# RICE FARMER'S RISK ATTITUDE: AN ANALYSIS OF PRODUCTION RISK IN JAWA BARAT

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## Abstrak

Makalah ini merupakan, pertama, suatu pendekatan untuk menyelidiki sikap petani terhadap resiko (risk) di Indonesia. Resiko ini secara eksplisit direfleksikan dalam keragaman produksi yang dihasilkan oleh petani. Kedua, tulisan ini mencoba mengevaluasi dampak penggunaan masukan terhadap resiko produksi. Petani-petani contoh dipilih dari enam desa di Daerah Aliran Sungai (DAS) Cimanuk, Jawa Barat. Analisis ini menunjukkan bahwa petani bersifat penghindar resiko (risk-averter) dalam penggunaan pupuk nitrogen dan tenaga kerja manusia. Selanjutnya diperlihatkan bahwa agaknya faktor produksi benih, pupuk nitrogen dan fosfat, serta luas areal berlaku sebagai masukan yang bersifat pembangkit resiko (risk-inducing), sedangkan masukan tenaga kerja (manusia dan ternak) bersifat pengurang resiko (risk-reducing) sebagaimana terlihat pada data musim hujan.

## Abstract

The paper is aimed, firstly, as a first attempt to investigate farmer's risk attitude in Indonesia. The risk are explicitly assumed reflected in the variability of rice production. Secondly, it evaluates the impact of input usage on the production risk. The sample farmers were obtained from six *desas* in the area of the Cimanuk River Basin, Jawa Barat. The analysis suggests that the farmers sample are risk-averter toward nitrogen fertilizer and human labor input. It also appears that seed, nitrogen and phosphorous fertilizer, and land holding indicate as risk-inducing factors of production while the amount of labor (from human or animal) behaves as risk-reducing inputs as shown as rainy season data.

## Introduction

Risk aversion concept is increasingly recognized as an important consideration in agricultural decision analysis, especially on farm-level decision making. Though empirical research on the subject of risk analysis has been applied in many developed and underdeveloped countries (for extensive survey see Barry, 1984; Feder, *et al.*, 1985; and Hutabarat, 1985), however, in Indonesian context, it has not been formally addressed. For instance, our experience during the last fifteen years to attain rice self-sufficiency level, is, of course, supported by the dissemination of agricultural innovation in the form of rice intensification program.

In most cases, innovations induce a subjective risk (that yield is more uncertain with an unfamiliar technique) and quite often also objective risks (due to

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weather variation, susceptibility to pests and diseases of new seeds, uncertainty regarding timely availability of important inputs). For example, Dalrymple (1978) acknowledges that HYV's (High Yielding Variety's) techniques require a well irrigated water supply and thus the attainment of the full potential of the HYVs without undue risk requires an assured water supply. Similarly, Wolgin (1975) and Moscardi and de Janvry (1977) conclude from their survey that the adoption of new agricultural technology may require the adopter to accept a greater degree of risk and uncertainty.

Our particular concern in this paper is to investigate farmer's risk attitude and to evaluate the impact of some input usage on yield variability.

## Methodology

### Data

The "ideal" data to be fitted into the type of analysis attempted in the paper would have been the combination of cross-section and time series recording of annual farm activities and other micro-environmental data such as soil fertility, water availability, crop stress, and others. However, since this type of data is not in existence in Indonesia, the study utilized the data collected by Survey Agro Economy (SAE) officed in Bogor, Jawa Barat.

The data are not as complete as the "ideal" data but as far as Indonesia's rice farms are concerned, these are the first panel data available having the same sample farmers observed in three cross-section years, even though, they are not consecutive. The data covered rice farming practices of 1977, 1978, and 1983.

Sixty farmers were selected by stratified random sampling as respondents to represent farmer population in a *desa* community from six *desas* of Jawa Barat. The *desas* were drawn from six *kecamatans* within five *kabupatens* by stratified random sample procedure (Table 1), in such a way that those desas came from six different kecamatans. The criteria for selecting desa were: (1) percentage of *sawah* accessible to irrigation water all year round, (2) accessibility to transportation (automative), (3) proximity to township, and (4) latitude stratum. Kecamatans and kabupatens sample were also drawn in the similar fashion.

The sample size tends to be decreasing over time because there were some farmers dropped out from the sample frame due to several reasons such as: (1) decease, (2) moving out from the village, (3) changing occupation, (4) no longer qualified.

In desa Ciwangi, an extra farmer was added in 1977 to maintain the overall sample size to 360.

