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Risk and Rice Farming Intensification in Rural Java

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The objectives of paper are to indentify how rural households in Java cope with risks and use management mechanisms and to investigate the incentive or disincentive effects of these mechanisms in food production. For these purposes, we have tried through our field survey to show evidence that rural households in our study area have adopted multiple measures for risk reduction. And we also make an empirical analysis about the incentive or disincentive effects of the mechanisms on crop prosuction. Form this study, we found that gifts through family ties and diversification of income to less risky sources gave positive incentives to enhance productivity, but share tenancy contracts had disincentive effects. We also found that serious pest damage discouraged the farmers to intensify current input use. It is remarkable that the farmers did not adopt the self-accumulation and/or deaccumulation of farm assets because it was unprofitable for the extremely small-scale Java farmers to hold fixed capital, and it was too costly to part with their owned land.

Key words: risk, rural household, market imperfection, risk-coping mechanism, risk-management mechanism, farming intensification.

1. Introduction

Since the beginning of the 1990s, food production in Indonesia has been characterized by stagnation. Indeed, it has advanced to such a stage that since the mid 1990s, food security itself has come under threat. Several economic forces responsible for the stagnation of food crop production have been identified in the literature. First, the declining trend in the relative prices of food crops in Indonesia has resulted in a decrease in the fertilizer subsidy (Hill [8]; Tujii and Dwidjono [19]; Yokoyama [20]). Second, Indonesian industrial policies have proved to be disadvantageous to the development of the agricultural sector (Krueger *et al.* [9]). Third, the food crop sector is characterized by a slow rate of technical change, decreased public expenditure on irrigation infrastructure, and limited research and development (Hill [8]). Fourth, capital accumulation has caused output in the food crop sector to fall because of rapid industrialization (Martin and War [12]). Besides these four factors, the policy of food deregulation and unfavorable climatological conditions led to increased volatility in market prices and food crop production in the 1990s, thus contributing to the stagnation of the food crop sector in Indonesia.

The 1997/98 food crisis resulted directly from stagnation in the food crop sector, consequently compelling the government to change its food policy and to encourage farmers to increase food production. We observed in our field research that small farmers who experienced serious pest damage were hesitant to intensify rice farming to avert production risk caused by crop intensification. It may thus be said that small-scale farmers are reluctant to further their crop intensification program where increasing prices and yield volatility are said to prevail. This would seem to indicate that an increase in risk and uncertainty is a major economic force causing stagnation in the food crop sector in rural Java.

People who live in rural areas of developing countries often face variations in income caused by, inter alia, unpredictable yield fluctuations in agricultural production, price uncertainty, and employment uncertainty in the labor market. However, the use of credit and insurance markets, which are popular

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measures to cope with these variations in income, are imperfect in developing countries. Therefore there are some indigenous mechanisms to allocate risks of variability in income (Bardhan and Udry [1]; Kurosaki [10]).

Confronting uncertainty and incomplete markets, households try to smooth their income stream through ex-ante mechanisms. These mechanisms include the accumulation and deaccumulation of assets, formal and informal credit, gifts through the extended family, marriage, and neighbors, among others. Households also might take ex-ante actions to reduce income variance. These mechanisms include a diversification of income sources, contractual arrangements such as share tenancy, and the adoption of risk-reducing production technologies (Kurosaki [10]).

Such increasing price and yield volatility, as mentioned above, might enable the ex-ante mechanisms to achieve income smoothing only partially through the mitigation of liquidity constraints (Bardhan and Udry [1], p. 100). Conversely, the ex-ante actions might provide the disincentives to adopt more profitable technologies for farmers who prefer risk reduction to profitability (Kurosaki [11]). Therefore it is not certain whether these mechanisms to cope with risk may contribute to the mitigation of disincentive effects. Empirical studies on these mechanisms in rural Java, however, have rarely been conducted, with the exception of Ravallion and Dearden [14], even though rural Java is prominent with respect to research on the social security system (Geertz [5]; Scott [16]).

The objectives of this paper are to identify the risk-coping and management mechanisms adopted by rural households in Java suffering from serious pest damage and severe economic hardship, and to investigate the incentive or disincentive effects of these mechanisms adopted by farmers in food crop production.

