Effects of Off-Farm Work on Farm Household Production Choices

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The impact of rural-urban migration on agriculture has important policy implications in less-developed countries, where policy makers face the dual task of facilitating food production for an underfed population and providing inexpensive labor for emerging industries. If labor migration from farm to industry reduces agricultural output, the consequent inflation can weaken industry competitiveness (Ray 1998). A number of probable conditions have been defined under which such an outcome is unnecessary. Lewis (1954) and Ranis and Fei (1961) argue farm labor is generally overabundant in less-developed countries, so farm production is little affected by labor movement. The Agricultural Household Model (AHM) predicts similarly, in the presence of a perfect farm labor market, that household production choices are independent of consumption and employment (Singh, Squire, and Strauss 1986). The New Economics of Labor Migration (NELM) postulates that, while productive labor lost to non-farm sectors reduces farm production in the short run, migrant remittances home can compensate for the loss by financing new farm technology (Stark and Bloom 1985).

Using a unique 1995 – 2002 panel dataset of 68 rural households in China's Anhui Province, this paper tests these various theoretical possibilities. Our analysis addresses a number of important issues in China's economic development. To what extent has China's rapid economic growth, fueled by inexpensive rural labor, compromised grain production? Has such an agricultural labor drain induced any technological progress in agriculture? Did rural labor supply continue by the turn of the 21st century to be responsive to rising industrial labor demand, when a considerable portion of the rural population already was working in cities?

Labor Market Equilibria

We cast our analysis in the Agricultural Household Model (AHM) framework. The AHM historically has been used to study agricultural household behavior and answer rural development policy questions (see Singh, Squire, and Strauss (1986) for a collection of applications). A feature of our model that is missing in traditional AHMs is the introduction of heterogeneous off-farm labor markets in which wages are allowed to be higher than the agricultural wage. Such a feature enables us to account for the urban-rural wage differentials widely observed in less developed countries, a phenomenon that has served as the foundation of reasoning in dualistic models of economic development (Lewis 1954; Ranis and Fei 1961).

Suppose that off-farm labor markets are heterogeneous in the sense that wages reflecting the personal productivities of a household's members. Such intra-household productivity heterogeneity implies that a rational household would send to off-farm work first its most productive member, then its second-most productive, and so on. In other words, intra-household productivity heterogeneity implies decreasing marginal returns to off-farm labor supply. To formalize this assumption in continuous time, let M denote the total amount of time the household members spend on off-farm work. Let $w^f(M;\alpha,\beta)$ denote the household's off-farm wage function, which decreases in M and depends on a vector α of household demographic and human capital characteristics and a vector β of off-farm labor demand factors. The household's total earnings from off-farm employment is the integral of that wage function over off-farm employment time:

$$R = G(M;\alpha,\beta) = \int_0^M w^f(m;\alpha,\beta)dm \tag{1}$$

where m is the integration variable for M. Off-farm wage is positive, $w^f > 0$, and decreases with time worked, $\frac{dw^f}{dm} < 0$. Therefore, the off-farm earnings function is increasing and concave in M: $G_M > 0$ and $G_{MM} < 0$.

The agricultural household's time allocation decision is made jointly with its consumption and production decisions. Suppose the household possesses and maximizes a twice continuously differentiable quasi-concave utility function

(2) $$U(C, S; \alpha)$$

subject to the budget constraint

(3) $$C + wS = I$$

where C is consumption, S leisure, w the market wage of agricultural labor, and I the budget constraint or full income of the household. Full income is composed of a time endowment, agricultural production profit, net off-farm income, and exogenous income:

(4) $$I = wT(\alpha) + pY - wL - rK + R - wM + E$$

where

$T(\alpha)$ = time endowment
Y = output
L = on-farm labor
K = non-labor input
M = off-farm labor
R = off-farm income
E = exogenous income
p = output price
w = agricultural wage
r = price of non-labor input.

The relationship between agricultural output and inputs is governed by a twice continuously differentiable and concave production function:

$$Y = Q(L, K; \theta) \tag{5}$$

in which θ is a vector of farmland characteristics and technology constraints which determine productive efficiency.

The above utility maximization problem can be solved recursively: full income (4) is first maximized subject to production function (5) and off-farm earnings equation (1). Utility function (2) is then maximized subject to the budget constraint (3), where full income I is now the maximized income obtained in the first stage (see Strauss (1986) for a formal treatment). Solving the full model gives the equilibrium quantities of consumption, production inputs and output, and off-farm employment. In the following, we focus only on production choices and off-farm employment, with which our empirical analyses are concerned.

