STATE RUN CROP INSURANCE AS A PUBLIC POLICY IN ACCELERATING AGRICULTURAL GROWTH IN DEVELOPING COUNTRIES

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Introduction

Modern varieties of agricultural crops, commonly referred to as high yielding varieties (HYVs), are being increasingly looked upon as a major source of the additional foodgrain required to attain self-sufficiency in a number of Third World countries. In spite of the demonstrated productivity gains with HYVs, the adoption rate has been rather disappointing in many of those countries. Part of the reason behind the farmer's reluctance must arise from the unfamiliarity and high costs of the new technology (increased cost of seeds, fertilizer, pesticides, and irrigation). One way of conceptualizing this would be to recognize that HYVs are riskier than traditional varieties. Even though the vagaries of nature may affect all crops similarly, the higher costs incurred in planting HYVs result in bigger losses in times of poor yields. Thus although the potential return is higher, the possible losses are also higher. Lack of familiarity with the new technology may, in itself, be a source of subjective risk (Lipton).

In this paper we show that a state run crop insurance programme may play a major role in the farmer's ability to take risks and allocate more land to cultivation of HYVs. The reasons for modelling a state run scheme are several. At the theoretical level, the recent literature suggests that insurance simply may not be provided by competitive markets due to imperfect information about the risk classes to which different farmers belong. At an empirical level, private insurance companies do not exist for agriculture alone. Further, private insurance companies, where they exist, use a large part of their budget to sell insurance. Although in a competitive environment one would expect that the increased social benefits from competition would outweigh the transaction costs, in view of the continual fight against starvation in many developing countries, it seems needless to waste resources selling insurance. There are thus sound theoretical and practical reasons for modelling crop insurance as a national programme.

The paper suggests that the main thrust of the theoretical findings has already found empirical support from whatever scarce evidence is available. In this light, prospects for a state run insurance programme in terms of food self-sufficiency are discussed for Bangladesh.

A Model of Public Crop Insurance

We begin by describing the problem of a typical farmer who maximizes expected utility in the face of prospects involving two states of nature, labelled 1 ("good") and 2 ("bad"). He starts off with A_0 units of land, of which he devotes A units to risky (HYV) farming and the rest, A_0-A, to safe (traditional) farming. The production function in risky farming is F(A), which has the usual concavity properties; the production function in safe farming is linear with a gross return of r.[2] The farmer can buy insurance at a rate of q per unit of land. In state 1, when things go well, he gets nothing in return; in state 2, when his risky output is assumed to be wiped out, the State gives him M, a predetermined subsistence level.[3] The probability of a disaster (i.e., state 2) is assumed to be p.

The farmer's maximization problem is given by:

(1) $\text{Max } V = (1-p)U(Y_1) + pU(Y_2)$;

where Y_1 and Y_2 are given by:

(2a) $Y_1 = F(A) + r(A_0-A) - q^A$, and

(2b) $Y_2 = r(A_0-A) + M - qA$.

The first order condition for a maximum gives us:

(3) $dV/dA = (1-p)U'(Y_1)(F'-r-q) - pU'(Y_2)(r+q) = 0$.

It may be easily checked that the second order condition, $(d^2V/dA^2) \equiv D < 0$, is satisfied given risk aversion ($U'' < 0$) and strict concavity of the production function. We wish to evaluate (dA/dq). From (3), it is seen that:

(4) $dA/dq = (A/D) \{[(1-p)U''(Y_1)(F'-r-q) - pU''(Y_2)(r+1)] + [(1-p)U'(Y_1) + pU'(Y_2)]\}$.

The first expression within the brackets on the right hand side can be identified as the income effect and can be shown to be positive under the assumption of decreasing absolute risk aversion. The second expression, however, is the substitution effect. Given $D < 0$, clearly $(dA/dq) < 0$.

The insurance agency is assumed to maximize gross output subject to the reaction curves of the farmers, which the agency is assumed to know. As the agency is assumed to handle a large number of insured, it can afford to be risk neutral:

(5a) $\max_q E(Z) = (1-p)[F(A^*) + r(A_0-A^*)] + p[r(A_0-A^*)]$,

(5b) subject to $qA^* = pM$.