The next section gives a brief description of the economic environment and the data of sample households relating to the ex-ante mechanisms adopted. We also describe ex-ante actions, such as risk-reducing technologies and contractual arrangements. The third section is a regression analysis of inputs and credit demand functions drawn from our theoretical model. The results of the analysis are presented to demonstrate whether these mechanisms have significantly positive or negative effects on the production incentives of rice-growing farmers.

2. Economic Environment and Mechanisms to Cope with Risk

1) Economic environment

Our field study was conducted in two hamlets in the northwest of Yogyakarta, Central Java, Indonesia, from 1998 to 1999. We sampled some 50 households with a random sampling method and interviews. The basic data on sample households are shown in Table 1.

The agricultural land in hamlet A was well irrigated under the technical irrigation system, and the land in hamlet B, under a rural irrigation system, was less efficiently irrigated (Hartono, Iwamoto, and Fukui [6]). In both hamlets, multiple cropping was commonly practiced. In hamlet A, triple rice cropping was possible because even in the dry season, farmers had access to a sufficient supply of water. In hamlet B, however, enough water for rice production could not always be drawn from the irrigation canal in the dry season. Therefore these farmers usually planted upland crops then.

The average yield of rice in a normal year amounts to 5 or 6 tons per ha, so the share of rice income is estimated at 30% or 40% of total income in a normal year, though the farm size is extremely small (Table 1) and farm households usually have nonagricultural income sources, including miscellaneous off-farm jobs.[1)]

In the 1997/98 crop year, the economic crisis, pests, and disease attacked the study area. In particular, the latter seriously damaged the household economy, and the average yield of rice declined dramatically (Table 1). Since the latter half of 1998, however, climatological conditions have changed for the better, and the average yields of rice have risen 20% in the rainy season and 75% in the dry season. As a result, the agricultural incomes of the sample households have partially regained lost ground (Table 1).

The average per capita income during the survey years rose in hamlet A to 1,175 kg in 1998/99, from 611 kg in 1997/98, and in hamlet B to 419 kg, from 393 kg. Although both hamlets have income levels above the poverty line (347 kg) set by the Indonesian government,[2)]

Table 1. Characteristics of sample households

Hamlet	A		B	
	97/98	98/99	97/98	98/99
Number of households	24	22	30	27
Number of farm households	20	20	26	25
Number of family laborers (man/hh)	2.08	2.18	3.00	2.48
Area of agric. -owned land (m * m/hh)	2,121	2,543	1,816	1,584
- Paddy fields	1,870	2,373	1,401	1,481
Farm size (m * m/hh)	3,006	3,163	2,595	2,320
Land use (planted area ; mm * /hh)				
- Paddy	6,474	7,212	3,918	3,743
- Nonrice crops	559	0	1,303	1,243
Crop intensity	2.34	2.28	2.01	2.15
Yield of paddy (ton/ha)				
Rainy	2.7	3.7	2.6	3.6
Dry I	3.0	3.7	3.0	3.3
Dry II	1.9	3.7	2.2	3.4
Farm asset (excluding land)				
Cow and buffalos (head/hh)	0.12	0.19	0.17	0.35
Tractors owned (number/hh)	0	0	0	0
Household income ('000 Rp/hh)	3,437	9,085	2,356	3,320
Ratio of agric. income (%)	48	64	29	35
Per capita household				
Income (rice kg/man) *	611	1,175	393	419
Outstanding debts ('000 Rp/hh)	429	675	320	138
Debt income ratio (%)	(12)	(7)	(14)	(4)

Note: To estimate the per capita income in terms of rice, we divided the nominal household incomes by the average rice prices in each year.

the level of income in hamlet B is approaching this official poverty line.

2) Risk-coping mechanisms

Next we explain the ex-post mechanisms to smooth the effect of external shocks (risk-coping mechanisms) on the basis of household data.

(a) Credit

Facing external shocks in the form of economic crisis and serious pest damage, rural households used various ex-post mechanisms to mitigate the effect of risk. Among them, the use of formal and informal credit markets to loosen liquidity constraints is the most commonly observed. Because of a sudden reduction of income, in 1997/98 many sample households borrowed from various formal and informal financial sources. In Table 1, only the average amount of long-term loans is shown, because detailed information on short-term loans could not be obtained. By definition they are considered high-frequency transactions.

