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Risk Aversion, Rural Financial Markets and the Demand For Crop Insurance

Hans P. Binswanger

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INTRODUCTION

We start this paper with the observation that the market for yield insurance of agricultural commodities has failed universally, even in the most developed countries. While some risk-specific yield insurances (hail, typhoon, flooding) are provided by private companies in developed countries on a profit making basis, general yield insurance comes into existence or survives only because of government subsidies.

We will show in section I that failure of the markets does not arise from lack of demand for consumption and/or income stabilization. Farmers in developing countries are poor and universally risk arise, if we are to believe the four recent experimental studies reviewed below. Furthermore, capital markets are also poorly developed which in principle should increase the demand for insurance on the part of risk-averse farmers. Furthermore yield risks are primarily weather related, i.e. they do not fall into a class of risk for which probability information is exceptionally difficult to find, such as war or damage to a nuclear reactor.

The main theme of the paper will be the rigorous exploration of the causes of the serious difficulties of both the credit market in rural areas as well as the yield insurance market. Indeed we trace them to an identical set of information, incentives and management problems. We then explore these similarities and trace the consequences for both markets and the potential for certain types of remedies or substitute solutions to the income/consumption stabilization problem. Substantial attention will be focussed on the question under which circumstances efficiency gains arise if suppliers of credit can compel demanders of credit to buy insurance, independently or as part of the credit contract. That such cases clearly exist on efficiency grounds may be a novelty to economists who perform all their analysis in the fairy tale world where information is costless and intentions of transaction partners are always as clear as a crystal ball.

However, before embarking on our main theme in section II we discuss a number of empirical and preliminary issues which impinge heavily on the benefits of crop insurance and which could arise potentially even in the fairy tale world mentioned above. Insurance benefits are higher, the higher the extent of risk aversion and we first review empirical evidence on that. Second, we discuss means for stabilizing consumption for any given variablity in agricultural income. Third we discuss alternative means for stabilizing agricultural incomes such as crop diversification, agronomic practices, and price stablization. The potential impact of crop diversification, crop insurance and price stabilization on revenue risks is then explored quantitatively across agroclimatic zones. Readers familiar with these issues and the empirical studies may want to move directly to section II.

I PRELIMINARIES

(a) Experimental Studies of Risk Aversion 1/

In 1980, I reported an experiment which measured risk preferences among a sample of villagers in semi-arid tropical India. In this experiment each respondent was offered a series of choices from sets of alternative such as the set illustrated in Table 1. After identifying his preferred alternative, the respondent flipped a coin whose outcome determined whether he would receive the high or low payoff for the designated alternative. Because those alternative offering higher expected payoffs also involve a larger spread, the respondent's revealed preference may be viewed as a reflection of his preferences between risk (here identified with variance) and expected gain. Unlike most previous studies, the payoffs cited in the games were not hypothetical, but were actually paid out. In later rounds the respondent made choices among alternatives offering payoffs comparable to the returns from agricultural investments.

Since the Indian risk aversion experiment at least three other researchers have applied my general experimental method in other LDC farming communities. Sillers (1980) compared the choice behavior of two matched samples of rice farmers in Central Luzon, the Philippines; one group faced gambles involving only gains, while the other group faced gambles involving both gains and losses. 2/ Walker (1980) measured risk preferences among maize farmers in northern El Salvado, and used the results to investigate the adoption of hybrid varieties. Finally, Grisley (1980) used a larger number of alternative gambles to give a more precise estimate of individual risk preferences, and several other methodological refinements in his study of rice farmers in norther Thailand. 3/

Because of the basic similarity in experimental method used in these four studies, we are able to compare the distribution of risk preferences in four peasant farming communities set in different agroclimatic environments, enjoying different absolute living standards, and conditioned by different cultural norms. Stated briefly, the results suggest that in the "typical" village, preferences among economically significant risks in gains may be concentrated within a relatively narrow band, with only a small proportion of farmers demonstrating either risk neutrality (or risk preference) or extreme risk aversion.

To facilitate comparisons among experiments and to give the reader a sense of the size of the experimental payoffs in terms of local incomes, all payoffs are expressed in experiment-specific "daily wage" units (DW´s), equal to the faily wage received by an unskilled agricultural laborer in the study area in question. 4/ Specifically, the "payoff scale" of a particular experimental game refers to the size of the riskless alternative in DW´s: thus, the game summarized in Table 1 reprepsents a .143 DW game (= 0.50 Rupees/3.50 Rupees per day).

Table 1. Alternative Gambles and Corresponding Risk Aversion Classification, Indian Risk Aversion Experiment a

Choice	Risk Aversion Class	High Payoff (Rupees)	Low Payoff (Rupees)	Proportional Insurance Premium IP (see text)
O	Extreme	.50	.50	.5
A	Severe	.95	.45	.3
B	Intermediate	1.20	.40	.2
C	Moderate	1.60	.20	.1
E	Slight-to-Neutral	1.90	.10	0
F	Neutral-to-Negative	2.00	0	0

a "Inefficient" alternatives S and D* used in the Indian and El Salvador experiments are excluded from the analysis in this paper. See Binswanger (1980, p. 396) for a discussion of these alternatives.

A second measure is introduced to express the degree of risk aversion implicit in observed choices. This "proportional insurance premium" (IP) expresses the proportional reduction in expected return which the respondent is willing to accept to achieve the reduction in risk he deems desirable. The insurance premium implicit in the selection of a particular alternative is first derived by subtracting its expected value from that of the risk-neutral alternative (that with the highest expected value). This difference is then normalized by the expected value of the risk-neutral alternative to yield the desired measure. 5/ One advantage of IP is that its use eliminated the need to specify a utility function; it moreover may be directly applied to gambles involving losses as well as gains. Application of IP is limited, however, to comparisons among choices with respect to gambles having similar probability structures, as in the present case where all games were two-outcome games with equal probabilities. And in later subsections we will need to go back to other measures of risk aversion.

Table 2 summarizes the distribution of risk preferences observed in the four experiments, breaking the Philippine sample who faced gambles with both gains and losses (GL subsample). For each experiment the games at the two highest payoff scales are presented, since behavior in thse games would seem to be the most relevant to significant economic decisions. Responses are divided into three groups: (1) "near-risk-neutral to risk-preferring" responses, (2) "moderate to intermediate risk averse" responses, and (3) "severe to extreme risk-averse" responses. 6/ All choices of the "inefficient" alternatives used in the Indian and El Salvador experiments are excluded from the analysis.

As shown in Table 2, the propotion of responses suggesting risk neutrality or preference for risk (alternatives F and F′) is very small in four out of five samples. Even when the slight-to-neutral responses (alternative E, alternative 10 and 11) are included in this comparison, the incidence of possible risk neutrality is everywhere less than 17 percent, for all but the El Salvador sample. With the same exception, increases in payoffs scale produce a definite shift away from risk-neutral or risk-preferring alternatives. Finally, the incidence of slight-to-negative risk aversion in the Philippine GL games was lower than that observed in the GO games. The clear outlier was the El Salvador sample, where around 30 perpcent of the respondents chose low risk aversion alternatives in each game shown. While we cannot dismiss the possibility that this sample actually included a high proportion of risk-neutral farmers, such a conclusion should be made cautiously in view of the low payoff scales and small sample size used in this sequence, and possible problems with the use of hypothetical payoff games. Taken together, the evidence of Table 2 strongly suggests that the underlying incidence of risk neutrality and preference for risk in peasant farming communities is generally quite low. 7/

On the other hand, the incidence of extreme risk aversion observed in the experimental games was also very low. In four out of five cases, choices of the riskless alternative make up less than 3 percent of total responses. "Severe" risk aversion characterizes a somewhat larger fraction in most cases. These results contrast sharply with the outmoded but tenacious image of LDC farmers as burdened by extreme aversion to risk.

Table 2. Distribution of Revealed Risk Preferences in Four Experimental Studies.

	Extreme or severe risk averse responses		Intermediate or moderate risk averse responses	Risk-neutral to risk-preferring responses			Efficient Responses
	O	A	B-C	E	F	F'	
India (Binswanger)							
50 Rupee (14.3 DW)	2.8	5.6	32.2	7.5	1.9	--	107
500 Rupee[H] (143 DW)	2.6	13.9	32.6	0	0.9	--	115
Philippines Gains-Only Subsample (Sillers)							
50 Peso (7.1 DW)	0	10.2	73.5	12.2	4.1	0	49
500 Peso (71 DW)	2.0	6.1	77.6	14.3	0	0	49
Philippines Gains-and-Losses Subsample (Sillers)							
50 Peso (7.1 DW)	0	10.2	79.6	6.1	4.1	0	49
El Salvador (Walker)							
10 Colon (2.5 DW)	1.4	8.3	58.3	19.4	11.1	--	36
50 Colon[H] (12.5 DW)	12.5	18.1	40.3	12.5	16.7	--	72
	1	2	3-9	10	11		
Thailand (Grisley)							
66.75 Baht (2.7 DW)	0	0	92.3	0	7.7		39
200 Baht (8 DW)	2.6	0	97.4	0	0		39

[H]Game used hypothetical payoffs only.

The proportion of highly risk-averse responses is higher for higher payoff scales in all cases but that of the Philippine GO subsample. Finally, one should note that the incidence of extreme and severe risk-averse responses is the same in the Philippine subsample facing losses as in the subsample facing only gains.

Mirroring the relatively low incidence of extreme responses was the concentration of revealed preferences in the "moderate" and "intermediate" risk aversion categories. For all but the El Salvador sample, such responses comprise upwards of 70 percent of the total. 8/ With the possible exception of the El Salvador experiment these findings suggest that, in most LDC farming communities, most villagers may hold rather similar pure preferences toward risk.

Finally, we note in passing an important aspect of the experimental risk distributions which has been analyzed in detail elsewhere, namely the non-relationship between the net household wealth of respondents and their measured risk aversion. In each of the cases where regression analysis was applied to determine the impact of household characteristics on risk aversion, neither wealth nor income had a significant effect on observed choices, despite large differences in the household wealth of respondents.9/

The general impliations of these comparisons of mean risk aversion across payoff scales and among samples are twofold. First, despite differences in detailed behavior, the data suggest that the pure risk preferences of peasant farmers may exhibit a surprising degree of cross-cultural homogeneity when the absolute size of the risks are deflated by an appropriate measure of local absolute living standards. Second, the relatively gradual increase in mean risk aversion seen for each of the samples considered here suggests that utility functions which exhibit constant partial risk aversion (Menezes and Hanson, Binswanger 1981) are likely to provide better summaries of farmer preferences toward risk than functions with constant absolute risk aversion, a point which may be helpful when specific information on the risk preferences of a particular group is not available.

b) Stabilizing Consumption and Insurance Substitutes

Utility or welfare of farmers depends on stability of consumption and only indirectly on agricultural income or yield. (For a detailed discussion of these issues see Newbery and Stiglitz 1981). Suppose agricultural income (farm income and agricultural wages) is variable, consumption can still be stabilized in a variety of ways:

1. Agricultural income may only be a fraction of total income. In Thailand, for example, farm households derive approximately one third of their income from nonagricultural sources (World Bank, 1982). However, only if the nongaricultural incomes are not highly correlated with farm income will they reduce the impact of agricultural income variability on consumption variability.

2. Producers may hold reserves in the form of cash, gold, financial assets, stocks of food or feed, and producer durables for the expressed purposes of stabilizing consumption over the years. However, while certain forms of reserves may be a low cost substitute for insurance, (such as financial assets) reserves held in the form of physical stocks and producer durables are usually high cost substitutes. Furthermore, as Jodha (1978) has shown, the value of producer durables as reserves may be sharply diminished by the covariance of their prices with crop disasters, i.e. the prices may be exceptionally low in bad years.

3. The credit market may serve to insure consumption in the face of income variability. If farmers could borrow unlimited amounts at the same interest rate as they can invest, the credit market would be a perfect and low cost insurance substitute. While we will see below that most rural credit markets are very far from this fairy tale world, it is nevetheless clear that improvements in credit markets must be considered as alternative policies to improvements in the crop insurance market.

4. Income transfers which are tied to disasters are another insurance substitute. Family networks and other social groups may provide such mechanisms and in environments with poor credit and risk markets individuals appear to invest more effort into the maintenance of such groups. We should note, however, the family networks usually are restricted to small regions. If crops fail in an entire region the family network cannot perform the function of consumption stabilization well. It can do so better for risks which are no covariate among its members. Other transfers are government relief efforts in the form of drought, flood or earthquakes which may take the form of direct food transfer or of emergency employment programs. Employment programs in particular are capable of insuring consumption for both farmers as well as landless workers and may be more powerful means of preventing famines or scarcities which result from what Sen (1981) calls entitlement failure, especially in cases where food availability is not a problem. Jodha, (1978) provides a good study of the effectiveness of employment programs.

5. Consumption may also be stabilized via shifts to other occupations such as construction labor etc. However, within individual regions general crop failure may sharply limit opportunities for such shifts,

again because reductions in final demand arising out of covariate income drops associated with crop failure. It is therefore not surprising to find that the shifts to other occupations usually is limited to, and associated with, temporary migration to other regions.

The extent to which these means can and do substitute for crop yield insurance will vary a great deal from region to region, among household types and with the extent of general development of transport facilities, markets and institutions. However to the extent that they function well, they do indeed reduce demand for insurance in general, and for crop insurance in particular.

c) Alternative means of stabilizing farm income

Total agricultural income is the sum of revenues from each livestock and crop enterprise, less costs. It can be stabilized in many ways.

1. Farmers can increase the degree of enterprise diversification to take advantage of the less than perfect correlation of revenues among the enterprises. While there are many other reasons for diversification, farmers will demand crop insurance only if the income risk reduction provided by the crop insurance cannot be achieved at a lower cost (in terms of income gains from specialization) via further diversification.

2. Within each crop, farmers can adjust agronomic practices such as sowing data, level of inputs etc. Or they can choose to intercrop (Jodha, 1978). Again they will weigh the benefits and costs of these options against insurance.

3. For inputs which are not committed before the weather factors of a particular year are known (late application of fertilizer and pesticides, harvesting costs) farmers can make mid-season corrections in their input

levels. Or if crops fail early, they can replant another shorter duration crop (Jodha, 1978).

4. Crop revenue risk can be reduced (or increased) by price stabilization either via a variety of price stabilization schemes or via futures markets. (For a very thorough theoretical analysis of price stabilization see Newbery and Stiglitz). Where crop yields are stable, such as an irrigated environments, prices are the major sources of risk and very little demand for crop insurance can be expected. Note also that price stabilization can increase revenue risk when prices and yield are negatively correlated. Even when stable prices lead to stabilized crop revenues this can result in transfers of producer welfare in favor of consumers. Furthermore, price stabilization has little impact on consumption stability of subsistence oriented producers.

5. Agricultural income can also be stablized by a variety of risk specific insurances for cattle, buildings and machines, as well as for specific crop risks such as hail.

If crop yield insurance is so difficult to implement, it is well worth to explore what policy can do to improve the functioning of these crop insurance substitutes. Furthermore, in many regions demand for crop insurance may be severely limited because the farming system and the factor market environment have adpted sufficiently to the risks faced that crop insurance, even if provided, would only have minimal benefits in terms of stabilizing consumption.

d) Agroclimatic variations and the potential revenue stabilization of crop diversification, crop insurance, and price stabilization.

This section is to be completed and will give a brief review of empirical work by Barah and Binswanger across different agroclimatic environments in India. This represents a quantitative analysis of the issues discussed in section Cl, and C4 above.

II ASSUMPTIONS

For our exploration of the links between credit and insurance markets we take as given the following behavioral, and technological, assumptions:10/

Behavioral:

B-1. Self Interest: In the first instance individuals are interested in their own utility.

B-2. All individuals dislike effort at least to some extent. Supervisory activities are also effort.

B-3. Individuals are risk averse whenever gains and losses exceed trivial levels of income. Risk aversion may vary among individuals and for the same individual with wealth

Technological:

T-1. There are at least four primary factors of production: Land, labor, animals and human capital (management and other skills), and their supply and supply processes are governed by entirely different forces.

T-2. Land is immobile: Cooperating factors have to brought to the land for production.

T-3. Acquisition of information is costly. Information and human capital often arise in the cheapest way as by-product to production or consumption in which one is personally engaged.

T-4. Transport and travel costs are high and time intensive. They fall with the level of development.

T-5. Spatial <u>Transmission of information is costly and time consuming</u>. There is, for example, often no telephone. Costs of transmitting information fall with the level of development.

T-6. There are four sources of risk

1. <u>Yield risk:</u> For any given level of agricultural inputs, the output level is uncertain.
2. <u>Timing uncertainty:</u> Optimal timing of inputs depends on weather, and losses associated with delays are often large, expecially for sowing, irrigation, harvesting and pest control.
3. <u>"Breakdown" risks:</u> Durable factors of production such as machines, buildings or animals can break down temporarily, fall sick, have accidents or burn down. The timing of repair costs and reinvestments is therefore uncertain.
4. <u>Life-cycle risks:</u> Individuals face risks of temporary or permanent absence from work because of illness, accidents or other life-cycle risks.

T-7. <u>Risk covariance:</u> Yield risk and timing uncertainties are weather induced and therefore have high covariance within small and sometimes even larger regions. Timing covariance is a consequence of seasonality of agricultural production. Covariances of breakdown and life-cycle risks within a region is much smaller except for specific events such as epidemics, floods, or war.

All of these assumption could individually apply to nonagricultural pursuits. But their combination is unique to agriculture. The following assumptions are especially important: T-1, Four primary factors; T-2, Immobile land; which leads to a spatial pattern of production which is unique to agriculture; T-6-1 and T-6-2, Yield and timing risks are especially severe for agriculture while breakdown and life-cycle risks are universal; T-7, Risk covariance in small regions: For most other productive activities covariance of returns arises from the market side, not the technological relations.

III. GENERAL CONSEQUENCE

The following major general consequences follow immediately: Consequences for agriculture will be discused later.

G-1. Asymmetric information: Information has value and is costly to acquire (T-3). Since individuals are selfish (B-1), they will not part with information they possess unless it is to their advantage. For example, high quality workers will want employers to have accurate information about workers' quality while inferior ones whould prefer it if worker quality was unknown to the employer, unless the employer has ways to penalize them once he finds out. The same applies to borrowers and lenders or to insurers and insured. Sellers of seeds and animals know more about their quality than the buyers and may have incentives to misrepresent seed quality. Such problems of asymmetric information arise in virtually all economic transactions to some extent.

G-2. Incentive Problems (Moral hazard, adverse selection and screening effects) When information is costly (T-3) and asymmetrically distributed (G-1), incentives problems arise in most economic transactions. A daily paid laborer has no icentive to work hard, unless supervised closely via direct observation of his effort or via monitoring or inspection of his output. Incentives to work hard may be improved by providing share contracts (piece rates at harvesting or for earth digging, or crop sharing tenancy contracts) 11/. Since the worker receives only a share of the full marginal product of his effort he will still not work as hard as if he was an owner-cultivator, unless again he is supervised or monitored in other ways, and penalized in terms of loss of future repeat contracts. A person who rents a bullock pair has little incentive to feed it beyond the minimum required to elicit the work effort which he desires. He may return the animal in underfed or damaged condition. A farmer, whose crop is insured relative to a "normal" level of output may not apply as much care, precautioning or inputs as if his crops was uninsured. It is in this insurance context that incentives problems were first called moral hazard problems. Unless the insurance company can stipulate input and/or care levels, and observe or monitor them at very low cost, insurance contracts may lead to inefficient resource use. Many contracts anticipate this and include coinsurance clauses, i.e. insure only a fraction of the shortfall in production, or of the damage. With such clauses the insured has again a partial incentive to use proper care and input levels, a situation very similar to share contracts or piece rate payments.

When it is hard for one partner in a transaction to distinguish between potential partners of high and low quality, screening problems arise. They were first noticed in the insurance case where they are called adverse selection. Among a group of potential insurance clients, those with a high exposure to risk will find insurance more attractive. The insurance company will attempt to distinguish high risk from low risk individuals and charge higher premiums to the high risk ones. If it cannot distinguish very well, it will use variables such as age, sex, race, caste etc. which are correlated with risk. If it can not distinguish at all, it will set the premiums so high that only high risk individuals find the insurance attractive and apply, and the insurance market fails to exist for the low risk ones. The presence of undistinguishable high risk individuals (1) impose a cost on the low risk ones and (2) forces the insurance company to use the terms of the contract to screen individuals into homogenous groups.

Similar situations have been hypothesized in other markets. What is now known as the screening literature shows examples how employers (Weiss, 1980) or landlords, (Newbery & Stiglitz, 1978) or creditors (Stiglitz and Weiss, 1980) can structure employment, tenancy or credit contracts which will lead employees (tenants, debtors) to reveal information by the choice of the contracts.

G-3 Imperfect enforcement of property rights

Where acquisition of information is costly (T-3) and asymmetrically distributed (G-1), property rights cannot be perfectly enforced. This follows from the fact that there is some positive incentive for theft which will be realized when it is easy to conceal the identity of the thief, i.e. when costs of ascertaining who did it are very high. We note here that many legal and cultural institutions are designed to reduce costs of information acquisition or to increase penalties for theft. Furthermore, other things equal, cost of information are lower, and penalties in terms of future opportunities higher, in small, immobile communities than in large ones with a high extent of mobility.

G-4. Desirability of a broad spectrum of insurances follows directly from risk (T-6) and risk aversion (B-3). Most individuals should be willing to pay some positive amounts to reduce their exposure to any one of these risks. Where insurance is unavailable they would be willing to alter their behavior in other ways to reduce exposure to risk, even at a cost (self insurance, self protection). Such behavior includes the holding of reserves, diversification of prospects, conservative input levels, investment in "creditworthiness" and family ties and etc. has been discussed in section I.

G-5 Collateral requirement.

A collateral requirement affects borrowers' and lenders' utility in complex ways. First we consider the case when a borrower has every intention to pay back. Default can then only be a consequence of bad luck and is involuntary. Note first that, for a given interest rate or loan size, raising collateral value from zero to some positive amount raises the expected return from the loan to the lender. With zero collateral the expected return is equal to (1) the rate of interest multiplied by the probability of succes of the project undertaken i.e. the probability of repayment, minus (2) the value of the loan times the probability of failure, (assuming that loans are either fully repaid or fully defaulted on 12/). As collateral is increased, the second term gets progressively smaller since only the difference between the loan amount and the collateral value is lost. Note that by raising collateral value to levels larger than the loan size, the expected return can be made larger than the rate of interest, a technique which can be used to circumvent the impact of interest rate ceilings.

Thus it is seen that, from the point of view of expected return, interest and collateral act as substitutes. It is feasible to achieve a given expected return on a loan by various combinations of rates of interest and values of collateral. If the lender is risk-neutral and the borrower is known not to default intentionally, and if both lender and borrower have the same information about the probability distribution of the outcomes of the project financed by the loan, the lender will be indifferent between the two methods of achieving the desired expected rate of return. If the expected return is sufficiently high, he will make the loan despite the possibility of losing his entire capital in the event of (unintended) default.

A collateral requirement between zero and the amount of the loan shifts a portion of the potential capital loss from the lender to the borrowers. If the borrower is risk-neutral he does not care whether collateral is or is not require: the expected value of the capital loss in the bad-luck case is offset by the lower expected interest costs in the good-luck case.

Now consider a risk-averse borrower. The fact that the expected value of the capital loss is just equal to the expected value of the rate reduction in the good-outcome cases is not sufficient to make him indifferent to the imposition of a collateral requirement. The large potential capital loss implies a high utility loss for the risk-averse individual, who would therefore rather accept a high-interest contract which allows him to default (involuntarily) in bad-luck cases at no additional cost. With risk-neutral lenders there would therefore not be a collateral requirement for honest borrowers. Conversely, risk-averse lenders will insist on some collateral, even if they know borrowers' intentions to repay. We thus see that collateral is a risk sharing device, 13/ and that the way in which agents view collateral requirements depends on their risk aversion.

The most severe problem of both risk-neutral and risk-averse lenders is the fact that they normally cannot know borrower's intentions about paying back loans. If there is no collateral, utility-maximizing borrowers will default if the utility cost of default falls short of the utility of the loan amount plus interest. Utility costs of default will be higher, the lower the mobility of borrowers, the easier it is to trace them and attach their assets and the easier information about their default can be transmitted to other potential lenders. Thus lenders, other things equal, are more likely to lend without collateral (1) for small loans rather than large one, (2) to owners who have invested in land and buildings rather than to tenant farmers, and (3) to resident workers rather than migrant workers. Since for most people the utility cost of default will be positive, even if it is small, small loans will often be given without collateral. For large loans lenders will almost never be certain that the utility costs of default exceed the value of the loan, and collateral will be used to make up for the lack of incentive to repay, i.e. collateral has an incentive effect. When the sum of the utility loss and the collateral is equal to the loan size plus interest, all the incentive for defaulting is removed. Thus when lenders compete and when there are no interest rate ceilings, full collateral for principal plus interest will only be demanded if the lender believes that the utility cost of default is negligible. For a given loan size the incentive effect of the same collateral amount thus varies with the personal characteristics of the borrower. Personal characteristics enter the loan market in an essential way which is simply irrelevant for sales transactions of goods. An impersonal market is not feasible.

To summarize, at a given interest rate, collateral has three effects or functions: (1) it increases the expected return of the lender and reduced the expected return for the borrower, (2) it partly or fully shifts the risk of loss of the principal from the lender to the borrower and (3) it provides those borrowers who have low disutility of default with additional incentive to repay loans. We now apply these insights to the issue of capital constraints for small and large farmers.

G-6 Consequences of collateral for credit markets

From our discussion of the collateral problem it is clear that small farmers who do not own land (or other units acceptable as collateral) will generally not be able to borrow to invest in fertilizer, but rather will have to invest out of savings and /or establish input-sharing arrangements with land owners. The credit market does not exist for them. Large owners, on the other hand, will obtain credit on favorable interest and collateral terms, since the only reason for collateral in their case will be to shift risk away from the lender. 14/ Small owners will be eligible for loans but lenders will usually insist on higher levels of collateral than for large owners to compensate for the higher risk of intentional default. This shifts a higher proportion of the risk of capital loss to small owners than to large owners and increases the expected cost of the loan as well. Thus small farmers will perceive these loans as both more risky and more expensive than those extended to large farmers, i.e. their utility cost of borrowing will be higher (relative, for example, to the utility cost of work). They may, of course, attempt to shift risk back to the lender by agreeing to higher interest rates in exchange for a reduction in collateral requirement, but the lender, even if risk-neutral, will only accept such a shift to the extent that they leave the lenders' expected return as large as that from loans to large owners, and as long as the collateral requirement provides sufficient incentive for repayment. If the disutility of the loan is sufficiently high, small owners may stop borrowing altogether, i.e. the credit market for small owners may disappear because of lack of demand, despite the fact that small owners may still have available collateral in the form of unemcumbered land.

It is thus clear that the full utility cost of borrowing (relative to other alternatives), including the extra risk, will be higher for small farmer than large ones. The loan market may disappear for small farmers from the demand side if the utility cost of the loans exceed the utility benefits from the projects. The market may also disappear from the supply side for farmers who do not own assets in forms acceptable as collateral or who already have high debt/equity ratios, i.e. have "used up" all collateral. 15/

G-7 Insurance as an imperfect collateral substitute:

Can a borrower obtain an unsecured loan more easily if he takes out some insurance which reduces the probability of some disaster and thus of default? We use the same approach as in the previous section of considering the impact of insurance on the rate of return, the risk of capital loss and the incentives for repayment for "dishonest" borrowers. Suppose the "project" is a current account overdraft facility and the insurance is a hail insurance which allows the farmer to pay back a loan in the case of hail damage. We choose hail insurance here because this largely circumvents the moral hazard issues of general crop insurance. Another example would be life insurance for the borrower.

The insurance will alter the probability distribution of the returns from the project by reducing the probability of one type of losses, and by reducing the returns of the project in every year by the premium amount. If the insurance is actuarily fair (i.e. there are no insurance management costs) this amounts to a mean preserving reduction in the spread of the return distribution, leaving the expected return of the project the same, but reducing its riskyness. Insurance company management costs and profits would further increase the premium and shift the mean of the return distribution downwards.

A bank will find an unsecured loan to an insured individual (who pays the premiums) more attractive than to an uninsured one, since the expected return of the loan will go up by the sum of the principle plus interest times the probability of hail (default). Thus insurance, like collateral, increases the expected return of the loan. However the increase is smaller than for a collateral requirement since collateral is realized for all causes of default while insurance is tied to one specific risk, i.e. hail. Any other cause of failure to repay of the borrower is not covered.

Second insurance shifts that portion of the capital loss risk which arises from hail away from the bank and to the insurance (instead of to the borrower). If the borrower is risk averse he will demand the insurance without compulsion unless it is very expensive, while the bank would be indifferent as to who carries this particular risk.

Third, for dishonest borrowers, in the sense discussed above, hail insurance will not provide the incentives to repay which collateral provides. If the borrower intends to default and no hail occurs, there is simply no effect of insurance on repayment. Only if the specific (initially uninsured) disaster of hail reduces a persons capital position sufficiently to reduce his repayment incentive from the level which insures honesty to the default level will hail insurance prevent default. Only an insurance for very major sources of risks would therefore alter incentives structures significantly.

Thus we see that insurance is an imperfect substitute for collateral in the following way: While it increases the rate of return to the bank on an unsecured loan and shifts part of the capital loss risk away from the bank, it does so less than collateral because it is tied to specific events, whereas collateral can be collected in the case of all disasters. And it has little, if any, effects on repayment incentives. From the point of view of a risk averse honest borrower, insurance is desireable compared to collateral since it shifts the risk of capital (collateral) loss for at least one source of risk to the insurance company.

There is, however, an additional monitoring function which insurance can play for the bank. If an uninsured borrower is in difficulty in a hail year and asks for rescheduling of his debt (whether it be secured by collateral or not), the bank has to make an assessment to what extent difficulties are indeed caused by hail (i.e. nonintentional) compared to problems which were under the control of the borrower. The insurance obviates this need since it makes a precise assessment of the hail damage and thus, in addition to lowering the default risk, provides the bank with accurate information on the borrower which would otherwise be hard to get. In particular, if the damage assessment requires specialized skills, an insurance company may generate such information more cheaply than a bank.