Now we make two assumptions as representative of the labor market conditions in less developed countries. Suppose that the agricultural labor market is imperfect in the sense the agricultural labor wage w does not clear the market. This occurs, for example, when family and hired labor are imperfectly substitutable in agricultural production or in the presence of agricultural labor supply shortage. Evidence abounds of agricultural labor market imperfection in less developed countries (e.g., Barrett 1996; Carter 1984; Jacoby 1993; Kevane 1994; Udry 1998).

Further, following Benjamin (1992) we assume off-farm employment opportunity is limited:

$$M^* \leq \bar{M}(\alpha, \beta). \tag{6}$$

Constraint $\bar{M}(\alpha,\beta)$ is determined either by demand factors in the off-farm labor markets for which a household's members are qualified, or by institutional and informational barriers to entry into those markets. Limitations to off-farm labor demands especially affect short-term off-farm jobs. Household members qualified for such jobs whose wage exceeds the agricultural wage would spend the remainder of their time in agricultural production or unemployment. China's *hukou*, a residence registration system, is an example of the institutional barrier to free rural-urban labor migration: the system has been, and is still, used to determine qualifications for urban work opportunities and welfare programs. The informational barrier refers to rural residents' inaccess to urban job information.

In the absence of a perfect farm labor market, and when the off-farm employment constraint is binding, the time allocation equilibrium condition of our model is

$$pQ_l(L^*,K^*;\theta) = w^*(p,r,\theta,\alpha,E,\bar{M}(\alpha,\beta)) < w^f(M^* = \bar{M}(\alpha,\beta)) \tag{7}$$

where w^* is the shadow wage of the last unit of labor employed in agricultural production. In an imperfect agricultural labor market, the opportunity cost of family labor is not the exogenously determined market wage; it is rather the shadow wage, which depends on the household's consumption, production, and employment decisions. Because of the binding constraint on off-farm employment, the returns to such employment remain higher than to on-farm employment. Solving the above equilibrium condition gives the equilibrium quantities of agricultural labor $L^* = L(p,r,\theta,\alpha,E,\bar{M}(\alpha,\beta))$, non-labor $K^* = K(p,r,\theta,\alpha,E,\bar{M}(\alpha,\beta))$, output $Y^* = Y(p,r,\theta,\alpha,E,\bar{M}(\alpha,\beta))$, and of off-farm employment $M^* = \bar{M}(\alpha,\beta)$. These factor demand and product supply equations are the theoretical framework of our ensuing empirical analysis.

Data

Our empirical analysis is based on a panel dataset derived from a multi-year repeated household survey conducted by the Research Center for the Rural Economy (RCRE) at China's Ministry of Agriculture. Our dataset contains detailed information on demography, land, production, and employment of 68 households from a village in Anhui province, China, from 1995 to 2002. The information was recorded in daily diaries by the respondent households and collected once a month by the county representative of RCRE's survey department. One of the most challenging issues with the RCRE data is intertemporal coding inconsistency, for example in household ID, due to recurring changes in the questionnaire and local survey personnel. Developing longitudinal datasets with a large number of households accurately matched overtime has proven difficult. We therefore requested experts at the RCRE to select a village they have visited and carefully match and verify the survey data in that village, using their knowledge of the survey process and the village's background information.

Table 1 presents summary statistics of the key variables in our analysis. The price indexes are for Anhui province, published in the Chinese Statistical Yearbook (1995-2002). Income is deflated to the 1995 yuan. Survey respondents did record the labor they hired; but its sample mean was less than 2 person-days per year, an indication of an inactive farm labor market. Off-farm employment is much more common in this sample, accounting for about 45% of total labor supply in the average household. The rest of the labor is allocated between rice production and a variety of activities, which are collectively called non-rice production.

The majority of farmland appears to have been used for rice production in the surveyed village. Multiple cropping seems to be a common practice in rice production, as the ratio of planted to household-owned land area is far greater than one. The average household owns 3.66 mu (0.6 acres) of farmland. Farming is highly labor-intensive, as indicated by the small amount of farm machinery reported. Nevertheless, the small land patches have been well exploited: an average household was able to harvest 453 kg of rice per planted mu of land, or 6,071 lbs/acre. By comparison, the average US rice farmer produced 5,983 lbs/acre during the same time period, although at a much larger operational scale and with highly sophisticated technologies (USDA, 2002 Rice Yearbook).