To examine the hypothetical view that the sample households used loans to reduce the negative impact of pest damage, we estimate the following regression function of a long-term loan, the dummy variable representing an external shock, and other variables affecting the amount of loan.

$$Ln\ \ Y=\alpha_0+\alpha_1 LnX1+\alpha_2 LnX2+\alpha_3 LnX3+\alpha_4 LnX4+\varepsilon$$

Y: Long-term loan amount for daily consumption and education in 1998/99; X1: Household income in 1997/98; X2: Number of dependents; X3: Area of owned land; X4: Pest damage dummy (If seriously damaged by pests=1, otherwise=0, in 1998/99); ε: Random variables. α_0, α_1, α_2, α_3, α_4 are parameters of independent variables.

Table 2 shows that the parameters of the

Table 2. Pest damage and loan

Independent variable	Dependent variable; the amount of loan (Rupiah)
Constant	-1,548,609
Ln (household income in 97/98)	136,187.34
(Rupiah)	(2.039)**
The number of dependents	140,544.94
(Man)	(1.407)
Ln (area of owned land)	-113,452
(ha)	(-2.263)**
Pest damage dummy	2,706,453.2
	(5.143)*
R2	0.492
Degree of freedom	38

Note: The figures in parentheses show t statistics.
* indicates 1% significant level; ** indicates 5% significant level.

pest damage dummy and income are significantly positive. This might indicate that the households damaged by pests in 1997/98 used loans in 1998/99 and that it is expected that the higher the borrower's household income, the more certain it becomes that the borrower can repay the debt.

(b) Asset holding

Table 1 shows that only a few farmers had their own fixed capital besides land, such as tractors and draft animals. It was also reported that no sample household sold these assets to compensate for the sudden reduction in income. And rural households in the study area do not usually have bank deposits. Therefore land holding is the most common measure for asset holding. Land is usually a farmer's only asset. It is thus the most valuable asset, though the average size may be very small. Selling had hitherto never been considered an option, even after a bad harvest. Instead, some farmers damaged by pest attack in 1997/98 leased their land through the advance payment contract system in 1998/99 (Table 9).

3) Risk management mechanisms

(a) Diversification of income sources

As mentioned earlier, rural households diversify their income sources to smooth out their income stream. A sample household income and its composition are shown in Table 3.

Agriculture is the most important income source. It includes rice and upland crop farming, garden crop cultivation, livestock farming, and catfish farming. Household members are frequently engaged in sundry nonagricultural jobs, such as daily wage labor, monthly wage labor, trading, and the household industry. In the sample households, nearly half the family laborers had off-farm jobs. Moreover, their annual working days amounted to 174, and the

Table 3. Household income by source (unit: Rp per household, %)

	Hamlet A		Hamlet B	
	97/98	98/99	97/98	98/99
Household income	3,437,373.4	9,084,901.1	2,345,820.2	3,319,708
	(100)	(100)	(100)	(100)
Agricultural income	1,660,769.2	5,767,096.9	678,786.8	1,152,598
	(48.3)	(63.5)	(28.9)	(34.7)
Rice income	657,260.9	1,315,555.9	465,431.4	790,931
	(19.1)	(14.5)	(19.8)	(23.8)
Nonrice crop income	27,791.7	0	200,241.7	166,320
	(0.8)	(0)	(5.6)	(5.0)
Livestock/fish income	975,716.7	4,454,541.0	82,118.3	195,347
	(28.4)	(49.0)	(3.5)	(5.9)
Nonagricultural income	1,632,229.2	2,906,804.2	1,547,700.0	2,085,043
	(47.5)	(32.0)	(66.0)	(62.8)
Remittance	144,375.0	336,875	119,333	82,067
	(4.2)	(3.7)	(5.1)	(2.5)

Table 4. Off-farm jobs

Kind of job	Number of family laborers and average working days for off-farm jobs (man/days)
Daily wage labor (unskilled) (a)	22/50
Daily wage labor (skilled) (b)	9/114
Monthly wage labor	12/260
Trading & household industry	16/314
Subtotal	59/174
Total number of family laborers (male)	115
Average working days for off-farm job (days)	97
Average working days for rice farming (days)	36

Note: (a) Includes agricultural wage labor and nonagricultural daily wage labor.
(b) Includes carpenters, smiths, and drivers.

average annual number of off-farm job working days of all family laborers total more than twice that of laborers involved in rice farming (Table 4). All these facts indicate that off-farm job opportunities for rural households in our study area are available more than we had expected.