We conclude this section by emphasizing that insurance on favorable terms does have some of the same effect as collateral, and in certain circumstances can convert non-borrowers into borrowers and/or increase loan amounts to existing borrowers. Thus efficiency gains may indeed arise in the capital market. However, we stress the fact that insurance does not generally solve problems of lack of incentives to repay, except to the extent that it may improves the bank's monitoring of the intentions and circumstances of the borrowers.

G-8 The insurance of collateral and compulsion

Lenders routinely force borrowers to insure houses or motor vehicles which are used as collateral against a variety of specific damages. Consider the case where the market value of a collateral item is equal to the loan amount. If the only way a lender can collect from a defaulting borrower is by foreclosure on the collateral, the lender carries all the "project" risks which arise from specific hazards to the collateral. Thus the lender's expected return can be increased in proportion to the probabilities of the insured collateral-specific risks, and his risk of capital loss correspondingly be reduced. If the lender were risk neutral, he could simply increase his lending rate and allow default in the case of damage to the collateral. But in this case, the bank needs to perform the actuarial calculations and also to assess the extent of damage and the causes. Since the bank accepts many different forms of collateral this might be expensive and gains from specialization may be large, i.e. a diversified insurance industry may provide the service more efficiently. Furthermore, banks may lend in small areas where risks to collateral are covariate, such as flood or fire risk to real estate. A specialized insurance can diffuse the risk over wider areas and therefore be cheaper. In these cases the bank will insist on collateral insurance, even if it is risk-neutral, and of course the more so if it is risk-averse.

Note here, that availability of insurance can convert risky assets into secure ones and make them useable as collateral in the first place. Unless automobiles could be insured for virtually all damages, including owner-caused collision, most developed countries' wage workers could not borrow to purchase automobiles. Similarly, the use of animals as collateral can only emerge when animals can be insured at least against theft and accidental death.

In the case just discussed (collateral value $\leq$ loan amount; no further recourse for collecting debt than foreclosure), even a risk averse borrower has no incentive to purchase insurance. The entire proceeds of the insurance accrue to the bank, and, in the absence of insurance, loss of collateral results in the elimination of debt. Therefore collateral insurance must be compulsory in this case, i.e. built into the loan contract as a requirement.

Absence of further recourse of banks in the case of collateral loss can arise in several ways. Loan contracts may be written that way in the first place, i.e. they may not create a personal liability beyond the collateral. Or even if a personal liability is created, it may be difficult to collect, as in the case of automobile loans to a highly mobile population. Or borrowers, or groups thereof may use legal or political means to sharply increase collection costs. Thus even in cases where a personal liability legally exists, lenders may wish to resort to compulsory collateral insurance.

Partial incentives for voluntary collateral insurance by the borrower arises in the case when a personal liabilities for the loan exists and/or when the value of collateral exceeds the value of the principle plus interest. The most common case is the conventional first mortgages where there is always an incentive to insure ones own equity in a house. Nevertheless, in the absence of compulsion, the full incentive to buy insurance will not arise.

We now may also have an explanation for the lack of demand for flood or earthquake insurance which is so frequently explained by a supposed inability of borrowers to assess the probabilities of flood (Kunreuther). Major floods or earthquake are likely to destroy a major proportion of a household's assets (especially for a farm household). The disasters may be so large that nothing holds households back and therefore a decision to move may ensue. These disasters also affect many members of the same community and they may therefore organize politically or legally to prevent lenders from making use of the personal liability clauses in loan contracts. If borrowers correctly perceive this possibility, they may have to be compelled to buy such insurance on the loan contract.

We conclude this section by noting that (if borrowers correctly perceive risks and insurance benefits) the only need for compulsion arises for the insurance of collateral-specific risks and in the absence of easily enforced extended personal liability for the loan amount. Again such compulsion is efficiency-enhacing. i.e. larger loans will be made and more classes of borrowers will become eligible.

IV. AGRICULTURE-SPECIFIC CONSEQUENCES

A-I. Absence of Crop Insurance

We discussed the puzzle of absence of crop insurance in the introduction. Rather than just taking this fact as given, we will try to relate it to our asumptions.

Insurance may fail to emerge for three reasons. First, in the absence of moral hazard and adverse selection (incentive effects), the information costs of assessing expected yield and its probability distribution, and of assessing the yield shortfall in any given year, may be excessive. The cost has to be charged as part of the premium. If the utility gain of the insured between the uninsured and the insured situation (i.e. the "insurance premium") falls short of the information costs of providing the insurance, no market will exist.

In the case of a full crop yield insurance the information costs are high. Fields differ enormously in expected return even in very small regions and require an assessment for every given field. Since shortfalls of production from "normal" yields are frequent, loss assessments have to be made frequently, in addition to the information gathering required to establish normal yields. Compare this to life insurance where death has to be ascertained at most once in during the duration of the contract and where probability information accrues cheaply to the insurance from many secondary data sources. The case of crop insurance for specific risks such as hail is also instructive: An ex-ante assessment of expected yield of a plot is usually not required. Damage occurs when crops are already well past the flowering stage and from the damaged crop itself, an experienced inspector can assess fairly reliably how much yield would have occured if the crops had not been damaged.

The second reason for failure of insurance markets are incentives problems or moral hazard. For genuine yield insurance, or for a cattle insurance which includes death caused by disease, the insurance itself reduces incentives for fertilizer application, feeding, plant or animal husbandry, and for disease prevention. Insuring animals against theft is often difficult because the owner would invest less in guarding the animals and, as an extreme case, may have incentive to eat or sell them and pretend they were stolen. Co-insurance clauses, deductives, limiting insurance to certain risks only are all means to reduce these incentives problems, but they all reduce the potential utility gain to the insured. Incentives effects can often differ in subtle ways: Incentives for the prevention of diseases and for proper care of the sick also arise in the case of human life insurance. But individuals suffer when they are sick and try very hard to survive and get well under most circumstances. Therefore human life insurance does not create the same incentive problems which an animal life insurance would create.

The yield assessment and incentives problems are both information problems which are less costly to overcome for a village resident than for a distant insurance company. Why do some villagers are not create an insurance market? Evidently even for them the two information problems may be too severe. However the potential insuror faces the third major reason for failure of insurance markets, namely high covariance of risks. Because crops of all insured farmers may and do fail at the same time, the insuror has to carry high reserves in the form of cash, gold, stocks, or short term financial assets. In order for a village resident to write a credible insurance contract for his fellows, his reserves at all time have to be equal to the total insured value, and the insurance degenerates to a centralized reserve scheme. Each farmer can self-insure at precisely the same cost (as long as the storage costs or returns from short term financial assets are the same for all individuals). And self insurance by holding reserves avoids all information and incentives problems, i.e., it will usually be preferred.

When short term financial assets with positive real interests are available widely in a rural area, tha reserve costs are lower than when they are not. Neither gold nor cash provide a positive expected rate of return; for physical stocks storage costs will arise as well.

Insurors who want to provide crop insurance face a tradeoff between the two informational problems and the covariance problem. The more geographically concentrated their operation, the more reserves they must hold, but the smaller the informationally related problems. The fact that crop insurance schemes in the developed world are organized at national levels with government backing suggest that, even at the national level, the covariance problem remains relevant and/or that information costs and incentives problems continue to be so severe that unassisted crop insurance would not emerge.

Providing national insurance is also costly in traditional agriculture because information transmission is time-consuming and costly (T-5).

Hail or typhoon insurance is easier to provide. Even in a country as small as Switzerland hail events are very loalized and tend to affect only a small proportion of farmers in any given year. Therefore it is not only the information costs but also the reserve costs which are much smaller. As mentioned in assumption T-6, covariance problems are also less for breakdown and lifecycle risks (except for epidemics at regional or village levels) and in developed countries insurance is provided for many such specific risks like cattle accident and theft, life, health, fire etc.

A-2 Reserves and credit as insurance substitutes in agriculture

We have seen above that a crop insurance scheme for a small region would be not much else than a reserve system. Reserves may be held in the form of cash, gold, financial assets, consumer durables, stocks of food, stocks of feed, and as durable factors of production (land, animals) which can be sold in an emergency.

Reserves can also be held as deposits or personal loans given to others, whether as a money lender or, less formally, to friends and relatives. Conversely, access to credit provides an important substitute for insurance where insurance is absent or costly. Credit can be a low-cost substitute for insurance if borrowing rates in bad years or in emergencies are not much higher than deposit rates or rates of return on financial assets, i.e. in systems with highly efficient financial intermediation.

The poor development of insurance in agriculture provides a rationale for very conservative debt-equity ratios, i.e. many small owners may not want to tie up all their assets as collateral to secure production loans. "unused" collateral value of land acts as an insurance substitute to ensure access to credit after bad events.

A-3. Absence of Financial Intermediation

Why do banks enter rural areas only at a very late stage of development? And why do money lenders not accept deposits but generally operate by lending out of their own equity? There is no reason why peasant agriculture cannot generate savings, i.e. deposits. Why is there no sufficient demand for depositing funds to make it attractive for money lenders to offer deposit services?

Compared to bankers in an urban trading center who lend to a variety of sectors of the economy, the rural money lenders probably face fewer information problems. Since they would lend primarily to farmers with covariate yield risks, they need knowledge of conditions in only one producing sector rather than several (in addition to knowledge about the borrowers' financial condition and other characteristics). However,covariance of yield risk leads to covariance of default risks. To overcome this problem, the bank, just like the insurance must operate with high reserve ratios, or must impose very stringent collateral requirements.16/ In addition, covariance among yield leads to covariance among income between depositors and borrowers. If crops fail in one year, most depositors will find that they have low incomes and will want to withdraw their deposits. But most borrowers will find it impossible to repay loans. A money lender who lends out of equity does indeed have a high level of "reserves" and therefore can reschedule loan repayment to a future year and charge interest. The expected return on such loans does not decline because of yield covariance. If instead he lends out of deposits he may have to collect the funds via sale of the collateral, which in the bad crop years may be marketable only at a discount or with other difficulties.

If farmer's yields were fully insured, covariance between depositors' incomes and borrowers' default would be sharply reduced. But in the absence of such insurance, the money lender cannot pay sufficiently high interests to attract depositors because reserve requirements are too high. And he cannot impose sufficiently high collateral requirements on borrowers to lend from their deposits when the borrowers need rescheduling. Furthermore if borrowers and depositors are both closely associated with agriculture, the money lender does not bridge an important information gap between them, (Virmani, 1981) and the depositor may be just as capable to lend to the borrower directly, i.e. without intermediation. (Of course he then also faces the costs of information, supervision, and collection). The direct lending opportunity limits the gap which can exist between the deposit rate and the lending rate fairly sharply, i.e. it puts a lower bound on the deposit rate below which depositors disappear. And this rate appears usually to be higher than the deposit rate feasible with a high reserve requirement.

A financial intermediary must operate in distinct agroclimatic regions just like an insurance company. But this geographic dispersion leads to similar informational problems as for the insurance company. The bank must be able to assess yields in order to make correct rescheduling decisions, and must evaluate the intentions of borrowers.

Costly transmission of information makes the management of a branch banking network across sufficiently large geographic zones difficult and the late emergence of branch banking for agriculture in rural areas is clearly associated with the gradual improvements in information transmission.

The same reasons which lead to absence of intermediation also makes it impossible for farms to issue bonds or bondlike instruments in a local bond market which could serve as an alternative to deposit banking. Bonds would be very risky instruments since in bad years both borrowers and lenders would want to sell them, leading to large bond yield and bond price fluctuations. A larger geographic market in bonds issued by farms faces even higher information and incentives difficulties than a branch network. Thus even the larger agricultural economy is not capable of generating fixed interest bearing securities from within, whose yields and prices are not highly correlated with agricultural production conditions. In order for fixed interest securities to become available in rural areas, they have to be created by borrowers outside of the agricultural system and be marketed in rural areas. But nonagricultural borrowers face higher information and sales costs in rural areas than in urban areas, where the potential purchasers are not spacially as widely dispersed as in rural markets.

One point is clear, however, from our discussion. There is no doubt that, if feasible at a low cost, partial or full replacement of a local money lending system based on equity finance by a regionally diversified branch banking system based on deposit banking would lead to efficiency gains for the rural sector as a whole.

A-4 Common Problems of Rural Bank Banking and Crop Insurance Network

Because intentions of borrowers and of the insured cannot be known with certainty, both banks and crop insurance networks face the common problem of assessing the nature and extent of the disasters which strike their clients. Banks must know the nature of the disasters in order to make decisions of whether to reschedule debts or not; insurors must assess whether the loss was caused by an insured disaster, and they must measure the extent of the loss. Furthermore both need to know the general agricultural return characteristics of the farmers which they serve, for banks in order to assess the likelihood of project success and for the insurance in order to measure the probability distribution of damages. Therefore a branch or agent system is required, with close contact between branch manager or agent on the one hand and client on the other. This immediately requires that a performance control system exist by which the quality of managers/agents can be assessed. Furthermore, managers and agents never have full incentives to behave like the parent company since their shares in company profits are usually fairly small. Indeed they may often have an incentive to collude with clients against the parent companies, for example when manager quality or manager income is assessed on a loan/insurance volume basis, i.e. when an incentive exists to extend credit and insurance to more risky clients. While these problems apply to any banking or insurance system, they are sharply increased in agriculture because of (1) the distance between head office and branch offices and, in developing countries, the absence of cheap telephones and (2) because of the covariance problem. If crops fail for most clients, debts have to be rescheduled and indemnities paid at the same time, i.e. branch or local office profits and other indicators used for monitoring will be small for that year. A profit maximizing strategy implies that the system must be able to accommodate several bad years in a row. Therefore, local office performance indicators may on occasion have to be low for several years in a row even with any excellent manager/agent. But since there are no perfect ways to distinguishing between bad or colluding managers/agents and bad years, central managers face great difficulties, which may in some cases be overcome by separating the authority of granting a loan/insurance from the authority to reschedule/ pay indemnities. But in a regionally dispersed organization such divorce of decision is costly in terms of requiring more people to travel extensively to acquire precise information about clients.

It is clear that any reduction in the cost of transmitting, storing and retrieving information to and at the head office will improve the feasibility of such branch systems.

A-5 Risk-averse behavior on the part of rural branch offices of banking and insurance systems:

Ideally the pooling of rural banking or insurance over broad agroclimatic zone could come close to allow a company to simulate risk neutral profit maximizing behavior of the systems with respect to individual contracts. Nevertheless the monitoring problem of local managers/agents in the presence of yield covariance is likely to induce risk-averse behavior on the part of each manager with respect to individual contracts under almost any set of monitoring rules, i.e. managers will try to reduce the year to year fluctuations in the monitoring indicators by choosing clients with low default risks or low probability of high damage levels. Thus the branch banking or insurance systems may never be able to overcome the covariance problem fully by pooling across regions.

V THE DEMAND OF FINANCIAL INSTITUTIONS FOR AGRICULTURAL INSURANCE

C-1 Rural collateral specific insurance

From section G-8 it follows immediately that rural financial institutions should be vitally interested in the spread of fire, theft and accident insurance for those nonland assets which have actual or potential collateral value: houses, motor vehicles, pumpsets and animals. Innovations which reduce marketing and damage assessment costs for such insurances should be considered desirable. For example, the marking and registration of animals might go a long way in reducing theft problems and making the animals eligible for accident and theft insurance. Such insurance might be sufficient to convert the animals into an asset with collateral value. It is also clear from section G-8 that, once insurance is in place on fairly favorable terms, banks will need to insist in their lending contracts that borrowers buy such insurance.

C-2 Other risk specific rural insurances

According to the discussion under G-7, individuals and lenders may also be interested in the extension of life insurance, medical insurance and even hail or typhoon insurance for crops to rural areas, since they do act as (imperfect) collateral substitutes for honest borrowers, thus allowing increased debt-equity ratios and extending the credit market to some individuals who own few assets with collateral value. It is indeed surprising that lending institutions and rural development experts rarely focus on these risk specific insurance to improve rural financial markets (For an exception see Michael Lipton 1978). Efforts of the banks and rural development experts appear to be focussed on obtaining government support for compulsory crop insurance. Why is there so much pressure, and why the emphasis on compulsion?

C-3 Institutional demand for crop yield insurance

An emphasis on compulsion for crop yield insurance is not warranted unless the standing crop is considered as collateral by formal financial institutions, and unless extended personal liability for the debt does not exist or is difficult to enforce. 17/. We have seen above that when these conditions are not met, and as long as the farmer is more risk averse than the financial institution, no case can be made for compulsion since the bank does not carry the collateral-specific risks. Thus we have to seek elsewhere for the reasons for the larger pressures for compulsory crop insurance relative to other types of insurance.

Consider again covariance: Rural Banks may perceive the default risks arising out of lifecycle and breakdown risks as much less of a problem than the crop related risks because the former have a much lower covariance among their borrowers. Thus, rural bank networks may be more easily able to design management and operating procedures to take forclosure or rescheduling decisions arising out of such disasters. They may be able to do without the insurance: If for example the transaction costs of providing a fire insurance in villages are high the bank may decide to carry fire related risks to collateral itself and to reflect these risks in the loan terms.

While financial institutions may be able to handle uncorrelated risks, the covariance of crop related risks may create very severe management problems for rural branch bank management (see section A-4). Crop insurance is potentially able to substantially reduce the bank's major covariate rescheduling problem. The bankers may not realize that the insurance will face exactly the same management problems, i.e. that the shift to compulsory crop insurance simply implies a shift of a severe management problem from one institution to another.

C-4 Financial regulation and the institutional demand for crop insurance

Lending terms of rural financial institutions are often severely restricted. The regulations may restrict collateral options to land. Bank may no be exposed to other collateral risks, and would not demand the corresponding insurance.

Even where collateral options are wider, interest rates may be regulated. In order to make profits, the bank restricts loans to borrowers with the lowest debt/equity ratio and/or to loans with high collateral. In both cases, bank profits both of which increase for a given interest rate. Governments may then respond by forcing banks to lend to other groups. Since insurance also tends to increase bank profits and reduce risk, the bank will attempt to improve its returns on such forced lending (which it perceives to be unprofitable) by asking the government to subsidize crop insurance. This will partly reduce the bank's management problems arising from covariance. Furthermore, the bank may recognize the reductions in management cost which arise from the monitoring value of the crop insurance discussed in section G-7.

Finally, the rural bank may correctly perceive the fact that covariate crop losses, i.e. a disaster year, may lead to coalitions of borrowers who use the legal or political system to prevent a bank from loan collection and foreclosure. This may drastically reduce the return and insurance value of any collateral the bank might have asked for, and crop insurance would solve this problem by focussing the actions of the potential coalition on insurance reimbursement.

If crop insurance was easy to provide, i.e. if moral hazard and information problems were low, the case for crop insurance to improve rural financial markets would be unexceptional, even in the case where the demand arises primarily from restricted financial institutions. But we have seen amply that the problems of providing crop insurance are precisely the same problems as the problems of branch banking. With the exception of the actuarial functions, the crop insurance needs the same (or more) information in order to pay claims as the branch banking network needs to handle covariate rescheduling decisions. Crop insurance simply shifts the cost from one agency to another and may lead to two branch networks where one might have been enough.

If farmer's private demand for crop insurance were sufficient to pay for the costs of providing it, a second network might be warranted because the amount of insurance coverage would in most cases exceed the loan amounts, i.e. farmers would obtain an insurance benefit, not just the financial institutions. Furthermore, even in agriculture, there may be some gains from specialization, despite the fact that any rural lender has a vital interest in the farming operation of the borrower, i.e. accumulates some of the same information as the crop insurance anyway. But farmers have universally decided that they do not want to carry the full costs of crop insurance (and we have seen before that the case for compulsion is very weak). Of course the government subsidy of insurance is valuable to the farmers and to the banking system if it is sufficiently large to make farmers buy crop insurance privately. But in extreme cases the only reason for the crop insurance may indeed be government created problems of rural financial intermediaries. To the extent that the covariance problem is at the root of the difficulty of even unregulated rural financial markets, it may be more appropriate to search for solutions which allow the branch network to self insure rather than creating a separate institutions.

C-5 Area based crop insurance

If covariance issues combined with incentives (moral hazard, adverse selection) problems are at the root of problems of both rural financial markets and insurance, a somewhat stronger case can be made for area based insurance, in which indemnities are proportional to area wide yields rather than individual yields (see Dandekar for details). Such insurance is mostly advocated on the basis that it eliminates moral hazard and adverse selection problems. The major drawback usually noted is the fact that yields of individuals farmers may not be sufficiently covariate with area wide yields to provide them with sufficient protection. But if the objective of such insurance is to eliminate the problem of covariate debt rescheduling for the financial system, this objection does not matter. Differences between area wide yield experience and individual yield experience are not correlated among individuals. Sharp shortfalls in yields of a particular farmer may in any given year still require an individual-specific rescheduling decision. But such (uncorrelated) rescheduling decisions arise from other risks as well, such as lifecycle and breakdown risks. Since they are fewer and not covariate, they pose lower information costs and fewer monitoring problems between head office and branch office than covariate rescheduling decisions. They also do not generate incentives for coalition formation among borrowers against the branch office or of the branch office and borrowers against the head office.

The major incentives problem which remains for area based insurance is coalition formation of the insured to affect the area-wide yield assessment on which indemnities are based. There is no question that, as soon as insurance payoffs become dependent on area based yields, the statistical agency in charge of crop cutting experiments will come under potentially strong pressure to measure very low yield in bad years and very high ones in obviously good crop years. The incentive for high yield assessment in good years arise from the effect of such good yields on average yields and hence indemnities. Administrative arrangements will have to be found which would minimize the incentives which can be given to statistical agency personnel to tamper with yield data.

V. CONCLUSIONS

We have shown in this paper that the case for individual crop yield insurance on efficiency grounds is very weak for several reasons. First, unless a single insured crop represents a major proportion of the cropping pattern, income risk reduction achievable from a single crop are quite small. Second, the information, moral hazard and adverse selection problems of crop yield insurance are exceedingly high for a variety of reasons explored in detail. These costs, not the absence of demand for stabilizing consumption are at the root of the universal lack of privately provided crop yield insurance. Third, we have shown that the information and incentives problems plaguing rural credit markets and crop insurance are substantially the same and that it may be no more difficult to solve these problems in the credit system than via insurance. This may assist in converting the credit system into a more effective insurance substitute. Fourth, while a case can be made for compulsory collateral insurance for collateral-specific risks, this case does not generally apply to crop insurance, and especially not to subsidized crop insurance. Finally, we have seen that a major source of demand for crop insurance may in fact not come from farmers themselves but from highly regulated financial systems which are unable to adjust their terms of credit contracts to the high costs of lending to particular target groups.

A stronger case can be made for area based credit insurance. First, it could potentially help to solve the covariance problem which is at the root of the difficulties of both financial and crop insurance markets. Such a case would be fairly strong in regions where yield risk rather than price risks is the major source of risk and where a single crop dominates the cropping pattern. Second such insurance could go beyond insuring the credit amount.

The case for such area based insurance is strengthen if most farmers consume substantial portion of the crop i.e. if price risk is largely irrelevant. However, if even the area-based insurance has to be subsidized, it may be more attractive to provide for consumption stabilization of the poorer groups in society via employment or food for work programs than via a subsidy to insurance. Work programs also insure the consumption of landless workers and not only that of borrowing farmers.

Much stronger than the case for area based credit insurance is the case for all types of risk-specific insurances of crops, livestock, buildings, machines and people for those risks where moral hazard and incentives problems are fairly easily overcome. Apart from the direct benefits of insurance, such insurance can extend the credit market to groups which previously could not obtain credit if (i) they sufficiently lower the default risk of honest borrowers to make lending and borrowing attractive and (ii) if they convert assets which previously had no collateral value into acceptable collateral.

Finally there is a strong case for institutional and techcnological innovations and investments which reduce the information and icentive problems at the root of these rural market difficulties. Telecommunications, credit bureau type innovations, and computerized data processing and retrieval for branch banking networks are potential alternatives (Note, however, problems of protecting privacy of the borrowers/insured). Also important are institutional innovation to make risky assets insurable and acceptable as collateral such as registration and branding of animals.

While is section I we covered fairly well researched areas (both theoretically and empirically), the set of inferences drawn in sections III and IV, while often consistent with casual observation have not yet been subject to vigorous empirical testing and have the nature of untested hypotheses. It is clear, however, that many of the inferences can be tested quite easily by screening case studies of rural financial markets and insurance more carefully for information they contain about the hypotheses. Other hypotheses, however, may require more elaborate testing. Since the hypotheses, if verified, have ready policy implication, such testing deserves fairly high priority.

FOOTNOTE

1. This section is extracted from Binswanger and Sillers.

2. In the Philippine study a gains-and-losses game was derived from each gains-only game by deducting from each payoff in the latter the payoff for the riskless alternative. The potential losses of the gains-and-losses subsample were covered by giving each respondent a sum of money equal to the riskless payoff in the corresponding gains-only game several days before he or she played the game. This approach capture direct-loss preferences only insofar as the respondent integrates the windfall into his or her overall budget during this period. However, some such device is necessary to avoid contamination from cash and credit constraints, and to avoid the moral problems which would arise in taking money from poor people.

3. Whereas Sillers focussed on extending the experimental method to different types of choice situations, Walker and Grisley used measured risk preferences as one input into much broader studies of agricultural production behavior.

4. Following the reports of the respective authors, we take one DW to equal 3.5 rupees for the Indian experiment, 7 pesos for the Philippines experiment, 4 colones for the El Salvador study, and 25 baht for the Thai experiment.

5. The value of IP for each of the alternatives in the Indian, Philippine, and El Salvador experiments appear in the right most column of Table 1. Note that the same values apply when the scale of the game is changed.

6. Group (1) corresponds to alternatives E and F (India and El Salvador); E, F, and F′ (the Philippines); and 10 and 11 (Thailand). Group (2) consists of alternatives B and C (India, El Salvador, and the Philippines); and alternatives 3 through 9 (Thailand). Group (3) consists of alternatives 0 and A (India, El Salvador, the Philippines); and alternatives 1 and 2 (Thailand). In some instances the letter designations originally used have been changed for the sake of consistency within the exposition.

7. In particular, compare these results with the high incidence of apparent preference for risk reported by Dillon and Scandizzo (1978) on the basis of interview methods, results analyzed in Binswanger (1980), pp. 400-402).

8. In the Thai experiment, where the highest degree of concentration in revealed preferences is seen, the sets of alternative gambles were given to the respondents printed on shuffled sets of cards, specifically to avoid any spurious concentration resulting from a tendency to choose alternatives near the middle of a list.

9. India (Binswanger 1980); El Salvador (Walker pp. 92-97).

0. These asumptions are most of the common assumptions of a larger model oncerned with production relations in agriculture which is currently in reparation.

1. For a review of the contractual arrangements literature in griculture, see Binswanger and Rosenzweig, 1981.

2. A more realistic repayment function is used by Virmani (1981), where artial repayment is made when the borrower's project yield less than the rincipal plus interest. Full default would occur only when the project utcome is so bad that partial repayment becomes infeasible. But ollateral/increase lender's returns also in that case.

13. It differs in its risk sharing dimension from a crop sharing contract where the sharing only "insures" the return on the loan of the capital item — land — and not of the capital itself. Since land is not used up like fertilizer in the production process, there is no need to insure it.

14. Many government-subsidized rural credit schemes are poorly managed. and allow large farmers to use their political power to press the government to accept default on their part. Such systems cannot survive in the long run in the absence of continued government subsidies and are not considered here.

15. When insurance markets are poorly developed, an open credit line substitutes for insurance by allowing borrowing after disasterous events. If all collateral value of land has been used to secure credit for production purposes, no credit lines are open any more and thus exposure to risk is substantially increased.

16. Seasonality of agricultural production is disemphasized here because it is not essential to the arguments which follow. However, seasonality also leads to a covariance of borrowing needs and deposit withdrawal, i.e. it substantially strengthens the arguments.

17. Note here that money lenders and money lending landlords do regard a standing crop as collateral. In traditional systems a money lender may send his bullock cart to the threshing floors and the landlords (or their agents) participate any way.

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THE IMPACT OF INSURANCE ON THE SUPPLY OF AGRICULTURAL CREDIT: A CASE STUDY OF CHIRIQUI PROVINCE, REPUBLIC OF PANAMA

A. Bernal
J. Herrera
L. G. Joly

San José, Costa Rica

THE IMPACT OF INSURANCE ON THE SUPPLY OF AGRICULTURAL CREDIT: A CASE STUDY OF CHIRIQUI PROVINCE, REPUBLIC OF PANAMA.

A. Bernal, J. Herrera, and L.G. Joly*

Introduction

This paper examines the impact of insurance on the supply of agricultural credit by private and state banks in Chiriquí Province, Republic of Panamá. The focus on this particular province is due to the following reasons. First, Chiriquí is regarded as the most agriculturally productive province in Panamá. Second, Chiriquí was the first area outside the transisthmian urban center in the cities of Panamá and Colón where a private bank, namely the Chase Manhattan Bank, opened in 1950 a branch to use "the resources of the private sector to encourage agricultural development in Panamá" (Pittí). The National Bank of Panamá, a state bank, had opened a branch in Chiriquí in 1940. Although the National Bank initially concentrated its operations in Chiriquí mainly on mortgages and loans, agricultural credit was extended in the form of personal loans and or mortgages of farms.

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* A. Bernal is Dean of Agronomy, J. Herrera is a Teaching and Research Assistant in Economics, and L.G. Joly is Professor and Researcher in Anthropology in the Faculty of Agronomy, University of Panamá.

The supply of public and private banking credit to agricultural producers, therefore, has been available in Chiriquí during the past 40 years. This historical framework and the nationally recognized characteristic of Chiriquí as the most important agricultural province in Panamá provide a good sounding board upon which to measure the impact of insurance on the supply of agricultural credit. Agricultural insurance in Chiriquí, however, only dates since April 1977 when branch of the Institute of Agricultutal Insurance (ISA) began operating in Chiriquí. This was a year after the principal offices of the Institute opened in Panamá City in 1976.

The impact of insurance on the supply of agricultural credit in Chiriquí is defined according to the following criteria. First, whether insurance is a factor taken into account in the selection and supervision of clients at present or in the future. Second, whether insurance affects the recovery rates of the bank's credit funds. Third, whether insurance enables the banks to obtain additional external funds for agricultural credit. Fourth, the implications of insurance as an instrument of agricultural policy in the banking system. This analysis takes into account the difference between private and state banks, and between commercial and development banks.

The data are based on interviews with crop credit analysis in banks with officers in David, the capital of Chiriquí Province. The public sector includes the National Bank of Panama (BNP) and

the Agricultural Development Bank (BDA). The private sector includes the Chase Manhattan Bank, of the United States banking system, and the Fiduciary Bank, of the French banking system. The manager of the branch office of the Institute of Agricultural Insurance in David was also interviewed. The interviews were conducted during November and December 1981.