Table 1. Number of rice farm samples and percentage of irrigated sawah in the area selected for the survey by residency.

| Residency | Wet season | | | Dry season | | | Percentage of irrigated sawah in the desa |
|---|---|---|---|---|---|---|---|
| | 1976 | 1977 | 1983 | 1976 | 1977 | 1983 | |
| 1. Wargabinanguna[a], Gegesik[b], Cirebon[c] | 60 | 60 | 52 | 60 | 60 | 52 | 90 |
| 2. Lanjan, Lohbener, Indramayu | 60 | 59 | 53 | 60 | 60 | 53 | 40 |
| 3. Gunungwangi, Argapura, Majalengka | 60 | 60 | 50 | 60 | 60 | 50 | 96 |
| 4. Malausma, Bantarujeg, Majalengka | 60 | 60 | 55 | 60 | 59 | 55 | 33 |
| 5. Sukaambit, Situraja, Sumedang | 60 | 60 | 49 | 60 | 60 | 49 | 71 |
| 6. Ciwangi, Blubur Limbangan, Garut | 60 | 61 | 53 | 60 | 59 | 53 | 96 |
| Total | 360 | 360 | 312 | 360 | 358 | 312 | — |

a) Desa; b) Kecamatan; c) Kabupaten.

Variables picked for the study are: (1) net paddy yield (kg), (2) seed use (kg), (3) nitrogen fertilizer use (kg), (4) phosphoros fertilizer use (kg), (5) human labor (mandays), (6) animal labor (animaldays), (7) landholding (ha), (8) insecticide or pesticide expense (Rp). Summary statistics for these variables are shown in Table 2.

Table 2. Means of selected variables.

| Variables | Rainy season | Dry season |
|---|---|---|
| Net paddy yield (kg) | 1326.70 | 962.90 |
| Seed (kg) | 19.67 | 16.65 |
| Nitrogen fertilizer (kg) | 104.79 | 80.88 |
| Phosphoros fertilizer (kg) | 37.93 | 28.93 |
| Human labor (mandays) | 366.50 | 247.03 |
| Animal labor (animal days) | 9.94 | 3.92 |
| Landholding (ha) | 0.48 | 0.37 |
| Insecticide or pesticide expense (Rp) | 567.48 | 315.82 |
| Number of observations | $223 \times 3 = 687$ | $185 \times 3 = 555$ |

## Literature Review and Model

In the literature, the risk subject is not very solid and its approach and empirical studies are quite diverse ranging from normative to positive studies, from descriptive to prescriptive analyses, and from subjective to objective models, even though these distinctions are still not exhaustive. For example risk models can be classified into three classes of decision rules, namely: (1) decision rules requiring no probability information, (2) safety-first rules, and (3) expected utility maximization. Its empirical studies can be grouped into five categories: (1) direct elicitation of utility function (DEU), (2) risk efficiency approach, (3) risk interval approach, (4) experimental methods, and (5) observed economic behaviour (OEB). In this paper OEB approach is applied to the data.

Application of traditional production function forms such as the Cobb—Douglas, with appending of additive or multiplicative random error terms, unduly constrain the variability effect of input usage. This has been shown by Just and Pope (1979 a, b). Naturally, some inputs may have decreasing effect on production risk (measured by the variance of output distribution) such as pesticides and possibly certified seeds. However, traditional specifications do not allow for a possibility that higher moments of outputs may also be functions of input use as has been demonstrated by Day (1967), Anderson (1973), Roumasset (1976), Just and Pope (1979 a, b), and Antle and Goodger (1984).

To relax some of the traditional model restriction, Just and Pope (1978, 1979 a, b), and later Antle (1983) generalized it. They have proposed a more flexible stochastic specification as follows:

$$y_i = f(X_i; \alpha) + g(X_i; \beta) u_i \tag{1}$$

where: $f(X_i; \alpha) = \alpha_o ( \prod_{k=1}^{K} X_k^{\alpha_k})$

$$g(X_i; \beta) = \beta_o ( \prod_{k=1}^{K} X_k^{\beta_k})$$

and it was assumed that

$E(u_i) = 0, \mathrm{Var}(u_i) = 1$, and

$\mathrm{Var}\{ g(X_i; \beta) u_i \} = \sigma_i^2$

This form will allow for a relation between uncertainty and inputs not solely determined through the relationship of input and expected output. Moreover, the term $g(X_i; \beta) u_i$ is possibly homogeneous allowing sufficient flexibilities such that the signs and magnitudes of $gg_i$ and $g_j g_{jj}$ ($g_i$ and $g_{ii}$ denote the first and second derivative of g with respect to i are not predetermined a priori and so input with decreasing risk effect could be tested.

The marginal effect of input usage on production variability can be derived as:

$$\mathrm{Var}(y_i) = \left\{ \beta_o \left( \prod_{k=1}^{K} X_k^{\beta_k} \right) \right\}^2 \mathrm{Var}(u_i) \tag{2}$$

and

$$\frac{\delta \mathrm{Var}(y_i)}{\delta X_k} = 2 \left\{ \beta_o \left( \prod_{k=1}^{K} X_k^{\beta_k} \right) \right\}^2 \frac{\delta \left\{ \beta_o \left( \prod_{k=1}^{K} X_k^{\beta_k} \right)^2 \right\}}{\delta X_k} \mathrm{Var}(u_i) \tag{3}$$

Equation (1) is estimated involving three-stage procedure in order to yield asymptotically efficient estimates as outlined by Pope and Just (1977)[1].