Remittances were also an important income source. As mentioned in section 1, gifts from relatives are sometimes adopted as ex-post mechanisms to smooth out income (Rosenzweig [17]). In our study area, however, of 14 of the sample households that received remittances from their relatives in 1998/99, only 3 had been damaged by pest attacks. This indicates that remittances were not necessarily adopted as a risk-coping mechanism. Nevertheless, it can be said that with farmers confronted by any external shock that might potentially reduce their income, remittances would undoubtedly contribute to the diminution of their liquidity constraint.

Only two years of data are not enough to identify the effects of income diversification on the smoothing out of income. But the simple regression analysis of income over the two years of the analysis implies that the parameter of off-farm income in the previous year is significantly positive, but that of crop income is not significant (Table 5). This suggests that off-farm income is more stable than crop income is. Therefore income diversification contributes to the stabilization of household income.

(b) Risk-reducing technologies

In hamlet A, rice cropping five times in two years was the most common cropping pattern, though triple cropping was also possible. The problem with triple cropping is that it causes soil fertility to decline; thus the rice plants will become vulnerable to pest attacks. In hamlet B, it was very common for farmers to plant rice in the rainy season and upland crops in the dry season. This was not only because it was very hard to grow rice during the second dry season because of a lack of water, but also because if the same crop is continually planted, soil fertility will decline and the plant will become more vulnerable to pest attacks. Thus the farmers in both hamlets chose the less intensive cropping pattern to maximum crop intensity (Table 1), because the former was

Table 5. Intertemporal correlation of income

	Off-farm income (1998/99) (Rp)	Crop income (1998/99) (Rp)
Constant	1,236,195	893,056
Off-farm income (1997/98) (Rp)	0.53(3.89)*	
Crop income (1997/98) (Rp)		0.14(0.62)
R2	0.25	0.01

Note: The figures in parentheses show t statistics.
* indicates 1% significant level.

Table 6. Crop intensity and profitability (1998/99)

Crop intensity	Average income (Rp/m2)	Coefficient of variation	Number of sample rice farmers
4 or 5 times in 2 years	1,100	0.97	25
6 times in 2 years	803	1.13	16

Table 7. Adoption of risk-reducing rice variety (Membramo)

	Number of farmers damaged by pests (household: %)	Number of sample rice farmers (household: %)
Not adopted	5	15
	(33)	(100)
Adopted	7	26
	(27)	(100)

Note: The figures in parentheses show the percentage ratio.

Table 8. Effect of pesticide application on pest damage

	Farmers damaged by pests (n=12)	Farmers not damaged by pests (n=31)	Test statistics (standard normal)
Pesticide application per unit area (Rp/m2)	2.930	5.694	1.45

more stable and profitable (Table 6).

Modern rice technologies have already been introduced in the study area, as they have in the other rice-growing areas in Java. In 1997/98, when the pest damage was particularly serious, about 90 percent of farmers used IR64 or Cisedane varieties with high yield potentials and pest resistance. Farmers then changed from the Cisadane to the Membramo variety, which has a stronger brown plant hopper resistance. From 60% to 70% of farmers used Membramo for at least one season in the 1998/99 cropping year. This new variety was expected to be effective in protecting the paddy from pest and disease. However, significant differences were not found between the frequency of pest damage among farmers who used Membramo and the frequency of pest damage among farmers who did not (Table 7).

The utilization ratio of pesticide by farmers increased in 1998/99, considered to be a response to the serious pest damage of 1997/98. To examine the hypothesis that pesticide has a negative effect on the vulnerability to pest attack, we tested the null hypothesis that the amount of pesticide used per unit area applied by the farmers who suffered serious pest damage is smaller than that applied by farmers who suffered no damage. Table 8 shows that the former is smaller than the latter, but the difference between the two is not significantly large.

(c) Contractual arrangements

Besides the adoption of risk-reducing technologies, farmers in rural Java commonly made contractual arrangements in rice farming. In our study area, we observed these arrangements as harvesting labor contract ("Bawon")[3] and share tenancy contracts utilized to cope with risk.

In the harvesting of rice, more than half the sample farmers hired laborers under the "Bawon" system (Table 9). Under this system, the wage is paid in kind on a sharing basis. The system is regarded as an arrangement for mutual help in the rural community.