Additional information was drawn from the personal banking experience of two of the authors as credit analyst, with the Chase Manhattan Bank, the National Bank of Panamá, the Fiduciary Bank, and the Agricultural Development Bank.

Factors used in the Selection of Clients

As shown by Ockwell and Batterham, there is considerable variation among and within finance institutions in regards to factors considered in appraising rural or agricultural loan proporsals. The four banks studied for this paper also show considerable variation in the criteria they use in selecting clients.

A major difference between the private and state banks is that the state banks carry agricultural credit lines that are financed by international development institutions which define the type of clients who are elegible for such programs, according to specific criteria. At present there are five international institutions which are funding programs for agricultural credit in the state banks in Panamá. These are the Interamerican Development Bank, the Agency for International Development, the International Bank for Reconstruction and Development, better known as the World

Bank, the Agricultural Development Fund (from Italy), and the Venezuelan Investment Fund. The latter two work jointly with the Interamerican Development Bank to provide the national official institutions the matching funds required by the contracts with the Interamerican Development Bank. In the latest negotiation between the Interamerican Development Bank (IDB) and the Agricultural Development Bank (BDA) in Panamá, the IDB suggested to the BDA that the agricultural loans to clients be compulsorily insured. However, this suggestion was not a condition *sine qua non* of the contract and the officials of the BDA considered it only as a technicallity during the negotiations.

Although in other Latin American countries like the Dominican Republic private banks such as the Chase Manhattan Bank manage agri cultural credit programs funded by international development institutions, in Panamá these funds are channeled only through official institutions of the public sector. Private banks in Panamá, therefore, operate with their own funds, thus relying on their own inter nal policies and the viability of their operations. As a consequen ce, they screen their agricultural clients according to a minimum amount for agricultural loans. For example, the Fiduciary Bank pre sently requires $ 25,000, and the Chase Manhattan Bank $ 15,000, as the minimum loan amount for farm purposes.

Although the BNP and the BDA are state banks with complementary functions and cooperative agreements to avoid duplication of functions, a major difference between the two has been drawn. At

present, agricultural insurance is compulsory for certain credit lines with the BDA while the BNP only applies the insurance to loans for cattle displayed and bought at fairs. Products selected for insurance coverage follow the annual programming made by the BDA and ISA according to national production plans of the Ministry of Agricultural Development.

Since insurance is not required for regular loan proposals of its agricultural clients, the BNP operates more along the lines of private banks in the method used to assure the profitability of a loan. In this regard, the National Bank gives equal value in prio rity to the repayment capacity and profitability of the loan. Table 1 shows the variance in priorities given by agricultural credit analysts to factor considered in appraising loan proporsals. It is noted that collateral plays a minor role for the Agricultural Development Bank and the Chase Manhattan Bank. Due to its function as a development bank that addresses the needs of small producers who often do not have legally titled lands, the BDA underplays the role of collateral and places greater value to the production history and managerial ability of a client, to the extent that some of its clients have been sent to management courses sponsored by the Ministry of Agricultural Development. Since most of its agricultural loans are only for a period of a year, the Chase Manhattan Bank minimizes the role of collateral and uses mechanisms such as pledging of crops and animals to secure its loans.

Insurance *per se* is not a factor affecting the appraisal of a proposal at present, not even for the Agricultural Development Bank where insurance is compulsory for certain products. The lack of interinstitutional support seems to be based on technicallities and differences in internal policies. For instance, even though the BDA extends insurance coverage from the moment it makes a loan, the insurance representative does not confirm coverage until an inspection has been made. This is particularly true in the case of loans for cattle. First a loan made for a lot of cattle does not mean that all the animals in the lot will be insured, as the insurance representative may reject some of the animals after inspecting them and exclude them from coverage. In other words, each animal is insured individually while the loans was made for the entire lot. Then, even tough ISA requires that bulls be purchased from the Association of Cebu Cattle Breeders (Criadores de Ganado Cebú en Panamá - CRICEPA), the animals registered with CRICEPA are examined only for their phenotype. CRICEPA does not guarantee the reproductive capacity nor the genotypic characteristics of its animals. Neither does ISA require a microscopic test of the semen nor an inspection of the offsprings for genotypic characteristics. Since CRICEPA includes among its members some of the biggest cattle owners in the country, this association could very well incur the cost of guaranteeing their animals genotypically. The above registered complaints from farmers, although petty as they may seem, have a strong adverse effect among bank staffers towards the

handling of insurance related paperwork.

To what extent agricultural insurance will affect the appraisal of loans by private and state banks in the future will greatly depend on more effective communication between ISA, bank personnel, and producers. A general criticism from personnel in private and state banks is the lack of information given by ISA credit analysts and producers at the local level.

Supervision or Inspection of Clients

Maurice gives a list of benefits to the agricultural sector brought about by inspection or supervision that insurance personnel must give to its clients. Two of these benefits -adoption of new technology and research feedback- were found to be significant in the case of Panamá where insurance is compulsory for certain credit lines in the Agricultural Development Bank. Transferring technological and research findings to producers should be an increasing part of the role of a bank such as BDA. This development role of technical assistance extends to ISA since most clients perceive the insurance as a mechanism that benefits the bank, more than the clients, due to the compulsory nature of the insurance.(Heckadon)

In practice, however, it was found that there is a lack of interinstitutional coordination between the BDA and the Agricultural Insurance with regard to technical assistance.

Insurance personnel in Chiriquí argue that they cannot give technical advice directly to producers because producers may

misinterpret the advice or not follow the instructions exactly, and the insurance personnel may be blamed for adverse effects in the production process. Insurance personnel, therefore, consider that technical advice should be given by personnel from the Agricultural Development Bank, and IDIAP, the Institute for Agricultural Research. The four inspector and one veterinarian in the Chiriquí branch of ISA only submit written reports of their field observations to the Agricultural Development Bank. Project analysts at the BDA, however, say that they are not aware of these reports. BDA credit analysts, on the other hand, consider that they do not have the time to do both office work and also be field technicians. Producers, as reported by Heckadon, have therefore a legitimate complaint in voicing their concern for the lack of technical assistance that they receive from any of the official agricultural institutions.

Technical assistance for clients of private banks is available at a cost. There is a service charge for the field technical assistance on supervision provided by the National Bank, the Chase Manhattan Bank, and the Fiduciary Bank (table 2). All three banks provide this field service only once during the term of the loan. Credit analysts at these banks, however, advise and discuss the production process with clients whenever clients visit the banks.

Technical assistance and supervision is given to tobacco producers in western Chiriquí by the two major tobacco companies in

Panamá -Tabacalera Istmeña and Tabacalera Nacional- under an agreement with the Chase Manhattan Bank, the only bank that gives credit to tobacco producers who have been assured purchase and sale of the crop by these two companies. After the tobacco has been harvested, the same plot is used for rice and corn which indirectly benefit from the residual effects in the soil of fertilizers, herbicides, and pesticides used for the tobacco.

Recovery Rates of Credit Funds

Finance institutions for agricultural development are generates characterized by a high rate of default. Crop credit insurance helps to correct this by increasing the recovery rate and thus prevent decapitalization of factors beyond the control of producers. In 1976, when the Agricultural Insurance Institute began its operations, there was a severe drought in Panamá that reduced the recovery rate on corn loans at the Agricultural Development Bank to 54 per cent (Arcia and Pomareda). In subsequent years the recovery rate increased to 80 per cent due, not only to normal climatic conditions, but also to the presence of the insurance. If another bad year comes about, the 80 percent recovery rate would be kept constant.

Credit analysts at the Agricultural Development Bank in Chiriquí claim that they maintain in Chiriquí an annual recovery rate that varies between 85 percent and 90 percent depending on the various programs or credit lines. Programs financed by the Interame

rican Development Bank ordinarily have a recovery rate of 90 percent since the IDB puts pressure on the BDA to correct the situations if default falls beyond 10 percent.

Default at the BDA also varies within the year depending on the products and the production and marketing phases. With regard to marketing, the BDA has an agreement with the Institute of Agricultural Marketing (IMA) and with private milk plants to make deductions from sales receipts to pay BDA loans whenever producers sells their products at IMA or at private milk plants. Producers must authorize the deductions, which very between 3 and 10 percent of the sale. In the marketing of rice, the BDA posts its personnel at road checkpoints to keep a record of sales of rice outside of the Province. In 1981 the contraband on Costa Rica rice, brought about by the devaluation of the Costa Rican currency, significantly affected recovery rates. Some local producers did not give adecuate care to their production and bougth Costa Rican rice for resale. Furthermore, locally produced rice could not be marketed at private mills because of the glut in the market caused by the Costa Rican rice. This situation has been further agravated in Chiriqui by cattle contraband from Costa Rica. The slow market and the contraband have also adversely affected the recovery rate on cattle loans, and it is highly suspected that it has caused an increase in insurance claims for cattle.

In contrast, insurance is not a mechanism used to increase the recovery rate at the National, Chase Manhattan, and Fiduciary banks. These banks use other means to correct default and maintain a high recovery rates (table 3). It is noted that the Chase Manha-

ttan Bank extends the term of a loan in special cases when producers are affected by climatic disasters or factors beyond the control of the producers. For example, in 1979 coffee growers in Chiriquí were affected by strong unseasonal winds which caused severe damages to coffee trees that were then in full bloom. Coffee producers who had loans with Chase Manhattan requested an extension of the terms of loans, which was granted by the bank.

All banks ultimately rely on legal action as a final mechanism for recovery. Legal action is not politically adviseable for the Agricultural Development Bank (Arcia and Pomareda); nevertheless, it has been taken by the BDA in Chiriquí in a few cases where it was suspected that funds were being diverted for non-agricultural activities.

Agricultural Credit Policy and the Banking System

At present, the only national agricultural policy that has been adopted by both private and states banks is Law 20 of July 1980, whereby the National Banking Commision authorized preferential interest rates on credit for qualified agricultural activities. At the time the law became effective in October 1980, this preferential interest rate was set at 14.25 per cent, while the normal interest rate was at 18 percent. Under these conditions, clients were granted, without any additional bureaucratic process, a discount or subsidy of 3 to 7 percent on the interest for agricultural loans. This benefit has amounted to $ 4.5 million between October 1980 and

1981 (La Estrella de Panamá). The subsidy is recovered with $^{1}/_{2}$ percent of the interest on personal and commercial loans. With a drop in the international interest rates in November and December 1981, the National Banking Commision announced that it will observe the behavior of the interest rates in order to adjust them accordingly, thus maintaining the stability of preferential interest rates for the agricultural sector.

Prior to 1980, the National Banking Commision, pursuant to Article 1, Law 95 of November 1974, had been granting a similar compensation to banks and finance institutions that gave credit to the agricultural sector and manufacturing industries (Comisión Bancaria Nacional 1975).

In addition to this type of compensation or subsidy, state banks have maintained interest rates lower than private banks. The National Bank usually keeps its interest 1 or 2 percent lower than private banks. Table 4 shows the subsidized interest rates as of June 3, 1981 at the Agricultural Development Bank. The BDA rates are even lower than at the National Bank, varying between 9 and 11 percent for the majority ot the programs.

Compared with total credit granted by the BDA in the entire country in 1980, the amount of credit for Chiriquí represents the highest percentages of all the provinces. However, only rice, corn, sorghum, beans, and cattle are insured at the BDA Chiriquí branch, even though credit is given for other products.

Regardless of the subsidv, the real interest rate includes service charqes for technical aqricultural supervision at the Chase Manhattan, Fiduciary, and National Banks. Insurance premium at the Aqricultural Development Bank can also be considered as part of the real interest rate, "a convenient device to raise interest rates without raisinq interest rates" (Aubey and Hoqan). In this reqard, small mechanized rice producers in Chiriquí who are clients at the BDA do consider the insurance premium as an added cost that decreases the amount of the loan (Heckadon).

Although credit insurance is part of the national agricultural policy, it is doubtful that private banks like the Chase Manhattan Bank and the Fiduciary, or even the National Bank, will adopt it in the near future as part of their agricultural credit programs. All of these banks fear that they might lose clients, and incur their ill-will, if they adopt a compulsory insurance program. Moreover, these banks consider that they have many years of experience with agricultural credit without having suffered great risks. Nevertheless, they do not disregard the possibility that in the future they may recommend their clients to purchase credit insurance, in the same way that Chase recommends life insurance to clients who have saving accounts of $ 1,000 or over. For this to happen, these banks recommend that the Agricultural Insurance Institute undertake a more effective promotional and educational campaign among producers.

Summary and Conclusions

The impact of insurance on the supply of agricultural credit in Chiriquí Province, Republic of Panamá, has been analyzed according to the selection and supervision of clients, recovery rates of credit funds, the negotiation for international funding and the implications of national agricultural policy on private and state banks.

Insurance it was found, is not a factor presently influencing the selections of clients at private and state banks, not even at the Agricultural Development Bank where it is compulsory. If the Institute of Agricultural Insurance establishes more effective means of communications with credit analysts and producers, then insurance may possibly affect the appraisal of loans. For insurance to be more attractive and better understood by credit analysts and producers, more actuarial studies are needed, particularly with regard to life and health insurance of producers.

Many of the present shortcomings of credit insurance are logistical in nature. For instance, the procedure to claim insurance on the death of an animal easily lends itself to hide animals from view of the inspector. Insurance can be claimed by turning in the branded ear of an insured animal, followed by an inspection to confirm the death of the animal within 72 hours after it occurred. Death of the animals is usually attributed to unpredictable causes like snakebites, lightning, and falls.

The Agricultural Development Bank and the Institute of Agricultural Marketing also need to set a better example with regard to their own timing in the granting of loans and the payment of products purchased. Prolonged delays in the granting of loans by the BDA often have adverse effects in the production process (Heckadon). Delayed business processes reduce credibility in the institution and effect the moral climate required of the clients. This situation is obviously not convenient for ISA.

To reduce delays in the loan process, it is adviseable that the Agricultural Development Bank and the Institute of Agricultural Insurance reach an agreement on the dates that are critical in the various production processes. More coordination is therefore needed on the elaboration of an agricultural calendar whereby the disbursement of funds may be better matched with the production process. Similarly, the lack of interinstitutional coordination extends to technical assistance. It should also be corrected.

Private banks have their own mechanisms to prevent default and assure a high recovery rate on their funds. The Chase Manhattan, for example, extends the term of a loan in case of climatic disasters or factors beyond the control of producers. Such a measure is a comparative alternative to the use of compulsory insurance at the Agricultural Development Bank as a preventive measure against default. As a mechanism against default, credit insurance has been discussed in the negotiations between the Agricultural Development Bank and the Interamerican Development Bank. BDA negotiators, however, do

not consider insurance as a necessary condition to obtain such international funding.

Although credit insurance has helped to increase the recovery rate on loans at the BDA, the effect on the entire BDA portfolio seems to be not significant enough to warrant more interest from part of the BDA. Due to the precautionary nature of an insurance program it is recommended that ISA steps up its information and promotion efforts to maintain interest in its program during normal years.

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TABLE 1

Variance in Priorities of Factors used in Appraising Loans.

FACTORS	BANKS			
	Chase	Fiduciary	National	Agricultural Development
Rentability of Loan	2	2	1	4
Repayment Capacity	1	3	1	3
Managerial Ability	4	5	4	2
Financial History (Production History)	3	4	3	1
Collateral	5	1	2	5

Note: Numbers indicate priorities, with 1 being first factor considered; i.e., having greatest priority.

TABLE 2

Field Inspection Charge by Banks

BANK	CHARGE
Agricultural Development	none
Chase Manhattan	1% of loan or a maximum of $ 2000.
Fiduciary	$ 50
National	1% of loan

TABLE 3

Rates and Methods of Recovery of Banks in Chiriquí Province.

BANK	RATE OF RECOVERY	METHODS OF RECOVERY
Agricultural Development.	85 - 90 percent depending on credit line or program.	Insurance Deductions at Agricultural Marketing Institute mills and at private milk plants. Traffic control of rice crop. Legal action.
Chase Manhattan	98 percent.	Analysis of the production cycle to adjust terms of loan to this cycle. Pledgind of crops and animals. Extension of terms of loan in case of climatic disasters or factors beyond the control of producers. Quality Control Department analyses defaul cases and interviews these clients to correct the situation. Legal Department takes legal action.
Fiduciary	97 - 98 percent	Pledging of crops and animals. Collateral. Legal Action.
National	(Not given)	Financial planning of loan so as to make even payments. Pledging of crops and animals. Collateral. Legal Action.

TABLE 4

Interest Rates at the Agricultural Development Bank. 1981

	Nominal Rate	Subsidized Rate
A. <u>Loans to Associated Producers</u>		
1. BDA-BID 554	16	9
2. PSP (Sectorial Production Plan)	16	9
3. AID Cooperative Program	7	7
B. <u>Individual Producers</u>		
1. BDA-BID		
a. Agricultural Assets up to 40,000 (U.S.$)	16	9
b. Agricultural Assets from 40,000 to 80,000 (U.S.$)	17	10
2. 109 and AID	16	9
3. BDA Program 127		
a. Assets up to 40,000 (U.S.$)	17	10
b. Assets from 40,001 to 80,000 (U.S.$)	18	11
4. PAN - 1672 (Coffee and Coconut)	17	10
C. Cattle Credit BID/376	18	11
D. Commercial Funds 13	18	14

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EX POST ANALYSIS OF A LATIN AMERICAN INSURANCE SCHEME: THE CASE OF BRAZIL

Mauro de Rezende Lopes
Guilherme Leite da Silva Dias

San José, Costa Rica

EX POST ANALYSIS OF A LATIN AMERICAN INSURANCE SCHEME: THE CASE OF BRAZIL 1/

Mauro de Rezende Lopes
Guilherme Leité da Silva Dias 2/

DISCUSSION PAPER
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GLOSSARY OF ACRONYMS

VBC	- Valor Básico de Custeio (Basic Cost of Production)
PROAGRO	- Programa de Garantia da Atividade Agropecuária (Program of Guarantee of Agricultural Activities)
COSESP	- Companhia de Seguros do Estado de São Paulo (The State of São Paulo Insurance Company)
SNCR	- Sistema Nacional de Crédito Rural (National System of Agricultural Credit)
BACEN	- Banco Central do Brasil (Central Bank)
CNPS	- Conselho Nacional de Seguros Privados (Nacional Council of Private Insurance)
IRB	- Instituto de Resseguros do Brasil (Institute of Reinsurance of Brazil)
VCM	- Valor Convencional Máximo (Maximum Convencional Value - out-of-pocket cost of production)
BEMGE	- Banco do Estado de Minas Gerais (The State of Minas Gerais Bank)
COSEMGE	- Companhia de Seguros de Minas Gerais (The State of Minas Gerais Insurance Company)
BDMG	- Banco de Desenvolvimento de Minas Gerais (Bank of Development of Minas Gerais)
CMN	- Conselho Monetário Nacional (National Monetary Council)

I - INTRODUCTION

HISTORICAL DEVELOPMENT

The first experience with crop insurance in Brazil dated 1954 when Decree-Law 2168 (01/11/1954) created the National Crop Insurance Company (Companhia Nacional de Seguro Agrícola). The primary objective of the company was to develop progressively an experience with crop insurance in the country. The Decree-Law 73 (11/12/1966) ceased the operations of this company. Several reasons contributed to the failure of this preliminary experience with crop insurance in Brazil. Among several others it should be mentioned premium underating, inadequacy of the insurance contracts, deficient funding to back the losses of the beginning years and the lack of trained personnel. The concentrations of risks in a small number of operations also contributed to the failure of the company.

Decree-Law No. 73 institutionalized the private insurance in Brazil, created the National Council of Private Insurance (CNSP) and declared crop insurance to be compulsory in all states of the country. Furthermore, it created the Crop Insurance Stabilization Fund, within the administrative supervision of the Institute of Reinsurance of Brazil (IRB) to support the operations of crop insurance in Brazil. This decree set the legal foundations of the crop insurance in the country.

The CNSP aproved through Resolution 5/70 (7/14/1970) the regulations of the crop insurance in the state of São Paulo, in an experimental basis, to be managed by COSESP - a state owned insurance company. This resolution is considered the first step to set forth detailed regulations for the crop insurance in the country. Two years later Resolution 2/72 extended the same set of regulations to the state of Minas Gerais through COSEMGE - a state owned insurance company.

Resolution 5/70 structured both the compulsory and the voluntary insurances, being the former linked to credit operations and the latter linked to farm assets. The norms and regulations of this resolution placed this crop insurance system

under the coverage of Crop Insurance Stabilization Fund (FESR), managed by the Institute of Reinsurance of Brazil (IRB). Therefore although the crop insurance systems of São Paulo and Minas Gerais are managed by state owned agencies, they are fully regulated by private insurance dispositions.

According to Resolution 5/70 coverage should be written, on a compulsory basis, on crop and livestock production credit, covering all the credit value granted on farm assets such as buildings, vehicles and machinery, under a financing operation, on any farm asset offered as a collateral in a credit operation, on any either stored or financed product subject to a marketing credit operation. Also a temporary life insurance was created in order to guarantee the payment of the balance due in the event of death of the insured. All other farm assets not subject to a credit operation would be elegible for an insurance, but on a voluntary basis.

In 1973 the Federal Government created the PROAGRO, Programa de Garantia da Atividade Agropecuária (Program of Guarantee of Agricultural Activities) through Law 5969 (12/11/1973) According to the new program all regulation on this insurance should be approved by the National Monetary Council (CMN), and the program itself should be administrated by the Central Bank (BACEN). The program was not experimental and would cover all states and all crops financed under the National System of Agricultural Credit (SNCR). In terms of the amount of resources engaged in the program, this is by far the most important crop insurance system in Brazil.

Nevertheless the other two state level programs are extremely interesting experiences of crop insurance on technical grounds.

Therefore, Brazil has at present two crop insurance systems in operation, one handled through state agencies such as in the states of São Paulo and Minas Gerais and the other handled by the Central Bank which is the PROAGRO. All of them are all-risk insurances.

Prior to 1973, the year when PROAGRO was created, Federal Government acted as the sole guarantor of crop and

livestock losses in calamitous years, specially in drought-stricken areas such as the Northeast. In disaster years, indiscriminate cancellations of credit debt was the only solution to avoid farmers' bankruptcy. In cases of localized losses, credit payment postponement was adopted as a partial solution, with an extra problem to credit expansion and monetary policy, since credit was subsidized through interest rates[1/].

At last, a final comment on the interest of private insurance company participation in crop insurance in Brazil is in order. Although the legislation has established the compulsoriety of crop insurance to all credit operations, only the states of São Paulo and Minas Gerais implemented this kind of a program. Private insurance companies found it rather complex, operationally expensive and demanding heavy technical assistance. The only branch believed to be atractive was farm assets, such as buildings, livestock and machinery. Incidentally, according to the experience in both states those are the insurance branches which proved to be highly profitable, even at low premium rates.

Therefore, the participation of private companies is still virtually none.

The following sections of this paper will present and discuss the experience of each of the programs in Brazil. A final section will present some concluding comments on the overall experience in crop insurance in Brazil.

II - PROAGRO

I - INTRODUCTION

Together with the Minimum Price Program and a policy of subsidized farm credit, PROAGRO is one of the most important short-run instrument of agricultural policy in Brazil. After the severe droughts which struck the country in the two consecutive years of 1978 and 1979, the government decided to place agriculture among the top economic priorities. In order to

1/ Decapitalization and erosion of agricultural credit funds under the system of credit payment postponement, under inflation rates from 40 to 80% and agricultural credit interest rates ranging from 18 to 45%, is quite high.

stimulate output expansion, and reduce food inports, the selected instruments were those with a high potential impact on reducing uncertainty, such as an aggressive Minimum Price Policy and a program like PROAGRO. A policy of increasing liquidity of farming, through a broad credit program was also implemented.

Considering not only the policy drive behind the program, but also its results in terms of loss ratios and implicit subsidies, PROAGRO is more a kind of a government program, at highly subsidized levels, than a crop insurance system. It was viewed by farmers and policy makers as an integrated part of a comprehensive program of new government incentives to foster output expansion.

Characteristically, PROAGRO is intended to be an insurance or short term credit. In one sense it is a way of insulating farmers from financial disaster. It is intended to provide farmers with increased confidence in taking risk in borrowing. On the other hand it greatly strengthened the financial position of credit institutions operating in agricultural credit. In short, it represents a way of aleviating both internal and external capital rationing on agricultural credit. In fact, it improves the position of the farmers in relation to credit institutions which, in the absense of such a program, could select only the low-risk farmers to grant credit.

The program started in 1973 under law 5969 which established that the program should be supervised by the National Monetary Council (CMN) and administered by the Central Bank (BACEN). It also stipulated that the basic premium rate should not exceed 1% on any credit operation, either for production or investment. Besides the revenue from the premium rates, the program would be funded through resources allocated by the Federal Budget, under the control of CMN. The limit of coverage was restricted to a maximum of 80% of the credit granted.

II - OVERALL FEATURES OF THE PROGRAM

The stated objectives of the program are: (a) to relieve farmers from financial obligations of credit on production, investment and on farm assets in the event of natural

disasters and uncontrolled plagues and diseases; and (b) to stimulate the adoption of modern technology under the supervision of extension service. In this concern the farmer is obliged to use the best available technology capable of insuring the proposed yields.

Prior to 1980 the program was voluntary. Due to the relatively poor performance of the program in terms of the high volume of indemnities, some changes gradually took place. In 1980 PROAGRO became compulsory for all crop and livestock production credit operations. It remained voluntary for investment credit operations. Concurrently the premium rate was raised to 3% in production credit granted under no specifications of technology; i.e. farmers' own technology1/.

The program also automatically excluded the same crop indemnifyied in the previous 2 years, with the same cause and in the same area (except when the repetition of the same cause is considered by extension services as an intirely random event).

Insurance is written mainly against excess rainfall, frost, hail, drought, rainstorm, freeze, windstorm, strong temperature variation and lightning. Coverage also includes any natural phenomena which may have any consequence on production and any plague or disease whithout a known method of control. It does not cover fortuitous fire, except if caused by lightning. Therefore it is an all-risk insurance in which any unavoidable loss is elegible for compensation.

PROAGRO covers the balance due of the capital, up to the limit of the credit upon which the premium had been charged, the portion of farmers' owned resources, aforesaid in the credit arrangement, except if the farmer had excluded this portion from the insurance, and, finally, all the financial charges (interest rates and taxes) included in the balance due.

An important feature of PROAGRO is that coverage is due for indemnity only if the revenue, resulting from the sale

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1/ A farmer is elegible for the lower rate of 1% if he spends at least 15% of his production budget in modern inputs, such as fertilizer and improved seeds.

of any portion of production, is not enough to pay for the loan. In other words, in case of partial loss, from the value of the indemnity there must be deducted the revenue from sales of the remaining production. The farmer is obliged to make a deposit corresponding to any sale of the product on the credit account and also to present all document refering to all sales made. When the quantity harvested, sold at market prices, is just enough to cover the balance due, no indemnity is paid, no matter whether yields have been below normal.

Today, the amount of indemnity is less if the crop is not harvested, and substantially less if the crop is destroyed at early stages of cultivation. Indemnity is virtually zero if an area seeded with one crop (for example rice) is also seeded with pasture. This prohibition avoids using PROAGRO indemnity to partially finance the costs of seeding pasture, a reasonably large cause of heavy indemnities in the past. All these procedures restrict the amount of indemnities close to the investment which the insured farmer has effectively made in the crop.

III - PREMIUM RATES

In the past, since 1973, when the program was created, farmers were charged a flat rate of 1%, which covered up to 80% of the credit granted.

In 1980 new directions were adopted in agricultural credit in Brazil. Interest rates were raised and the share of VBC (the out - of - porket costs of production) financed under subsidized interest rates was reduced from 100% to 60% for large farmers and from 100% to 80% for medium-size farmers. In practice, however, the vast majority of these farmers had to borrow from financial institutions the remaining of the cash necessary to face production expenses, or draw from their own capital reserves.

According to PROAGRO dispositions, this share of the capital was not insured and, without guarantee farmers would neither engage their own resources nor borrow. In order to avoid farmers' lack of interest on increasing production and a self imposition of internal capital rationing, with obvious consequences upon output and productivity, and, at the same time,

in order to increase premium revenue to face a prospective higher level of indemnities, coverage was extended in 1981 on a voluntary basis, up to 100% of VBC financed at increasing premium rates (see table below). Nevertheless the 70% minimum coverage of VBC remained compulsory.

On the other hand, the relatively high concentration of indemnities on few crops (wheat and rice, predominatly)[1/] and for almost the same number of farmers and about the same regions suggested that the flat 1% premium rate should be progressively increased, particularly for those farmers who more often receive a indemnities from PROAGRO.

Therefore the premium rates were established in an increasing way in two dimensions, both with the percent of coverage of VBC and with the frequency in which the farmer received indemnities from PROAGRO in the past (see again the table below).

IV - AN ASSESSMENT OF THE PERFORMANCE OF THE PROGRAM

During the 6 - year period (Table A1) PROAGRO presented extremely high loss ratios, particularly in the first two years, with ratios over 40.0. In 1975 severe losses in wheat and rice contributed to the mentioned ratios. PROAGRO accumulated heavy losses at the beginning. It is worth noting that the losses of the first two years were substantially higher than the losses of 1978 and 1979, the years of severe drought in agriculture.

One possible reason to explain the extremely high loss ratios such as 40.1 and 42.1 in 1975 and 1976 respectively is the fact that premium rates did not correspond to the risk attached to crops insured. A simple comparison with the rates charged by COSESP in São Paulo indicates that, under the system

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1/ Indemnities for wheat started with 3.7% of total value of production in 1976 and reached 22.4% in 1980. Data below show the increasing size of the indemnities in relation to output value from 1976 to 1980.