Having estimated these equations, the next issue is to compare the optimal input use under the corresponding production functions. For the production risk model with linear mean-variance utility of profit and no price uncertainty, factor demand equations can be derived as follows {see Anderson, *et al.* (1977), Just and Pope (1979a) and Hallam, *et al.* (1982)}.

$$P \frac{\delta\, E(y)}{\delta X_k} - \phi P^2 \frac{\delta \mathrm{Var}(y)}{\delta X_k} = w_k \tag{4}$$

For equations (1) through (3), then equation (4) becomes

$$P \frac{\alpha_k E(y)}{X_k} - 2\phi \frac{\beta_k \left\{ \beta_o \left( \prod_{k=1}^{K} X_k^{\beta_k} \right) \right\}^2}{X_k} \mathrm{Var}(u) P^2 = w_k \tag{5}$$

By rearranging (5), factor demand equations would be

$$X_k = \frac{\alpha_k P E(y)}{w_k} - 2\phi \frac{\beta_k \left\{ \beta_o \left( \prod_{k=1}^{K} X_k^{\beta_k} \right) \right\}^2 P^2}{w_k} \mathrm{Var}(u) + e_k \tag{6}$$

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[1] The estimation of Just-Pope model (Pope and Just, 1977) is done as follows:

STEP 1: A nonlinear regression of $y_i$ on $f(X_i, \alpha)$ obtaining $\hat{\alpha}$

STEP 2: An OLS regression of $\ln u_i^{*2} = \ln (y_i - f(X_i, \hat{\alpha})^2$ on $l_n X_i$ obtaining $\hat{\beta}$

STEP 3: A nonlinear regression of $y_i^* = y_i g^{-1/2}(X_i, \hat{\beta})$ on $f^*(X_i, \hat{\alpha}) = f(X_i, \hat{\alpha}) g^{-1/2}(X_i, \hat{\beta})$ obtaining $\tilde{\alpha}$

where $w_k$ is the price of input k, $\phi$ is risk aversion coefficient (that is, $\phi > 0$ represents risk-aversion, $\phi = 0$ risk-neurality, and $\phi < 0$ risk-preference, respectively) and $e_k$ is the disturbance term such that $E(e_k) = 0$. The complete system of factor demand equations would then be written as:

$$
\begin{array}{l}
X_1 = \theta_{01} + \theta_{11}Z_{11} + \theta_{21}Z_{21} + e_1 \\
X_2 = \theta_{02} + \theta_{12}Z_{12} + \theta_{22}Z_{22} + e_2 \\
\cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \\
\cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \\
\cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \\
X_K = \theta_{oK} + \theta_{1K}Z_{1K} + \theta_{2K}Z_{2K} + e_K
\end{array}
\qquad (7)
$$

where

$$Z_1k = \frac{aPE(y)}{w_k} \text{ and } Z_2k = \frac{2bP^2}{w_k}$$

where

$$
a = \begin{cases} \hat{\alpha}_k \text{ from Cobb-Douglas production function} \\ \hat{\alpha}_k \text{from Just-Pope production function} \end{cases}
$$

$$
b = \begin{cases} \hat{\alpha}_k \ \left\{\alpha o\left(\prod_{k=i}^{K} X_k^{\beta_k}\right)\right\}^2 \mathrm{Var}\,(e^{\epsilon}) \text{ from Cobb-Douglas production function} \\ \hat{\beta}_k \ \left\{\beta o\left(\prod_{k=1}^{K} X_k^{\beta_k}\right)\right\}^2 \mathrm{Var}\,(u) \text{ from Just-Pope production function} \end{cases}
$$

## Results and Discussion

The first step in the estimation is by applying Cobb-Douglas production function through its loglinear transformation. The model is estimated by OLS and results of the estimation are summarized in Table 3. All of factors of production coefficients are statistically significant in both data sets, rainy and dry season, except animal labor and insecticide or pesticide expense. All coefficients have the expected positive signs with the exception of insecticide expense. We anticipate that for any percentage increase in a factor of production, ceteris paribus, there will be a percentage increase in yield. With respect to insecticide or pesticide expense of rainy season data, the sign is negative but is relatively very small and not statistical-

Table 3. Estimated coefficients of Cobb-Douglas production function, rainy and dry season.

| Factor of production | Coefficients | |
|---|---|---|
| | Rainy season | Dry season |
| Intercept | 6.5547<br>(21.3640)*** | 4.5068<br>(19.3490)*** |
| Seed | 0.0751<br>(2.0049)** | 0.4584<br>(8.6724)*** |
| Nitrogen fertilizer | 0.0433<br>(2.1424)** | 0.0588<br>(2.6049)*** |
| Phosphoros fertilizer | 0.0569<br>(5.5118)*** | 0.0206<br>(1.8211)* |
| Human labor | 0.0824<br>(2.0828)** | 0.1788<br>(5.5896)*** |
| Animal labor | 0.0087<br>(1.2817) | 0.0088<br>(0.8983) |
| Landholding | 0.6818<br>(11.3700)*** | 0.2580<br>(5.9071)*** |
| Insecticide or pesticide expense | -0.0073<br>(-0.7218) | 0.0103<br>(0.7297) |

[a]Numbers in parentheses are respective t-ratios.