In terms of where it stands in the national population of villages, the surveyed village is moderately above average in both rice yield and per capita income. Our sample-mean yield (453 kg/mu) is slightly above the national average, 415 kg/mu, in the same period (International Rice Research Institute, 2009). In 2004, the surveyed village's per capita income was 3,700 yuan, 26% higher than rural China's average per capita income, 2,936.

Empirical Results

We first check the comparative statics implications of our theoretical model against our data. The comparative static analysis follows Strauss (1986). We report the key results in table 2, which contains the signs of the derivatives of the shadow wage (w^*), agricultural output (Y^*), labor (L^*), labor-saving input (K_{sub}^*), and labor-complementing input (K_{com}^*) with respect to off-farm employment ($\bar{M}$), exogenous income (E), output price (p), labor-saving input price (r_{sub}), and labor-using input price (r_{com}).

We regress factor demands and output supply—labor in rice production, labor in non-rice production, owned farm machinery, fertilizer use, planted rice land area, and rice output—on off-farm labor, off-farm income, and other the production and price variables presented in table 1. For each dependent variable, an additional regression is run excluding off-farm income. The coefficient of off-farm employment in that regression represents both a labor-drain and an income effect. When off-farm income is instead included, the same coefficient measures the labor-drain effect only. These regressions are estimated with the Random and Fixed Effects model, each with an AR(1) error, and the results presented in tables 4 and 5, respectively.

The parameter signs in tables 3 and 4 agree uniformly with the signs predicted in table 2, provided that farm machinery is interpreted as labor-saving and fertilizer- and land-use intensity as labor-using. And those interpretations are reasonable: farm machinery in our surveyed village is mainly a labor-saving substitute for the cattle used in land cultivation, and fertilization and intensified farming each require an especially large labor input. The first four column of tables 3 and 4 show that boosting off-farm employment reduces labor use in both rice and non-rice production. In particular, the negative effect on non-rice production is much stronger than that on rice production, indicating that labor productivity is higher in rice than in non-rice production. The extra income from off-farm employment appears also, as predicted in table 2, to bring increased leisure and to reduce labor supply in both rice and non-rice production, although the statistical significance is—especially in the fixed-effects models—low.

The fifth and sixth columns of tables 3 and 4 show that as a substitute for labor, farm machinery stocks respond positively but nonsignificantly to both labor withdrawal and

increased income, mitigating the resulting labor shortage. It also responds negatively and moderately significantly to own-price changes. Machinery stocks respond positively as well to output prices, and farm labor use responds positively to machinery price. These results are consistent with the comparative statics in table 2. Finally, the regressions for fertilizer use, planted rice land, and rice output in the next six columns of tables 3 and 4 show that the effects of labor withdrawals—and of the resulting income gains—on the demands for labor-using inputs and output are all negative. These are intuitively rational responses to a shortage of agricultural labor and are consistent with the comparative statistics.

Despite the weak statistical significance of some of these parameters, such complete agreement between theory and data strongly supports our model as the data-generating process underlying our sample. We now use those regressions to examine the impacts of off-farm employment on agricultural production.

Impact Assessment

We first examine the impacts on households' time allocation decisions. Implicit in the table 3 and 4 regressions is that the household's total time endowment is divided into four activities: leisure, rice production, non-rice production, and off-farm employment. Labor withdrawn to off-farm employment perturbs the time allocation equilibrium in two ways. The first way is that lost family labor simply reduces the labor available to the other three activities; this is the labor drain effect. The strength of such an effect may, depending on their relative contributions to the household's collective utility, differ across household activities. The second way is an income effect. Because the return to off-farm employment is higher than its opportunity cost, additional off-farm employment raises total family

income, in turn boosting the demand for leisure and further dampening the labor supplied to rice and non-rice production.

The size estimates of these effects are summarized in table 5. Households with an opportunity to lift their off-farm employment time will draw about 70% of that time from leisure and 30% from household production activities. Of the 30% production time lost, most will come from non-rice production and only a small fraction from rice production; this is the overall effect. The extra income from better-paid off-farm work does stimulate leisure consumption, but only weakly so. In particular, the income gained from a 100-person-day rise in off-farm employment increases leisure by 12 person-days; this is the income effect. Had income compensation not been provided in exchange for the labor drain, about 80% of the lost time would have been drawn from leisure; this is the labor drain effect.