YEAR	1976	1977	1978	1979	1980
OUTPUT VALUE (IN CR$ Millions	6710	6550	11126	15541	31860
INDEMNITY (IN CR$ Millions)	245	405	607	1600	7141
INDEMNITY / OUTPUT VALUE (%)	3.7	6.2	5.5	10.3	22.4

TABLE OF PROGRESSIVE PREMIUM RATES

I - PRODUCTION CREDIT GRANTED UNDER TECHNICAL ASSISTANCE (EXTENSION SERVICE)

LEVEL OF COVERAGE OF VBC (%) \ NUMBER OF INDEMNITIES (*)	0	1	2	3
	PREMIUM RATES (%)			
70	1:00	3.00	5.00	7.00
80	2.50	4.50	7.50	11.00
90	3.50	6.00	10.00	15.00
100	5.50	8.00	12.50	18.50

II - PRODUCTION CREDIT GRANTED UNDER FARMERS OWN CHOICE OF TECHNIQUES

LEVEL OF COVERAGE OF VBC (%) \ NUMBER OF INDEMNITIES (*)	0	1	2 ou 3
	PREMIUM RATES (%)		
70	3.00	5.00	7.00
80	4.50	7.50	11.00
90	6.00	10.00	15.00
100	8.00	12.50	18.50

(*) Number of indemnities paid to the same farmer, in the last three years and in the same region.

of voluntary participation, in order to equate premiums to indemnities in crops such as rice and corn, the premium rates should not have been lower than 6%. The flat premium rate of 1% was therefore heavily subsidised. As a matter of fact, farmers paid in effect a contribution, instead of a premium rate; the government paying the remaining 5 points percent.

Another reason for the early losses was that farmers very often seeded pasture together with rice and if the rice crop was destroyed they claimed indemnities on rice. This practice was forbidden, but caused heavy losses to the program.

As a result of the changes introduced in 1979 and effective in 1980 the loss ratio dropped in the latter year. In 1980 PROAGRO became compulsory, which broaded the base of contribution. The loss ratio dropped to 2.74.

While the program was voluntary, only a relatively small number of participants adhered to the program. The losses were at the beginning concentrated in wheat and upland rice ("arroz de sequeiro"). Although there are no reliable statistics available, only the high - risk farmers and regions adhered to the program. Low premium rates in effect atracted operations of high risk. In some sense it was easier to collect indemnity than to cultivate the crop properly.

It must be emphasized that after few years of program operation substantial changes were imposed to the system, with relatively reasonable improvement in the performance of the program.

Table A2 shows the participation of indemnities of individual crops in the total volume of indemnities of PROAGRO from 1979 to 1981. Wheat participation is in fact quite high, ranging from 29% in 1981 to 52% in 1979. This crop will be particularly affected by the recently adopted system of progressive premium rates. It must be said that wheat to a great extent motivated the adoption of the progressive rates for repetitive events.

Besides wheat, rice takes a good portion of total indemnities of the program: 18% in 1979 and 21% in 1981. All the other crop participation ranged from 1 to 5%. Therefore these

results suggest the need of a study to estimate the amount of expected volume of indemnities, taking the historical distribution of yields of wheat and rice, in order to compare the expected to actual volume of indemnities.

Table A3 shows the sources of funds and the expenditure with the program. It shows that in 1976 and 1977 the Federal Budget was the predominant source of funds to cover the losses of the program. In the following two years of 1978 and 1979, resources from the Monetary Budget were chanelled to PROAGRO. These last resources should be recovered because they represent monetary expansion and the Monetary Budget is not supposed to have fiscal funds. In 1980, the funds from the Federal Budget and premium revenue were the predominant sources of funds used to cover the expenditure of the program.

This data shows not only how much PROAGRO depends on external sources of funds but also how vulnerable the whole program is. Although in 1980 the premium revenue became quite important as a source of funds, still the Federal Budget had to cover over 50% of the costs of the program. It is desirable, in order for PROAGRO to subsist, to reduce its dependence on the Federal Budget. From 1979 to 1980 the contribution of the Federal Budget increased from 113 million to 7801 million cruzeiros, which is quite an increase.

Finally, in terms of payments, the commission of the extension service has presented a decreasing participation in program's total costs. From 14.6% in 1976, it reached 4.3% in 1980.

The results for 1980 greatly reflect the fact that PROAGRO became compulsory. For example, premium revenue increased almost 44 times, while indemnities increased only 5 times. It must be taken into account that 1980 was an exceptionally good year in terms of yields. However, there is a considerable improvement in the performance of the program with compulsoriety. The loss ratio has dropped in 1980 to 2.7 (Table A1), which is now an acceptable level for this ratio.

V - CONCLUDING REMARKS

PROAGRO was, when it started, a temerity.

It did not start in an experimental basis. It had to learn from its own experience, with relatively high losses at the beginning. The personnel from extension services and from financial institutions had to learn in practice, even having no previous experience of this sort.

Some corrections of early directions were adopted, such as compulsoriety, increase in premium rates, voluntary coverage from 70 to 100%, including the coverage of farmers' owned resources.

To some extent, PROAGRO is still much concentrated on relatively few farmers, compared to the total number of farmers in Brazil. But so is agricultural credit. Since we cannot separate one from the other the program further aggravates the distribution and equity problem of subsidized and fully insured agricultural credit in Brazil. We must realize that PROAGRO increased immensely the attractiveness of borrowing, beyond to much extent the attractiveness of subsidized interest rates.

PROAGRO being the most important crop insurance in Brazil, and further anticipating the next two state systems, we must say that there is no production insurance in the country. All of them, predominantly PROAGRO, are credit insurances.

However there are a few positive aspects in PROAGRO. In the first place, the financial institutions only started to operate with small farmers, in a significant volume of operations, when credit was covered under the system. In this line, PROAGRO contributed to extend credit operations to medium size farms and small farms; both, under supervised credit and credit without any technology.

Secondly, there is a consensus that modern technology envolves risk of capital losses, sometimes to a high level. There is positive need for protection of credit, if thecnology is to be adopted at a fast rate in agriculture.

Finally, the financial institutions, under credit protection of this kind, would be induced to operate with landless farmers. In the absence of such a program, in a country like Brazil, with a large proportion of landless farmers, this program has a high pay off if banks require "less" collateral to their loans.

A key question is in order at this point: what is the price we must pay in order to have a simplified system of crop insurance in operation? PROAGRO is a relatively simple insurance system to operate, compared to other systems. Loss verification and checking is relatively simple.

If there is some suspicion of fraud, it must be considered that: (a) when large areas of crop production are destroyed by events such as drought, for example, overaccumulation of damage verification causes quality of the services of inspection to drop; and (b) although program is now 5 years old there is still much need for training personnel in the task of checking the losses.

The question is whether the losses with the program are justifiable in terms of a broad range of benefits (technological change, operations with landless farmers, etc.). Although there is a full recognition of the benefits of the program, there exists also consensus among government policy-makers that losses must be brought to reasonable proportions if the program is to be continued. If the losses which occured in the past had persisted, the program would have been discontinued. It is hoped that the recent changes will bring about a considerable improvement in the performance of the program. The program inaugurates a second probatory period, we must say.

PROAGRO is in some sense a compromise solution between a complex system of crop insurance and a credit insurance. Provided that the losses can be kept within manageable proportions. not requiring substantial provisions from the Federal Budget, specially under the new changes introduced in 1980 and 1981, the system will work.

Nothing prevents that in the future we could combine a government credit insurance system with a private complementation of coverage through private insurance companies. Government would continue to subsidize the premium rates up to the coverage of 70% of credit, or subsidize indemnities paid. And, at the same time, in the margin, private insurance companies would provide the additional coverage necessary to reach 100% at the progressive premium rates.

The idea is to leave the additional coverage to be

made by private insurance companies. The government would take the bulk of the losses in case of a severe drought, for example; the government would therefore back the whole system by providing a "insurance" on 70% of the credit granted.

In this sense variations among regions and differences among individual farmers and crops would have their indemnities paid by other private insurers, such as insurance companies. This would be the beginning of a process of privatization of credit insurance in the Brazilian agriculture.

Finally, for the near future, with the gradual elimination of subsidized interest rates in agriculture, the role of PROAGRO will become extremely important, both for borrowers and for lenders in agricultural credit, as a guarantee against risk. Not only the outright raise in annual interest rates (from 20 to 45%), but also the gradual reduction of the portion of the credit granted at subsidized rates (which in fact further reinforces the move towards higher rates, since the farmer must borrow the difference at market rates) reveals the government desire to push medium-size and large farmers to market rates, although gradually. Therefore in this context PROAGRO will be extremely important in the coming years.

III - CROP INSURANCE IN SÃO PAULO

I - INTRODUCTION

The first experience of crop insurance in Brazil occured in the State of São Paulo. In 1939 an experimental insurance was written against hail for cotton growers. In 1952 coverage was written on grapes, also against hail. Finally in 1954 the same type of insurance was extended to garden crops and fruits against grost. All of them were fully supported by the State Secretary of Agriculture.

What is now the crop insurance system of São Paulo started with that previous experience and was further developed after three important events: The Decree-Law 73 of 1966 which created the national insurance regulations and established the compulsoriety of agricultural insurance in Brazil, the foundation

of COSESP in 1967 and the Resolution 5/70 which authorized COSESP to operate in crop insurance in an experimental basis in the state.

All-risk insurance only appeared in 1974, initially for cotton. Later on this insurance was extended to other crops. It covers all meteorological events, and plagues and diseases which do not have a known method of control. Today, coverage is written on cotton, grapes, peanuts, corn, soybeans, bananas, wheat, garden crops, forests and livestock. Last year, coverage written on potatoes and tomatoes was supressed due to the relatively poor performance of results and lack of interest on part of farmers. Although Resolution 5/70 authorized insurance on farm assets, COSESP has no coverage written in this line.

Except for cotton, which is strictly compulsory, all other insurances are voluntary. The insurance is written against hail, frost, drought, excessive rainfall, rainstorm, windstorm, fire (on forests) and uncontrolled plagues and diseases.

Coverage is based on an estimated value of out-of-pocket costs - the VCM (the maximum conventioanl value) - which is established according to types of farm practices. For permanent crops coverage is established on the basis of yearly expenditure on plant care.

The three levels of VCM are calculated according to technical coefficients of cost of production recommended by experimental stations and extension services. Type A of VCM is based in the best technology available; type B roughly corresponds to the state average costs of production; and type C is the farm practice which uses a minimum amount of modern inputs.

In terms of indemnities if the area insured had a 100% loss, a technician will calculate all expenses incurred by the farmer until the date of the loss. If the farmer replants the area, the technician will also calculate the costs of replanting the area, and the indemnity fully covers the initial losses. In case of partial losses indemnities are made based in the following formula:

$$IV = MIV - (RP \times MP),$$

in which IV is the amount of the indemnity paid, MIV is the maximum amount insured (out-of-pocket cost of production), RP is

the production harvested after the loss and MP is the guaranteed oficial Minimum Price1/.

The operations are fully backed by the Crop Insurance Stabilization Fund, under the supervision of IRB. IRB reinsures all operations on a quota-share basis (80%) of the risk written by COSESP, which keeps 20% of the responsibility of all insurance. IRB further passes part of the 80% to almost all insurance companies in the country.

The state government developed this system al least in part as a response to constant losses due to damages in crops such as grapes, cotton and grains, caused predominantly by excessive rainfall and rainstorm (50% of the total value of indemnities paid), hail (15%), windstorm (15%) and drought, which required financial resources of the state to help farmers. A broad insurance system could avoid large disbursement of resources on the part of the state government and the postponement of crop credit debt at subsidized interest on the part of state owned financial institutions.

II - PREMIUM RATES

Premium rates, expressed in terms of percent, are directly applied to out-of-pocket costs calculated by COSESP, in the starting balance due of the credit operation. The table below presents a picture of the evolution of the rates over time. It shows a comparison between original and present rates.

1/ This insurance might be properly termed "agricultural crop credit insurance". Besides crops, the insurance includes all other farm activities, such as farm asset insurance, liability insurance on animals, fire insurance on forests, etc.

CROP INSURANCE IN SÃO PAULO

PREMIUM RATES

RESOLUTION 5/70 AND PRESENT RATES

RESOLUTION 5/70 (1970)		PRESENT SITUATION (1981)	
	Premium Rates (%)		Premium Rates (%)
Crops	2.5	Cotton	2.5
		Grapes	5.0
		Corn, Soybeans and Peanuts	6.5
		Wheat	7.0
		Potatoes	8.0 1/
		Tomatoes	8.0 1/
		Banana	5.0
		Irrigated Edible Beans	3.5
		Suchini, Carots, Green Pepper, Letuce, Cucumber	4.5
Livestock	from 3.55 to 4.5	Cattle	from 2.5 to 3.5
		Horses	from 4.0 to 4.5
		Forests	from .95 to 2.8

1/ These two insurances were canceled in 1981.

Resolution 5/70 fixed in 2.5 the minimum rate for compulsory crop insurance. This rate was maintained for cotton 1/, in part due to low loss ratios which made this particular insurance quite successful. Also cotton is a compulsory insurance. All other crops, including grapes, which is incidentally an operation as old as cotton, have premium rates as high as 5 and 6%. Wheat rates reach 7%, which is quite high.

COSESP revised rates several times in the past five years. For potatoes and tomatoes the rates were 5% at the beginning. In 1981 when the insurance was cancelled this rate reached 8%. For corn, soybeans and peanuts the premium rate was raised form 5 to 6.5%. But still premium revenue was low compared to indemnities paid.

1/ Higher levels of productivity, which correspond to higher cost have higher rates: 3.5% for the highest technology A and 3% for technology B (state average cost of production).

Premium rates in voluntary crops were raised as an atempt to reduce loss ratios over time, given the results presented in early years of operation. Given the relatively good results of livestock coverage, cattle premium rates were considerably reduced. Also irrigated crops have lower rates.

In sum, given previous premium underating for relatively high-risk crops, with the 2.5% suggested by Resolution 5/70, the rates were gradually adjusted up to levels as high as 5 to 7%.

Voluntary and low participation in crop insurance systems, coupled with relatively high loss ratios sometimes forces insurance companies to raise premium rates in order to equate premium revenue to indemnities paid. Sometimes this is a self-defeating policy. If participation is already low, raising premium rates will result in even lower program participation on the part of the farmers. The elasticity of program participation with respect to premium rates is quite high, mainly at premium rate levels as high as 6 and 7%. Participation concentrates in risky farmers and high risk operations, and operational costs increases over time.

Therefore, a raise in premium rates brings forth a need for another raise in the rates. If this process goes on and on, even in a small group of products with a large program, excessive loss ratios which are a natural consequence of this process can jeopardize the entire program.

In order to cut deep losses with potatoes and tomatoes COSESP decided to cancel these two insurances when premium rates reached 8%, as we shall see ahead.

III - A REVIEW OF THE EXPERIENCE

This part of the paper examines the experience with COSESP all-risk crop insurance. Our analysis focuses primarily on cotton and grapes insurances, both of which operated throughout the 17-year period 1965/1981 for which there are data available. Data for these two crops are presented in tables B1 and B2 in the Appendix.

COTTON

This is a pioneer insurance in Brazil, operated for 41 years in the State of São Paulo. It covers all cotton growers of the state, even the small farmer who does not have access to credit.

During the 17-year period 1965/1981 reported in Table B1, the cotton program had a loss ratio below 1.00 in 12 years. Despite the two years of high losses (1976 and 1978), the cumulative premium revenues exceeded indemnities for the first 6 years of the period until 1971. Then a surplus of cumulative premiums reappeared afterwards for three consecutive years. Since a company such as COSESP would be, and in fact is, highly sensitive to high-loss years, particularly at the beginning, the reported loss ratios made the program quite successfull: high-loss years occured after a premium surplus had been accumalated.

For cotton, the annual loss ratios ranged from .44 to 2.03, and average 1.21 in the 17-year period; which is a quite satisfactory result.

Nearly all of the elegible cotton acreage is insured. The data below further reinforces this observation.

YEARS (SELECTED YEARS)	1966	1968	1970	1972	1974	1976	1978	1980
AREA CULTIVATED (IN 1000 HA)	477	338	702	630	395	223	345	276
AREA INSURED (IN 1000 HA)	474	338	641	594	379	220	339	276
AREA INSURED/CULTIVATED	.99	1.00	.91	.94	.96	.99	.98	1.00

Furthermore damaged area represented a small proportion of total area insured and total area cultivated. In the 11-year period from 1965 to 1975 area damaged did not exceed 6% of total area insured, with four years with proportions as low as 2% in the period.

In the State of São Paulo soybeans replaced cotton in many important producing counties. Average insured area droped from 517 720 hectares per year in the period 1965-1973 to 305 005 hectares in the period 1973-1981. This partially

contributed to the relatively poor performance of the crop insurance in São Paulo in the last few years.

GRAPES

The results for grapes are not as good as the ones for cotton. During the 17-year period reported in Table B2 the annual loss ratios ranged from .34 to 2.88, and average 1.82; which is higher than the average for cotton. The grape program had a loss ratio below 1.00 in half of the years. In the other half the ratio approached 2.00 in 5 years. In two years the ratio was higher than 2.00. At the beginning of the period 3 consecutive years presented loss ratios below 1.00; but this period was followed by a 5-year period of ratios above 1.00.

The number of trees damaged was quite high. The percent of damaged over insured trees ranged from 18 to 92%. Considering that almost all trees are insured the amount of the crop damaged is quite high. In 7 of the 17 years damages reached over 40% of the insured trees.

Considering that the premium rate for grapes has reached 5%, there is not much way of increasing this rate in order to improve the results.

POTATOES, TOMATOES AND BANANAS

In the case of these crops, excessive losses like the ones presented in table B3 can jeopardize the success of the entire program. Given the low level of participation (the insurance is voluntary) and the concentration in high-risk operations (since only the high-risk regions and farmers adhere to the program) the loss ratios where quite high.

Coverage written on potatoes and tomatoes started in 1975. After the last three years of high loss ratios (1978, 1979 and 1980) the coverage was canceled.

Coverage written on bananas started in 1979 and like potatoes the results of the operation in terms of loss ratios are extremely poor: loss ratios of 5.82 in 1979 and 5.00 in 1980.

This group of products presented an extremely poor

performance in the experimental phase. Two have been canceled and possibly the insurance on bananas will also be discontinued.

In sum, low farmer participation, to a great extend motivated by the relatively high premium rates, was the dominant reason to discontinue the program. In potatoes, from the 105 farmers who adhered to the program at the beginning, participation was only of 23 farmers in 1980. In the case of tomatoes the participation dropped from 28 farmers in 1975 to 5 in 1981.

GRAINS AND LIVESTOCK

The results for this group of products are presented in Table B4. Although the results in terms of loss ratios are still rather poor for feed-grains and wheat, the results for livestock are rather encouraging. The results for livestock help to understand why the premium rates dropped from 3.55% established in Resolution 5/70 to 2.5% (presente rate for cattle).

Farmer's interest in insurance on peanuts, soybeans and corn has decreased overtime.

In must be said that it is particularly hard to evaluate a program only 6-years old; having two years of drought in the period (1978 and 1979). The loss ratios for corn in 1979 was 16.19, soybeans in 1979 was 8.51 and wheat in 1978 was 12.77.

In contrast, livestock insurance presented highly compensating results. Loss ratios ranged from .48 to 1.28. The number of participants continues to grow in both cattle and horses.

LOSS RATIOS OF INDIVIDUAL CROPS (TABLE B5)

A review of the loss ratios shown in table B5 indicates that there has not been a substantial improvement in the insurance experience for most crops since the program was extended to all-risk insurance and to other crops in 1975. For products such as bananas, soybeans, corn, and wheat, the loss ratios are still not acceptable (almost all of them close to 6.00) and additional charges and premium rating would be necessary.

Nevertheless raising premium rates under voluntary participation might turn out to be a self-defeating policy.

To persist on a voluntary basis, perhaps it will be necessary to discontinue insurance on several grain crops after a few more years of experimentation. It is known in the literature that it was necessary to discontinue insurance on crops with loss ratios over 2.5 or 3.0 after a number of years of experimentation. Under present conditions the coverage written on feed grains (corn and soybeans) and on wheat is a very high risk type of insurance, although being experimental, it is possible to undergo constant and deep-charges.

It is noteworthy that these results which cover a short period of 5 years (Table B5) are much affected by weather conditions in 1978 and 1979, the poorest years for agricultural production in the decade. Even so, the loss ratios for 1977 and 1980 are still relatively poor for corn, soybeans, peanuts and wheat.

On the other hand, for two crops - cotton and grapes - the loss ratios of tables B1 and to some extend B2 indicate that there has been a substantial improvement in these two crop insurance programs. The many years of experience has given time to learn and to perfect cotton insurance and to a great degree the grape insurance. A key factor to explain the relative success of cotton insurance has been the fact that it is compulsory.

OVERALL PERFORMANCE (TABLE B6)

Given the relative poor performance in recent years, the state government may feel inclined to reduce drastically the operations of COSESP. Beginning with the 1977 crop year, the system accumulated heavy losses, as shown by Table B6. It must be aknowledged that the 120 Million Cruzeiros lost in the last five years will never be recovered from operations (despite the fact that at least part of the losses are spread over a large number of insurance companies through IRB reinsurance).

In any insurance system it is hoped that, within certain limits, a premium fund will keep ahead of the claims against it, at least to some reasonable extent. This is not the

case when we consider the results shown by the last column of Table B6. In some years indemnity claims way exceed premium revenues, but the accumulations of five years in succession of severe losses may threaten the entire program. These results virtually obviate the character of a subsidy embodied in the program.

On balance, if it were possible to drop a year such as 1978 of severe drought, the COSESP record on most of the insurances probably represents (as shown by the column Loss Ratio of Table B6) the correspondence achievable between premium revenue and indemnity claims in the long run. Unfortunately a single year such as 1978, added a net deficit to the "premium fund" at the amount of 86 Million Cruzeiros.

CONCLUDING REMARKS

Some concluding remarks are in order:

1. Most of the indemnity claims correspond to damages caused by excessive rainfall and rainstorm (over 60%). Hail and windstorm together do not respond for more than 25% of the claims. Also there is a clear concentration in some areas. These results indicate the need for an actuarial study to check whether there has been some concentration of high risk operations which burdens the whole program, since São Paulo (COSESP) has good data to do the study.

2. In the last 5 years there had been a need of an injection of 125.1 Million Cruzeiros in indemnities over premium revenue. On top of that amount, in the same period some extra 79.9 Million Cruzeiros were provided by the state itself and the state bank in terms of administration costs. These two figures add up to 205.0 Million Cruzeiros in net deficit of the program.

3. Administration costs are still quite high compared to premium revenue. The table below

shows this relationship:

YEAR	PREMIUM REVENUE (IN 1 000 000 Cruzeiros) (A)	ADMINISTRATION COSTS (B)	(B)/(A) (%)
1976	37.1	5.2	14.0
1977	44.1	7.2	16.3
1978	45.4	14.9	32.8
1979	77.5	18.6	24.0
1980	142.2	34.0	23.9

Source: COSESP - Companhia de Seguros do Estado de São Paulo.

In the last five years administration costs as a percent of premium revenue range from 14 to 33%, which is quite high. If it were not for the subsidy to the program in terms of administration costs sponsored by state agencies the entire program would not be possible.

4. In São Paulo, although the premium rates of COSESP crop insurance were higher than PROAGRO, even substantially higher, the farmers would prefer COSESP's system. Damages at the beginning of the cultivation would be fully indemnified so that the farmer can re-plant the area destroyed. Farmers under COSESP insurance in this case is fully elegible for indemnity. Under PROAGRO the farmer would have to wait until the crop is harvested. The farmer would receive indemnity only if the revenue from the sale of the product is not enough to cover the balance due of the credit account.

5. Since crop insurance is only a branch of company's operations, this sector is drawing from company's capital reserves. At the prevailing loss ratios, crop insurance is reducing the financial stability of the company and also reducing at an even faster rate the capacity

to finance the full risk burden. Continued losses could threaten the solvency of the program and eventually bankrupt the entire program.

6. Although it has shown some poor results, crop insurance is quite important for the agricultural sector of the state. Low level of participation can be explained in part by the level of premium rates and in part by being voluntary. This would help to explain the relatively poor financial performance of the program.

IV - CROP INSURANCE IN MINAS GERAIS

I - INTRODUCTION

The system of crop insurance in the State of Minas Gerais followed the same lines of the one developed in São Paulo. Resolution 2/72 of CNSP extended to the Insurance Company of Minas Gerais (COSEMIG) the authorization to write coverage on several crops and farm assets, also in an experimental basis (although excluded the temporary life insurance). The operations started in 1973/1974 crop year.

This particular insurance program was not broadly spread all over the state. The insurance was linked to a planned agricultural credit program, basically developed by the state government in the area of "cerrados", in the Southwestern part of the state, called "Triangulo Mineiro". At the beginning, the basic credit source was the Bank of Development of Minas Gerais (BDMG), under the assistance of the state agency of extension service. Later on with the implementation of a Federal Government program for "cerrados" the so-called POLOCENTRO, a new source of credit had been added to the existing system, which further enhanced the entire project.

Therefore, the experience in Minas Gerais is rather interesting in several aspects:

(a) at the beginning, the program was concentrated in a relatively small and risky area of poor

soils, where the crops take 3 to 4 years to reach full technically feasible yield (due to heavy requirement of lime treatment);

(b) this was an integrated credit insurance program, since it covers all production plus investment credit;

(c) this insurance, no matter the results, was specifically designed for an integrated plan of regional development, as a subsidized part of the whole plan.

The relatively poor results of the program in the last three years obviated the critical need for further expansion of operations. Insurance on new crops is being offered in a few experimental pilot counties, with a very limited number of farmers, (14 producers in Capinópolis county) who have relatively good farm records.

BEMGE has been quite cautious in extending the crop insurance to other areas of the state, although there is the recognition that spreading risks and increased participation is critical to future permanence of the program. Additional areas will not be added until the Company is sure that a satisfactory program can be developed for the newly insured crops and counties.

II - GENERAL FEATURES

The BEMGE insurance has coverage written on important crops for the state, such as cotton, peanuts, rice, edible beans, corn, soybeans, wheat, and sorghum. Besides crops it covers all farm assets such as buildings, machinery, vehicles, and stored products. This is also an all-risk insurance. To cope with the possibility of heavy crop-loss claims the insurer (BEMGE) diversified its liability among several crops and, most importantly, among several farm assets.

It follows almost all the characteristics of the system prevailing in São Paulo. The most important difference is related to the calculation of the indemnity to be paid. In BEMGE system, the calculations are made based on the following steps:

(a) at first, the value per hectare to be paid is calculated according to the expenditures estimated up to the moment of the event which destroyed the crop, within certain specified limits of plant development; and

(b) the value per hectare thus obtained is multiplied by the number of hectares damaged, which will give the total basic indemnity to be paid; and

(c) the number of hectares damaged is determined by the division of the yield efectively obtained by the maximum yield stipulated by the insurance company, multiplied by 100 and the total acreage of the crop.

Therefore, indemnity is payable only if the yield from the insurance unit is less than the average yield of the region, and farmers are paid up to the maximum of the expenses made. This is the distinctive feature of the BEMGE insurance contract.

III - PREMIUM RATES

The premium rates are reported in the table below. The rates for crops (3.5%) are higher than the ones stipulated by Resolution 5/70 (2.5%) but lower than the ones for the insurance in São Paulo (6%). The rates for coverage written on buildings is expected to drop to .35% and on vehicles to be raised to 6%. In the case of vehicles, the true actuarial rates for regular insurance is between 6 and 8%.

The problem with those rates is insufficient long term data on crop yields and losses to rate premium. Therefore, the premium rates are a kind of tentative rate, based on the capacity of the farmer to pay.

IV - OVERALL PERFORMANCE

The basic data is reported on tables C1 through C9. The program started to operate in 1973/74 crop year which permits a reasonable evaluation of its performance.

CROP INSURANCE IN MINAS GERAIS

PREMIUM RATES

RESOLUTION 5/70 AND PRESENT RATES

Resolution 5/70 (1970)		Present Situation (1981)	
	Premium Rates %		Premium Rates %
Crops	2.5	Cotton, Peanuts, Rice, Edible Beans Corn, Soybeans, and Wheat	3.5
Buildings	.4	Buildings	.4
Machinery and Equipment	.8	Machinery and Equipment	
		Owned	.8
		Rented	1.5
Vehicles	2.0	Vehicles	
		Owned	2.0
		Rented	4.0
Forests	-	Forests	From .95 to 2.8
Horses and Cattle	From 3.55 to 4.5	Horses and Cattle	From 2.5 to 3.5
Temporary life Insurance	.5		
Stored Products	.4		
Marketing loans	.3		

The results for all crops were extremely poor in terms of loss ratios. The average of loss ratios ranged from 2.77 for corn to 7.62 for rice. For all crops the average of the loss ratios in the 7-year period was as high as 3.54, with a wide fluctuation along the years. In this period the Crop Insurance Stabilization Fund had to cover the deficit between premium revenues and indemnities paid.

Except for soybeans, for almost all crops the proportion of insured area over total acreage cultivated is very low and never reaches 10%. In particular, for edible beans and corn this proportion does not reach 1%.

On the other hand, the results for farm assets were extremely good. For the final result of the loss ratio of the crop insurance in Minas Gerais, which ranged from .24 to 5.07, with an average of 2.53, the participation of coverage on farm assets was quite important.

V - CONCLUDING COMMENTS

Brazil is learning from its own experience how to manage the crop insurance business. Like the U.S. in the 40's, loss ratios are particularly high averaging 18.2 in PROAGRO 3.8 in São Paulo and 4.53 in Minas Gerais. For some individual crops, such as wheat, corn, and soybeans the average loss ratios over the experimental period are extremely high.

After reviewing the heavy losses of the beginning years, the insurance companies of the states decided to raise premium rates hoping to build up some reserves after matching premiums to indemnities. In some cases, raising rates up to 6 and 7% caused a drop in participation to such a extent that the program was discontinued (the case of COSESP). In other cases, such as the BEMGE in Minas Gerais the raise in premium rates to a moderate level of 3.5% did not reduce the deficit between indemnities to premium revenue.

PROAGRO started in 1981 a completely new experience. The program was entirely re-shaped under progressive premium rates and full coverage of credit granted. However in the preceding years the results were quite unsatisfactory. The program

drew heavily upon Federal fiscal budget, which made it particularly vulnerable.

Of course the government, both at state and federal levels should provide support to financial deficits in the beginning years. On grounds of economic viability some subsidy must be granted to such programs. But, when losses are accumulated over time it is hard to justify grants from the fiscal budget in increasing amounts.

Although the evaluation of the experiences are not positive, the prevailing systems have relative advantages over the past system where the government was the sole guarantor of years of severe floods or droughts. It must be said that under the present system premium revenue is important, although not enough to pay for the indemnities. There is more control in the present system, since extension service agents and people of the financial institution are responsible for checking the damages. There is probably a stronger inducement of technology and better distribution of credit, besides a greater acceptability of farmers as credit risk to banks.

In any case this system may be better than the indiscriminate cancellation of credit debt.