* Significant at $\alpha_{0.10} = 1.645$.

** Significant at $\alpha_{0.05} = 1.960$.

*** Significant at $\alpha_{0.01} = 2.576$.

ly significant. The insignificance of animal labor and insecticide or pesticide expense in production function is probably dictated by the uncommon application of the factor in the sample farmers. Most farmers use human labor as source of labor either as coming from the family or hired from outside if he can afford to. Only a few farmers applied insecticide or pesticide. They usually are relatively large-scaled farmers (more than 0.50 ha landholding).

The second specification estimated is the Heteroskedastic model of Just and Pope type (1978, 1979a, b) as outlined in footnote (1). The estimates of mean production are summarized in Table 4. Comparing with the results from the previous alternative, the estimates are quite different. For rainy season data, all estimates are statistically (and asymptotically) significant with the exception of nitrogen fertilizer coefficient. In dry season data, all coefficients are statistically significant with the exception of insecticide expense which also has a negative sign.

By using this procedure, it is very surprising to see that elasticity of mean production with respect to nitrogen fertilizer is statistically not significant which is contrary to that shown by the first model. This might have happened because the effect of nitrogen fertilizer on production might be confounded by other inputs, because inputs other than labor and land are obtained from the package of BIMAS in fixed proportions. To substantiate this assertion, simple correlation coefficients among inputs are computed in the Appendix Table A1. As we can see from the table, simple correlations of nitrogen fertilizer with seed, phosphoros fertilizer, and insecticide are all significant in both rainy and dry season data.

Furthermore, Table 4 also shows that in the dry season data, the sign for insecticide expense is negative which is also contrary to the previous results. One possible explanation has something to do with the improper application of insecticide or pesticide in terms of technique or timing.

Specific to the Cobb-Douglas production type, these estimates are also designating to elasticities of mean production with respect to the corresponding factors of production. By using the nonlinear or heteroskedastic estimation results, a 1 percent increase in each factor of production of seed, nitrogen fertilizer,

Table 4. Estimated coefficient of mear production for Just-Pope model.

| Production factors | Mear production | | | | | |
|---|---|---|---|---|---|---|
| | Rain season | | | Dry season | | |
| | First stage[a)] | Second stage | Final stage | First stage | Second stage | Final stage |
| Intercept | 1221.3 | 13.376 | 832.70 | 633.44 | 7.6310 | 693.86 |
| | (4.2171)*** | (14.2370)*** | (816.9200)*** | (3.7835)*** | (12.2070)*** | (182.98)*** |
| Seed | 0.0827 | 0.0558 | 0.1301 | 0.1068 | 0.4045 | 0.1136 |
| | (1.7694)* | (0.9726) | (3.0915)*** | (3.8476)*** | (5.7021)*** | (3.4654)*** |
| Nitrogen fertilizer | -0.0080 | 0.0167 | 0.0025 | 0.0140 | 0.0662 | 0.0319 |
| | (-1.6096) | (0.5403) | (0.3279) | (0.5057) | (2.1870)** | (2.0684)** |
| Phosphoros fertilizer | 0.0409 | 0.0017 | 0.0434 | 0.0139 | 0.0272 | 0.0212 |
| | (6.8227)*** | (0.1062) | (6.3006)*** | (2.2415)** | (1.7940) | (3.6099)*** |
| Human labor | 0.0711 | -0.1423 | 0.0899 | 0.1761 | 0.0817 | 0.1276 |
| | (2.4395)** | (-2.3497)** | (3.8735)*** | (4.5114)*** | (1.9041) | (6.0639)*** |
| Animal labor | 0.0254 | -0.0137 | 0.0143 | 0.0413 | 0.0186 | 0.0267 |
| | (8.8131)*** | (-1.3168) | (4.7252)*** | (9.9878)*** | (1.4157) | (6.1854)*** |
| Landholding | 0.8290 | 0.9396 | 0.7366 | 0.6759 | 0.2108 | 0.6809 |
| | (15.3090)*** | (10.2340)*** | (27.7500)** | (14.072)*** | (3.5975)*** | (24.6230)*** |
| Insecticide or pesticide expense | 0.0091 | 0.0341 | 0.0112 | -0.0212 | 0.0115 | -0.0091 |
| | (1.7982)* | (2.1890)** | (2.4960)** | (-4.1398)*** | (0.6046) | (-1.4305) |

[a)] Numbers in parentheses are respective asymptotic t-ratios.

