THE IMPACT OF RISK AVERSION BY FILIPINO CROP PRODUCERS ON ENTERPRISE SELECTION, RESOURCE RETURNS AND ADOPTION OF HYV RICE

By

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Introduction

In recent years, the bulk of agricultural research in the Philippines has emphasized crop technologies that increase average yields without considering risk as an important aspect of agricultural technology. The hypothesis is widely accepted that Filipino farmers are risk averse. Thus the neglect of risk variables usually results in over-estimating farmers' returns from new farm technology. In the aggregate, this economic return bias leads to unnecessary overstatements of the supply of farm products produced under the new technology.

By ignoring risk, economic analysis may also seriously overstate imputed returns to farm resources. But risk does not likely affect the same resources. Returns to some resources may actually increase.

The objective of this paper is to show the impact of risk on enterprise selection and resource returns of rice farmers who face the decision of adopting high yielding rice varieties. The crop alternatives are limited to rice, corn and selected vegetable crops. Other crop alternatives are available but are of less importance and consequently no data are available. The research methodology used to achieve this objective is a micro $E\text{-}V^{1/2}$ (mean-standard deviation) programming model.

The Risk Programming Model: A Preview

The pioneering work of Markowitz [9] in the formulation of a portfolio risk model provides an analytical framework within which

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uncertainty in farm decisions can be incorporated. The traditional behavioral assumptions in a typical E-V farm-firm model are that farmers are risk-averse and that farmers' utility, U_n, among alternative farm production plans are a function of expected income (Y_e) and expected income variance (V_y),[1] i.e.

$$U_n = U_n(Y_e, V_y) \qquad (1)$$

The following conditions are assumed to hold along each indifference curve for a risk averse farmer:

$$\frac{dY_e}{dV_y} > 0, \qquad (2)$$

i.e., along each iso-utility curve, the farmer prefers a strategy with higher V_y if and only Y_e is also greater.

$$\frac{d^2 Y_e}{dV_y^{\,2}} > 0, \qquad (3)$$

i.e., compensation in Y_e must increase at an increasing rate with increases in V_y.

Three iso-utility curves (U_0, U_1 and U_2) are shown in figure 1.

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[1] Given a continuous utility function, U(Y), where Y is a random variable, the stochastic Y variable can be rewritten as the sum of its mean, $\overline{Y}$, plus the deviation from the mean, X. Hence: $U(Y) = U(\overline{Y} + X)$. Using Taylor's Theorem we have:

$$U(\overline{Y} + X) = U(\overline{Y}) + U'(\overline{Y})X + U''(\overline{Y})X^2/2! + \ldots + U^{n-1}(\overline{Y})X^{n-1}/(n-1)! + R_n$$

where R_n is the remainder term.

Taking expectations of the above expression results in:

$$E[U(Y)] = \int_{-\infty}^{\infty} U(\overline{Y} + X)\, f(X)\, dX = U(\overline{Y}) + U''(\overline{Y})M_2/2! + U'''(\overline{Y})M_3/3! +$$

$$\ldots + U^{n-1}(\overline{Y})\,\overline{M}_{n-1}/(n-1)! + R_n$$

where f(X) is the density function of X and M_2, M_3, and $\overline{M}_{n-1}$ are the second, third, and successive higher central moments of the probability distribution.

In the E-V model we are working only with the first two moments of the density function which implicitly assumes that the expectation series, which was previously defined, converges so that for fairly close approximation, the terms beyond the second moments can be ignored.

