. 7, No. 1, February, pp. 67-86.

Kanwar, Sunil (1994), "Are Production Risk and Labour Market Risk Covariant?", CDE Working Paper No. 24, Delhi School of Economics, Delhi.

Newbery, D. and J. Stiglitz (1981), *The Theory of Commodity Price Stabilization: A Study in the Economics of Risk*, Clarendon Press, Oxford.

Roe, T. and T. Graham-Tomasi (1986), "Yield Risk in a Dynamic Model of the Agricultural Household", in Inderjit Singh, L. Squire and J. Strauss (Eds.) (1986), *Agricultural Household Models: Extensions, Applications, and Policy*, The Johns Hopkins University Press, Baltimore, U.S.A.

Rosenzweig, Mark (1980), "Neoclassical Theory and the Optimizing Peasant: An Econometric Analysis of Market Family Labour Supply in Developing Countries", *Quarterly Journal of Economics*, Vol. 94, No. 1, February, pp. 31-56.

Sumner, Daniel (1982), "The Off-Farm Labour Supply of Farmers", *American Journal of Agricultural Economics*, Vol. 64, No. 3, August, pp. 499-509.

Walker, T. and K. Subbarao (1982), *Yield and Net Return Distributions in Common Village Cropping Systems in the Semi-Arid Tropics of India*, Report 41, International Crops Research Institute for the Semi-Arid Tropics, Patancheru (A.P.).

Young, Douglas (1979), "Risk Preferences of Agricultural Producers: Their Use in Estimation and Policy", *American Journal of Agricultural Economics*, Vol. 61, No. 5, December (Proceedings Issue), pp. 1063-1084.