The breakdown in table 5 reveals clearly the household's subjective ordering, by contribution to collective utility, of the four activities to which time is allocated. In descending order, they are off-farm employment, rice production, non-rice production, and leisure. Because, as said earlier in the data section, our sample is moderately above the national average in rice yield and per capita income, the implication is that by the end of the 2002 sample period, rural labor supply remained abundant and highly elastic in a large part of China. Its abundance is indicated by the significant number of low-return non-rice production activities, and its high elasticity by the substantial amount of leisure given up when labor is withdrawn from household production.

Consider now off-farm employment's impacts on rice output. Its overall impact on rice yield is a negative 73 (36) kg per 100 person-days in the fixed- (random-) effects estimator (see the last two columns in tables 4 and 5). Applying the 73 kg per 100 person-

days ratio to the sample-mean number of days worked in off-farm employment, we find that, had no off-farm employment been available at all, rice yield would have been only 10% higher than it was. Considering that labor drains also reduce household food demand—73 kg is close to a 100-day rice intake in an average southern Chinese for whom rice is the principal grain—such yield loss is of little consequence. From the standpoint of government officials concerned with grain output and price stability, the paucity of rice yield given up when farm labor is withdrawn suggests China has long escaped, or perhaps never endured, surplus labor in the Lewis sense. A better characterization of China's development stage at the turn of the 21st century is one of disguised unemployment, in which the marginal productivity of labor is nonzero but fairly low (Ranis and Fei 1961).

In production theory, resource constraints affect output supply by altering input use or technology. It is interesting, therefore, to further decompose the overall production loss into its input and technology components. The result is sharper insight into the adjustments households make in the face of off-farm employment opportunities. Consider the first-order decomposition of off-farm employment's impact on rice yield:

$$\frac{dY}{d\bar{M}} = \sum_{i=1}^{4} \frac{\partial Y}{dX_i} \frac{dX_i}{d\bar{M}} + \frac{\partial Y}{d\theta} \frac{d\theta}{d\bar{M}} \tag{8}$$

where Y is rice output, X is a vector of four inputs (labor, farm machinery, fertilizer, and land), and θ an efficiency index summarizing all immeasurable technological constraints. Because off-farm employment's effects on factor demands ($dX_i/d\bar{M}$) and output supply ($dY/d\bar{M}$) have been estimated in tables 3 and 4, it suffices to estimate the rice production function in its first-order-approximation form. We thus regress rice output on the four production inputs and on the control variables used in the factor demand and output supply

regressions in tables 3 and 4. This amounts, by the Frisch-Waugh theorem, to regressing the residuals from the rice supply regression on the residuals from the input demand regressions, thereby eliminating the correlation between output and inputs that is induced by the controls. Even after such a procedure, endogeneity bias may—as noted by Mundlak (2001)—arise in the presence of any missing variable influencing input use. Mundlak suggested the fixed-effects estimator for correcting such bias.

For comparison, we report in table 6 the production functions estimated through the fixed and random effects AR(1) estimators. Parameter estimates on all inputs but farm machinery are statistically significant at the 1% level, and their magnitudes fairly stable across regressions. The off-farm-employment parameter becomes, after controlling for inputs, highly insignificant. The suggestion is that off-farm employment is responsible for no productivity progress, that it affects rice production only by way of the input use adjustments induced through the increased family labor scarcity. The fixed-effects model's parameter estimates for off-farm income, on the other hand, are significantly negative at the 5% level. Rising leisure demand can be reflected in both work time and work intensity, and this negative income effect may be capturing the lowered work intensity.

In light of off-farm employment's insignificant productivity effect, we drop the last term in decomposition equation (8), then compute and report in table 7 the components associated with inputs. The fixed-effects estimator's overall rice output effect *estimated* from table 5's output supply regression is remarkably close to the *computed* value using decomposition equation (8) and table 6's production function parameter estimates (-0.731 vs. -0.729), while the random effects estimator's is much less so (-0.357 vs. -0.464). The fixed-

effects estimator's superior performance indicates the possible presence of Mundlak-type endogeneity bias in production function estimation.

The last column of table 7 provides the proportional decomposition of the overall rice output effect of off-farm employment. Labor-replacing mechanization does mitigate the labor shortage brought about by increased off-farm employment, but this mitigation accounts for only about 1% of total output loss. Mechanization's negligible rice yield effect, combined with its weak statistical significance in the machinery adoption regressions in tables 3 and 4, suggest machinery's limited substitutability for labor in Chinese rice production. This is hardly surprising in light of the generally small and fragmented land holdings of rural Chinese households, which restrain effective farm machinery use.