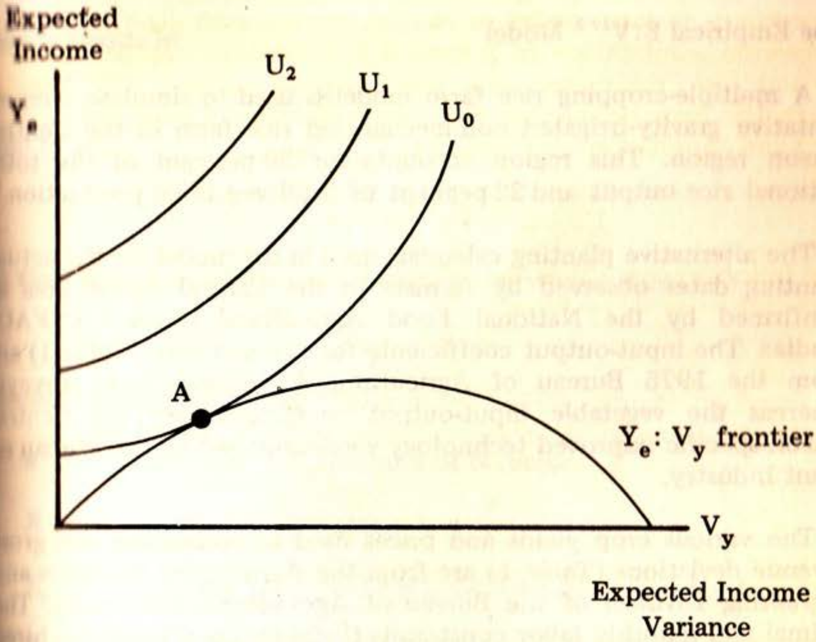

Figure 1. Illustration of optimal $Y_e : V_y$ farm plan

The $Y_e{:}V_y$ frontier describes all feasible solutions for a given set of farm resources. Points on the frontier represent the maximum attainable expected income level for a specified level of variance. Point A in figure 1 represents the optimal farm plan for this set of utility functions and resources. Note that the risk averse nature of the utility functions results in an optimum expected income level less than the maximum.

The approach used in this study differs in three ways from the above. First, the standard deviation of expected net income ($V^{1/2}$) rather than the variance is used as a measure of dispersion. Second, since only data on gross revenues are available, the standard deviation of gross revenue is used as a substitute for the standard deviation of expected net income. Third, a unique optimum equivalent to A in figure 1 is not obtained. The utility functions are not quantified for Filipino farmers but those functions are assumed to exhibit aversion to risk, i.e., conform to (2) and (3). The procedure used in this study is to compute alternative solutions along the $Y_e{:}V^{1/2}$ frontier and observe how the farm plan changes. Conclusions then can be drawn about how alternative levels of risk aversion affects (1) the selection of crops, and (2) the adoption of alternative technologies.

The Empirical E:V$^{1/2}$ Model

A multiple-cropping rice farm model is used to simulate a representative gravity-irrigated non-mechanized rice farm in the Central Luzon region. This region accounts for 30 per cent of the total national rice output and 22 per cent of total vegetable production.[2]

The alternative planting calendars used in the model are the actual planting dates observed by farmers in the Central Luzon area as confirmed by the National Food Agricultural Council (NFAC) studies. The input-output coefficients for rice and corn (Table 1) are from the 1975 Bureau of Agricultural Economics farm surveys, whereas the vegetable input-output coefficients are the Central Luzon-specific improved technology recommended by the Bureau of Plant Industry.

The various crop yields and prices used in computing the gross revenue deviations (Table 1) are from the Agricultural Statistics and Marketing Division of the Bureau of Agricultural Economics. The animal and monthly labor constraints (include household plus hired labor) are based on the International Rice Research Institute (IRRI) Survey of Central Luzon rice farms in 1970. The effective absolute crop area is assumed to be 1 hectare (which is the modal farm size for the Philippines as confirmed by the 1970 Bureau of Census Agricultural Survey). The working capital constraint which includes loanable short-term capital plus initial capital is based on Clemente's study [3] of the financial structures of rice farmers who are users of the World Bank local farm credit.

The model in matrix notation is:

$$\text{Max } \pi' X - \phi \sigma X_s \qquad (4)$$

Subject to:

$$AX \leqslant b \qquad (5)$$

and rows estimating the risk parameter as follows:

$$d_t = \sum_{j=1}^{n} \left| (C_{jt} - \bar{g}_j) X_j \right| = R_t X \qquad (6)$$

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[2] Based on the Bureau of Agricultural Economics Crop Statistics (for the period 1965-1975).