From the constraint, it immediately follows that $qA^*(q) = pM$, so that $A^*(q)$ is a rectangular hyperbola in $[q, A^*(q)]$ space. In figure 1, we have drawn this rectangular hyperbola. In the same diagram, we have drawn a possible graph of the $A^*(q)$ function as obtained from the equilibrium condition (3). Given its negative slope [see condition (4)], the two curves will generally intersect.[4] Among the several possible points of intersection, we are interested in the intersection which maximizes the value of E(Z). It is easily checked that $dE(Z)/dq < 0$:

(5c) $dE(Z)/dq = (1-p)[F'(A^*)(dA^*/dq) - r(dA^*/dq)] - pr(dA^*/dq)$

$= [(1-p)F'(A^*) - r](dA^*/dq)$.

From the first order conditions, we have $[U'(Y_1)/Y'(Y_2)](1-p)(F'-r-q) = (r+q)p$. But $Y_1 \geq Y_2$, so $U'(Y_1) \leq U'(Y_2)$. Hence $(1-p)(F'-r-q) > r(p+q)$, or $(1-p)F'-r > q > 0$. We thus have the following simple and intuitive result:

Proposition 1: The optimal policy for a risk neutral national insurance agency is to set the smallest value of q at which it breaks even (subject, or course, to its acting along the reaction function of the farm).

Although this result is obtained in a model of perfect information (i.e., all farmers are identical), so long as we use the notion of a pooling equilibrium (i.e., both high and low risk farmers are offered identical contracts), it generalizes to the case of imperfect information where the insurance agency is ignorant of the risk class to which individual farmers belong (Ahsan and Rashid).

For a more detailed understanding of the model, let us consider some special cases. First, if we set indemnities at rA (so that $Y_2 = rA_o - qA$), we thereby replace the arbitrary M by the amount rA. The farmer's optimal land allocation condition is now modified into:

(6) $(1-p)U'(Y_1)(F'-r-q) = qpU'(Y_2)$.

It may again be checked that $dA/dq < 0$. The insurance agency's problem is, however, very simple. This is due to the fact that constraint ($qA^* = prA^*$, or, $q = pr$) uniquely determines the premium rate, and no explicit optimization is necessary. Thus in figure 1, the hyperbola is replaced by a vertical line, yielding a unique equilibrium. From (6), it follows that the optimal value of A* is given by the condition that:

(7) $F'(A^*) > (r/1-p)$.

Next, we analyze the consequences of setting premiums proportional to the value of the risky crop. The individual optimization condition is now given by $F'(A) = (r)/(1-q)$. Further specializing F(A) to be kA^{β} ($\beta<1$), allows us to obtain a unique value of q as optimal for the insurance agency. The constraint to the agency becomes $(1-p)qF = prA$, and when combined with the specific form of F and the farmer's optimality condition, we have:

(8a) $q = p\beta/[(1-p) + p\beta]$, and

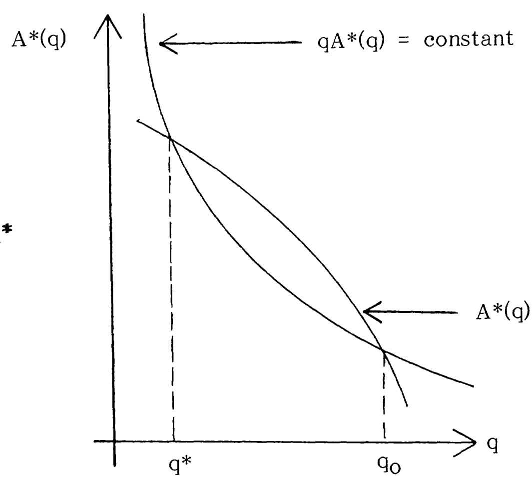
(8b) $F'(A^*) = r[1+p(\beta-1)]/(1-p)$.

In view of $(\beta-1) < 0$, and comparing (7) to (8a and 8b), we have:

Proposition 2: Setting premiums proportional to risky output rather than the amount of land devoted to risky farming leads to greater risk taking.

Figure 1.

Optimal Premium Rate, q*



We conclude this section by noting that the above results (specifically proposition 2) have far reaching theoretical consequences. First, in the context of such models, it can be demonstrated that the uniqueness of the equilibrium solution remains unaltered by a reasonable formulation of moral hazard. Next, even if we move away from the realm of expected utility maximization (as indeed some authors claim that under conditions of poverty peasants are more likely to behave according to "safety first" type models), the above results still apply (Ahsan and Rashid). In particular, it is shown that if the farmer maximizes the expected value of his output subject to a probabilistic constraint stating that income must exceed some "disaster" level (say, M) with some preassigned probability, and the insurance premium is based on risky output, the (post-insurance) equilibrium values of $F'(A^*)$ are the same in both the expected utility and the "safety first" models.