Conclusions

The impact of rural-urban migration on agriculture has important policy implications in less developed countries, where policy makers are facing the dual tasks of facilitating food production for an underfed population and providing inexpensive labor for emerging industries. Recent food price inflation in China has raised great concerns among policy makers about the food security implications of the grand rural-urban migration China now is experiencing. Using a unique panel of rice farmers in Anhui, China, this article examines migration's impacts on farm production.

The households in our panel have responded to labor withdrawals in a manner highly consistent with the Agricultural Household Model. In the face of increased labor scarcity, they have adopted farm machinery to replace the labor-consuming cattle, reduced land and fertilizer intensity, and cut back on both leisure and non-rice production labor. Yet the

overall rice output effects of these adjustments have been of little consequence. This is because labor supply has remained both abundant and highly elastic. The implication is that Lewis's dualistic model of economic development remains relevant for the development path of China, even after a sizable proportion of its rural population has already moved to cities.

On the other hand, labor withdrawals and increased household income have spurred little productivity improvement to the rice farmers in the analyzed panel. While the stability of rice production should relieve China's policy makers, stagnant agricultural productivity growth is unfortunate evidence of the paucity of profitable investment alternatives available to rural Chinese. Further land market reforms and greater research and extension efforts are required to improve the livelihood of China's rural population.

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Table 1. Descriptive Statistics of Key Variables Analyzed

Variable Name (Unit)	Mean	S.D.	Min.	Max.
Demographic and Educational Variables				
Education of Household Head	2.55	0.64	1.00	4.00
Age of Household Head	40.52	10.33	19.00	67.00
Number of Working-Age Members	2.53	0.85	1.00	6.00
Time Allocation				
Labor in Rice Production (person-days)	210.87	93.58	0.00	740.00
Labor in Non-Rice Production (person-days)	179.16	125.56	0.00	1142.00
Off-Farm Labor (person-days)	312.93	145.63	0.00	933.00
Off-Farm Income (yuan)	7,312.28	3,507.25	9.00	24,470.00
Production and Price Variables				
Rice Output (kg)	2,316.50	784.85	0.00	5,100.00
Farm Machinery (horsepower)	0.85	1.52	0.00	8.00
Fertilizer Use (yuan)	564.49	202.35	0.00	1,580.00
Planted Rice Land Area (mu)	5.44	2.01	0.00	11.60
Owned Land Area (mu)	3.66	1.16	0.80	6.00
Rice Price (1995 Price = 1.00)	1.63	0.23	1.16	1.94
Machinery Price Index (1995 Price = 1.00)	0.89	0.08	0.76	1.00
Fertilizer Price Index (1995 Price = 1.00)	0.90	0.11	0.77	1.09
Rainfall (mm)	1,151.73	174.28	858.06	1,394.16

Note: The dataset is a balanced panel with 544 observations on 68 households from 1995 through 2002. Education of Household Head is a categorical variable with illiterate, elementary school, middle school, and high school and above indicated respectively by the values 1 through 4, in ascending order. Off-Farm Income is deflated by the Rural Consumer Price Index published in the China Statistical Yearbook; Fertilizer Use is the total fertilizer expenditure divided by a Fertilizer Price Index. The Fertilizer Price Index and Machinery Price Index are provincial-level data taken from the Chinese Statistical Yearbook.

Table 2. Comparative Statics under Imperfect Agricultural Labor Market and Binding Off-farm Employment Constraint

	Off-Farm Employment ($\bar{M}$)	Exogenous Income (E)	Output Price (p)	Labor-Saving Input Price (r_{sub})	Labor-Using Input Price (r_{com})
Shadow Wage (w^*)	+	+	+	+/-	-
Output (Y^*)	-	-	+/-	+/-	+/-
Labor (L^*)	-	-	+/-	+	+/-
Labor-saving Input (K^*_{sub})	+	+	+	-	
Labor-using Input (K^*_{com})	-	-	+/-		+/-

Note: Entries are signs of the derivatives of row (endogenous) variables with respect to column (exogenous) variables; an indeterminate sign is indicated by "+/-".