The basic virtue of the state systems, COSESP in São Paulo and BEMGE in Minas Gerais, is that they are a bridgehead to a future transfer of the responsibility of crop insurance from government to other agents. The Central Bank and the Federal Government would be willing to transfer this responsibility to other state agencies or private insurance companies.

For the two state programs the insurance technology is quite developed and fully mastered. Very capable and sufficient staffing has been provided by state government, the State Banks, extension service and by the state insurance companies. A competent staff has played a critical role in the relative success of the program. Both state programs were attached to the Institute of Reinsurance of Brazil which has provided adequate support and financing to both companies.

However, the commom element of failure of these two

program has been the crucial role of the heavy loss ratios, not the difficulty of mastering the technology. The heavy loss ratios call for continuing subsidy. These losses make the financial viability of both programs questionable. Furthermore, extra economic benefits are also questionable. Being the insurance voluntary, participation has been reduced to a minor share of the total number of farmers. The effect of the adoption of technology is also questionable. The program has only created benefits to high risk farmers, who pay a subsidized premium rate.

The solution might be to turn the crop insurance in both states compulsory and to reduce premium rates. It is worth noticing that premium rates are relatively high for a crop credit insurance, although they are low for certain high risk farmers and activities. For this group of farmers, rates as high as 6 to 7% are not high enough to prevent excess losses.

By changing the insurance from voluntary into obligatory it is expected to protect both programs against adverse selection, which refers to the contingency where poorer risk will buy insurance, whereas better risks will not. Both state programs are predominatly plagued with adverse selection. (Adverse selection often together with voluntary insurance).

After these changes, the state companies can take over insurance in São Paulo and Minas Gerais, thus replacing PROAGRO in all credit operations in both states.

DATA APPENDIX

TABLE A1

PROAGRO

PREMIUMS, INDEMNITIES AND LOSS RATIO

(1975/1980)

YEAR	PREMIUMS	INDEMNITIES	LOSS RATIO 1/
	(IN CR$ 1 000 000)		
1975 2/	.7	28.1	40.14
1976	9.2	386.9	42.05
1977	76.1	693.8	9.12
1978	215.4	2 397.6	11.13
1979	128.5	3 056.3	23.78
1980	5 689.9	15 601.7	2.74

SOURCE: Original Data: Banco Central do Brasil.

1/ Loss ratio = $\frac{\text{Indemnites}}{\text{Premiums}}$.

2/ Program started in 1975.

TABELA A2

PROAGRO
INDEMNITIES

PARTICIPATION OF INDIVIDUAL CROPS IN TOTAL VOLUME OF INDEMNITIES

(1979/1981)

CROPS	1979		1980		1981 1/	
	VALUE	PARTICIPATION	VALUE	PARTICIPATION	VALUE	PARTICIPATION
	(IN CR$ 1 000)	(%)	(IN CR$ 1 000)	(%)	(IN CR$ 1 000)	(%)
COTTON	67 679	2.22	1 161 259	7.44	180 193	1.18
RICE	539.920	17.66	739 429	4.74	3 268 456	21.35
COFFEE	142 231	4.65	130 178	0.83	38 021	0.25
EDIBLE BEANS	61 687	2.02	1 171 552	7.51	1 949 530	12.74
CORN	87 771	2.87	176 539	1.13	324 771	2.12
SOY BEANS	430 713	14.09	377 783	2.42	236 797	1.55
WHEAT	1 599 539	52.34	7 141 207	45.78	4 447 533	29.06
OTHER CROPS	126 746	4.15	4 703 788	30.15	4 859 119	31.75
TOTAL	3 056 286	100.00	15 601 735	100.00	15 304 430	100.00

SOURCE: Original Data: Banco Central do Brasil.

1/ Until September, 30.

TABLE A3

PROAGRO

SOURCE OF FUNDS AND PAYMENTS MADE

(1975/1980)

(IN CR$ 1 000 000)

YEAR		1975	1976	1977	1978	1979	1980
MENTS							
EMNITIES	Value	28.1	386.9	693.8	2 397.6	3 056.3	15 601.7
	(%)	(58.91)	(85.43)	(90.97)	(93.19)	(89.58)	(95.46)
IISSIONS OF E.S.1/	Value	19.6	66.0	68.9	175.1	355.7	692.5
	(%)	(41.09)	(14.57)	(9.03)	(6.81)	(10.42)	(4.25)
IISSIONS OF F.I.2/	Value	-	-	-	-	-	39.9
	(%)						(0.24)
OGRAPHICAL SERVICES	Value	-	-	-	-	-	9.1
	(%)						(0.05)
AL	Value	47.7	452.9	762.7	2 572.7	3 412.0	16 343.2
	(%)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)
NDS (SOURCES OF FUNDS)							
EMIUMS	Value	0.7	9.2	76.1	215.4	128.5	5 689.9
	(%)	(100.00)	(8.42)	(43.21)	(6.07)	(4.82)	(42.15)
DERAL BUDGET	Value	-	100.0	100.0	106.2	112.6	7 800.6
	(%)		(91.58)	(56.79)	(2.99)	(4.23)	(57.79)
NETARY BUDGET	Value	-	-	-	3 228.4	2 422.3	-
	(%)				(90.94)	(90.94)	
HER FUNDS3/	Value	-	-		-	-	1.8
	(%)						(0.01)
NES	Value	-	-		-	0.3	6.7
	(%)					(0.01)	(0.05)
TAL	Value	0.7	109.2	176.1	3 550.0	2 663.7	13 499.0
	(%)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)

OURCE: Original Data: Banco Central do Brasil.

/ Comissions of the Extension Service.

2/ Comissions of the financial institutions.

3/ Fund for the Development of Agriculture.

OTE: The difference between total payments and total funds represents a deficit covered by advancements of Central Bank.

TABLE B1

CROP INSURANCE IN SÃO PAULO

LOSS RATIO AND INSURED AREA

COTTON

(1965/1981)

CROP YEAR	PREMIUMS	INDEMNITIES	LOSS RATIO	AREA INSURED	AREA DAMAGED	AREA DAMAGED/ INSURED
	(IN CR$ 1 000)			(IN HA)		(%)
1964/65	644.6	308.8	.48	653 400	11 788	1.80
1965/66	833.2	370.3	.44	474 320	10 902	2.30
1966/67	468.4	327.9	.70	287 980	8 244	2.86
1967/68	812.7	787.5	.97	338 800	17 378	5.13
1968/69	1 209.1	1 021.6	.85	447 700	25 843	5.77
1969/70	3 689.2	1 753.1	.48	641 300	20 366	3.18
1970/71	3 194.6	3 328.6	1.04	605 000	31 123	5.14
1971/72	3 123.5	2 385.6	.76	594 954	23 805	4.00
1972/73	3 264.1	1 764.8	.54	615 863	13 178	2.14
1973/74	3 016.2	2 041.2	.68	379 401	15 604	4.11
1974/75	7 006.8	7 249.9	1.04	333 655	19 961	5.98
1975/76	12 654.5	25 708.8	2.03	220 517	30 200	13.69
1976/77	30 871.5	25 141.1	.81	358 039	39 625	11.07
1977/78	33 674.6	72 455.6	2.15	339 029	47 698	14.07
1978/79	36 291.8	31 651.9	.87	248 982	18 166	7.30
1979/80	63 217.5	111 659.7	1.77	276 117	30 962	11.21
1980/81	126 154.6	98 088.9	.78	284 301	n.a.	-

SOURCE: Original Data: COSESP - Companhia de Seguros do Estado de São Paulo.

n.a. = not available.

CROP INSURANCE IN SÃO PAULO

LOSS RATIO AND INSURED TREES

GRAPES

(1965/1981)

CROP YEAR	PREMIUMS	INDEMNITIES	LOSS RATIO	TREES INSURED	TREES DAMAGED	TREES DAMAGED/ INSURED
	(IN CR$ 1 000)			(IN 1 000 TREES)		(%)
1964/65	33.2	11.3	0.34	5 568	1 156	20.76
1965/66	44.7	32.7	0.73	6 400	1 430	22.3[illegible]
1966/67	31.7	23.9	0.75	3 511	965	27.49
1967/68	92.8	150.7	1.62	5 642	2 607	46.21
1968/69	158.9	237.7	1.49	5 728	2 945	51.41
1969/70	268.6	292.6	1.09	6 592	3 236	49.09
1970/71	373.7	552.3	1.48	7 217	5 098	70.64
1971/72	557.7	1 608.5	2.88	8 525	7 874	92.36
1972/73	755.5	579.4	0.77	8 495	2 779	32.71
1973/74	901.1	1 077.7	1.20	9 723	5 156	53.03
1974/75	1 383.8	685.9	0.49	9 818	2 322	23.65
1975/76	1 393.3	818.7	0.59	7 654	1 564	20.43
1976/77	1 275.9	2 170.2	1.70	3 901	1 405	36.02
1977/78	1 238.1	740.5	0.60	2 931	523	17.84
1978/79	1 475.6	1 070.4	0.72	2 631	495	18.81
1979/80	1 608.5	3 074.9	1.91	2 503	688	27.49
1980/81	1 960.5	4 892.1	2.49	2 078	853	41.05

SOURCE: Original Data: COSESP - Companhia de Seguros do Estado de São Paulo.

TABLE B3

CROP INSURANCE IN SÃO PAULO
POTATOES, TOMATOES AND BANANA
PREMIUMS, INDEMNITIES AND LOSS RATIOS

(1975/1980)

CROP YEAR	POTATOES			TOMATOES			BANANA 2/		
	PREMIUMS	INDEMNITIES	LOSS RATIO	PREMIUMS	INDEMNITIES	LOSS RATIO	PREMIUMS	INDEMNITIES	LOSS RATIO
	(CR$ 1 000)			(CR$ 1 000)			(CR$ 1 000)		
1975	595.2	5 010.8	8.42	163.4	1 715.4	10.50	-o-	-o-	-o-
1976	769.4	18.9	0.02	279.9	1/	-	-o-	-o-	-o-
1977	387.7	178.5	0.46	20.2	1/	-	-o-	-o-	-o-
1978	606.6	3 610.6	5.95	174.2	71.4	0.41	-o-	-o-	-o-
1979	2 030.9	13 006.5	6.40	218.5	1 151.2	5.27	709.3	4 131 2	5.82
1980	1 184.9	3 600.7	3.04	232.6	217.1	0.93	2 019.1	10 103.7	5.00

SOURCE: Original Data: COSESP - Companhia de Seguros do Estado de São Paulo.

1/ No indemnity was claimed.

2/ The operations started in 1979.

NOTE: In 1981 the insurance on potatoes and tomatoes was canceled.

TABLE B4

CROP INSURANCE IN SÃO PAULO

PEANUTS, CORN, SOY BEANS, WHEAT AND LIVESTOCK

PREMIUMS, INDEMNITIES AND LOSS RATIOS

(1975/1980)

CROP YEAR	PEANUTS			CORN			SOY BEANS			WHEAT			LIVESTOCK		
	PREMIUMS	INDEMNITIES	LOSS RATIO	PREMIUMS	INDEMNITIES	LOSS RATIO	PREMIUMS	INDEMNITIES	LOSS RATIO	PREMIUMS	INDEMNITIES	LOSS RATIO	PREMIUMS	INDEMNITIES	LOSS RATIO
1975	-o-	-o-	-o-	-o-	-o-	-o-	-o-	-o-	-o-	-o-	-o-	-o-	41.4	- 1/	-
1976	328.9	1/	-	294.1	- 1/	-	1 154.5	1/	-	2 223.0	2 824.3	1.27	71.2	- 1/	-
1977	260.3	979.9	3.76	100.1	337.5	3.37	1 161.4	4 103.7	3.53	6 276.7	33 406.5	5.32	878.8	497.4	0.57
1978	229.8	634.7	2.76	456.3	634.8	1.39	1 485.3	7 832.9	5.27	3 428.0	43 786.1	12.77	1 156.3	865.1	0.75
1979	65.8	68.5	1.04	59.1	957.1	16.19	1 845.2	15 708.2	8.51	3 855.0	17 388.0	4.51	3 823.9	4 896.0	1.28
1980	-	-	-	117.9	1/	-	398.8	3 382.5	8.48	-	-	-	9 399.9	4 533.0	0.48

SOURCE: Original Data: COSESP - Companhia de Seguros do Estado de São Paulo.

1/ No indemnity was claimed.

NOTE: Premiums and indemnities in CR$ 1 000.
Except for livestock all operations starded in 1976.

TABLE B5

CROP INSURANCE IN SÃO PAULO
LOSS RATIOS 1/

(1975/1980)

CROPS	CROP YEAR						
	1975	1976	1977	1978	1979	1980	AVERAGE
POTATOES	8.42	.02	.46	5.95	6.40	3.04	4.05
TOMATOES	10.50	- 2/	- 2/	.41	5.27	.93	4.28
BANANA	-o-	-o-	-o-	-o-	5.82	5.00	5.41
PEANUTS	-o-	-o-	3.76	2.76	1.04	- 2/	2.52
CORN	-o-	-o-	3.37	1.39	16.19	- 2/	6.98
SOYBEANS	-o-	-o-	3.53	5.27	8.51	8.48	6.45
WHEAT	-o-	1.27	5.32	12.77	4.51	- 2/	5.97
LIVESTOCK	- 2/	- 2/	.57	.75	1.28	.48	.77

SOURCE: Original Data: COSESP - Companhia de Seguros do Estado de São Paulo.

1/ Except Cotton and Grapes. The average loss ratio for cotton was .96 and for grapes 1.23.

2/ No indemnity was claimed.

TABLE B6

CROP INSURANCE IN SÃO PAULO

ALL TYPES OF INSURANCE

(1971/1980)

CROP YEAR	PREMIUMS	INDEMNITIES	LOSS RATIO	BALANCE	CUMULATIVE PREMIUM FUND 2/
	(IN CR$ 1 000)	(IN CR$ 1 000)		(IN CR$ 1 000)	(IN CR$ 1 000)
1971	3 568.9	174.8	0.05	+ 3 394.0	3 394.0
1972	4 224.2	4 823.8	1.14	- 559.6	3 343.5
1973	4 292.8	2 295.5	0.53	+ 1 997.3	5 775.5
1974	11 005.5	3 604.6	0.33	+ 7 400.9	15 082.3
1975	16 130.7	30 106.9	1.87	-13 976.3	4 725.7
1976	37 091.1	29 254.1	0.79	+ 7 836.9	14 311.1
1977	44 139.6	66 789.4	1.51	-22 649.8	- 4 045.4
1978	45 377.8	131 290.9	2.89	-85 913.2	- 91 414.8
1979	73 142.4	92 437.4	1.26	-19 294.9	-153 674.7
1980	142 201.9	145 344.3	1.02	- 3 142.3	-235 191.0

SOURCE: Original Data: COSESP - Companhia de Seguros do Estado de São Paulo.

1/ In current cruzeiros (CR$).

2/ A Fund capitalized at government borrowing rate.

TABLE C1

CROP INSURANCE IN MINAS GERAIS
LOSS RATIO AND INSURED AREA

COTTON

(1974/1980)

CROP YEAR	PREMIUMS	INDEMNITIES	LOSS RATIO	INSURED AREA	TOTAL AREA CULTIVATED 1/	AREA INSURED/ TOTAL
	(IN CR$ 1 000)			(IN HA)		(%)
1973/74	124.6	1 005.3	8.06	2 311	98 000	2.4
1974/75	419.7	1 005.6	2.40	5 695	108 202	5.3
1975/76	275.9	50.9	0.18	3 055	93 623	3.3
1976/77	551.3	1 772.7	3.22	4 146	116 144	3.5
1977/78	761.0	3 997.4	5.25	3 185	120 419	2.6
1978/79	386.2	- 2/	-	1 018	100 043	1.0
1979/80	584.6	- 2/	-	953	103 195	0.9

SOURCE: Original Data: BEMGE - Companhia de Seguros de Minas Gerais.

1/ Area cultivated in the State.

2/ No indemnity was claimed.

TABLE C2

CROP INSURANCE IN MINAS GERAIS
LOSS RATIO AND INSURED AREA

PEANUTS

(1974/1980)

CROP YEAR	PREMIUMS	INDEMNITIES	LOSS RATIO	INSURED AREA	TOTAL AREA CULTIVATED 1/	AREA INSURED/ TOTAL
	(IN Cr$ 1 000)			(IN HA)		(%)
1973/74	5.9	- 2/	-	177	8 256	2.1
1974/75	2.9	- 2/	-	77	6 305	1.2
1975/76	13.2	70.6	5.35	230	3 807	6.0
1976/77	11.9	- 2/	-	152	2 972	5.1
1977/78	23.9	55.4	2.32	158	3 247	4.9
1978/79	46.4	118.6	2.55	175	4 542	3.8
1979/80	-	-	-	-	-	-

SOURCE: Original Data: BEMGE - Companhia de Seguros de Minas Gerais.

1/ Area cultivated in the State.

2/ No indemnity was claimed.

TABLE C3

CROP INSURANCE IN MINAS GERAIS

LOSS RATIO AND INSURED AREA

RICE

(1974/1980)

CROP YEAR	PREMIUMS	INDEMNITIES	LOSS RATIO	INSURED AREA	TOTAL AREA CULTIVATED 1/	AREA INSURED/ TOTAL
	(IN Cr$ 1 000)			(IN HA)		(%)
1973/74	34.0	312.6	9.19	2 420	713 908	0.3
1974/75	439.8	5 779.6	13.14	17 407	814 100	2.1
1975/76	419.0	1 355.2	3.23	12 829	852 656	1.5
1976/77	220.9	2 421.2	10.96	5 719	708 883	0.8
1977/78	212.9	1 334.9	6.27	2 636	631 943	0.4
1978/79	139.8	408.7	2.92	1 585	509 364	0.3
1979/80	73.4	- 2/	-	-	-	-

SOURCE: Original Data: BEMGE - Companhia de Seguros de Minas Gerais.

1/ Area cultivated in the State.

2/ No indemnity was claimed.

TABLE C4

CROP INSURANCE IN MINAS GERAIS

LOSS RATIO AND INSURED AREA

EDIBLE BEANS

(1974/1980)

CROP YEAR	PREMIUMS	INDEMNITIES	LOSS RATIO	INSURED AREA	TOTAL AREA CULTIVATED 1/	AREA INSURED/ TOT.L
	(IN Cr$ 1 000)			(IN HA)		(%)
1973/74	7.9	26.6	3.37	399	849 330	0.04
1974/75	69.5	783.9	11.28	1 921	566 997	0.3
1975/76	77.8	110.5	1.42	1 795	555 534	0.3
1976/77	87.9	1 146.9	13.05	1 936	598 460	0.3
1977/78	99.8	420.4	4.21	724	559 384	0.1
1978/79	56.8	24.6	0.43	608	449 943	0.1
1979/80						

SOURCE: Original Data: BEMGE - Companhia de Seguros de Minas Gerais.

1/ Area cultivated in the State.

TABLE C5

CROP INSURANCE IN MINAS GERAIS

LOSS RATIO AND INSURED AREA

CORN

(1974/1980)

CROP YEAR	PREMIUMS	INDEMNITIES	LOSS RATIO	INSURED AREA	TOTAL AREA CULTIVATED 1/	AREA INSURED/ TOTAL
	(IN Cr$ 1 000)			(IN HA)		(%)
1973/74	25.4	.5	-	1 201	1 281 000	0.1
1974/75	298.0	1 837.7	6.17	8 832	1 622 706	0.5
1975/76	590.9	1 055.6	1.79	14 062	1 682 588	0.8
1976/77	514.2	1 127.5	2.19	9 700	1 795 197	0.5
1977/78	802.3	4 159.5	5.18	7 916	1 691 222	0.4
1978/79	608.5	647.3	1.06	4 547	1 595 629	0.3
1979/80	234.8	55.0	0.23	1 235	1 740 046	0.1

SOURCE: Original Data: BEMGE - Companhia de Seguros de Minas Gerais.

1/ Area cultivated in the State.

TABLE C6

CROP INSURANCE IN MINAS GERAIS

LOSS RATIO AND INSURED AREA

SOY BEANS

(1974/1980)

CROP YEAR	PREMIUMS	INDEMNITIES	LOSS RATIO	INSURED AREA	TOTAL AREA CULTIVATED 1/	AREA INSURED/ TOTAL
	(IN Cr$ 1 000)			(IN HA)		(%)
1973/74	291.2	1 839.1	6.31	11 186	48 000	23.3
1974/75	1 021.9	4 462.8	4.37	34 107	75 781	45.0
1975/76	1 484.2	1 398.7	0.94	38 222	79 664	47.9
1976/77	1 984.9	14 757.5	7.34	41 843	99 820	41.9
1977/78	3 471.5	8 919.8	2.57	39 209	112 094	34.9
1978/79	3 201.7	200.1	0.06	22 996	117 149	19.6
1979/80	1 115.6	1 199.5	1.07	4 613	162 799	2.8

SOURCE: Original Data: BEMGE - Companhia de Seguros de Minas Gerais.

1/ Area cultivated in the State.

TABLE C7

CROP INSURANCE IN MINAS GERAIS

LOSS RATIO AND INSURED AREA

WHEAT

(1974/1980)

CROP YEAR	PREMIUMS	INDEMNITIES	LOSS RATIO
	(IN CR$ 1 000)		
1975/76	72.9	366.4	5.03
1976/77	216.7	1 205.5	5.56
1977/78	581.6	458.0	0.79
1978/79	946.6	2 073.7	2.19
1979/80	15.2	819.8	53.93

SOURCE: Original Data. BEMGE - Companhia de Seguros de Minas Gerais.

1/ Area cultivated in the State.

TABLE C8

CROP INSURANCE IN MINAS GERAIS
PREMIUMS, INDEMNITIES AND LOSS RATIOS

CROPS, BUILDINGS AND MACHINERY

(1974/1980)

ITEMS	1973/74			1974/75			1975/76		
	PREMIUMS	INDEMNI-TIES	LOSS RATIO	PREMIUMS	INDEMNI-TIES	LOSS RATIO	PREMIUMS	INDEMNI-TIES	LOSS RATIO
CROPS	489.3	3 184.1	6.51	2 256.9	13 956.7	6.18	2 933.9	4 408.4	1.50
BUILDINGS	16.8	39.9	2.38	119.9	306.9	2.56	291.7	589.6	2.02
MACHINERY	125.8	5.5	.04	677.6	94.3	.14	1 250.6	253.6	.20
VEHICLES	12.2	12.3	1.01	179.4	94.8	.53	355.7	379.1	1.07
TOTAL 1/	644.1	3 241.8	5.03	3 233.9	14 452.6	4.47	4 858.5	5 664.1	1.17

ITEMS	1976/77			1977/78			1978/79			1979/80		
	PREMIUMS	INDEMNI-TIES	LOSS RATIO	PREMIUMS	INDEMNI-TIES	LOSS RATIO	PREMIUMS	INDEMNI-TIES	LOSS RATIO	PREMIUMS	INDEMNI-TIES	LOSS RATIO
CROPS	3 587.8	22 431.3	6.25	5 952.9	19 345.3	3.25	5 386.2	3 473.2	.65	2 023.6	2 301.5	1.14
BUILDINGS	355.9	647.0	1.82	664.2	911.9	1.37	2 315.5	606.4	.26	4 822.4	343.6	.07
MACHINERY	1 450.0	385.9	.27	1 729.4	145.3	.08	3.954.2	513.7	.13	6 450.5	709.8	.11
VEHICLES	497.8	222.2	.55	506.0	267.7	.53	769.7	175.2	.23	1 837.8	352.6	.19
TOTAL 1/	5 824.0	23 766.5	4.08	8 854.0	20 670.4	2.33	12 465.7	4 768.4	.38	15 177.7	3 707.6	.24

SOURCE:

1/ Includes also other small items such as [illegible] and stored products.

NOTE: Premiums and indemnities in Cr$ 1980

TABLE C9

CROP INSURANCE IN MINAS GERAIS
LOSS RATIOS
(1974/1980)

CROPS, BUILDINGS AND MACHINERY	CROP YEARS							AVERAGE
	1973/74	1974/75	1975/76	1976/77	1977/78	1978/79	1979/80	
CROPS	6.51	6.18	1.50	6.25	3.25	.65	1.14	3.54
Cotton	8.06	2.40	.81	3.22	5.25	-	-	3.95
Peanuts	-1/	-	5.35	-	2.32	2.55	-	3.41
Rice	9.19	13.14	3.23	10.96	6.27	2.92	-	7.62
Edible Beans	3.37	11.28	1.24	13.05	4.21	.43		5.60
Corn	-	6.17	1.79	2.19	5.18	1.06	.23	2.77
Soybeans	6.31	4.37	.94	7.34	2.57	.06	1.07	3.24
Wheat			5.03	5.56	.79	2.19	53.93	-o-2/
BUILDINGS	2.38	2.56	2.02	1.82	1.37	.26	.07	1.50
MACHINERY	.04	.14	.20	.27	.08	.13	.11	.14
VEHICLES	1.01	.53	1.07	.55	.53	.23	.19	.58
TOTAL	5.07	4.47	1.17	4.08	2.33	.38	.24	2.53

SOURCE: Original Data: BEMGE - Companhia de Seguros de Minas Gerais.

1/ No indemnity was claimed.

2/ The average was not calculated.

CONFERENCE ON AGRICULTURAL RISKS, INSURANCE, AND CREDIT IN LATIN AMERICA

February 8-10, 1982

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PUBLIC POLICIES TOWARDS FORMAL CROP INSURANCE

Ammar Siamwalla
Alberto Valdés

San José, Costa Rica

Preliminary Draft
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Ammar Siamwalla and Alberto Valdés

International Food Policy Research Institute

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"Is there any point to which you would wish to draw my attention?"
"To the curious incident of the dog in the night-time."
"The dog did nothing in the night-time."
"That was the curious incident," remarked Sherlock Holmes.

I. INTRODUCTION

Crop insurance programs are promoted with two basic underlying concerns in mind. First, to the extent that risk could have a substantial effect on resource allocation, crop insurance is seen as an effective instrument in reducing this misallocation cost induced by excessive risks in agricultural production. Second, complemented with other policy instruments, crop insurance is presented as a relief to farmers in order to mitigate the ill effects of fluctuations in their income. In other words, the broad objectives are to reduce inefficiency and to achieve rural income stabilization, with the underlying premise that social benefits exceed the costs of crop insurance programs.

Critics of crop insurance point out two alleged major shortcomings of such programs, namely that they usually cover only yield variation and not price variation, and thus their contribution to income stability could be quite limited; and secondly that the provision of crop insurance usually involves high social costs, due to the moral hazard and adverse selection problems, and high administration costs.

The fact is that with few exceptions, farmers are unwilling to pay the full cost of all-risk crop insurance, and thus they depend on a government subsidy. Farmers do, however, pay full costs of insurance

on some specific, albeit important, types of risks, such as hail and fire.

In the abundant literature on risk management for agriculture, issues concerning the welfare economics of crop insurance are rarely discussed. (An exception is Roumasset, 1979.) The major question examined in this paper relates to the concern that a competitive market may not offer farmers adequate opportunities for risk-pooling and risk-shifting unless there is a subsidy. But the fact that the insurance market is incomplete does not in itself imply that there is a true inefficiency. Therefore the question is whether or not the existing inadequacy of crop insurance in LDCs can be attributed to some type of market failure in crop insurance, or rather whether insurance services are not available because the real costs exceed the benefits.

As crop insurance is usually embedded in an economic system which has various alternative means of coping with risks, evaluation of its introduction cannot be considered in isolation from these alternatives. Credit and price stabilization policies are predominant in any attempt to find solutions to resource inefficiency and income instability, which represent two of the major economic problems confronting agricultural policy. Crop insurance must be examined in conjunction with these supplementary policies.

After a brief discussion of relevant concepts and definitions, we examine farmers' demand for crop insurance in the context of risk-pooling in general. Emphasis is given to discussing the possible nature of market failure, and thus the argument for public intervention in crop insurance.

We then examine the supply of crop insurance in light of the fact that risk-pooling is done across individuals, a fact which makes it susceptible to moral hazard and adverse selection problems. The final section presents conclusions and policy implications.

II. SOME CONCEPTS AND DEFINITIONS

Farmers cope with the inherent riskiness of agriculture in many ways. First they engage in either loss-prevention or loss-reduction activities. Loss-prevention is an activity that shifts the probabilities of adverse events. For example, crop spraying reduces the likelihood of pest infestation. Loss-reduction reduces the impact of adverse consequences, thus investment in tubewells reduces losses from drought. Crop diversification also has the same result, whereby the farmer attempts to lower the variance of income for safety reasons, beyond those resulting from technical conditions of production. Occasionally, _not_ taking certain actions may help reduce risks, thus farmers may refrain from using fertilizers to minimize losses should the weather turn out poorly. These are actions that farmers may take by themselves and do not presume any institutional innovations, although their actions do have social consequences, as will be seen below.

A second way to cope with risks is to pool them over time by adjusting assets and liabilities. This presupposes a functioning capital market. The costs of using this mode of risk-pooling would tend to vary with the efficiency of that market.

Finally, there may be risk-pooling _across individuals_, or risk-sharing. Landlords and tenants share risks in a sharecropping contract. There is also some risk-sharing between borrowers and lenders in the capital market because of the possibility of default. Governments share

some of the farmers' risks when the tax rate (whether for land tax or income tax) varies with the latter's income. These types of risk-sharing are really by-products of contracts and rules which have other purposes. Formal crop insurance is uniquely an institutional device whose sole function is to share the risks that farmers face.

PRICE RISK, QUANTITY RISK, AND INCOME RISK

If public policy is to be directed at risk reduction, its primary objective should be to lessen income risk. Broadly speaking, income is a product of output price and quantity from all income sources.[1/] With some exceptions, public policy has tended to address the price and quantity risks separately, simply because the instruments used to reduce them are different. Price risks are usually tackled through a price stabilization scheme involving forward prices, or a variable trade tax or subsidy. The conventional market approach to quantity risks is by means of crop insurance. A different approach, representing a direct attack on income risk, has been proposed, in Australia for example, in the form of a farm income stabilization scheme (Australia, 1978). However, even under such income oriented schemes, mitigating the effect of rural income fluctuations is likely to demand more than a single stabilization instrument. In a similar vein, Peter Hazell has suggested:

1/ As agriculture is modernized the rising share of cash input costs may increase substantially the coefficient of variation of the net revenue from the crops. Input availability risk is also quite significant for many less-developed countries. The solution to this should be on the marketing and distribution side as much as possible. Where this is not physically possible (as in the case of irrigation water), it may be regarded as another hazard to be insured against.