The harvesting labor wage under "Bawon" (5 or 10 kg per day) was higher than the agricultural fixed daily wages (5 kg / day) for other kinds of labor. Furthermore, farmers whose crops were seriously damaged by pests more frequently participated in the "Bawon" system (Table 9). This indicates that the "Bawon" system was used as a measure to help

Table 9. Contractual arrangement (1998/99)

Kind of contractual arrangement	Number of contracts
Land tenancy (cases)	93
Share	51
Kin	26
Nonkin	25
Leasehold	38
Kin	6
Nonkin	32
Payments after harvest	28
Advance payments	10
Other types	4
"Bawon" system	
Employer	28
Employee	7
Damaged by pests	6 (12)[a)]
Not damaged by pests	1 (31)[b)]

Note: a) The figures in parentheses show the number of farmers damaged by pests in 1998/99.
b) The figures in parentheses show the number of farmers not damaged by pests in 1998/99.

the farmers whose rice income had been reduced. This would suggest that the "Bawon" System still played an important role for mutual help in the rural community and that it contributed to the smoothing of income for farmers who had suffered pest damage.

In the study area, more than half the sample farmers leased or leased out their agricultural lands. The share tenancy contract was the predominant tenancy form in the study area (Table 9). One of the strong arguments for the contractual choice of share tenancy is that it has the function of risk sharing between landowner and tenant (Cheung [3]; Stiglitz [18]). But this also implies that share tenancy generates Marshallian inefficiency, even though many empirical studies in Southeast Asia do not support the Marshallian inefficiency hypothesis (Fukui [4]; Otsuka, Chuma and Hayami [13]; Hayami and Otsuka [7]).

A key to this puzzle is the kinship in share tenancy contracts. Kinship networks have an effect of providing an environment conducive to altruistic behavior. This induces share tenants who have a kinship relationship with their landowners to behave efficiently in input use, despite the disincentive effects caused by the sharing of output (Sadoulet, de Janvry, and Fukui [15]).

Table 9 shows that share tenancy contracts with kins were frequently observed. This suggests that they may not necessarily cause Marshallian inefficiency in our study area.

3. Impacts of Income-Smoothing Behavior on the Intensification of Rice Farming

Based on the results described in the previous sections, we test the effects of ex-post and ex-ante mechanisms to cope with risk on the incentives and disincentives to increase production. For this purpose, we first consider a two-period expected utility maxmization model of a farm household to draw an empirical model. Here it is assumed that output and current input markets are perfect. These assumptions are not unrealistic. It is also assumed that there are no constraints on farm labor supply. This assumption can be justified by our findings of sufficient job opportunities in section 2 and by the findings of Benjamin [2] in which the evidence is not consistent with surplus labor. Furthermore, it is assumed that there is no credit rationing except when the loan amount depends on the borrower's ability to repay. No evidence of strict credit rationing was found except when the loan amount was constrained by the borrower's income and owned land area, as shown in section 2. In regard to the land tenancy market, a competitive contract market with a "take-it-or-leave-it" offer under information asymmetry is assumed.

Assuming that plot size is exogenous to the input decision under consideration, the problem is written for a unit of area under these assumptions as follows.

Each farm household maximizes the following present value of utility over two periods under a land tenancy contract made with a landowner in period one.[4)]

$$W_j = E_0[u_j^1(y^1+D) + \beta E_1 u_j^2\{y^2-(1+i)D\}]$$

W_j is the present value of the household's utility over two periods in period one. A household in period one can borrow D in a credit market and repay it, and interest iD in the second period. Here, D depends on the household income in the previous period (y^0) and owned land area (A). The farm household receives a random income $y^k(k=1,2)$ in two periods. y^k is composed of farm income and off-farm income as follows.

$$y^k=(1-r)\cdot P\cdot\theta\cdot q(x,\ L\ ;\ z)-(1-r')\cdot(p_x\cdot x)+w\cdot(\bar{L}-L)-R+T,$$

where p, p_x, and w are the prices of output, current input, and labor, respectively. $q=q(L,\ x\ ;\ z)$ is a production function where z is fixed factor and θ is the realization of a positive random variable distributed with mean 1 in the normal condition and variance σ^2. We assume that the mean of this random variable is lowered to $\bar{\theta}$ (<1); if in period one, the farmer expects that the harvest will suffer pest damage in period two.