Thus we have shown that at the theoretical level public provision of crop insurance can be both financially feasible, and desirable on efficiency grounds in order to stimulate agricultural production.

Food Policy in Bangladesh

That insurance may lead to increased productivity by undertaking risky production was recorded at least a decade ago by Ray, analyzing the Sri Lankan experience. Crop insurance was introduced in Sri Lanka in 1958 on a pilot basis, and the coverage has been extended periodically, beginning in 1962/1963. Ray observed that "particularly in high risk areas, farmers may, as a result of insurance, cultivate land which otherwise they would not have cultivated...for the first time in Yala [season] 1962, 58 acres of rainfed paddy land were cultivated in Anuradhapura district because of such insurance" (p. 8). In fact, within the first 7 years of its operation, with a meagre 15 percent of all paddy land covered by insurance, rice production rose by 40 percent, yielding an annual rate of productivity growth of over 5 percent. Of course, without a detailed analysis of the Sri Lankan situation, it is not possible to deduce to what extent this growth experience was the result of insurance.

Bangladesh presently experiences an average annual shortfall of about 2 million tons of rice (15 percent shortfall over actual production).[5] Given the present population trends, it is estimated that production must grow at or better than 6 percent per year for self-sufficiency in food to be attained in the foreseeable future. This may be contrasted with the recent growth experience of about 2 percent for rice (all varieties). In the period 1973/1974 to 1979/1980, the index of rice production grew at an annual compounded rate of approximately 2 percent. The situation is somewhat better for all food grains taken together, mainly because of the spectacular growth in wheat production. This is due to both increased acreage placed under wheat cultivation and the relative success of the HYV wheat seeds.[6] However, the relative share of wheat in overall food production (e.g., only 2.6 percent of food grain production consisting of rice and wheat in 1977/1978) is still rather significant. Thus, over the medium term (10-15 years) any significant food gap will have to be met by increased rice production or importation.

HYV seeds are yet to be widely cultivated in rice production. A meagre 18 percent of total paddy acreage is currently under HYVs, yielding an impressive 31 percent of total output.[7] From our theoretical discussion and from whatever empirical evidence is available (e.g., Sri Lanka), we claim that agricultural insurance may provide the necessary incentive for farmers to go ahead and adopt HYVs of both rice and wheat. What about the likely costs of such insurance to the national treasury? First, according to the Sri Lankan loss experience, a premium rate of $1.00 (as of the early 1960s) per acre was sufficient for the insurance agency to break even. In terms of present rice prices, this would perhaps translate to $6.00. Thus even if the government (with or without international assistance) bears the entire cost of insurance, the entire 25 million acres of paddy fields (annual acreage) can be covered at a cost of about $150 million annually. Second, using Japanese data of over 30 years of crop insurance experience, the total cost (whether farmers pay the premium or not) of a viable insurance programme for developing countries has been estimated to be approximatley 2 percent of the value of output (Ahsan). Using a price of $600 per ton of rice would imply an estimate of $156 million as the cost of implementing a comprehensive paddy rice insurance programme for Bangladesh. It is interesting to note that these two estimates of the likely costs of insurance, though obtained by rather different methods, agree.

Are such amounts too high? There are several ways of looking at it. The magnitude of foreign assistance in the form of food aid (both grants and loans) has over the past 10 years averaged at $250 million annually. In addition, the government's food subsidy met from its own resources has approached $100 million annually in recent years. Probable insurance costs are thus within the limits of what is currently spent on essentially ad hoc measures of food policy.

Notes

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[2]Although restrictive, these assumptions are fairly standard in the theoretical literature on agricultural decisionmaking under risk (e.g., Fedor).

[3]Later in the paper we discuss the likely magnitude of M as well as its implications on the indemnity structure.

[4]Clearly, the location of the hyperbola is fixed by the size of M, and thus, given an arbitrary M, we may not have an equilibrium. It has been shown elsewhere that for large values of M we may always be assured of an equilibrium (Ahsan and Rashid).

[5]All data on Bangladesh are obtained, unless otherwise stated, from Government of Bangladesh (various issues), and those on Sri Lanka from Ray.

[6]Between 1972/1973 and 1977/1978 the production level rose by nearly 300 percent while the acreage planted rose by nearly 60 percent.

[7]See Government of Bangladesh (1981).

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