Table 3. Effects of Off-Farm Employment on Household Production Choices: Random Effects-AR(1) Estimation

	Explained Variable					
	Labor in Rice Production		Labor in Non-Rice Production		Farm Machinery	
Off-Farm Labor	-0.026	-0.038*	-0.201***	-0.282***	2.8E-04	4.4E-04
	(0.026)	(0.021)	(0.044)	(0.037)	(3.7E-04)	(3.3E-04)
Off-Farm Income	-0.001		-0.007***		1.7E-05	
	(0.001)		(0.002)		(1.6E-05)	
Lagged Rice Price	89.217***	88.336***	2.906	-7.134	0.312	0.337
	(24.658)	(24.587)	(39.099)	(39.301)	(0.309)	(0.308)
Fertilizer Price Index	506.913***	500.900***	354.949***	310.653***	0.804	0.916
	(57.274)	(56.799)	(92.475)	(92.522)	(0.825)	(0.819)
Machinery Price Index	133.933	142.259	43.928	99.870	-2.018	-2.174
	(104.101)	(103.652)	(167.276)	(168.065)	(1.464)	(1.457)
Rainfall	0.041**	0.041**	-0.046*	-0.049*	3.3E-04	3.4E-04
	(0.017)	(0.017)	(0.028)	(0.028)	(2.2E-04)	(2.2E-04)
Owned Land Area	26.443***	26.556***	9.053	10.535	0.215*	0.212*
	(3.518)	(3.517)	(8.109)	(8.329)	(0.120)	(0.120)
Education of Household Head	5.322	5.265	2.539	2.953	0.002	0.001
	(4.864)	(4.865)	(9.245)	(9.394)	(0.091)	(0.091)
Age of Household Head	0.644*	0.636*	-0.308	-0.367	0.018*	0.018*
	(0.350)	(0.350)	(0.773)	(0.792)	(0.010)	(0.010)
# of Working-Age Members	18.773***	18.711***	43.567***	39.797***	-0.017	0.001
	(4.903)	(4.904)	(10.688)	(10.915)	(0.136)	(0.135)
R^2	0.61	0.61	0.39	0.35	0.07	0.07
Autocorrelation Coeff.	0.25	0.25	0.28	0.29	0.51	0.52

Table 3 (continued). Effects of Off-Farm Employment on Production Choices: Random Effects-AR(1) Estimation

	Explained Variable: Rice Yield					
	Fertilizer Use		Planted Rice Land Area		Rice Output	
Off-Farm Labor	-0.086	-0.158***	-1.7E-03***	-2.2E-03***	-0.238	-0.357*
	(0.066)	(0.056)	(4.1E-04)	(3.6E-04)	(0.233)	(0.200)
Off-Farm Income	-0.006**		-4.5E-05***		-0.010	
	(0.003)		(0.000)		(0.010)	
Lagged Rice Price	-5.836	-14.520	-0.651*	-0.721**	733.550***	709.304***
	(58.315)	(58.232)	(0.352)	(0.349)	(206.029)	(204.821)
Fertilizer Price Index	409.280***	367.692***	-0.738	-1.029	44.507	-12.652
	(138.105)	(138.214)	(0.927)	(0.928)	(492.576)	(489.307)
Machinery Price Index	-729.879***	-676.093***	1.046	1.426	2709.907***	2747.010***
	(249.737)	(250.594)	(1.644)	(1.649)	(888.785)	(885.828)
Rainfall	-0.076*	-0.078*	-1.9E-04	-2.1E-04	0.663***	0.653***
	(0.041)	(0.041)	(2.5E-04)	(2.5E-04)	(0.145)	(0.145)
Owned Land Area	63.964***	65.333***	1.140***	1.148***	375.499***	378.173***
	(13.739)	(13.747)	(0.101)	(0.101)	(49.835)	(49.876)
Education of Household Head	0.668	1.308	0.098	0.103	-33.580	-32.776
	(14.421)	(14.495)	(0.096)	(0.097)	(51.580)	(51.622)
Age of Household Head	4.480***	4.385***	0.005	0.005	11.778***	11.636***
	(1.279)	(1.285)	(0.009)	(0.009)	(4.629)	(4.641)
# of Working-Age Members	44.272***	40.300**	0.454***	0.422***	213.589***	205.997***
	(17.616)	(17.600)	(0.126)	(0.125)	(63.622)	(63.446)
R^2	0.29	0.29	0.61	0.61	0.42	0.42
Autocorrelation Coeff.	0.28	0.30	0.48	0.51	0.30	0.31

Table 4. Effects of Off-Farm Employment on Household Production Choices: Fixed Effects-AR1 Estimation