* Significant at $\alpha_{0.10} = 1.645$.

** Significant at $\alpha_{0.05} = 1.960$.

*** Significant at $\alpha_{0.01} = 2.576$.

phosphoros fertilizer, human labor, animal labor, landholding, and insecticide or pesticide expense, respectively, other things remaining constant, will cause a 0.13, 0.00, 0.04, 0.09, 0.01, 0.74, and 0.01 percent increase in yield in rainy season data and 0.11, 0.03, 0.02, 0.13, 0.03, 0.68 percent increase and -0.01 percent decrease in yield for dry season data.

The next important aspect needing to be considered is the relationship between the level of inputs and the variance of production as can be deduced from the Cobb-Douglas and the Just-Pope model. We hypothesize that the coefficients associated with human and animal labor, and insecticide and pesticide expense, to have a risk-reducing effect on the variance of the production.

The amount of labor spent during the production process is considered to make production more stable to a certain level, especially if it is given at the right time. The same argument holds for insecticide and pesticide expense. A rice grower is willing to spend additional money to buy insecticide or pesticide in the expectation that production level becomes more certain than it otherwises would have been. Again this assumption will be true if the timing for application of insecticide is right during the cultivation.

For seed, nitrogen fertilizer, phosphoros fertilizer, and land-holding, the coefficients are expected to be positive indicating the risk-inducing effects. As pointed out in the previous section, these inputs are thought to be making production yield more susceptible to environmental condition.

Table 5 shows the coefficient estimates for the Just-Pope model (The corresponding results for the Cobb-Douglas model are not presented because it can be shown that the magnitude of variance given by the model are very huge and to give interpretation for them is difficult). The table shows that nitrogen fertilizer picks up the correct negative sign showing a risk-inducing factor in rainy season data but again it fails to show risk-reducing effects of insecticide or pesticide expense in both data sets, and of human and animal labor in dry season data.

Further, from the variance of production models we can estimate elasticities of the input use on the variance of production. With respect to Cobb-Douglas and Just-Pope models these elasticities are shown Table 6[2]. The magnitude of estimat-

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[2] i) For Cobb-Douglas function,

$$y = (\alpha_o \pi X_i^{\alpha_i}) e^u$$

$$Var(y) = (\alpha_o \pi X_i^{\alpha_i})^2 \, Var(e^u)$$

$$\frac{\delta Var(y)}{\delta X_i} \frac{X_i}{Var(y)} = 2\alpha_i \text{ (the risk elasticity)}$$

ii) For Just-Pope model

$$y = \alpha_o \pi X_i^{\alpha_i} + \beta_o \pi X_i^{\beta_i} u$$

$$Var(y) = (\beta_o \pi X_i^{\beta_i})^2 \, Var(u)$$

$$\frac{\delta Var(y)}{\delta X_i} \frac{X_i}{Var(y)} = 2\beta_i \text{ (the risk elasticity).}$$

Table 5. Estimated coefficients of variance of production for Just-Pope model.

| Factor of production | Variance of production[a] | |
|---|---|---|
| | Rainy season | Dry season |
| Intercept | 13.376 | 7.6310 |
| | (14.2370)*** | (12.207)*** |
| Seed | 0.0558 | 0.4045 |
| | (0.9726) | (5.7021)*** |
| Nitrogen fertilizer | 0.0167 | 0.0662 |
| | (0.5403) | (2.1870)** |
| Phosphoros fertilizer | 0.0017 | 0.0272 |
| | (0.1062) | (1.7940) |
| Human labor | -0.1423 | 0.0817 |
| | (-2.3497)** | (1.9041) |
| Animal labor | -0.0137 | 0.0186 |
| | (-1.3168) | (1.4157) |
| Landholding | 0.9396 | 0.2108 |
| | (10.2340)*** | (3.5975)*** |
| Insecticide or pesticide expense | 0.0341 | 0.0115 |
| | (2.1890)** | (0.6046) |

[a] Numbers in parentheses are respective asymptotic t-ratios.
* Significant at $\alpha_{0.10} = 1.645$.
** Significant at $\alpha_{0.05} = 1.960$.
*** Significant at $\alpha_{0.01} = 2.576$.

Table 6. Estimated elasticities of output variability with respect to factor of production implied by Cobb-Douglas and Just-Pope model evaluated at means.

| Factor of production | Elasticities | | | |
|---|---|---|---|---|
| | Rainy season | | Dry season | |
| | C-D[1] | J-P[2] | C-D[1] | J-P[2] |
| Seed | 0.15 | 0.11 | 0.92 | 0.81 |
| Nitrogen fertilizer | 0.09 | 0.03 | 0.12 | 0.13 |
| Phosphorous fertilizer | 0.11 | 0.00 | 0.04 | 0.05 |
| Human labor | 0.16 | -0.28 | 0.36 | 0.16 |
| Animal labor | 0.02 | -0.03 | 0.02 | 0.37 |
| Landholding | 1.36 | 1.88 | 0.52 | 0.42 |
| Insecticide or pesticide expense | 0.01 | 0.07 | 0.02 | 0.02 |