which results in,

$$R_t X - d_t \leqslant O \qquad (6)$$

and finally,

$$C'd - \frac{T}{K} \sigma X_s \qquad (7)$$

A final constraint is the usual non-negativity constraint, i.e.:

$$X, X_s \geqslant O \qquad (8)$$

where

π = vector of net revenues of N crops

X = vector of production levels of N crops

X_s = activity level of the standard deviation activity

R_t = row vector of absolute deviation of crop revenues for year t

d = vector sum of the absolute deviation of revenues

A = input-output coefficient matrix of M constraints and N crops

ϕ = risk aversion scalar which is exogenously specified and parameterized from 0 to 2.5

σ = standard deviation of gross revenues over five years for each of N crops

b = vector of M resource constraints

T = number of years' observations of gross revenue (five)

K = $\left[\frac{3.1416T}{2[T-1]}\right]^{1/2}$

C = vector of ones

C_{jt} = gross revenue of one unit of the j^{th} production activity in period t

$\bar{g}_j$ = average gross revenue of one unit of the j^{th} production activity

X_j = level of the j^{th} production activity

The linear programming tableau is given in Table 1.

The measure of variation in gross revenue used in this study is the standard deviation. The approach is adapted from Hazell [6]. The standard deviation is approximated using Fisher's estimator, i.e.,

$$S = \frac{K}{T} \left[\sum_j \left| \sum_t (C_{jt} - \bar{g}_j) X_j \right| \right] \tag{8}$$

where:

K = a correction factor, as defined above, to convert the sample mean absolute deviation to an approximation of the population standard deviation

Fisher's estimation does not require a normally distributed population.

Solutions are obtained for six levels of risk aversion with the risk aversion scalar, ϕ, assigned values of 0 (profit maximum solution or risk neutral solution), .5, 1.0, 1.5, 2.0, and 2.5. In statistical terms, ϕ can be thought of as a t-value (assuming the revenue variable is normally distributed and possesses small sample properties) or as the parameter, K, in Chebyshev's inequality:

$$P(|X - \overline{X}| \geqslant K\sigma) \leqslant \frac{1}{K^2}$$

The above expression means that, given any arbitrary probability distribution which has a mean, $\overline{X}$, and a standard deviation σ, the probability of obtaining a value that deviates from the mean by more than k standard deviations is less than

$$\frac{1}{k^2}$$

Thus, a ϕ of 3 or 4 reflects extreme conservatism on the part of farmers. Barker and Cordoba [2] had empirically shown that a risk level of 2.5 is the maximum aversion parameter for irrigated rice farm tenants or full-time owners in the Philippines.[3]

Risk Programming Model Results

The optimal alternative cropping plans ($E\text{-}V^{1/2}$ efficient set) are shown in Table 2. The risk neutral plan includes traditional palay, tomatoes and onions. Traditional palay enters the solution rather than HYV palay, even though the latter has a higher net return per hectare, because traditional palay yields a higher return to scarce animal labor and capital in this problem. The imputed value of these scarce resources are shown on the first row of Table 3.

If the farm operator has an aversion to risk, he will prefer solutions with ϕ greater than zero. As the risk aversion level increases both expected income and the standard deviation of gross revenue decrease. For example, net farm income and standard deviation of gross revenue falls 61 per cent and 86 per cent, respectively, by increasing ϕ from zero to 1.5 (Table 2). Also, the efficient set of crops shift from traditional palay and vegetables to HYV palay and corn. Vegetables are high income-high risk crops that become undesirable for highly risk averse farmers.

An interesting result within this programming framework is the presence of the "new" rice technology in the stochastically efficient set at the risk-aversion level range of 1 to 2.5. This finding implies that the adoption of the improved rice varieties is not as risky as growing the traditional varieties. Roumasset [13] using lexicographic safety-first models and a study area comprising irrigated rice farms located in four different villages, came up with a similar conclusion, i.e., ". . . under-investment due to risk aversion is not significant, at least for rice production in the Philippines. . . In some situations the farmer can increase his chances of reaching a minimum-target profit level by buying more cash inputs than called for at the risk neutral optimum".

Assuming the absence of serious measurement errors in the absolute levels of the model resource constraints, it is interesting to compare the imputed values of resources in the risk neutral solution

[3] Highest risk "cost" which a rice farmer will be willing to pay per unit of resource used in the planting of rice.