r is the landlord's share of output; r' is the landlord's share of the current input x; and R is a fixed land rent ($0\leqq r,\ r'\leqq 1$). If $r=r'=0$, the contract form is a fixed rent contract; if $r>0$, it is a share tenancy contract; if $r=1$ and $r'=0$, it describes an owner farmer. The first and second terms on the right-hand side signify agricultural income. In the third term, $\bar{L}$ is family labor endowment, and L is labor input for agriculture and signifies wage income earned in the labor market. The fourth term is exogenous nonagricultural income such as remittances.

The farm household chooses the levels of labor, current input, and loans, which maximizes its present value of utility, in periods one and two.

$$\max_{Xk,\ Lk,\ D} W_j=E_0[u_j{}^1\{y^1((1-r)\cdot P\cdot\theta\cdot q(x,\ L\ ;\ z)-(1-r')\cdot(p_x\cdot x)w\cdot(\bar{L}-L)-R+T)+D\}+\beta E_1 u_j{}^2\{y^2-(1+i)D\}]$$

$$k=1,\ 2$$

We focus on the decision making in the first period. Taking a first-order Taylor expansion of utility function around $\theta=1$ (or if damaged by pest$=\bar{\theta}$) and denoting ρ the coefficient of relative risk aversion, we find the first-order conditions are

$$x_1;\quad (1-r)p\cdot(\partial q/\partial x)=(1-r')\cdot p_x\Big/\left[1-\rho\cdot\frac{(1-r)\cdot p\cdot\theta\cdot q}{y^1+D}\cdot\sigma^2\right],$$

$$L_1;\quad (1-r)p\cdot(\partial q/\partial L)=w\Big/\left[1-\rho\cdot\frac{(1-r)\cdot p\cdot\theta\cdot q}{y^1+D}\cdot\sigma^2\right],$$

$$D;\ (1+i)=E_0u'(y^1+D)/\theta E_1u'[y^2-(1+i)D]$$

Here in period one, if a farmer suffers pest damage, $\theta=\bar{\theta}$; otherwise $\theta=1$. In period two, we assume that $\theta=1$ because the assumption that the farmer cannot predict a pest attack two years in advance is realistic.

In this model, the landowner maximizes his present value of expected utility V subject to the incentive compatibility and participation constraints of the farmer, with respect to r, r', and R. This optimal contract continues to be maintained until period two.

$$\max_{r,\ r',\ R} V=E[U^1(rp\theta q-r'p_x x+R)+\gamma U^2(\cdot)],$$

$$\text{s.t. Max } W=\bar{W}$$

where $\bar{W}$ is the farmer's reservation utility.

From this system of structural equations, we can derive the following optimal input and loan demand or supply functions.

$$X^*=x(p,\ p_x,\ w,\ r,\ r',\ R,\ z,\ \theta,\ \rho,\ \sigma^2,\ S_\theta,\ i,\ T,\ y^0,\ A)$$

$$L^*=L(p,\ p_x,\ w,\ r,\ r',\ R,\ z,\ \theta,\ \rho,\ \sigma^2,\ S_\theta,\ i,\ T,\ y^0,\ A)$$

$$D^*=D(p,\ p_x,\ w,\ r,\ r',\ R,\ z,\ \theta,\ \rho,\ \sigma^2,\ S_\theta,\ i,\ T,\ y^0,\ A)$$

where $S_\theta=(1-r)p\cdot q/y^2$.

We then estimate these optimal inputs per unit area and loan demand equations simultaneously and investigate the effects of farm household behavior in coping with risks in rice production.

The levels of output and the other input prices are expected to have a positive effect on the value of input use, and the individual price of each input is predicted to have a negative effect. Fixed capital, which is a labor substitute, is expected to have a negative effect on labor input.

The presence of interest rates, remittances, and income in period one, which reflects the availability of liquidity to the household essential for income smoothing, captures elements of liquidity constraints and risk aversion. These sources of liquidity are expected to facilitate the use of inputs for rice production.

The level of riskiness is predicted by the ratio of risky income in total S_θ, the generation of pest damage, and water conditions. The higher level of riskiness is predicted by the restraint in usage of inputs.