(b) The product is not traded in the world market, or if traded, the domestic price is insulated from the world price by policy. Not only that, the price insulation policy that is followed must be of a somewhat peculiar variety, namely where the domestic price is permitted to vary with domestic output. This condition by itself would rule out quite a large number of agricultural commodities.

(c) Any government market intervention is neutral with respect to price variations (e.g., there may be a specific excise tax on the output, but there may not be any stock operations).

Nevertheless, we have chosen to follow the conventional two-track approach of treating price stabilization and crop insurance as parallel devices to tackle the income risk problem of the farmer for two reasons.

(a) Severe practical problems exist with the explicit revenue insurance scheme suggested by Hazell in that the scheme would in effect guarantee a minimum price for the farmers (except when the low price is associated with a bumper crop). Unlike the buffer stock scheme which is able to capture the upside benefit to pay for the downside risk, the insurance agency's only way to capture that upside benefit is by collecting a high premium. The net transfers involved may end up being the same but it is unrealistic to expect farmers to fork out a high premium at planting time to cover their price risk.

(b) The second problem arises from the fact that most crops are subject to some form of government price intervention, either in the form of directly administered prices or indirect controls through trade measures. Thus, this price risk falls outside of the predictable risk

situation for which actuarial calculations can be made based on objective measurement of the chance of risk. Furthermore it encourages a departure from what seems to us to be a more effective approach in dealing with downward price instability, namely a proper minimum price support scheme.

To follow the two-track approach does not necessarily imply that one may generally ignore the interdependence between price and quantity risks. If prices and quantities are negatively correlated, then provision of either price stabilization or of crop insurance by itself would destabilize income. The correct approach is to provide neither or both. Where there is no covariation between individual farm yields and prices, or where such covariation turns out positive, either price stabilization or crop insurance by itself would be at least partially beneficial. Obviously, the first item of the research agenda before a crop insurance program is launched should be an analysis of these covariations.

RISK, UNCERTAINTY, AND NEW TECHNOLOGY

Advocates of crop insurance have tended to insist that crop insurance should be based on sound actuarial principles. (See, for example, Hazell 1981.) This suggests that we are dealing with the old Knightian concept of risk. As this is a far easier concept to deal with than uncertainty, we shall quite happily follow in this tradition in most of the discussions below. Certain biases do follow from this approach that need to be brought out.

Concentration on insurance against measurable risks tends to underplay the role of the public sector in reducing farmers' risks. It causes us to overlook one very important class of situations (call them 'uncertainties'), for which there may be an important role for the public sector. These situations arise from the introduction of new technologies, in particular those that are the outcomes of public research activities.

When farmers are introduced to a new technology, they are being asked to take a leap into the dark. Their response to reduce that uncertainty has been to undertake certain information-gathering activities, most frequently by starting an "experimental plot" of their own by allocating only a portion of their land to the modern method (for example, a new variety), or by waiting to see the results of a neighboring farm's "experiment." Now, this privately rational action can be socially quite wasteful as there will be a large number of farmers engaged in the activity of obtaining a better estimate of a single object--a yield distribution function. A faster and more socially economical method may well be through a centralized research network that will be engaged not just in obtaining a point estimate of the yield under new technology as has tended to be the case, but the whole yield distribution under the variety of hazards faced by the farmers. All that is needed is for that research network to disseminate the information either to the farmers or to private insurance companies.

However, it may be the case in some countries that such information dissemination may not elicit a sufficient degree of trust on the part of the farmers. The public authorities may be required to "put its money where its mouth is." They may then use the actuarial information acquired through their research activities to provide insurance coverage to farmers

at least for a number of years after a new technology is introduced. In fact, if the public agencies are disciplined by being required to provide insurance coverage to accompany any major recommendations they may make, it may even have salutary effects on their research directions as well.

There is no reason why this externality between research and insurance should be confined to the public sector. The above argument may be found to be equally valid when a private firm, such as a seed company, is introducing a new technology. It may then be just as desirable that the government imposes a requirement that the firm introduces crop insurance alongside any new seed that it introduces, at least for the first few years. Such a requirement may have another bonus: it may put a damper on exaggerated claims for a particular input.

Such a system would also have a cost. If the risk is transferred from farmer to research or development agency, it is quite possible that the latter organization may then adopt a risk-averse behavior instead of the farmers. They may consequently delay the introduction of new technology at great cost to society until they are absolutely certain, unless the government itself takes up the risk burden. Here is a valid agrument for strong public action to back new technology by insurance.

III. POTENTIAL SOCIAL BENEFITS OF CROP INSURANCE

SPILLOVER EFFECTS OF CROP INSURANCE

An argument for public intervention in crop insurance is that there is a possibility of a divergence between social and private returns from this particular activity, generating substantial externalities. If so, private firms may have insufficient incentive to engage in this activity which therefore needs subsidizing to bring the economy back to optimum.

The key externality pinpointed by advocates of crop insurance is the spillover effects of the benefits of crop insurance on consumers. Peter Hazell has forcefully argued that with the reduction in risk made possible by crop insurance, production of many crops will increase.

> "Increases in production induced by crop insurance will benefit consumers as well as producers. If demand is inelastic, average farm incomes may actually decline, and consumers will reap all the benefits. These distributional effects may require that governments, rather than private companies, establish crop insurance programs. Private insurance companies can only collect premiums from farmers. But governments, acting in the interest of society at large, could subsidize insurance for farmers when the cost can justifiably be recouped from consumers."

We attach particular importance to the need to clarify the logic behind the case for a subsidy, simply because public funds spent on crop insurance could be drawn away from other activities which do generate external economies, such as primary education and physical infrastructure. Thus the need exists for some sort of cost-and-returns calculation in establishing the case for public investment.

Consider first a commodity market in a world without crop insurance. The supply curve for the commodity will be given by S_0 in Figure 1. Included in this supply curve will be a risk-premium component for which the farmers have to be compensated because of the riskiness which cannot be shifted. In cases where farmers diversify in other safer crops at some cost to the average returns on this crop, that cost is also included in the risk premium. Suppose now that a crop insurance system is introduced for which farmers pay the full cost. The insurance enables the farmers to 'charge' less for risk premium, consequently the new supply S_1 is below S_0. To simplify the exposition, we will assume that both S_0 and S_1 refer to the supply in 'normal' years, to abstract from short-run shifts around S_0 and S_1 due to various random factors affecting yields. We also assume that these supply curves correspond to an 'undistorted' capital market situation. This assumption will be revised later in examining the possible interaction between market failures in the insurance and credit markets.

To the extent that demand is not perfectly elastic, there will be a fall in price from P_0 to P_1 with consumers capturing P_0ADP_1 as extra surplus. In the case of traded products, there is no change in price. There is then no spillover to consumers and the argument for subsidy disappears. This is not an infrequent situation; in fact, it often applies to food crops such as cereals and oilseeds, and applies to exportables such as fibers and sugar.

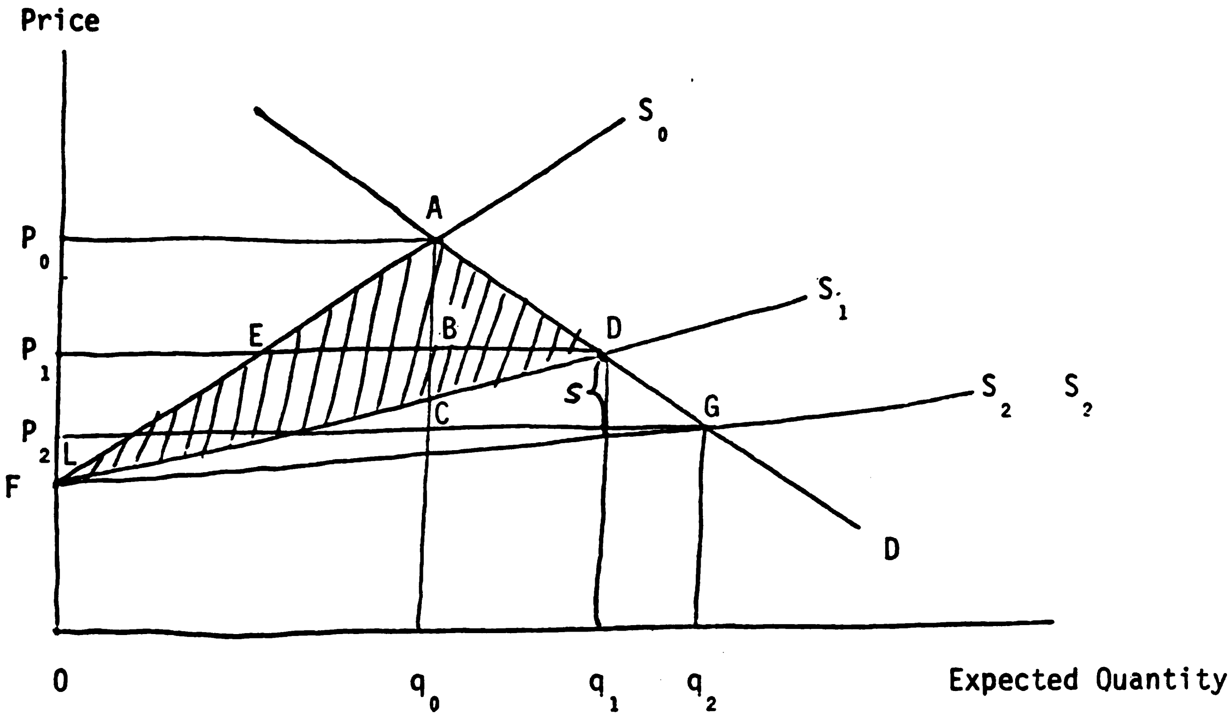

Figure 1. Welfare Gains to Consumers and Producers

We shall then concentrate on the more interesting case of an inelastic demand. We observe in Figure 1 that initially the cost to farmers of producing 0_{q_0} is reduced by AC, with a net savings of FACF in producing 0_{q_0}. This cost savings is a sufficient incentive for farmers to buy crop insurance without any subsidy. Once crop insurance is generally adopted, the price will drop as mentioned, so that the net welfare gain for producers will be P_1DF less P_0AF which may be positive or negative. Consumers will gain P_0ADP_1. For society as a whole, the net welfare gains are represented by the area FADF. The amount of the gain will depend on the magnitude of the shift of supply from S_0 to S_1, and the relevant demand and supply elasticities. Thus the welfare gains

depicted by the area FADF measures the value of the introduction of this institutional innovation to society, net of the full cost of providing insurance. We have counted as a cost whatever profit was made by providers of insurance services, and the resulting estimate of benefits consists of social returns, consequent upon the farmers adopting the innovation, which they will individually do even if they may end up collectively being the loser.

Is it possible that with the leakage of benefits to consumers, there is too little insurance provided, and that the government should 'return' that surplus to farmers by subsidizing crop insurance? Such a subsidy would in effect shift the supply curve further to some level such as S_2, causing the equilibrium production to shift from q_1 to q_2 and output price to come down further from P_1 to P_2. It can be easily shown that the gain in consumers' and producers' surpluses consequent on such a subsidy is FDGF, less than the subsidy cost of s x 0_{q_2} causing a deadweight loss. As the level of subsidy is arbitrary, there will always be a deadweight loss regardless of how much subsidy was provided. There is, therefore, no ground for the belief that leakage to consumers has to be corrected by a subsidy to either insurers or farmers.

The introduction of crop insurance can therefore be regarded as a cost-reducing institutional innovation. If it is an economically viable innovation, it generates an increase in social welfare or a 'free lunch,' some or all of which accrues to consumers. Sometimes there is even a further transfer from producer to consumer so that the farmers end up with a loss. This leakage to consumers, however, will not in any way prevent its adoption. As long as the cost of the insurance is fully

paid by the farmers, there is no reason to suppose that a suboptimal amount of insurance will be provided.

It would be instructive to compare crop insurance against the new technology produced by agricultural reserach. On the face of it, there are many similarities, even though one is a technological innovation and the other an institutional innovation. Both can generate social surplus which in the case of agricultural research has been demonstrably very large but which is not entirely captured by the producers. Generally economists, even those highly skeptical about the value of much government intervention, have always pressed for a strong public support of agricultural research (Schultz, 1979). Would not the same arguments apply to crop insurance?

The key difference emerges if we examine the nature of the "product" of agricultural research. Agricultural research generates knowledge which is a public good--one person's utilization of that knowledge will not in any way detract from another person's capacity to do so. If left to their own devices, no private firm will engage in the production of such knowledge because there is no way that its output can be sold individually to each user.

Some research results cannot be patented, such as self-pollinated seed production and agronomic practices. Even when patenting is possible, charging for the use of that knowledge may cause underutilization, relative to the optimum, as the social marginal cost of its use is zero. Government support is therefore required for the production and distribution of such knowledge.

Note that if the basic knowledge is used in the production of private goods, such as hybrid seeds and pesticides, the arguments for public subsidy at this later stage disappear because seed firms can recover the cost of seed production (including its development cost) from the farmers.[1/]

The picture for crop insurance is quite different. It is clear that crop insurance itself is not a public good. Firms can sell coverage to individual farmers and recover their costs from them. In this, their situation is analogous to the seed companies rather than those engaged in basic agricultural research.

It may be argued that the institutional innovation of crop insurance does require subsidy of more basic research akin to the basic genetics that led to hybrid maize. There is considerable ignorance now on the actuarial questions of crop insurance, which holds back its supply, as well as on how crop insurance would actually affect the distribution of farmers' net income, which affects demand. This argument for a subsidy however, implies that it should be directed at the research activity rather than at crop insurance itself.[2/] The only case that can be made for the latter subsidy is if learning-by-doing is less costly or more

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1/ This argument applies to the specific case of hybrid seeds, where farmers have to come back and repurchase the seeds from the company year after year, so that it is relatively easy for firms to protect their proprietary rights. For self-pollinating crops, production of seeds would have to be subsidized, there being no way that seed firms can recover the full costs of developing and producing a new variety, as farmers can replicate the seeds by themselves after the first crop.

2/ The more so as information thus generated is immensely useful for purposes other than crop insurance.

productive than learning-by-research with crop insurance being regarded as essentially an 'infant' industry. But then the objective of the subsidy should be narrowly specified and the subsidy withdrawn once the lesson has been acquired.

Such promotional pricing of insurance in the early years must be demonstrably based on the premise that insurance 'pays' in the long run. The Japanese case is quite instructive. They launched their crop insurance program in 1939. Despite the very high quality of data Japan possessed even then, it is generally agreed that the actuarial basis for insurance was rather poor until about 1954 (Ahsan, 1981).

As the absence of insurance implies that markets are severely incomplete, there must be substantial gains to providing it. There is then the puzzle as to why self-supporting crop insurance is almost universally absent. The argument that public subsidy to crop insurance is needed to transfer the "leaked" gains back from consumers to farmers or insurers before they will adopt it, if valid, would have provided a ready explanation. We have argued that this leakage argument for public subsidy is an invalid one, so that we are still left with the puzzle. There are alternative types of market failures, which may hold the key, of which the infant industry argument above is one.

INCOME STABILITY AS A SOCIAL OBJECTIVE

Most individuals are risk-averse and consequently take various actions themselves to reduce income instability. This is usually done at a price. There are two reasons why society should also concern itself with income instability.

(a) Because of institutional or market underdevelopment, individuals purchase income stability at "too high" a price. This is the efficiency ground for supporting the provision of crop insurance, and is the basis for much of the rest of this paper.

(b) There may be a subset of individuals who are for some reason or another unable to buy that income stability. We shall here single out people with relatively little assets and who are therefore in a poor year pushed into destitution. All societies have various provisions to ameliorate the position of the destitute, suggesting that they place some value on the prevention of such destitution. A subsidy on crop insurance can then be clearly justified on this ground, provided that the insurance is targeted only to the population exposed to such a possibility.

Crop insurance is better regarded and is normally conceived as a service to be sold to all who wish to pay the price, since it increases the utility of all who are exposed to income risks. If an equity objective such as in (b) is to be tacked on, then the way to handle it, provided it is feasible, is to provide a subsidy targeted only to those individuals at the lower end of the wealth distribution.1/

1/ This targeted approach would take care of Roumasset's valid objection (1977, pp. 13-14) that an across-the-board subsidy would not necessarily aid the poor as opposed to the better-off farmers.

It is by no means clear that crop insurance is the best approach in attaining the equity objective. One type of "spillover" effect that arises from crop losses may come about if factors of production, particularly labor, are immobile or factor prices rigid. Then the income losses originating from crop shortfalls would affect nonfarmers through the well-known multiplier process. In this case, normal crop insurance would provide an automatic stabilization mechanism, which restores the income back to the farmers and hence may also reverse the process somewhat. This provides, in our view, a valid and possibly even powerful argument for subsidizing crop insurance.

Research is, however, needed on the question of how the effects of crop losses percolate through to the nonfarmers in the affected region. They not only reduce farmers' incomes but also factor demands at the later stages of the production cycle. Harvesting labor is an obvious example, demand for services of the processors is another. Recompensating farmers for their losses would be insufficient to cover these other losses. It would be desirable then to introduce public works programs to reverse the fall in factor demand as well. In fact, in terms of the magnitude of the task involved, such programs may end up being much larger than crop insurance. Only a slight expansion of such programs would then be needed to take care of the multiplier effects of the fall in farmers' own income.

Against this, we should note that public works programs and other relief measures tend to be ad hoc and discretionary, and do not provide the certainty of a fixed rule such as that which accompanies crop insurance. Finally, an advantage of crop insurance which is of immeasurable value is the fact that the recipient receives his compensation as a right and not as a degrading handout.

IV. RISK, INSURANCE, AND CAPITAL MARKETS

Farmers can, in principle, self-insure by borrowing or running down assets in bad years and saving in good years; in other words they can individually pool their risks over time, without having to pool them across/among individuals. For this mode of risk-pooling to be effective, a perfect capital market has to be assumed, however. Indeed, as has been shown by Masson (1972), individuals who are risk-neutral will act as if they were risk-averse when confronted with market distortions.

Even though the capital market facing farmers in LDCs is notoriously imperfect, and despite the high price they have to pay for credit, they nevertheless resort to it habitually when crops are poor (Jodha, 1978). Capital market issues are thus inextricably linked to crop insurance.

In many instances, capital market imperfection should not always be looked at as a cause of the lack of crop insurance. Indeed, there are grounds for arguing that the lack of crop insurance itself may be a partial cause of the capital market imperfection. When farmers borrow money, risks are shifted in significant ways. Where the penalty for loan default is very large, the primary risk from price and yields is borne in its entirety by farmers, as a borrower's risk. In reality, this risk would in many instances be shared with the lender because of the possibility of default. Part of the primary risk then becomes lender's risk. Crop insurance then becomes relevant to lenders as a means of reducing lender's risk, particularly where a lenders' operations are highly localized such as with small money lenders or traders. There

is then an acute need to shift risks <u>out of</u> that area (Lipton, 1979). For this type of credit operation, crop insurance is complementary.

Where credit operations, say by a nationally chartered commercial bank, cover a wider area, the lender's risk is pooled internally by the bank. Such credit operations then are substitutes for crop insurance. We thus have what appears to be a paradoxical situation where the strongest advocates of crop insurance are, in fact, the large organized credit institutions who should in fact be, in a sense, its competitors. This "paradox" can be resolved if we look at the major constraint that credit institutions work under.

In both cases, lenders have taken over willy-nilly some of the risks farmers face. Where they are free to do so, they will charge borrowers for the additional risks they incur. Thus, under flexible interest rates the interest rate charged would vary according to the risks each borrower faces to account for the risk premium specific to him. Such fine-tuning of interest rates is possible only with small local operations or else would incur very high information costs.

Large-scale credit agencies are subject to somewhat severe limitations in their ability to vary interest rates in accordance with the risk class that each of their clients belongs to. Consequently they have to charge *uniform* interest rates. Since they cannot charge for the risk they have to bear, they minimize it by rationing the amount they lend. This they do by demanding a relatively lower ratio of borrowed to owned capital and by demanding a high return on capital on the farmer's operation. Such credit-rationing naturally imposes a social cost in that it prevents farmers from investing to the point where the rate of return is equal to the cost of

capital. It also imposes a cost on the credit institution themselves in that they are not able to expand their operation to meet the full extent of the demand.

Thus the paradox as to why many credit institutions are keen to see a formal crop insurance program developed is resolved. It enables them to act in a much less risk-averse fashion and thus expand their operations.

The introduction of crop insurance represents a financial innovation which, in reducing the default risk as perceived by the lender, reduced the transaction costs of lending to farmers. Its benefits are not merely a reduction in transaction costs, but they could result in real income gains as a result of more efficient resource allocation at the farm level. The basic premise here is that the primary benefit will not accrue only to the lenders, in the form of reduced default risk, but that a reduction in capital rationing will takeplace, whereby some of this may be passed on to the borrowers as reduced interest rates or, what is more likely, as a willingness to supply farmers with more funds at the given interest rate.

An interesting research question remains. We do not know whether it is easier or less costly, from a social point of view, to have existing credit institutions conduct risk assessments and include them in their interest charges, or to set up a separate specialized crop insurance institution that would essentially do the same job.

V. COST AND SUPPLY OF INSURANCE: REFLECTING ON THE ROLE OF THE GOVERNMENT

Provision of insurance involves real resource costs which may be quite high due to moral hazard, adverse selection, and field supervision costs. These costs will vary according to the type of risk covered. So-called specific insurance in selected geographic areas (e.g., against hail, fire, and flood) is available in many countries, offered by private firms or government agencies at subsidized rates. However, this is not the case with multiple-risk insurance (which, when available, applies to yield risk only--seldom to price) which is uncommon.

In contrast to specific insurance, in multiple-risk insurance the supplier of insurance usually monitors the output effect, rather than the specific change in the 'state of nature.' But there are many possible sources for a fall in yield (often interacting among themselves), and they cannot be easily monitored. To the extent that it is difficult to distinguish between the probability of a 'state of nature' and the decisions of the insured, moral hazard could become a reality

MORAL HAZARD

As indicated in Section II, the presence of risk affects farmers' behavior in many ways, as they buy more certainty by sacrificing some income. Crop insurance is merely another mode of buying that certainty. Consequently, its introduction would modify their behavior from what it would otherwise be. Some of these shifts in behavior are socially desirable

and indeed provide the justification for crop insurance in the first place, but there is a possibility that there may be other shifts that, as it were, take too much advantage of the crop insurance and can end up being socially costly. This type of behavior defines moral hazard. Deciding what type of behavior consititutes moral hazard is not an easy task.

Take the use of pesticides, for example. Absence of crop insurance may induce farmers to use an excess amount of pesticides from a social efficiency point of view. The introduction of crop insurance would reduce farmers' use. Up to some point, that reduction would bring some social gains, but it is quite possible, indeed likely, that farmers may reduce pesticide application by "too much" or eliminate it altogether, in which case some social costs are imposed. At what point the reduction becomes excessive is not easy to establish even theoretically. Recent work by Marshall (1976) suggests an approach which is worth some examination.

The economic theorist's approach to risk problems is to specify various states of nature with attached and <u>fixed</u> probabilities. Each state, together with agents' actions, determine an outcome. Marshall's contribution has been to show that if insurance policies specify payments based entirely on states of nature, then no moral hazard problems can possibly arise. To be sure, farmers' behavior would be influenced by the presence or absence of crop insurance, but in this instance, provided insurance is competitively priced, they would be moved to change their behavior which will be confined to loss-reducing or self-insuring activities just to the point of socially optimum, given our assumption of fixed probabilities.

There is therefore some theoretical attraction in using states of nature rather than outcome as triggers for indemnity in crop insurance. It is surely no accident that the only cases of which we know where private firms have offered crop insurance on an unsubsidized basis anywhere is to cover hail damage, although the size of the indemnity in this case is still based on actual loss and therefore does depend on outcome. Research should be conducted on how to specify certain extreme and hence presumably easy-to-monitor weather conditions in the policies to be offered. Another attraction of this type of policy is that the administrative cost of the insurance can be drastically reduced, as it is possible to dispense totally with the generally expensive monitoring of outcomes of individual farmers. What the insurance agency could do is essentially to accept bets at close to actuarial odds on particular adverse events.1/ Farmers would come and place bets to the amount of their own choice in favor of those events occurring, to ensure that their income from farming and from these bets is negatively correlated. Where meteorological data are good, the data basis for the calculation of the odds is already available.

The fact remains that in many cases our assumption that the probability of each state's occurrence is fixed and beyond farmers' manipulations, is violated. Then loss prevention activities are possible, and moral hazard problems can arise,2/ although if frequent claims by any individual farmer

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1/ Because of its similarity to gambling, there may have to be some changes in the law on gambling in some countries where such activities would be otherwise banned.

2/ At the formal level, it is possible to specify states of nature in such a way as to make them invoilate to farmers' manipulations. Thus in the pest example above, instead of using pest infestation as an indicator of the state of nature, we can use the various natural conditioning factors that give rise to pests to specify the states of nature. Pest infestation can then be

would result in his premium rates going up and if he is aware of this penalty, much, but not all of the social losses arising out of the moral hazard may be reduced (Marshall, 1976).

Insurance policies where the indemnities are triggered by outcome, i.e., by yields, have a great deal of attraction because the number of risks facing agriculture are very large. To specify them all or even a large proportion of the variance would be difficult. Concentrating on a single number such as yield would be a great simplification. Against this must be set the very high social cost of moral hazard, which may only partially be reduced by means such as deductibles or coinsurance.

An elegant compromise between the purist demands of theory and the practical demands of the real world has been proposed by Dandekar (1977). It is related to the system in use in Sweden. As triggers, Dandekar suggests the use of the average yield of all the farmers in a predefined "homogeneous area" rather than yields of individual farmers. If, therefore, any hazard causes yield to fall, farmers in the area who are covered will be paid indemnities proportionate to the area insured, which need not be the same as the area actually cultivated.

The first problem with this approach is that it assumes the only factors influencing average area yield to be natural hazards. In traditional agriculture, where use of cash inputs is small, this assumption is a good approximation. Where yields become partially a matter of choice by the

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regarded as an intermediate outcome which then affects yields. Application of pesticides then becomes a loss-reduction activity rather than a loss-prevention activity. Then the sufficient condition for no moral hazard to occur is to write policies with the pristine state of nature as triggers for payment. While formally correct, it is beyond the realm of practical festibility in many cases.

farmers, crop insurance may end up providing coverage against certain market hazards as well. For example, a shortage of fertilizers, or a general expectation of low crop price may affect yields. These hazards affect all farmers and therefore the average yield on which the indemnity is based. While the extension of crop insurance to cover market as well as natural hazards may be regarded by some as desirable, it makes the actuarial task of the program extremely difficult if not impossible.

The remaining problems with this are implementation problems. The major one is of course the definition of "homogeneous area" which should be one where the yield variability among individual farms (although not necessarily yield levels)[1/] are highly correlated. Roumasset (1979) is skeptical on the existence of these homogeneous areas. The fact is that very little empirical data exist on the variability of yields at the farm level and how closely correlated they are within any given area.[2/] These data are essential for the definition of a homogeneous area. Higher level data (say, within a given administrative area) can be a highly misleading guide for the insurers as they already incorporate those very correlations that we are interested in.

A precondition for adopting such a homogeneous area approach is, therefore, a much more systematic system of data collection. Since the information thus gathered may be regarded as a public good, the government has a very clear role as far as the insurance itself is concerned.[3/] Furthermore,

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1/ Although where yield levels do differ, care must be taken that when the areas are sampled for calculation of area-wide variability, there are no sampling errors.

2/ Newbery and Stiglitz (1981, pp. 108-110) survey the estimates that are available on the magnitude of yield variability at various levels, which tends to show that the magnitudes tend to get much larger at lower levels of aggregation, suggesting that the intercorrelation is not very high.

3/ See the section of welfare effects of crop insurance.

since the data have uses beyond crop insurance proper, "their costs need not be charged to the crop insurance scheme." (Dandekar, 1977, p. 4).

Moral hazard can be overcome only if compensation is not paid on the basis of individual outcome. If it is, moral hazard will undoubtedly occur, leading to losses for society as a whole, and is independent of whether the supplier of the insurance is the government, a cooperative, or a private firm.

ADVERSE SELECTION

Adverse selection may arise in crop insurance if all three of the following conditions are met:

(a) The insurance agency has poorer information than the insuree about the specific risks facing the latter. As a consequence of that poor information, the agency is incapable of charging every insuree a correct premium for the specific risk class that he belongs to, although the agency may attempt to break even by averaging risks across different risk classes.

(b) Indemnity is paid on the basis of specific outcome experienced by each insuree.

(c) Insurance is voluntary.

If all these conditions are met, then it has been shown (Rothschild and Stiglitz, 1976) that there may exist no profitable way of providing insurance, as the better risks within each risk-class will always opt out of the program, raising the insurer's loss ratio. If we concede condition (a) above on the grounds that to design and obtain information to administer

a finely meshed program with premia tailored for every existing risk class would be impossibly costly, there are obviously two ways of handling adverse selection, that is by removing either condition (b) or condition (c).

If the insurance agency partitions farmers arbitrarily into different risk-classes, calculates premia based on these risk-classes, and then pays out indemnity to insuring farmers on the basis of the average outcome of that class, the average being taken from among the insuring as well as noninsuring farmers, then adverse selection will not threaten the program's viability. Adverse selection behavior may still occur in that farmers with better risk experience than the class to which he is assigned may decide to opt out, as the "insurance" may increase rather than decrease his income variability, but their departure does not threaten the scheme's viability because it does not affect the premium-indemnity ratio. The system becomes merely a bet on the average outcome. This applies to and is another attraction of Dandekar's area approach.

A more common proposal is to make crop insurance compulsory. Compulsion then merely means that the less risk-prone or risk-averse farmers within each risk-class are being taxed to finance the cost of the error made by agency in making the risk-class partitioning. On the other hand, the cost of correcting such an error by a more refined partitioning of the risk-classes may be significant. The deadweight loss imposed by the implicit tax must then be balanced against the cost-saving made possible by compulsion. There are thus possible efficiency grounds for compulsion. How valid these are depends on the specific context, although we would

speculate that in the introductory states of crop insurance, with generally poor data at hand, it is highly unrealistic to expect insurance agencies to make the assessments for correct partitioning of farmers into risk-classes. Consequently, the government may decide to introduce compulsory crop insurance as a quick means of data gathering. As compulsion removes the incentive and the discipline for the agency to try to make the proper assessments, there should be a fixed time limit of say, ten years, at the end of which insurance will become voluntary.