Accounting Deviation

	Cabbage	Onions	Deviation Activities					Standard Deviation Activity
Objective Function (₱ per hectare)	₱5,137.5	₱4,650.77						$-\phi\sigma_x$
Monthly Man Labor Requirements (Man Days Per Hectare)								
January	66.38	124.11						
February	66.38	27.15						
March		16.47						
April								
May								
June								
July								
August								
September								
October								
November								
December	49.41	26.77						
Animal Labor Requirements (Man Days Per Hectare)	28.67	18.67						
Monthly Land Requirements (in hectares)								
January	1	1						
February	1	1						
March		1						
April								
May								
June								
July								
August								
September								
October								
November	1							
December	1	1						
Working Capital Requirements (₱ per hectare)	3,191.28	2,786.59						
Gross Revenue Deviations (₱ per hectare)								
Year 1	5,836.83	3,270.75	-1					
Year 2	2,185.62	2,712.33		-1				
Year 3	990.68	215.97			-1			
Year 4	1,175.04	913.52				-1		
Year 5	7,838.41	7,228.52					-1	
Accounting Deviation			1	1	1	1	1	-T/K = -3.57

TABLE 1

Basic Tableau for Sample Problem

	Palay HYV	Palay Traditional	Corn	Mungo	Pechay	Tomato
Objective Function (₱ per hectare)	₱1,514.21	₱1,335.02	₱ 861.03	₱ 966.0	₱4,761.31	₱4,952.00
Monthly Man Labor Requirements (Man Days Per Hectare)						
January						11.97
February						18.34
March						
April			17.32			
May			15.96			
June			4.08			
July			16.98			
August	38.23	27.78			65.67	
September	4.89	4.13			77	
October	28.03	19.97		42.07		
November				21.05		28.37
December				31.55		33.66
Animal Labor Requirements (Man Days Per Hectare)	13.29	8.24	18.67	21.67	28.67	26.67
Monthly Land Requirements (in hectares)						
January						
February						
March						
April			1			
May			1			
June			1			
July			1			
August	1	1			1	
September	1	1			1	
October	1	1		1		
November				1		1
December				1		1
Working Capital Requirements (₱ per hectare)	386	238.69	1,348.26	891.69	1,677.06	2,321.57
Gross Revenue Deviations (₱ per hectare)						
Year 1	436.21	525.42	259.64	558.07	1,381.61	4,815.03
Year 2	299.84	176.06	25.20	228.02	1,573.16	1,251.67
Year 3	240.23	265.64	88.59	152.55	1,928.06	3,705.13
Year 4	331.53	320.07	113.82	326.10	1.1	193.97
Year 5	638.71	646.96	259.62	612.53	4,883.93	9,587.86

TABLE 2

Risk Model Results for Sample Problem

Item	Unit	Risk-Neutral Plan	Risk-Averse Plans				
			I	II	III	IV	V
ϕ		0	0.5	1.0	1.5	2.0	2.5
Objective function	(₱/hectare)	5266	3351	1718	1039	701	409
Expected income	(₱/hectare)	5266	5263	3740	2054	2054	1582
Standard deviation of gross revenue	(₱/hectare)	4112	3822	2022	677	677	469
HYV palay*	Hectare				1.0	1.0	0.476
Traditional palay*	Hectare	1.0	0.851	0.343			
Corn	Hectare			0.179	0.627	0.627	1.0
Mungo	Hectare						
Pechay	Hectare		0.149	0.657			
Tomatoes	Hectare	0.144					
Cabbage	Hectare						
Onions	Hectare	0.691	0.735				

*[illegible]

TABLE 3

Imputed Value of Resources in Sample Problem

Risk Level	Land (₱/hectare)	Man Labor (₱/day)	Animal Labor (₱/day)	Capital (₱)
0	294[1]	0[3]	96.92	1.02
0.5	244[1]	0	89.41	0.35
1.0	476[1]	7.10[4]	34.91	0
1.5	307[1]	0	29.30	0
2.0	108[1]	0	23.70	0
2.5	126[2]	0	11.32	0

[1] Land is a constraint in August only.
[2] Land is a constraint in April only.
[3] Not a constraint. Imputed value is thus zero.
[4] Labor is a constraint in September only.

with those in the risk-averse ones. For example, a rice farmer (within our model context) will be willing to pay ₱1.02 for a per unit increase in working capital in the risk-neutral solution. However, once the risk aversion scalar is set at .5, the shadow price of capital drops from ₱1.02 to ₱0.35 per unit, Table 3. With increased risk aversion, capital becomes surplus. Animal labor which commands an imputed value of ₱97 per man day in the deterministic solution, is "worth" only ₱11 at a risk level of 2.5. Man labor is a binding constraint in only one solution.