	Explained Variable					
	Labor in Rice Production		Labor in Non-Rice Production		Farm Machinery	
Off-Farm Labor	-0.066**	-0.072***	-0.184***	-0.205***	2.2E-04	3.1E-04
	(0.031)	(0.028)	(0.050)	(0.046)	(4.1E-04)	(3.8E-04)
Off-Farm Income	-0.001		-0.002		1.1E-05	
	(0.001)		(0.002)		(1.8E-05)	
Lagged Rice Price	166.957***	166.639***	-31.652	-33.720	0.275	0.286
	(27.168)	(27.085)	(44.420)	(44.318)	(0.350)	(0.349)
Fertilizer Price Index	282.062***	275.754***	366.812***	346.352***	1.315	1.438
	(68.907)	(67.912)	(116.747)	(115.370)	(1.220)	(1.205)
Machinery Price Index	379.453***	385.679***	32.235	55.961	-2.318	-2.429*
	(107.740)	(106.667)	(177.729)	(176.145)	(1.489)	(1.477)
Rainfall	0.060***	0.060***	-0.059**	-0.060**	3.3E-04	3.4E-04
	(0.017)	(0.017)	(0.027)	(0.027)	(2.2E-04)	(2.2E-04)
Owned Land Area	5.692	6.119	105.087***	107.310***	-0.092	-0.104
	(21.224)	(21.164)	(34.883)	(34.803)	(0.275)	(0.274)
Education of Household Head	0.701	0.813	8.808	9.199	-0.018	-0.020
	(7.468)	(7.459)	(12.387)	(12.388)	(0.107)	(0.107)
Age of Household Head	0.750	0.756	1.006	1.045	0.001	0.001
	(0.933)	(0.933)	(1.571)	(1.574)	(0.015)	(0.015)
# of Working-Age Members	26.459**	25.307**	-14.394**	-18.895	0.038	0.059
	(12.308)	(12.008)	(20.525)	(20.073)	(0.185)	(0.181)
R^2	0.46	0.46	0.09	0.08	0.00	0.00
Autocorrelation Coeff.	**0.25**	**0.25**	**0.28**	**0.29**	**0.51**	**0.52**

Table 4 (Continued). Effects of Off-Farm Employment on Household Production Choices: Fixed Effects-AR1 Estimation

	Explained Variable					
	Fertilizer Use		Planted Rice Land Area		Rice Output	
Off-Farm Labor	-0.198***	-0.260***	-2.1E-03***	-0.002***	-0.441*	-0.731***
	(0.076)	(0.069)	(4.3E-04)	(0.000)	(0.265)	(0.243)
Off-Farm Income	-0.007**		-4.1E-05**		-0.031***	
	(0.003)		(1.9E-05)		(0.011)	
Lagged Rice Price	40.669	34.631	-0.800**	-0.839**	-24.952	-57.693
	(66.525)	(66.493)	(0.371)	(0.367)	(232.406)	(233.476)
Fertilizer Price Index	292.466*	225.840	0.265	-0.092	2847.554***	2610.695***
	(175.349)	(176.031)	(1.239)	(1.259)	(624.575)	(626.474)
Machinery Price Index	-597.783**	-526.401**	1.081	1.548	41.980	374.427
	(266.360)	(265.335)	(1.560)	(1.549)	(934.842)	(934.575)
Rainfall	-0.059	-0.061	-2.0E-04	-2.2E-04	0.493***	0.475***
	(0.041)	(0.041)	(2.4E-04)	(2.3E-04)	(0.143)	(0.144)
Owned Land Area	21.452	25.883	0.710**	0.741***	330.548*	356.774**
	(52.260)	(52.304)	(0.292)	(0.288)	(182.946)	(183.857)
Education of Household head	-27.467	-26.152	-0.128	-0.116	-144.720**	-139.106**
	(18.572)	(18.706)	(0.112)	(0.112)	(65.367)	(66.015)
Age of Household Head	4.096*	4.096*	0.007	0.008	-1.021	-0.620
	(2.358)	(2.394)	(0.016)	(0.016)	(8.369)	(8.497)
# of Working-Age Members	79.065***	64.098**	0.515***	0.435**	389.924***	322.035***
	(30.787)	(30.400)	(0.192)	(0.190)	(108.678)	(107.531)
R^2	0.22	0.23	0.56	0.58	0.35	0.37
Autocorrelation Coeff.	0.28	0.30	0.48	0.51	0.30	0.31

Table 5. Impacts of Off-Farm Employment on Time Allocation

	Estimator: Fixed Effects with AR(1) Errors		
	Labor Drain Effect	Income Effect	Overall Effect
Labor in Rice Production	-6.6%	-0.6%	-7.2%
Labor in Non-rice Production	-7.2%	-13.3%	-20.5%
Leisure	-86.2%	13.9%	-72.3%
	Estimator: Random Effects with AR(1) Errors		
	Labor Drain Effect	Income Effect	Overall Effect
Labor in Rice Production	-2.6%	-1.2%	-3.8%
Labor in Non-rice Production	-20.1%	-8.1%	-28.2%
Leisure	-77.3%	9.3%	-68.0%