The incidence of the compulsory insurance system, across income classes, is a priori unpredictable, varying as it does according to riskiness of the individual farms, the risk aversion of the individual farmers, and the other alternatives that are available to shift risks. There is no clear evidence available to us that indicates whether each of these factors are systematically related to the levels of income of the farmers. In fact, the apparent randomness of this incidence is probably the strongest argument against a premature adoption of a compulsory system.

FIELD SUPERVISION COSTS

Field supervision costs cover the costs of gathering data for actuarial calculations as well as monitoring outcomes for indemnity payments. These field supervision costs could add significantly to transaction costs of crop insurance, particularly if individual outcome is used as a basis for indemnities. This is yet another argument

against the individual outcome approach. If an area approach is to be adopted however, then the collection of data both for actuarial calculations and for monitoring purposes should be a public activity, as the information generated is a public good in that use of the information by one firm does not affect the cost nor the productivity of its use by others. Furthermore, data thus obtained has immense usefulness in other activities, such as credit, tax collection (which may be its kiss of death), extension and general statistical services.

If the individual outcome approach is still to be maintained, crop insurance provided in coordination with credit programs, which usually require a similar type of information, could reduce transaction costs. A bank in coordination with the crop insurance agency could internalize these economies of scale, with the two organizations sharing the cost. The only ground for a subsidy in this situation is its possible use for tax purposes and other public activities.1/

REINSURANCE

A successful crop insurance program pools risks among the insuring farmers. If the factors influencing different farmers' yields are statistically independent, then if the pooling is done across a sufficiently large number of farms, there would be no risks remaining for the primary insurer. If the yields are not independent because the insurer's operations are highly localized, or specific to only one

1/ The usefulness of these data for public services from a statistical point of view is less than the case of the area approach, because in the former the sample would not be random.

Of course, there is no need for the government, even of a fairly large diversified economy, to undertake reinsurance. It may decide to import that service by having the primary crop insurers reinsure overseas, which is the case in Chile.

VI. CONCLUDING REMARKS

This paper explores crop insurance as a means of ameliorating the risks that farmers face. We have concentrated on yield risk, arguing that price risks should be handled through market interventions rather than through insurance.

We first tackle the welfare economics of crop insurance, and attempt to weigh various arguments in favor of government intervention. Our conclusion is that the benefit of crop insurance is one of institutional innovation and must be weighed against the cost of inducing such an innovation. Ruled out is any simple across-the-board subsidy of crop insurance, except perhaps as an infant industry. We have pinpointed the inadequacy of data and information as the major barrier to the development of a crop insurance industry. As these are classic examples of public goods, the government's role in its provision is clear. We also favor other ad hoc relief measures rather than crop insurance in the alleviation of hardships that follow from crop losses, as the impact of such losses tend to fall on a much broader class than cultivators--the only group who would normally be covered by crop insurance.

We next examine the important linkage between crop insurance and credit. This linkage arises essentially because credit agencies are constrained from varying interest rates to farmers by risk-classes, and therefore need some extraneous agency to standardize risks for them. Another, perhaps cynical, way of making the same point is that levying an insurance premium is merely a device by which farmers can be charged

extra interest rates. However, if the banks loosen their rationing of credit and thus expand their agricultural portfolio, farmers' welfare may rise because the loosening of the ration more than offsets the effect of the insurance premium.

Finally, we examine various strands that flow from the single basic problem of information costs: moral hazard, adverse selection, and administrative costs. Our conclusion is that these factors tend to argue in favor of specific risk coverage rather than multiple risk coverage. If the latter has to be adopted, then an area approach may be the better route to take. These broad conclusions are based largely on nonempirical judgements and have to be modified in the light of the specific environment within a country.

Indeed, the task we have set ourselves to in this paper is to address a number of issues that would generally be raised by the introduction of formal crop insurance. We have proceeded in a frankly a priori fashion simply because that is the only way these general issues can be raised. One final generalization that we would like to make is that institutions that deal with agricultural risks have to be very location-specific, and therefore considerable empirical research needs to be done by every country that wishes to introduce formal crop insurance. A checklist of the questions that then need to be addressed now follows.

(a) What is the magnitude of farm-level yield risks and how do they vary among farms of different sizes? Also, what are the extent and nature of the covariations among the various farms within a village, a region, and the country as a whole?

(b) What are the dominant factors that explain price fluctuations? In particular, is domestic production one of them?

(c) Our bias is very much towards insurance which covers specific yield risks rather than multiple yield risks. If this hunch turns out to be correct, then obviously it becomes essential to find out which specific hazards affect yields the most and how easy it is to monitor such hazards. As this monitoring is a role for which the public sector is more suited, do existing public institutions exist to perform the task?

(d) Crop insurance has generally been very much favored by formal credit institutions. We have argued that a major reason for this backing is the constraint that banks have on varying interest rates by risk-classes. Crop insurance is then merely a way of making these risk-classes uniform from the lender's point of view. As an alternative to crop insurance would be for the lenders to bear the risks themselves, we need to know how powerful this contraint is. If it is due to the very high cost of classifying farmers by lending institutions, then perhaps a specialized crop insurance agency is called for.

Answers to all of these questions are necessary before a crop insurance program is designed. From the experience of those countries in which crop insurance is already in operation, the following questions need to be raised.

(a) What is the extent of public subsidy and, more importantly, to which particular activity is the subsidy directed?

(b) Where the history of such a program has been sufficiently long, what is the evolution of the public subsidy? In other words, does the infant industry ever grow up?

(c) What conclusions can be drawn about the farmers' and lenders' responses to crop insurance?

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AGRICULTURAL DEVELOPMENT BANKING AND THE SUPPLY OF CREDIT: A CONCEPTUAL FRAMEWORK

Carlos F. Pomareda

San José, Costa Rica

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Carlos F. Pomareda*

January, 1982

*Research Economist, Inter-American Institute For Cooperation on Agriculture (IICA), P.O. Box 55, 2200 Coronado, San José Costa Rica.

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AGRICULTURAL DEVELOPMENT BANKING AND THE SUPPLY OF CREDIT: A CONCEPTUAL FRAMEWORK

Carlos F. Pomareda

1. INTRODUCTION

The financing of agriculture in developing countries has been a long time debated issue around two basic points: On one hand the organization, and quality of service provided by the development finance institutions, and on the other hand the financial policies themselves.

Institutional design has made of most agricultural development banks (ADBs) a type of rather specialized farm credit agencies. As such, they provide loans for agricultural production and no other financial services. On the other hand they rely mostly on international soft loans and government subsidies, all of which contributes to their limited capacity to act as financial intermediaries.

Financial policies towards agriculture depart from the basic philosophy that low cost credit is a necessary condition for technical substitution, and increased income in rural areas. There is,however, much controversy on the validity of these policies. They are in part, responsible for a series of distortions in the capital markets, and the inability of the development banks to grow at the expense of their own resources.

Limited earnings, because of interest rate policies and limited financial intermediation capacity, are major reasons for ADBs to provide a low quality service. The situation is jeopardized by the fact that, in fulfilling development goals, ADBs must serve

a large number of small farmers, hence facing high operating costs.

If agricultural development is to be accelerated, it is be done with appropriate supply of capital. If such is the case, it is mandatory to reappraise the financial policies toward agriculture and the role that agricultural finance institutions must play. This appraisal is already under way [World Bank/EID, 1981], and new strategies are being suggested.

Considering that the instability of farmers income (because of crop failures) is an important reason for low loan repayment, credit insurance is being considered among the components of a new strategy to increase the supply of credit. How effective this policy can be,is up to now a theoretical issue; however, evidence exists that credit insurance increases loan recovery rates, and hence the availability of loanable funds. Nevertheless, even when this is the case, the question still remains as to how credit insurance changes the bank's efficiency.

The remaining sections of this paper analyze the points outlined above,i.e. the institutional design of ADBs and their financial policies; the risks in agriculture and their effect on income stability and loan repayment, the determinants of the supply of credit, and the effects of credit insurance on the later.

2. AGRICULTURAL DEVELOPMENT BANKING: AN OVERVIEW

2.1. Development Purposes and Political Constraints

Development banks are a peculiar type of institution, created

as part of the system necessary to support economic development. As such they have particular ways of fulfilling their functions and also, they are highly exposed to government intervention.

Development banking emerged in the post-World War II period to meet a need to supply low price capital for economic growth. These banks are intented to provide a complete package of services, including capital and management for development purposes [Basu,1974]. Most development banks were created with the purpose of serving a particular sector (industry or agriculture), and hence specific types of development projects. The later are characterized by high social rates of return but also they need from low cost capital to be financially viable.

Given this characteristic of development projects, banks face a conflict of purposes. Kane [1975] explains that the conflict emerges because, as a development institution, the bank should deal with those projects with the highest ranking on the development impact scale;and as a banking institution, it should finance those projects with the highest ranking in the interest rate scale.

In deciding which development projects to finance, the development banks are influenced by government goals and policies and by financial criteria. Governments exercise pressure on the banks to finance particular projects expected to benefit target groups. Once this is decided the banks must seek funds to implement such projects. However, the lower the expected monetary return of the project,

the more difficult it is to get the funds to finance it. To the extent that the government wishes to reach certain political targets and groups, it will increase the level of subsidy, and/or the pressure to get external-low cost funds. While fulfilling these functions a development bank becomes a mere conduit for funds and less of a financial intermediary.

The above functioning of development banks has been criticized. The criticism is more severe on public development banks than on private or mixed capital development banks.[1] To the extent that the bank leans more towards private ownership, profit,and hence monetary retun on projects,becomes more important criteria in project financing. In this regard Kane [1975] concludes that public development banks therefore, make a more significant contribution to economic development than private banks. This assertion is questionable in the long run, when banks with low earnings have a slower growth as a function of their financial performance, relying almost exclusively on external donors and soft domestic loans.

This brief discussion is indicative that development banks intend to operate as banks within the limits imposed by political constraints and institutional design. Hence, they are concerned about earnings only while fulfilling development goals.

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1 Public (private) banks are those in which all of the capital stock is owned within the public (private) sector and operating policy is under public (private) sector control.

2.2. Institutional Design of Agricultural Development Banks

In a political context ADBs are an instrument of government policy for agriculture. As such they serve particular large groups of producers, usually the small commercial farmers, while excluding the smallest subsistence farmers. They provide credit for crops that have high priority, either as part of food supply programs or for those that provide the basic foreign exchange earnings. They are characterized by very large operating costs, because of the type of clientele they serve. Finally, as a general rule, they have poor loan collection performance, which reduces even further the earnings margin or makes it negative, hence the permanent need for government subsidies.[1]

There has been a strong believe that ADBs as well as other development banks, should be specialized institutions. In fact, it is possible and rational for and ADB to specialize in lending to the agricultural sector. But that is not to say that the bank should specialize in being a lending agency and not playing the role of a financial intermediary. This misconception has led to the design of institutions with a very peculiar structure.

Many Agricultural Development Banks are very specialized institutions. In fact Von Pischke, Hefferman, and Adams [1981] refer to them as "specialized farm credit institutions". The great majority of them are publicly owned banks, limited to offering farmers

1 Poor loan collection is strongly influenced by political decisions when the government wants to benefit particular groups who claim crop disasters.

low interest rate loans, but no other financial services. They do not accept checking and savings deposits, provide money transfer services, store valuables for safe-keeping or serve as fiduciaries. Therefore, their only sources of funds are: a) Loan recovery; b) domestic borrowings from the Central Bank; and c) external borrowings from International Financial Agencies, usually at very low rates and long deferment and repayment periods.

The limited sources of funds for these institutions inhibits them from acting as financial intermediaries. Von Pischke [1981] suggests that the limited capacity to access market funds results in allienation of the institution, because it can not intermediate between rural savers and borrowers, and it limits itself to serve as a link between the government and the rural sector. On the other hand, this institutional design and high operating costs does not allow the bank to compete favorably with rural private lenders [see Ladman, 1981].

A significant portion of the financial resources for agriculture is provided, however, by non-specialized public, private and mixed ownership development banks. Because of the structure of their asset and liability portfolios these institutions have better possibilities for acting as financial intermediaries. Yet, they are subject to the same financial policies towards agriculture, particularly the provision of credit at interest rates below market rates.

The diversification of these institutions exists in terms of the sources and uses of funds. In the liability side they look much like commercial banks since they borrow from internal and external sources, and receive demand and time deposits. On the assets side they serve various sectors (although they may concentrate on agriculture), they invest on securities and issue loans of different maturity and risk, hence allowing for more flexibility in the management of the portfolio.

In a recent analysis of the portfolio composition of 95 development banks in Latin America[1], Pomareda [1982] found that those banks that serve exclusively the agricultural sector, were the smallest of all and the most dependent on public funds. ADBs with 100 percent of their loans in the agricultural sector, had a liability side structured by 57 percent of public funds and 16 percent of S&T deposits; while banks that served various sectors (with an average of 41 percent allocated to agriculture) depended on 17 percent on public funds and 30 percent on deposits. The banks in this later group were on the average (in terms of total assets) almost 10 times larger that the specialized ADBs.

The discussion here presented is indicative that the ADBs have much to gain from acting more as financial intermediaries, by restructuring the composition of their liabilities. This is to say that an ADB can in fact concentrate its assets in agriculture[2],

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1 Members of the Latin American Association of Development Finance Institutions (ALIDE).

2 Loans of different size, maturity, risk and physical resource requirements.

and even charge low rates to agriculture,if it can earn more in its role as financial intermediary i.e. in checking and savings accounts and other liabilities.

2.3. Financial Policies Towards Agriculture

As part of the same philosophy of finance for development, interest rates for agriculture are below market rates. Most developing countries provide subsidized interest rates to agriculture with the main purpose of inducing the adoption of capital intensive technologies that would result in increased productivity. Low interest rates have been visualized as a necessary condition for agricultural development, yet much controversy exists on the subject. Besides the criterion of "low interest rates to induce technolgy adoption", several other arguments are offered to justify this policy. Some of these arguments are discussed below.

Low interest credit is offered as an alternative to high cost capital supplied by informal lenders in the rural markets. These groups are believed to exercise monopoly power, and hence, to receive returns above their costs. Research to date is not exhaustive on these issues, but it has been found that informal lenders usually offer farmers other services like input supply and a guaranty of purchasing the harvest [Barton, 1977, Bouman, 1979],hence justifying a higher cost of capital. On the other hand the high cost of informal credit, usually delivered at the farm, may not be higher than the real cost of official credit which includes the farmer's time until the credit is obtained and during the loan

supervision period [Adams, 1981]. In many cases, however, the "coyotes"or"intermediarios" do exploit the opportunities in the rural sector and exercise monopoly power, particularly among the less fortunate farmers who do not qualify as "sujetos de crédito" according to the ADB criteria.[1]

Perhaps, the strongest argument for low cost credit has its roots in the historical time when development policies were originally designed. The development philosophy gained strength in the 30's when the world recesion implied negative rates of interest. Therefore, it did not seem strange to offer development finance at 2 or 3 percent interest rates. However, if we focus on real rates of interest, the rate on the loan should include at least the cost of inflation, and hence higher rates. Failure to do so will result in decapitalization of the banks and this has been the case for many Latin American countries, which failed to reconcile their financial policies and current inflation rates [Galbis, 1981].

When inflation was not so severe and when international financial agencies had a stronger position, they could lend at very low rates. It was believed therefore, that domestic development banks should provide farm credit at the same rates. That, however, ignores the administrative costs of credit: Because of the rather large

1 Many times the reasons the ADB gives for not providing a loan are the absence of ownership title; a plot that is to small or a technology adoption capacity that is unreliable.

number of small loans, administration costs are very high and ADBs, if they act as banks, may have the right to transfer those costs to the borrowers. Of course, that if they act as instruments of government policiy, then they can expect government subsidies.

The higher the cost of capital, the lower the expected profitability of the financed enterprise, and hence, a smaller profit to the farmer. Since profit is a determinant of loan bearing capacity, it is believed that lower rates increase the later, and hence, loan repayment ability. Low rates, however, induce misuse of credit obtained for agriculture but used in alternative projects. As a result,the farmer is an excellent payer to the bank because of higher returns to the borrowed money put in other uses, but not because of a larger profit margin in agriculture.

If it was agreed upon to increase interest rates, an issue of relevance is the responsiveness of farmers to higher interest rates. It is argued that the elasticity of demand for public credit is rather insensitive to changes of the nominal interest rate, because the later is only a small portion of the total cost of credit the farmer faces [Adams, 1981]. Furthermore, this sensitivity could decrease if better quality loan services are provided and larger volumes of credit made available.

One of the strongest and most debated arguments for low cost credit to agriculture is the income distribution effects, expected to benefit the rural poor. This, however, assumes larger benefits to be distrubuted among a large number of small producers [González-Vega, 1977, 1981]. In practice, however, even though ADBs show a large number of loans, the number of beneficiaries is much smaller. The reason being that loans are provided on a crop-site basis, hence a large commercial farmer, with several properties and growing various crops, may receive 5 or even more of the largest loans; while small farmers receive one or at the most two loans.

Much debate still exists on these issues; yet many governments in Latin America are in the process of revising their interest rate policies for agriculture, to keep lending institutions financially viable, and able to manage in the current inflationary process [ALIDE, 1981]. However, there are other countries willing to continue subsidizing agricultural credit for political reasons. Low interest rates to agriculture may be claimed to compensate farmers for an unfair externally influenced rise in input prices and low domestic product prices, which reduce farmers income.

In the case of other countries were inflation has been low for a long period of time and suddenly becomes a major drawback on the economy, its psychological effects may be more pervasive on interest rates than anticipated. When interest rates rise rapidly

they have a strong effect on decreasing investment,and hence, on the demand for credit. A case in point is the current situation of Costa Rica,where at current interest rates the demand for agricultural credit has declined, at least until farmers expectation adjust and until they learn to live with inflation.

Although from a financial point of view, subsidized rates may not be justified, there are other reasons why at a particular point in time agricultural interest rates may need to be low. If that is the case, the banks should then be prepared to supervise agricultural credit,for farmers to use it in the desired investments and not in alternative uses. This, however, increases the banks operating costs. On the other hand,the ADBs should be prepared to generate financial resources from other activities, in order to allow themselves to fulfill their development goals.

An interesting paradox exists on interest rate policies and agricultural risks. Low interest rates to agriculture have been justified from the farmers' point of view,because of high risk-low profit of agricultural enterprises. Low interest is therefore, expected to compensate for the cost of risk. However, from the bank's point of view, as a financial institution, it would charge a higher interest rate on loans to the riskier enterprises, i.e. a higher rate to agricultural loans. This paradox and the naturally expected high default on development bank agricultural loans, is an important reason for the ADBs limited growth as a function of their own resources. More comments are offered on this issue

in the following sections.

3. RISKS IN AGRICULTURAL PRODUCTION AND LOAN REPAYMENT

3.1. The Nature of Risks in Agriculture

Agriculture is a risky enterprise and risk averse behavior among agricultural producers has been given as an explanation for low investment, limited technique adoption and slower growth of agriculture compared with other sectors, particularly in developing countries.

Risk in agriculure stems from various sources: First, uncertain yields and product prices that imply risk of gross returns. Second, uncertain input supplies and prices which make production costs a random variable. There are also risks because of storage and marketing loses that the farmer often has to sustain. In order to manage risks, farmers recur to different means,including crop and technology diversification,reluctance to use modern inputs and credit, or use of agricultural insurance, when available.

Uncertain input prices are not widely recognized in the literature as a primary source of risk. However, experience shows that to avoid crop damage from unexpected diseases or pests, farmers will rush to purchase insecticides and fungicides; and if there is panic, prices will rise to very high levels because of short term inelasticity of supply. The use of insecticides and pesticides can reduce risks; however, Just and Pope [1979] have demonstrated

that a risk averse farmer will tend to overinvest in such inputs and this can be just as socially inefficient as under-investing in inputs which increase risks (as fertilizers). There is also often the case that in spite of the farmers' willingness to use certain inputs as part of a modern technology, these can not be obtained. In fact the success of some rural credit and development projects has been guaranteed thanks to the provision in kind of those inputs. Such situation was reported for example by Scobie and Franklin [1977] in Colombia and our recent experience of the credit insurance program in Bolivia [IICA, 1981].

Yield variability is a common source of risk and it is as significant in the arid environments as it is in the humid and subhumid tropics. In both cases it is usually associated with drought, fire, dust storms, hurricanes and river floods. Also, diseases and inappropriate use of technologies can result in loss. Yield variability associated with climatic factors is widely documented in the agronomy and agricultural economics literature as shown for example by Anderson, Dillon, and Hardaker [1977]. Yield variability associated with higher levels of input use is also evidenced in the works of de Janvry [1972], Moscardi and de Janvry [1977]; and it has been given as an important reason for low rates of technology adoption as explained by Berry [1977], Green [1978], and Binswanger [1978]. The risks of agricultural production emerging out of yield variability have provided the rationale for crop insurance, a system widely extended in the developed countries and with

potential in developing countries, as it will be discussed in a following section.

Price risk has been given greater attention in the literature, particularly in developed countries. The U.S. agriculture price programs are an indication of the importance of the issue with some disregard of yield risk. The reason may be that under the existence of the Federal Crop Insurance Corporation program for the past 45 years, there was no major public concern about yield variability. Much of the research on price variability has been with regard to its effects on consumers welfare, as reported in the works of Waugh [1944], Subotnik and Houck [1976], Masell[1969], Just et. al [1977], among others. On the producers side, the desirability of price stabilization has been demonstrated by Turnovsky [1974], and Hazell and Scandizzo [1975], among others. Agricultural price stabilization programs in national and international schemes have been widely advocated, yet few are under effective operation, mainly because their large costs and lack of political feasibility [Hazell and Pomareda, 1981]. The income stabilization effect of price support programs in U.S. agriculture was recently examined by Baker and Dunn [1979], and Gardner [1979]; concluding that such programs affect positively the financial viability of farms.

Income stabilization can have important consequences on farmers' debt bearing capacity [Hanson and Thomposon, 1980]; however, the income stabilization effects of debt bearing capacity may be

perceived differently by the bank and by the farmer. In this regard, Hazell [1981] indicates that one can expect that the bank would take a more stringent attitude.

This section suggest that there are several sources of risk in agricultural production and similarly several ad-hoc ways of handling them. Clearly, agricultural insurance is only one way of stabilizing farmers income when yield failure occurs, but on the other hand the relation between yield and price variability would determine the effectiveness of agricultural insurance as an ~~income stabilizing~~ policy.

3.2. Agricultural Risks, Income Stability and Loan Repayment Capacity

The way that income and variance of income affect the farmers' debt repayment capacity can be examined in Figure 1. Following the principle of money fungibility, the different money sources are aggregated into a capital input, which is in turn assigned to different production processes according to the farmer's decision criteria.[1] This rationality of money allocation is a fact in agricultural production, where all money is held in one account

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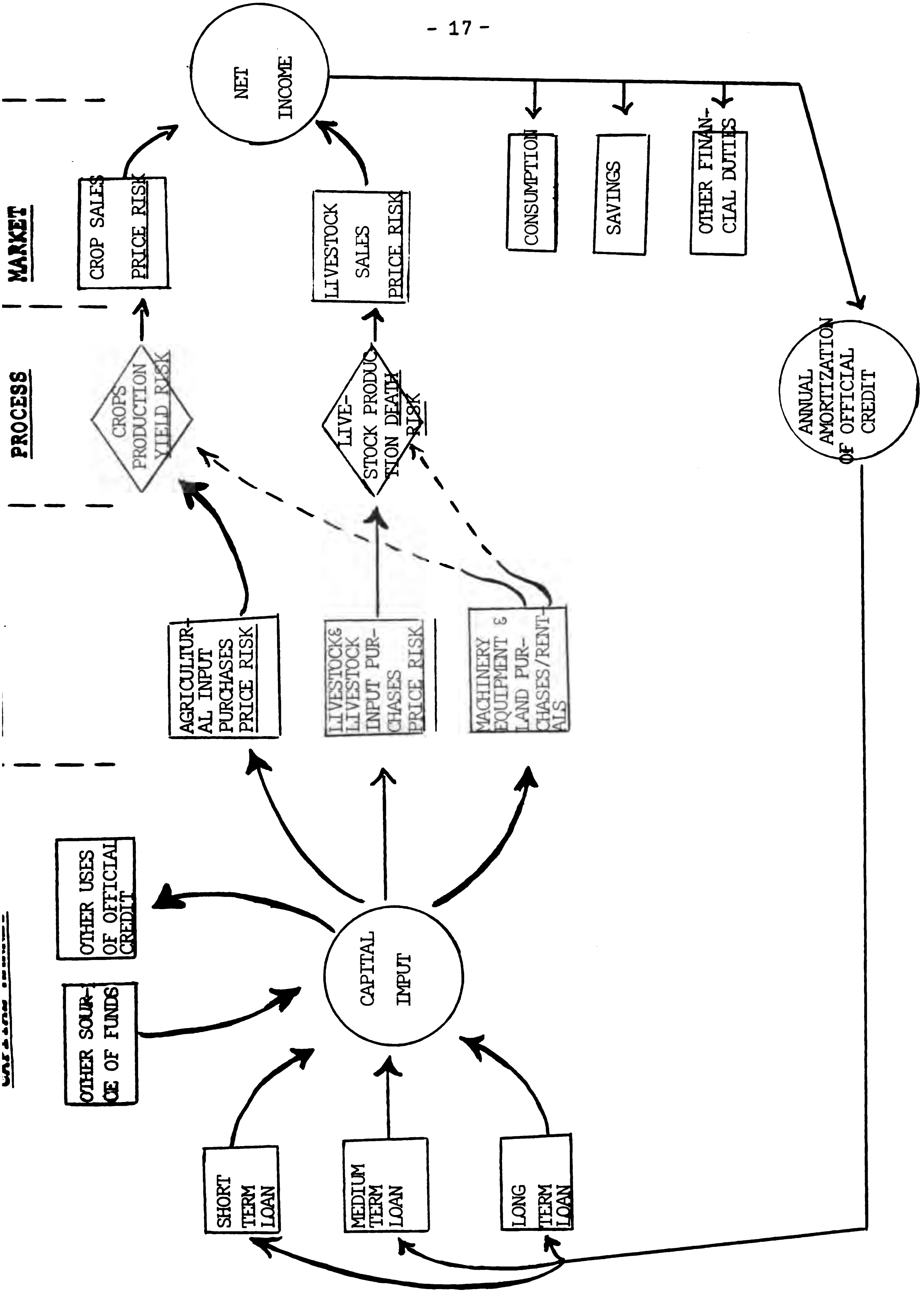
1 Von Pischke and Adams [1980] highlihted the primary implications of money fungibility in agricultural finance; particularly as it makes difficult to evaluate credit programs, where credit is usually treated as another production input.


MARKET
PROCESS
NET INCOME
CROP SALES
PRICE RISK
LIVESTOCK SALES
PRICE RISK
CONSUMPTION
SAVINGS
OTHER FINAN-CIAL DUTIES
CROPS PRODUCTION
YIELD RISK
LIVE-STOCK PRODUC-TION DEATH RISK
ANNUAL AMORTIZATION OF OFFICIAL CREDIT
AGRICULTUR-AL INPUT PURCHASES
PRICE RISK
LIVESTOCK& LIVESTOCK INPUT PUR-CHASES
PRICE RISK
MACHINERY EQUIPMENT & LAND PUR-CHASES/RENT-ALS
OTHER USES OF OFFICIAL CREDIT
OTHER SOUR-CE OF FUNDS
CAPITAL INPUT
SHORT TERM LOAN
MEDIUM TERM LOAN
LONG TERM LOAN

and used for the most pressing needs. The later, of course, include present consumption and uses outside agriculture, both favored by the low interest rates at which official agricultural creit is obtained.[1]

Money is used to purchase agricultural inputs and, as discussed before, here is the first origin of risks. Input market risks exist because of variability of input prices and shortages in input supplies which affect production costs. In addition, whether inputs are or not used at the optimal time, production is exposed to the variabilities of climate which affects yields. Climatic yield variability can produce a total crop loss in all or part of the total area grown, or it can be partial loss in the total area. The last source of risk in the cycle is market risk. Market risk emerges out of the variability of product prices which can not be anticipated with perfect certainty. In many countries price risk is reduced considerably through government price guarantee programs.

With reference to Figure 1, it is clear that net income (at the far right of the diagram) is a random variable. Beyond this point are additional elements that determine the available funds

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1 Ladman and Tinnermeier [1981] present and interesting description of such capital markets in Bolivia, where money borrowed for agricultural purposes is used in the construction and other sectors, where returns are much higher.

to repay the bank loans: Farmers allocate net income into planned consumption, savings and payment of outstanding debts. It is common to find that farmers would engage in luxury consumption even before paying outstanding debts, or else that present consumption is given greater importance than future consumption (savings). In any event, there are only exceptional cases when the banks intervene product sales to guarantee recovery of the loans. This is particularly the case when the products are commercialized through a government owned marketing agency.

This process of the allocation of capital,and the risks faced by the farmer at each stage of the process, explain why farmers may be unable or unwilling to repay their loans. The banks' awareness of this process for each individual borrower would provide the basis for loan provisions. However, besides careful selection of its clientele, there is not much the bank can do to improve the position of those not qualifying for loans. The banks can, however, pinpoint at the problem, and request government intervention in opportune input supplies, support to input and product prices or provision of agricultural insurance schemes, all of which would contribute towards a higher and more stable income.

This simplified analysis of income variability at the farm level provides the rationale for income stabilization policies of different kinds. However, a point is worth emphasizing: Farm income can be stabilized and that should increase the farmers' debt

repayment capacity; yet even if all income variability was removed, that by itself does not guarantee the bank the recovery of the loan, because possible moral risk induced in part by a higher opportunity cost of credit in alternative uses.

3.3. Agricultural Insurance and Credit Insurance

As discussed, farmers confront numerous risks throughout the growing season. Within this array of risks, there are specific measures and policies to deal with each one. Agricultural insurance has been devised with the specific objective of compensating farmers against yield failure. By purchasing an insurance policy the farmer protects the value of his crop harvest against specific disasters that reduce yields. In principle the coverage can be for as much as 100% of the crop harvest. Expected product prices are used to calculate the value of the harvest or the total coverage.

Agricultural insurance schemes are widely difused in the developed countries. The U.S. Federal Crop Insurance Program has more than forty years of experience and covers more than thirty crops against most natural disasters (hail, drought, flood, fire, and others). Long existing programs are also in Canada, Sweden, Israel, Japan,and Australia. In the developing world, agricultural insurance is rather new except for Mexico and Puerto Rico were the programs exist since the 1950's. Of all the programs referred to above, only the case of Mexico is a credit insurance program.