Land is a binding constraint in the month of August in all solutions when ϕ is parameterized from 0 to 2, and in April in the last solution. The surge of land values from ₱244 to ₱476 at a ϕ range of .5 to 1.0 is due to the increase in the activity level of Pechay (a highly profitable leafy vegetable crop which requires land in August) in the optimal solution from .15 to .66 hectare.

Research Implications

The empirical results show that risk and risk-averse behavior by farmers can be a constraint (in the form of risk premium) to the diffusion of some crop technology at the farm level (vegetable crops), but not a serious constraint for others (HYV rice). The results also show a wide divergence of the imputed values of resources under the risk-neutral and risk-averse farm decision states considered. Implications are important for both the researcher and policymaker.

The absence of risk considerations in our research models can lead to poor estimates of the adoption of new technology by farmers. In this sample problem, the risk-neutral plan includes high-income but high-risk vegetables, and HYV palay is excluded. Adoption of these vegetables by farmers could be over-estimated from these results whereas adoption of HYV palay could be underestimated. Absence of risk considerations also may lead to over-statements of imputed values for farm resources utilized under an improved crop technological scheme, e.g., the case of working capital. Failure on the part of agricultural policymakers to consider these biases in the imputed values of resources, e.g., land values increase initially due to the introduction of a land-saving technology, may lead them to the conclusion that the resource "market treadmill" process (in de Janvry's sense) is well on the way.[4] If farmers had a high risk-averse level the opposite policy conclusion could be drawn.

Conclusions

The simple $E:V^{1/2}$ model shows that risk can have a significant impact on the adoption of modern crop technologies. Resource returns are also affected. Some possible reasons for risk premiums differing among farmers are their different levels of knowledge about marketing costs (including market information costs) of each crop and differences of opinions about locational adaptability of the new technology.

Various price, credit, and crop-insurance schemes initiated by the government may reduce these risk premiums. The relevant policy maker should, however, bear in mind that there are also risk-cost reduction alternatives (induced by market forces) which are usually provided by the institutional structure within which farmers operate. The ultimate policy choice depends upon how the former views the "risk-benefit-cost ratios" of each policy alternative.

The findings in this paper hinge crucially upon the assumption that farmers are risk-averse. The "propriety" of assuming a risk

[4] The "market-treadmill" process refers to the adoption by farmers of a new technology that has higher imputed returns in the short run to resources used.

averse behavior on the part of farmers is still an empirically and theoretically inconclusive issue. Studies conducted by Cancian [4], Dillon [5], Officer and Halter [10], O'Mara, G.T. [11], Hazell and Scandizzo [7] suggest strongly that farmers behave in risk averse ways. However, Kenneth Arrow[1], and John Hicks [8] argued that the E-V utility function involves the highly implausible implication of increasing absolute risk-aversion (despite increases in assets or wealth of the individual). The basic stance adopted in this paper is a pragmatic one. The third and higher moment parameters of the various crop probability density functions, especially for vegetable crops, are quite difficult to estimate with the current data base. Furthermore, the farmer does not ordinarily know the exact shapes of the distribution functions of net farm returns.

A more serious limitation of the present methodology is that it is basically a partial equilibrium framework. Initial findings, however, derived from a general equilibrium risk programming model of Philippine agriculture are consistent with the results in this paper.

Another limitation of the present analysis arises from the *a priori* assumption that a *sufficient stock* of improved alternative crop technologies exists. This stock level depends largely upon the research capabilities of the economy. For a small country, like the Philippines, this research stock may be a binding constraint to the diffusion of improved agricultural techniques. At the moment, this "research constraint" has not been explicitly included even in the previously mentioned general equilibrium framework.

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