Note: Estimates of the labor drain effects on rice and non-rice labor are from the corresponding regressions in tables 4 and 5 which control for off-farm income; estimates of the overall effects are from the regressions excluding off-farm income; the income effect is the overall effect net of the labor drain effect. The labor drain effect on leisure is computed by subtracting from negative one the labor drain effects on rice and non-rice labor; the income effect on leisure is the negative of the total effects on rice and non-rice labor; the overall effect on leisure is negative one minus the overall effects on rice and non-rice labor. The numbers reported in the text are approximate averages of the estimates by FE-AR(1) and RE-AR(1).

Table 6. Rice Production Function Estimation

	Explained Variable: Rice Output			
	FE-AR1		RE-AR1	
Production Inputs				
Labor in Rice Production	3.87***	3.81***	2.73***	2.73***
	(0.39)	(0.40)	(0.39)	(0.39)
Farm Machinery	28.20	24.94	25.07	25.28
	(23.04)	(23.12)	(16.96)	(16.92)
Fertilizer Use	0.98***	1.01***	1.34***	1.34***
	(0.16)	(0.16)	(0.15)	(0.15)
Planted Rice Land Area	90.91***	99.88***	72.82***	72.46***
	(24.71)	(24.51)	(21.53)	(21.44)
Control Variables				
Off-Farm Labor	0.212	0.058	0.181	0.206
	(0.201)	(0.189)	(0.194)	(0.161)
Off-Farm Income	-0.018**		0.002	
	(0.008)		(0.008)	
Lagged Rice Price	-608.49***	-608.67***	599.68***	601.80***
	(186.17)	(187.24)	(184.10)	(183.66)
Fertilizer Price Index	1037.94**	891.42**	-1893.32***	-1880.73***
	(441.71)	(439.05)	(455.35)	(451.83)
Machinery Price Index	-758.87	-542.90	3621.17***	3604.02***
	(709.10)	(706.16)	(766.81)	(762.52)
Rainfall	0.38***	0.38***	0.70***	0.70***
	(0.11)	(0.11)	(0.13)	(0.13)
Owned Land Area	231.05*	235.96*	99.21***	99.49***
	(135.60)	(136.36)	(35.55)	(35.51)
Education of Household Head	-105.56**	-100.22**	-44.86	-44.68
	(47.24)	(47.44)	(37.48)	(37.44)
Age of Household Head	-8.35	-8.32	5.35*	5.37*
	(5.84)	(5.87)	(2.84)	(2.84)
# of Working-Age Members	187.42**	145.09*	53.84	54.35
	(78.63)	(76.63)	(39.22)	(39.14)
R^2	0.68	0.68	0.74	0.74
Autocorrelation Coeff.	0.23	0.23	0.23	0.23

Table 7. Decomposition of Off-Farm Employment' Effects on Rice Output

	$\frac{dX}{d\bar{M}}$ & $\frac{dY}{d\bar{M}}$	$\frac{\partial Y}{\partial X}$	$\frac{\partial Y}{\partial X}\frac{dX}{d\bar{M}}$	
	(Estimated)	(Estimated)	(Computed)	(Computed %)
	Estimator: Fixed Effects with AR(1) Errors			
Choice Variable *X*				
Leisure	-0.723	–	–	–
Labor in Non-Rice Production	-0.205	–	–	–
Labor in Rice Production	-0.072	3.810	-0.274	37.6%
Farm Machinery	3.1E-04	24.940	0.008	-1.1%
Fertilizer	-0.260	1.010	-0.263	36.0%
Planted Rice Area	-0.002	99.880	-0.200	27.4%
Rice Output	-0.731	–	-0.729	100.0%
	Estimator: Random Effects with AR(1) Errors			
Leisure	-0.680	–	–	–
Labor in Non-Rice Production	-0.282	–	–	–
Labor in Rice Production	-0.038	2.730	-0.104	22.4%
Farm Machinery	4.4E-04	25.280	0.011	-2.4%
Fertilizer	-0.158	1.340	-0.212	45.7%
Planted Rice Area	-0.002	72.460	-0.159	34.4%
Rice Output	-0.357	–	-0.464	100.0%