[1] C-D, Cobb-Douglas specification.
[2] J-P, Just-Pope specification.

ed elasticities of Cobb-Douglas and Just-Pope model are very close to one another but they are derived from different mean production functions. The signs of elasticities in Cobb-Douglas function are already determined in the mean production functions unintentionally while the signs of elasticities in Just-Pope model are free from the results of the mean production functions due to the fact that the mean and the variance functions are allowed to be independent of one another. In other words, we could still have an input having positive marginal product but negative marginal risk. This is one of the advantages of using Just-Pope model as outlined in previous section.

Turning to the results from Table 6 of Just-Pope model, a 1 percent increase in the use of seed results in a 0.11 (0.81) increase in the variance of the production in rainy (dry) season data, everything held constant. And 1 percent increase in the use of nitrogen fertilizer, ceteris paribus, results in 0.03 (0.13) percent increase in the variance of production of rainy (dry) season data. The same thing can be applied to other remaining estimated elasticities.

The implication of estimated production models on the input use estimations is laid out in equations (4) through (7). The estimated coefficients are presented in Table 7 and 8 for rainy (dry) season data. The input-use equations implied by Cobb-Douglas and Just-Pope models are analyzed. In each model, two variates are considered, that is, risk-responsive case and risk-neutral case, where risk-neutral is risk-responsive variates with risk coefficient equals zero. Only two major inputs are considered because the same interpretation could be applied to other inputs.

Most of the coefficients in the input-use equations are statistically significant. Also, almost in all cases, the coefficients of $O_1i$ are statistically different from 1 as implied by the models. Furthermore, the coefficient of $O_2i$ are also statistically significantly different from zero excluding that of nitrogen demand on risk-responsive Just-Pope model. Recalling from equations (4) through (7) by the implication assuming that the models are true, this coefficient measures the risk aversion parameter for particular input. It is found that the coefficient ranges from $0.62 \times 10^{-12}$ to $0.21 \times 10^{-6}$ for nitrogen fertilizer and from $-0.17 \times 10^{-5}$ to $0.30 \times 10^{-10}$ for human labor on rainy season data and for dry season data, the respective range is from $0.12 \times 10^{-9}$ to $0.80 \times 10^{-7}$ for nitrogen and from $-0.14 \times 10^{-6}$ to $0.33 \times 10^{-9}$ for human labor. Hence, as far as nitrogen fertilizer is concerned, the farmers are risk-averters (the coefficient is positive) even though average dosage applied for nitrogen fertilizer by farmers sample are about 210 and 245 kg per ha in rainy and dry season, respectively, (as can be calculated from Table 2) as opposed to 200 kg recommended by research stations. One explanation probably lies in the inefficient use of the fertilizer by farmers. This, in turn, will contribute to the widening yield gap between experimental stations and farmers plots. However, the results from this analysis have to be taken with caution. Three notes must be in order: (1) the implicit assumption that the amount of input use is solely a function of two "aggregate" variables may not be realistic, (2) the clear departure from the asumption that $\theta_{1i} = 0$ and $\theta_{1i} = 1$ that must be imposed as in equation 6, and (3) the possibility of conflicting interpretation of the risk aversion coefficients derived for each input. Hence, these input-use equations have to be interpreted carefully.

In terms of human labor input, the sign of the coefficients are in the range from negative to positive for rainy season data and always negative for dry season data. Therefore, it would be safe to conclude that risk coefficient sign for human labor is indetermined, but it appears to be in the negative direction. It then suggests that farmers are also risk-averter toward labor.

Table 7. Estimated coefficients of implied input-use equations for Cobb-Douglas and Just-Pope models, rainy season[a].

| Parameters/ statistics | Cobb-Douglas model | | | |
|---|---|---|---|---|
| | Risk-responsive | | Risk-neutral | |
| | Nitrogen[b] | Labor | Nitrogen | Labor |
| $0_{0i}$ | 18.295 | 269.360 | 31.297 | 300.99 |
| | (3.4862)*** | (16.4620)*** | (6.9940)*** | (14.3670)*** |
| $0_{1i}$ | 1.4900 | -0.1375 | 1.1525 | 0.5610 |
| | (17.6960)*** | (-2.4876) | (29.435)*** | (11.5560)*** |
| $0_{2i}$ | $0.2071 \times 10^{-6}$ | $-0.1768\text{x}^{10-5}$ | — | — |
| | (4.5023) | (-17.265)*** | — | — |
| $R^2$ | 0.67 | 0.53 | 0.66 | 0.23 |
| F | 461.900 | 259.892 | 866.425 | 133.552 |
| | Just-Pope model | | | |
| $0_{0i}$ | 30.935 | 238.47 | 31.297 | 300.99 |
| | (5.8588)*** | (13.669)*** | (6.9940)*** | (14.367)*** |
| $0_{1i}$ | 20.1130 | 0.2570 | 19.938 | 0.5132 |
| | (13.3040)*** | (6.4689)*** | (29.4350)*** | (11.5567)*** |
| $0_{2i}$ | $0.6184 \times 10^{-12}$ | $0.3049 \times 10^{-10}$ | — | — |
| | (0.1293) | (15.397)*** | — | — |
| $R^2$ | 0.66 | 0.49 | 0.66 | 0.23 |
| F | 432.274 | 220.350 | 866.425 | 133.552 |

[a] Only two major inputs, that is, nitrogen and labor, are considered.