In our theoretical framework, the share tenancy contract leads to allocative inefficiency, as Marshallian theory predicts. But if kinship relations between landowner and tenant induce altruism and relations of trust, the share tenant may agree with the achievement of an efficient input level (Sadoulet, *et al.* [15]). Should this happen, the adoption of a share tenancy contract has not had a negative effect on production.

Under the share tenancy contract with a cost-sharing arrangement, tenants usually shoulder all costs except for those of fertilizer and harvesting labor. Furthermore, the sharing ratio of output has a strong correlation with the sharing ratio of input. Therefore we neglect the cost-sharing arrangement and assume that r' is equal to zero.

Among such risk-reducing technologies as the introduction of pest-resistant rice varieties and the control of cropping intensity, the pest-resistant rice variety was not effective in protecting against pest attack. Therefore we regard only the latter technology as risk reducing in our empirical analysis.

Taking into consideration these elements, we find the optimal input and loan functions from the structural equations can be specified as follows.

$$LnY = a0 + a1LnX1 + a2LnX2 + a3LnX3 + a4LnX4 + a5LnX5 + a6LnX6 + a7LnX7 + a8LnX8 + a9DM1(1-r) + a10DM2(1-r) + a11DM3 + a12DM4 + a13DM5 + a14DM6 + \xi$$

Y: Value of current input per ha (rupiah/ha) in 1998/99; Labor input per ha (man days/ha) in 1998/99; Outstanding Debt or Credit in 1999 (rupiah).

$X1$: Remittance in 1998/99 (rupiah)

$X2$: Risky income ratio (rice income/household income) in 1998/99

$X3$: Household income in 1997/98 (rupiah)

$X4$: Rice price (rupiah/kg)

$X5$: Fertilizer price (rupiah/kg)

$X6$: Labor wage (rupiah/day)

$X7$: Fixed capital (rupiah)

$X8$: Owned land area (m^2)

$DM1$: Share tenancy dummy (if share tenancy contract with nonrelative land owner=1; otherwise=0)

$DM2$: Share tenancy dummy (share tenancy contract with relative land owner=1; otherwise=0)

$DM3$: Pest damage dummy (if seriously damaged by pest=1; otherwise=0 in 1998/99)

$DM4$: "Bawon" dummy (if participated in Bawon=1; otherwise=0)

$DM5$: Irrigation dummy (if technical irrigation =1; nontechnical irrigation=0)

$DM6$: Cropping pattern dummy (if 3 times a year=1; otherwise=0).

$a0$-$a14$ are parameters and ξ is random variable.

The parameters of owned land area and "Bawon," irrigation, and cropping-pattern

Table 10. Statistics of sample farm households

Variables	Mean	Standard deviation
Current input (Rp/m2)	60	37
Labor input (man • day)	190	166
Loan (Rp/household)	346,391	1,246,256
Remittance (Rp/household)	196,879	802,158
Risky income ratio (%)	0.11	0.35
Share tenancy contract with nonkin (%)	0.17	0.38
Share tenancy contract with kin (%)	0.24	0.43
Pest damage (%)	0.29	0.45
Household income in 97/98 (Rp/household)	1,160,223	2,939,650
Rice price (Rp/kg)	1,068	225
Fertilizer price (Rp/kg)	1,221	982
Wage (Rp/man • day)	4,067	3,421
Fixed capital (Rp/household)	40,189	117,336

Table 11. Input and loan functions: an estimation of empirical model

	Dependent variables		
(Rp per ha)	Ln (current input per ha) (man * days per ha)	Ln (labor input per ha) (Rp per household)	Loan
Constant	6.628	4.046	-4990.3
LN (remittance)	0.027	-0.024	-16,606.0
(rupiah)	(2.881)*	(-1.602)	(-0.681)
LN (risky income	-0.082	-0.053	98,813.8
ratio)	(-3.930)*	(-1.611)	(1.817)
Share tenancy	-0.365	-0.569	0.121E+7
Nonkin	(-2.366)**	(-2.328)**	(3.010)*
Share tenancy	-0.154	-0.446	-129,041
Kin	(-1.087)	(-1.991)	(-0.349)
Pest damage dummy	-0.348	-0.547	0.119E+7
	(-2.372)**	(-2.358)**	(3.099)*
Income in 97/98	0.043	-0.037	220,057
	(1.738)	(-0.953)	(3.444)*
LN (rice price)	0.608	0.698	322,687
	(2.743)**	(1.991)	(0.558)
LN (fertilizer price)	0.255	-0.208	-794,139
	(2.432)**	(-1.256)	(-2.903)*
LN (wages)	-0.052	-0.533	-48,771.1
	(-1.356)	(-0.884)	(-0.491)
LN (fixed capital)	0.035	-0.084	79,255.5
	(2.004)**	(-3.044)*	(1.743)
R2	0.700	0.393	0.555
Degree of freedom	30	30	30
Log of likelihood function		-657.078	