[b] Numbers in parantheses are respective t-ratios.

* Significant at $\alpha_{0.10} = 1.645$.

** Significant at $\alpha_{0.05} = 1.960$.

*** Significant at $\alpha_{0.01} = 2.576$.

Table 8. Estimated coefficients of implied input-use equations for Cobb-Douglas and Just-Pope models, dry season[a].

| Parameters/ statistics | Cobb-Douglas model | | | |
|---|---|---|---|---|
| | Risk-responsive | | Risk-neutral | |
| | Nitrogen[b] | Labor | Nitrogen | Labor |
| $0_{0i}$ | 14.758 | 114.840 | 22.828 | 102.460 |
| | (3.0637)*** | (10.863)*** | (5.5312)*** | (9.7182)*** |
| $0_{1i}$ | 0.9654 | 0.5908 | 0.7875 | 0.7752 |
| | (14.977)*** | (11.6580)*** | (25.1050)*** | (23.0770)*** |
| $0_{2i}$ | $0.7974 \times 10^{-7}$ | $-0.1431 \times 10^{-6}$ | — | — |
| | (3.1474)*** | (-4.7550)*** | — | — |
| $R^2$ | 0.64 | 0.61 | 0.63 | 0.59 |
| F | 327.720 | 293.220 | 630.280 | 532.556 |
| | Just-Pope model | | | |
| $0_{0i}$ | 14.056 | 110.290 | 22.828 | 102.46 |
| | (2.9400)*** | (10.352)*** | (5.5312)*** | (9.7182)*** |
| $0_{1i}$ | 1.8636 | 0.8643 | 1.4495 | 1.0858 |
| | (14.1540)*** | (10.7460)*** | (25.1050)*** | (23.0770)*** |
| $0_{2i}$ | $0.1155 \times 10^{-9}$ | $-0.3339 \times 10^{-9}$ | — | — |
| | (3.4875)*** | (-3.3721) | — | — |
| $R^2$ | 0.64 | 0.60 | 0.63 | 0.59 |
| F | 330.781 | 279.468 | 630.280 | 532.556 |

[a] Only two major inputs, that is, nitrogen and labor, are considered.

[b] Numbers in parentheses are respective t-ratios.

* Significant at $\alpha_{0.10} = 1.645$.

** Significant at $\alpha_{0.05} = 1.960$.

*** Significant at $\alpha_{0.01} = 2.576$.

## Conclusion

This paper performs two alternative production specifications of estimating mean production function and implication of the estimation on the variance of production. The specifications are Cobb-Douglas and Just-Pope models. The mean production estimates of each model gives very different results. In spite of the possibility that they may result in the same positive marginal products of inputs as we expected, the implication of each model on the effect of input on the variability of output may be quite different.

Based on the Just-Pope model, the model that could separete the effect of inputs on mean production and variance of production, the elasticities of output with respect to inputs seed, nitrogen and phosphoros fertilizer, human and animal labor, landholding, and insecticide expense for rainy season data are 0.13, 0.00, 0.04, 0.09, 0.01, 0.74, and 0.01, respectively. Furthermore, the model confirms that human and animal labor, and insecticide inputs behave as risk-reducing factors while other factors of production perform risk-inducing effects, such as seed, nitrogen and phosphoros fertilizer, landholding, and insecticide expense. In dry season data, all factors of production are shown to have risk-inducing effects.

The elasticities of variance of output with respect to inputs in rainy season data are 0.11, 0.03, 0.00, -0.28, -0.03, 1.88 and 0.07 for seed, nitrogen, phosphoros fertilizer, human labor, animal labor, landholding and insecticide expense, respectively. For dry season data, the respective elasticities are 0.81, 0.13, 0.05, 0.16, 0.37, 0.42, and 0.02. With the exception of landholding and insecticide inputs, the elasticities in dry season data are always higher in absolute values than in rainy season data. It appears that the existence of sufficient moisture during the cultivations in the rainy season helps to mitigate the variance of output caused by inputs.

These risk aversion coefficients, given the estimates of production functions are true, are ranging from $0.62 \times 10^{-12}$ to $0.21 \times 10^{-6}$ for nitrogen fertilizer and from $-0.14 \times 10^{-6}$ to $0.30 \times 10^{-10}$ for human labor. So, it is probably suggesting that the sample farmers are risk-averter on nitrogen fertilizer and on labor.