Note: The figures in parentheses show t statistics.
* indicates 1% significant level; ** indicates 5% significant level.

dummies were not significant in all the estimated equations.[5)] Excluding these variables, Table 10 summarizes the statistics of empirical variables used for the best estimation fits. The estimation results are shown in Table 11.

In regard to the current input, the parameters of remittances, rice price, fertilizer price, and fixed capital are significantly positive, and those of pest damage, risky income ratio, and the share tenancy dummy are significantly negative. From these results, we find that remittances had a positive effect on current inputs used through weakening the liquidity constraint, and that serious pest damage had a disincentive effect on current input usage. We also find that share tenancy contracts among nonrelatives, which were devised to share the production risk, were impacted on by the disincentive effects as a result of product sharing. In contrast, share tenancy contracts with relatives were not because the landowner, with a wider range of instruments at his disposal helped tenants and provided incentives for cooperative behavior in share tenancy contracts among relatives (Sadoulet *et al.* [15]). The findings, that the share of risky income had a negative effect on current input usage, implies that diversification to less risky income sources gave a positive effect on current input use. The parameters of prices show the same direction as had been expected, except with respect to fertilizer price, which has a positive effect on the value of current input use. But the estimated parameter is more or less 0.3, which is much lower than 1. This indicates that the price effect on current input "volume" is negative.

Conversely, only the parameters of pest damage, share tenancy, and fixed capital in labor input function are significant and negative. The parameter of risky income ratio is insignificant but negative. These results suggest that pest damage, share tenancy contracts, and risky income ratios gave the farmers disincentives to input labor.

In the loan function, the parameters of pest damage, income in period 0, and share tenancy are significantly positive. The risky income ratio is insignificant, but positive. All these results are consistent with the theory.

4. Summary and Conclusion

In this paper we presented evidence to suggest that rural households in our study area adopted multiple measures for risk reductions. We find that among these measures, gifts through family ties, such as remittances, and diversification of income to less risky sources, gave positive incentives to enhance productivity, but share tenancy contracts had a disincentive effect. We also find that serious pest damage discouraged the farmers from increasing the use of current inputs. It is remarkable, however, that the farmers did not adopt the accumulation and/or deaccumulation of farm assets because holding fixed capital was not profitable for the microscale Java farmers, and parting with their own land was too costly for them.

As mentioned above, the actual income-smoothing mechanisms adopted by Java farmers are not as simple as pointed out in previous studies on other countries, but very complex. Although the Indonesian government tried to encourage the farmers to intensify rice farming after the food crisis of 1997/98, they were reluctant to do so. If the government continues to maintain a deregulation of food policies over the next few years, the increasing volatility of market prices, and the increasing instability of food crop production caused by climate uncertainty will have a disincentive effect on Indonesian farmers who produce food crops. To make farmers accept the technologies and institutions for sustainable development in the food crop sector, these technologies and institutions must be compatible with their incentives, especially in regard to risk and uncertainty. The information we provided in this paper may help to elucidate the incentive-compatible mechanisms of rural households in Indonesia and therefore to develop appropriate food policies.

1) For off-farm jobs, see Table 4.
2) Yokoyama [20]. The original data source is "Biro Pusat Statistik," 199, p. 574.
3) Generally, this type of harvesting labor institution has been called "derep" or "derepan" in Java (Yonekura [22]). However, we call it the "Bawon" system here because the villagers we interviewed, comprehended this term as the harvesting labor institution under which wages were paid in kind on a sharing basis.
4) We introduce the principal-agent model with the assumption that the work effort of farmers is unobservable.
5) The insignificance of "Bawon" and cropping pattern dummy variables can be explained by the strong correlation with the pest damage dummy variable and risky income ratio, respectively.

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