## References

Anderson, J.R. 1983. Sparse Data, Climatic Variability, and Yield Uncertainty in Response Analysis. American Journal of Agricultural Economics, 55 (1): 77-83.

Anderson, J.R., L. Dillon, and J.B. Hardaker. 1977. Agricultural Decision Analysis. Ames, Iowa: Iowa State University Press.

Antle, J.M. 1983. Testing The Stochastic Structure of Production: A Flexible Moment-Based Approach. Journal of Business and Economic Statistics, 1 (3): 192-201.

Antle, J.M. and W.J. Goodger. 1984. Measuring Stochastic Technology: The Case of Tulare Milk Production. American Journal of Agricultural Economics, 66 (3): 342-350.

Barry, P.J. (ed.). 1984. Risk Management in Agriculture. Ames, Iowa: Iowa State University Press.

Dalrymple, D.G. 1978. Development and Spread of HYV of Wheat and Rice in LDCs. Foreign Agricultural Report No. 95, USDA, Washington, DC.

Day, R.H. 1965. Probability Distributions of Field Crops. Journal of Farm Economics, 47 (3): 713-741.

Feder, G., R.E. Just, and D. Zilberman. 1985. Adoption of Agricultural Innovation in Developing Countries: A Survey. Economic Development and Cultural Change, 33 (2): 256-298.

Hallam, J.A., R.E. Just and R.D. Pope. 1982. Positive Economic Analysis and Risk Considerations in Agricultural Production. *In* G.C. Rauser (ed.). New Direction in Econometric Modelling and Forecasting in U.S. Agriculture. Edited by G.C. Rauser. New York: North-Hulland.

Hutabarat, B. 1985. An Assessment of Farm-Level Input Demands and Production Under Risk on Rice Farms in The Cimanuk River Basin, Jawa Barat, Indonesia. Unpublished Ph.D. dissertation, Iowa State University, Ames, Iowa.

Moscardi, E. and A. de Janvry. 1977. Attitudes Toward Risk Among Peasants: An Econometric Approach. American Journal of Agricultural Economics, 54 (9): 710-716.

Just, R.E. and R.D. Pope. 1979a. On the Relationship of Input Decision and Risk. *In* Roumasset, Boussard, Sigh (eds.) Risk, Uncertainty and Agricultural Development. SEARCA and ADC, Laguna, Philippines.

———. 1979b. Production Function Estimation and Related Risk Consideration. American Journal of Agricultural Economics, 6 (2): 111-118.

Pope, R.D., and R.E. Just. 1977. On the Competitive Firm Under Production Uncertainty. Australian Journal of Agricultural Economics, 21 (2): 111-118.

Roumasset, J.A. 1976. Rice and Risk: Decision Making Among Low-Income Farmers. Amsterdam: North-Holland.

Wolgin, J.M 1975. Resource Allocation and Risk: A Case Study of Smallholder Agriculture in Kenya. American Journal of Agricultural Economics, 57 (4): 622-630.

Table A1. Simple correlation coefficients among factors of production in sample farmers.

| | Dry season | | | | | | |
|---|---|---|---|---|---|---|---|
| | Seed | Nitrogen fertilizer | Phosphoros fertilizer | Human labor | Animal labor | Landholding | Insecticide or pesticide expense |
| Seed | 1.00 | 0.62*** | 0.33*** | 0.33*** | 0.04*** | 0.53*** | 0.11*** |
| Nitrogen fertilizer | | 1.00 | 0.71** | 0.63*** | 0.21*** | 0.84*** | 0.43*** |
| Phosphoros fertilizer | | | 1.00 | 0.52*** | 0.22*** | 0.64*** | 0.53*** |
| Human labor | | | | 1.00 | 0.36*** | 0.69*** | 0.24*** |
| Animal labor | | | | | 1.00 | 0.22*** | 0.09** |
| Landholding | | | | | | 1.00 | 0.49*** |
| Insecticide or pesticide expense | | | | | | | 1.00 |
| | Rainy season | | | | | | |
| Seed | 1.00 | 0.74*** | 0.48*** | 0.73*** | 0.16*** | 0.90*** | 0.39*** |
| Nitrogen fertilizer | | 1.00 | 0.69*** | 0.65*** | 0.25*** | 0.78*** | 0.52*** |
| Phosphoros fertilizer | | | 1.00 | 0.55*** | 0.43*** | 0.57*** | 0.51*** |
| Human labor | | | | 1.00 | 0.27*** | 0.79*** | 0.29*** |
| Animal labor | | | | | 1.00 | 0.24*** | 0.12*** |
| Landholding | | | | | | 1.00 | 0.42*** |
| Insecticide or pesticide expense | | | | | | | 1.00 |

** Significant at $\alpha_{0.05} = 1.960$.

*** Significant at $\alpha_{0.01} = 2.576$.