Credit insurance is slightly different than agricultural insurance. It protects only the value of the investment and not the total value of the harvest. By purchasing a credit insurance policy, the farmer protects his loan or a portion thereof. If the harvest (or part of it) is lost,or if the animal dies, the insurance agency pays the bank the amount due by the farmer, thus allowing him to return to production without seriously decapitalizing his resources.

On theoretical grounds, one can discuss the benefits of credit insurance from various points of view. Some of these benefits as well as the costs have only recently began to be tested [Hogan, 1981; Pomareda, 1980]. Credit insurance pays the farmers' debt in the event that yield loses affect his income. By doing so, it stabilizes the farmers' income and increases his debt bearing capacity. By paying his bank debt, it allows the farmer to return to the bank in the following year and request a new loan and continue investing. Within the agricultural system, insurance spreads risks among farmers, regions and crops over time and it precludes the need to expensive ad-hoc disaster efforts as the insurance system itself is able to offset losses from the reserves collected in good years and in unaffected areas.

Although highly favored as part of a rural development strategy in developing countries [Ray, 1974; Tewari and Sharma, 1978; Koropecky, 1980; Gudger and Maurice, 1978], crop insurance, and credit insurance have been questioned on two grounds. First,

its justification is questionable when the variability of yields is small and when traditional methods of risk management prove to be effective. Second, its feasibility is limited by its costs, particularly if premiums may need to be too high for the program to be financially self sufficient or else need to recur to government subsidies [Roumasset, 1979; Crawford, 1979]. The later point has been a major reason for debate with regard to agricultural insurance and agricultural credit insurance. The concern is valid, particularly when cosidering that agricultural development banks (especially those servicing a large number of small farmers) engage in huge administrative expenses. An insurance agency servicing the same clientele will face similarly high costs and therefore require from government subsidies.

A third question, directly relevant for credit insurance, rests on the reasons for loan defaults faced by the banks. Loan default may be due to low incomes because failure of the marketing system which implies low product prices, high input prices or lack of inputs; or due to moral risk. In those cases few arguments can be made for the benefits of credit insurance.

In the analysis of costs of insurance, two distict components of costs are to be examined. First, the administrative costs, which can be decreased by an appropriate composition of the insurance agency portfolio in terms of size of farms and regions.[1] Second, the financial costs,

1 These may include farm loans issued by different banks.

(i.e. premium/indemnities ratio), which can be managed by the optimum composition of the portfolio of the insurance agency in terms of low positive and negative correlations among the insured items.

Given the costs of risk in agricultural production, commercially issued insurance is usually considered too expensive for farmers to purchase. It would in addition be too expensive because premiums are calculated on an actuarial basis without paying particular attention to a portfolio structure. For an insurance program servicing agriculture for development purposes, the objective of the institution is not necessarily the maximization of profits; but rather staying financially viable while serving farmers at the lowest cost. Within such objectives, the protfolio approach to insurance and investment practices, even when considering government subsidies appears to be the most suitable approach [see Pomareda, 1981; Arcia 1981].

To conclude, agricultural risks that make farmers income stochastic, decrease debt bearing capacity and hence, loan repayment. However, stabilizing farmers' income is not a guarantee of loan repayment. If,on the other hand, credit insurance is demanded, it would guarantee loan repayment to the bank only when yield failure is the reason for income variability. The effects of credit insurance on the supply of credit are examined in Section 4.4.

4. DEVELOPMENT BANK MANAGEMENT AND THE SUPPLY OF AGRICULTURAL CREDIT

4.1. Introduction

It is evident that there are conflicts of interest and policy in development banking: These emerge from the philosophy of financing risky agricultural production at the lowest rates of interest. Furthermore, managing an ADB portfolio is highly exposed to political decisions that have important consequences on the bank's growth, and hence, on the supply of credit. Managing the bank portfolio goes beyond balance sheet management, however, this point is taken as a reference to understand the mechanism of the supply of credit over time.

This section conceptualizes the credit supply mechanism for the case of a rather specialized ADB. On the asset side the bank is assumed to issue only loans of different maturity, size, expected return, risk of return, and demand for bank's human and physical resources. On the liability side the bank can engage only in short and long term borrowing from the Central Bank, domestic commercial Banks (with government subsidy),and from International financial agencies. The bank may also receive direct government subsidies.

This rather simple composition of the balance sheet is typical of many specialized ADBs. This, however, takes an extreme position, because most banks have on the asset side some small amounts of cash, investment (bonds), real assets and some fixed

assets. Also on the liability side most ADBs have some pending accounts and net capital. For simplicity those banks that handle checking and savings deposits and other sources of funds are excluded from this analysis.

4.2. The Determinants of Bank Earnings

Profit may not be a motive in development banking, yet annual net earnings are an important indicator of the bank's performance and ability to supply credit. Furthermore, expected net earnings can be modified by internal bank policy and by external factors. A basic net return function can be expressed as:

$$E(NR)_t = E(GR)_t - (FC)_t - (OC)_t \qquad (1)$$

where:

$E(NR)_t$, expected net return

$E(GR)_t$, expected gross return

$(FC)_t$, financial costs

$(OC)_t$, operating costs

Expected gross returns are derived from the loans maturing in period t; and they can be modified in several ways. The expected interest earnings on a loan i maturing in period t is the risk adjusted interest rate $r_{i,t-j}$ charged for that loan when issued, any time before period t. The principal of a loan

of type i maturing on period t can be defined as $L_{i,t-j}$ therefore:

$$\pi_{it} = (r_{i,t-j} \cdot L_{i,t-j}) + (L_{i,t-j}) \qquad (2)$$

where:

π_{it} is gross return on loan of type i paid back on period t and issued in period t-j, where j is the maturity.

If the recovery rate is γ_i, and the nominal rate charged on the loan is R_i, then the expected interest rate is:

$$r_i = R_i \cdot \gamma_i \qquad (3)$$

Expected gross returns in period t can therefore, be modified by increasing the nominal rate and/or the recovery rate. Increasing the nominal rate is fundamentally a political decision with important implications already discussed, yet operationally "easy to do" by legislation. Improving the recovery rate, however, is more a managerial problem for which the alternatives are: Stronger loan selection criteria, more loan supervision, other government policies oriented to stabilize farm income and ultimately, credit insurance. As it will be discussed later, there is a close relation between the recovery rate and the availability of resources at the bank.

Financial costs have not been a major concern for agricultural development banks. Funds have been obtained at very low rates (many times equivalent to negative real rates) and long deferment periods. Also ADBs have enjoyed a significat amount of government subsidies to allow for their existence. Nowadays, however, domestic

government funds are more scarce and international financial policies are tighter; hence financial costs are expected to rise.

Financial costs in period t are defined by the interest and principal payments on the banks contractual debts:

$$(FC)_t = (\bar{R}_k B_k) + (P_k)_t \tag{4}$$

where:

$\bar{R}_k$, is the nominal rate on borrowed funds from source k

B_k , is the volume of borrowed funds from source k, hence

$(\bar{R}_k B_k)_t$, is interest expenses due in period t

$(P_k)_t$, is principal from source k due in period t.

These costs have no element of uncertainty as the bank arranges for repayment conditions in advance. There is the possibility, however, that the bank may refinance its debt.

Operating costs are a major determinant of bank net earnings. Furthermore, there are important trade offs between the availability and use of operating capital and resources and bank performance. Operating costs can be considered to include costs of personnel for loan appraisal and supervision, vehicles for field work, maintenance of office facilities, computer services, etc. Operating costs can be expressed as:

$$(OC)_t = H_t + V_t + R_t \tag{5}$$

where:

H_t = personnel costs

V_t = vehicles maintenance and repair

R_t = other expenses including office facilities equipment and other.

The bank can increase the loan recovery rates through stronger loan selection procedures, hence rejecting those loans that do not qualify;or else rationing credit according to debt bearing capacity criteria. Doing this, however, implies a larger amount of time spent on each loan appraisal, and hence, a larger demand for bank staff. Similarly, loan recovery rates can be increased through more intensive loan supervision, which implies more contin-uos contact between the loan officer and the farmer, therefore, larger requirements of staff, more vehicles and more operating capital for vehicle fuel, maintenance and repairs.

In trying to save operating costs, the banks contribute to increase loan defaults. Also, because of the rather large number of loans administered, the bank has no choice but to accept the operating conditions, and hence the resulting performance. For optimal operating conditions most agricultural development banks in Latin America would have to enlarge and upgrade their staff, and increase considerably their operating budget, in order to service the same number of loans and minimize default rates.

The conflict of purposes in the management of agricultural development banks can now be more fully understood. On one hand, for development purposes, within currently conceived philosophies, ADBs want to reach the largest number of farmers and provide them with the least cost credit. On the other hand,the banks face high operating costs, low earnigns, and very slim operating budgets. The result can not be other than a poorly performing institution characterized by high loan default and low quality credit supplied at low interest rate, but at a high cost to the farmer.

4.3. Dynamic Balance Sheet and Credit Supply

Bank portfolio management relies fundamentally on dynamic management of the balance sheet, i.e. decisions regarding the sources and uses of funds over time. This section develops the principles for the determination of the supply of loanable funds for the case of a specialized ADB.

The amount of funds that the bank can allocate in period t to loans of different characteristics, ($\bar{L}_{i,t,}$) is limited by the availability of loanable funds:

$$\begin{bmatrix}\text{loanable}\\ \text{funds}\end{bmatrix} \leq \begin{bmatrix}\text{loan}\\ \text{recovery}\end{bmatrix} + [\text{borrowings}] - \begin{bmatrix}\text{financial}\\ \text{costs}\end{bmatrix} - \begin{bmatrix}\text{operating}\\ \text{costs}\end{bmatrix}$$

$$\Sigma\, \bar{L}_{i.t} \leq [\Sigma L_{i,t-j} + \Sigma\, r_i L_{i,t-j}] + (B_k)_t - (FC)_t - (OC)_t \quad (6)$$

where:

$\Sigma\, \bar{L}_{i,t}$, funds allocated in period t

$\Sigma L_{i,t-j}$, principal of loans maturing in period t and issued in period t-j

$\Sigma r_i . L_{it}$, interest earnings on outstanding loans maturing in period t or afterwards. A loan maturing in period t+j, pays in period t only the interest rate.

All other terms are already defined.

Loan recovery in period t is a function of management and financial policies in previous periods, which directly or indirectly affect expected returns through the nominal rate of interest or through the loan recovery rate. Furthermore, time preference will affect the issuance of loan maturing in period t, t+1, t+2.. t+j. The higher the rate of inflation, the shorter the maturity preferences. However, longer maturity loans demand less bank services because money is turned over less frequently, and hence, less paper work is needed. Therefore,when trying to optimize its resources the bank faces a trade off between the value of money and the available physical resources.

Borrowings in period t could be considered an exogenous decision with an unlimited supply. In practice, however, the bank is not likely to be able to borrow beyond its financial and administrative capacity, as appraised by the lending agencies, either domestic or foreign. These criteria, however, are deleted for the moment, and we can assume that annual borrowings can not exceed a certain limit:

$$\Sigma B_{kt} \leq B_t^* \tag{7}$$

The selection from among alternative sources of borrowed funds is a function of interest rates and repayment conditions. The bank would therefore, select its sources of funds simultaneously with the decision on uses of funds, searching for the largest earnings margin, while fulfilling its development goals and servicing a particular clientele. In many cases, however, the bank negotiates the repayment conditions on borrowed funds depending upon the use to which the funds are to be put on.

Financial costs in period t are determined by contractual arrangements in previous periods. Operating costs are defined in the previous section and they are not to exceed the institution's budget.

This brief analysis provides the rationale for bank growth and the supply of credit in each time period. It is evident that interest rate policies, borrowing strategies, management of inflation;and allocation of physical and human resources are important determinants of bank growth. Simultaneous decisions on these issues will determine the bank's capacity to supply larger amounts of credit.

Differences in profitability, risk, maturity and resource requirements,will determine the allocation of funds to particular loans. These include various annual crops, perennial crops, livestock and farm improvements. However, the bank may be limited in its decisions by government legislation, institutional agreements and/or political pressure to guarantee the supply of credit for

particular purposes. These restrictions would affect the bank's optimal resource use and aggregate credit supply but they would, on the other hand, guarantee short term fulfillment of development goals. One could,with certainty,indicate that the nature of these restrictions provides the fundamental difference between the operating practices among commercial and development banks.

4.4. Credit Insurance and the Supply of Credit

Although much has been mentioned about goals in development banking, no specific criteria has been given yet for the institution's objective(s). On this regard the author believes that there is no such a thing as a single objective in development bank management. However, banks in general, and ADBs are no exception, can be considered as utility maximizers in the sense that they trade risk by return. As such the institution's board of directors would act as risk averse a la Baumol, i.e. the risk of return is given a certain weight in the decision-making. This would depend on forecasted situations and the current financial position of the institution. In other words if a utility function could be conceived, it would be:

$$U = E(R) - \phi \sigma \qquad (8)$$

where:

U , is utility,

$E(R)$, are expected discounted returns over a multiperiod horizon,

ϕ , is a risk aversion parameter; and

σ , is the standard deviation of dicounted returns over a

multiperiod planning horizon.

In the extreme cases of a fully supported-government guaranteed institution, ϕ would be zero, yet that may exist only in a very hypothetical situation. As risk aversion increases the bank would prefer to invest on the most secure loans, i.e. those with the highest recovery rate. Hence, the opportunity cost of credit insurance is expected to rise as the banks become more concerned with risk management. In other words,credit insurance becomes more desirable when the ADBs depend more on their banking capacity, than on their bargaining ability to obtain government subsidies to cover up for loses. As the availability of government funds becomes more limited,ADBs will benefit from requesting credit insurance if they want to fulfill development goals,even without changing their internal management and financial policies.

This is not to say, however, that credit insurance is justifiable on all grounds; but it should be considered as an alternative if credit supply is to reach potential viable farmers exposed to risks in production. Such farmers are viable in terms of their average productivity,and hence, credit insurance provides them with a guarantee of loan repayment when, for reasons beyond their control,they could not pay back their loans.

There is evidence that agricultural credit insurance provides direct benefits for the lending institution. The insurance agency

pays the bank the farmers' debt when farmers income is reduced because of crop yield failure, animal death or loss of function. In Panama in 1979 and 1980 the ISA payed the BDA indemnities for US$194 642 and US$402 143 respectively, which allowed for a significant improvement on loan recovery (ISA/IICA), 1982). The loan recovery rate for industrial tomatoes was improved from an average of 82 percent between 1976 and 1978 to 95 percent in 1979 and 99 percent in 1980. [Pomareda y Fuentes, 1981].

Other advantages of credit insurance to the lending institution are that it reduces its costs of "farmers hunting" to collect the deliquent loans, and it provides additional control for the most optimal use of credit. The insurance supervision program helps the bank to set aside those farmers that do not want to pay versus those that can not pay. For the later group the insurance agency will pay the bank the amount due by the farmer. However, since credit insurance provides coverage only for yield losses, its protection is only partial, because farmers can still have reduced incomes because of excesive costs of production or low product prices. Credit insurance would therefore, provide the largest benefits for the bank when lack of loan repayment is due mostly to yield failure.

It should be pointed out that although credit insurance allows the bank to show a healthier portfolio, it is a cover up for the bank's low capacity to recover its loaned funds. In this sense

credit insurance does not offer an incentive for the bank to improve its loan selection procedures and inspection practices to increase loan recovery. However, it is a way a guarantying loan recovery and it should allow the bank to grow at a faster rate. Its desirability is clearly high for the bank, yet its justification is to be based on cost effectiveness.

An issue for debate still remains. If credit insurance compensates for losses in agricultural production and therefore stabilizes farm incomes, then there should be no reason anymore for such highly subsidized interest rates. With credit insurance therefore, agricultural development banks could charge higher interest rates to farmers. The net effect on the bank would therefore be a higher recovery of loans and higher interest earnings. Under such scenario, should be the farmers who pay the cost of insurance or should it be the bank who pays for it?

From the farmer's point of view, used to pay a low cost of credit, it is unlikely that he would be very willing to pay the cost of insurance and a higher interest rate. One would therefore expect a decreased demand for credit. The above will be particularly the case when there are no policies or programs addressed to increase the average expected returns of farmers i.e. higher support prices, lower input costs or higher yield technologies.

5. CONCLUDING COMMENTS

More financial resources are needed to allow for a more rapid and equitable agricultural growth. To achieve such objectives, agricultural development banks are expected to play a more meaningful role by increasing the supply of credit. In achieving their targets, however, ADBs face problems of institutional design and policies that limit their performing ability. On the other hand, lending to agriculture continues being a risky enterprise which exposes the banks to low loan recovery rates.

ADB could improve their long term capacity to supply credit for agriculture by acting more as true financial intermediaries; which implies restructuring their balance sheet and offering more financial services to farmers. This would increase their earnings. The later could also be improved by revising interest rate policies, and the banks internal organization, management, and resource availability to increase expected returns and loan recovery rates.

However, given that agriculture is risky and hence, farmers' income instability is many times a reason for low loan repayment, credit insurance should be enforced. It should be pointed out, however, that credit insurance is not a substitute for improved bank management.

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PORTFOLIO MANAGEMENT AND THE DESIGN OF INSURANCE: THE CASE OF PANAMA

Gustavo Arcia

San José, Costa Rica

PORTFOLIO MANAGEMENT AND THE DESIGN OF INSURANCE: THE CASE OF PANAMA

Gustavo Arcia*

San José, Costa Rica
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* Research Economist, Interamerican Institute for Cooperation on Agriculture, Panama, Republic of Panama

PORTFOLIO MANAGEMENT AND THE DESIGN OF INSURANCE: THE CASE OF PANAMA

Gustavo Arcia*

I. Introduction

The objective of this study is to provide the Instituto de Seguro Agropecuario de Panamá (ISA) with a strategy for the technical and political optimization of its portfolio a necessary step for the evaluation of the impact of crop credit insurance on the financial component of the farm sector. By comparing the actual and normative performances of the agency's portfolio it is expected that some insight will be gained with respect to the problems affecting agricultural insurance. As an added benefit, such insight will yield information of value to the other insurance programs now in the process of implementation.

The problems facing the rural credit delivery system in Latin America are fairly obvious. [Von Pischke, Adams, and Donald]. Faced with low interest rates and obligatory lending

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* Research Economist, Interamerican Institute for Cooperation on Agriculture, Panamá, Rep. de Panamá.

laws for farmers, private bankers are continually attempting to minimize the losses implied. As a rule, farm credit is allocated in terms of a few large, low-risk loans to a small number of farmers, with a consequent reduction in the cost of administering the bank's portfolio. Farm development banks, on the other hand, face a different problem. By having most of their portfolio in the agricultural sector, these banks have a large share of their funds allocated among many small producers with highly fluctuating farm incomes. As a consequence, the rural credit system in many Latin American countries is in a state of disarray. Private lenders are reluctant to expand their activities in the farm sector, and development banks - plagued by high default rates and negative returns to capital- are being decapitalized.

Concomitant with the imperfections in the rural capital markets, risk and uncertainty in agriculture is being increasingly recognized as a deterrent to farm growth. The fluctuations in farm income brought about by unforeseen variations in prices and yields have produced a highly cautious farmer whose collective behavior may not be socially optimal [Hazell,1980; Just and Pope].

Crop credit insurance, a variant of crop insurance, is a risk management tool long advocated as a solution to farm risk. It enables the farmer to repay his loan in case of a

crop failure covered by a policy purchased at a relatively low cost. The implementation of an insurance scheme in the developing countries, however, has had little support. Questions abound about the adequacy of the administrative mechanisms, the lack of actuarial information, the poor institutional infrastructure, and the moral hazard. This latter aspect has consistently been the most worrisome [Halcrow; Roumasset]. Crop insurance agencies, it is argued, are prone to political manipulation. By declaring an artificial disaster in order to gain support, a government may easily destroy the agency. The other constraints are not as limiting.

In 1975 the government of Panamá created the Instituto de Seguro Agropecuario (ISA), an insurance agency aimed to protect farmers against loan default.' With no technical base or actuarial information the program insured loans given to maize, sorghum and rice growers on an *ad-hoc* actuarial basis. In 1979, ISA signed and agreement with the Interamerican Institute for Cooperation on Agriculture (IICA) to undertake a more ambitious project. The four-year agreement gives ISA technical and financial assistance as well as administrative support. Furthermore, the agreement provides IICA with the opportunity to evaluate the impact of crop credit insurance on the development of the farm system.

This study is part of the evaluation process. Its main objective is to analyze ISA's current portfolio and to provide

guidelines for its improvement. In addition, the study deals with the trade-offs involved in the optimization of the portfolio; that is, the shadow prices of the technical and political alternatives. Finally, the study discusses the necessary conditions for future growth, as well as its implications for planning.

II. Crop Credit Insurance in a Development Context

The constraints facing crop insurance agency in a developing country are both technical and institutional. Both inhibit the agency's diversification strategy. On the institutional side, the agency competes with other government agencies for funds and qualified personnel. On the technical side there are limits to insurance experience, low initial acceptance from farmers, and lack of actuarial information. Both types of constraints preclude a rapid diversification strategy. Moreover, the presence of private insurers in the urban and industrial sector further restrict a more diversified portfolio. As a consequence, crop insurance agencies must take full advantage of short-cycle agriculture and base their diversification strategy on spatial and intertemporal options.

The Experience in Panamá

The crop credit insurance program in Panamá was initiated

with a social role in mind. ISA was created in response to petitions from a few medium-sized farmers who wanted protection against climatic risk. The benefits to the development bank and to technical assistance were not foreseen at the time.

Participation is now compulsory for farmers borrowing funds from the Banco de Desarrollo Agropecuario (BDA) for activities covered by the insurance program. At present, five crops and three livestock activities are covered; independent farmers and farmers with private loans participate on a voluntary basis. A five percent average premium for crops and a three percent average premium for livestock enable farmers to recover at least seventy percent of their cost of production in the case of disaster. Each farmer gets his crop or animal inspected at the initiation of the policy. A policy may, at that point, be cancelled on technical grounds. Inspections occur at the initial period, at the request of farmers for technical advice, and at harvest time if a claim is filed [Pomareda; Velásquez]. Technical assistance is automatic in the case of livestock since the animals are vaccinated at the time of the first inspection.

Unlike other crop insurance programs, the ISA program does not guarantee price; it only guarantees repayment of the loan. If a claim occurs at harvest time, the salvage value of

the crop is assessed at the floor price specified by government programs. Adverse selection is avoided by the compulsory nature of the program and effective inspections.

ISA is currently operating at a net loss due to its high operating costs relative to its total coverage. The net deficit is compensated by a government budget subsidy and by a grant from IICA. The insurance portfolio, however, is actuarially sound, leaving a positive balance between premiums and indemnities.

Although it is clear, from the above description, that ISA has little room for diversification, program performance may be improved by modifying premium rates and the spatial allocation of insurance.

III. The Portfolio Model

The present model is based on a portfolio selection model developed by Hogan at the request of IICA. In its most simple form it assumes that a set N of insurance policies with mean returns E and variance V is preferred to a set with mean E and variance $V^{*}>V$. Realistically, however, ISA's portfolio must consider the inclusion of a riskless asset such as cash reserves, as well as the probability of large stochastic cash demands [Cummins and Nye; Chen, Jen, and Zionts]. The inclusion of a riskless asset implies borrowing costs, while large stochastic cash demands imply emergency loans and

reinsurance. Both are considered important for ISA's purpose.

It is assumed that the number and total amount of claims is stochastic with a probability distribution whose variance is finite. In addition, the cost of income variance is represented by the interest rate on borrowing, and by the premium rate for reinsurance.

The objective of the insurance agency is a mixture of profit maximization and social efectiveness. ISA needs to build up its cash reserves and extend its coverage, while keeping in mind the objective for which it was created, that of protecting farmers at a minimum social cost. Hence, the objective function of the agency is to select an insurance portfolio that maximizes profits while guaranteeing insurance coverage to a basic combination of crop and provinces, as mandated by farm policy.

Finding the optimum portfolio is a quadratic programming problem of selecting a vector of insurance options $\underline{X}$ which maximizes

$$F(\underline{X}) = \underline{E}\underline{X} - \phi(\underline{X}'Q\underline{X})^{1/2} \qquad (1a)$$

, the model's objective function, subject to

$$\underline{A}\underline{X} \leq b \qquad (1b)$$

$$\underline{X} \geq 0 \qquad (1c)$$

, where $\underline{E}$ is a (1xn) vector of net earnings per option ,$\underline{X}$ is and (nx1) vector of insurance options, Q is a symmetric positive semidefinite covariance matrix, ϕ is a risk aversion parameter, A is an (mxn) technical coefficients matrix, and $\underline{b}$ an (mx1) vector of resource constraints [Baumol]. This nonlinear model can be solved linearly by using the mean of the absolute deviations (MOTAD) method, [Hazell, 1971], which states that the effect of the quadratic portion $(\underline{X}'Q\underline{X})^{1/2}$ of the objective function (1) can be approximated by the objective function $f(\underline{X})=\underline{EX}-\phi\sigma_x$, where $\sigma_x=(\underline{X}'Q\underline{X})^{1/2}$ is the standard deviation of earnings. This standard deviation can, in turn, be approximated by

$$\hat{\sigma}_x=H\{\frac{1}{T}\sum_t|\sum_j(E_{jt}-\bar{E}_j)X_j|\} \qquad (2)$$

, where $\bar{E}$ is the expected value of earnings for option j, j=1,...n;E_{jt} represent the earnings for option j in the year t, t=1,...,T; and $H=[T\pi/2(T-1)]^{1/2}$. It can be shown that $\hat{\sigma}_x$ is a less efficient but unbiased estimator of σ_x [Herrey].

Without loss of generality, let the objective function be expressed as

$$\max_C \quad U=R\sum_i\sum_j r_{ij}C_{ij}-RI-G-\phi S+dF \qquad (3)$$

where

R is the quota share for reinsurance coverage.

r_{ij} is the premium rate charged to crop i in province j;

C_{ij} is the coverage, or amount covered by insurance, for crop i in province j;

I is the sum total of indemnities paid;

G is the sum total of administrative costs;

ϕ is the risk aversion parameter.

S is the estimated mean absolute deviation of earnings from the portfolio.

d is the interest rate paid on cash reserves.

F is the share of net earnings set aside for reserves.

The R scalar attached to both net premiums and total indemnities reflects the quota share ruling established by the reinsurance company. The quota share means ISA yields a fixed percent of its portfolio to a reinsurance agency in exchange for limited protection against catastrophic risk, thus allowing for a significant reduction in the cash reserve allotment F. The administrative cost G, however, is entirely borne by ISA. The objective function (3) is subject to the following constraints:

$$\sum_i \sum_j C_{ij} \leq 1 \qquad (4)$$

This constraint indicates that options in the optimal portfolio are expressed as fractions or percentages of the total portfolio, thus allowing for changes in ISA's total coverage without having to update the model's coefficients. Also,

$$\sum_i \sum_j b_{ij} C_{ij} - G \leq 0 \qquad (5)$$

$$\sum_i \sum_j P_{ij} C_{ij} - I \leq 0 \qquad (6)$$

, where

b_{ij} is the administrative cost for crop i in province j:

P_{ij} is the fair premium rate, or indemnities to coverage ratio, also called the loss cost.

Equations (5) and (6) generate the sum totals for administrative costs and indemnities included in the objective function. Similarly, the sum total for the minimum loss ratio imposed on the portfolio may be written as

$$\sum_i \sum_j L_{ij} C_{ij} \geq \overline{L} \qquad (7)$$

, where $\overline{L}$ is the average loss rate, or indemnities to net premiums ratio, for the entire portfolio during the five years of operation. This restrictions forces ISA to return as indem-

nities at least a proportion $\bar{L}$ of the net premiums. $\bar{L}$ is therefore defined as the ratio of total indemnities over total net premiums for all the years of operation:

$$\bar{L} = \left[\sum_{i}\sum_{j}\sum_{t} L_{ijt} r_{ijt} C_{ijt}\right] / \left[\sum_{i}\sum_{j}\sum_{t} r_{ijt} C_{ijt}\right] \qquad (8)$$

Previous to the adquisition of reinsurance ISA set aside 20 percent of their actuarial earnings to a cash reserve, in spite of operating at a net budgetary loss. With reinsurance coverage now available, this share is assumed to decrease to 10 percent of net premiums.

This cash reserve restriction may be written as:

$$0.10\left[R\sum_{i}\sum_{j} r_{ij} C_{ij}\right] - F \leq 0 \qquad (9)$$

The MOTAD estimator of the standard deviation of the portfolio may be derived from equation (2). Following Hazell [1971], the net revenue deviation equations may be written as:

$$\sum_{i}\sum_{j} (P_{ijt} - \bar{P}_{ij}) C_{ij} - Z_t \leq 0 \qquad (10)$$

$$2\sum_{t} Z_t - (T/H)(-\phi) = 0 \qquad (11)$$

$$t = 1, \ldots, T$$

Where $\overline{P}_{ij}$ is the historical average loss cost for option i in the j province and $Z_t \leq 0$ is a deviation counter measuring positive deviations around the mean for the t$\underline{th}$ set of revenue outcomes.

The social goals and logistical limitations of the agency may be expressed as:

$$\sum_i\sum_j g_{ijk} C_{ij} \gtrless D_k \tag{12}$$

, where g_{ijk} is the share of option i in province j on the social or logistical restrictions D_k, k=1,...,K. The logistical restrictions include limitation on the agency's personnel for covering the farming area, accesibility to all areas, the crop types and technologies in the areas, and the total coverage implied by the total amount of funds lent to farmers.

Finally, to guarantee the solidity of the portfolio, a chance constraint is incorporated into the model. ISA will select items in the portfolio until the probability of catastrophic losses -and therefore the use of reinsurance- is at most α. This constraint may be expressed in probabilistic terms as:

$$Pr\{\sum_i\sum_j \overline{P}_{ij} C_{ij} \leq \Psi \sum_i\sum_j r_{ij} C_{ij}\} \geq (1-\alpha) \tag{13}$$

$$, \quad 0 \leq \alpha \leq 1 \; ; \; 0 \leq \Psi \leq 1$$

As show by Hazell [1980], such a constraint may be expressed in terms of a standard normal distribution as:

$$\sum_i\sum_j \bar{P}_{ij}C_{ij} - \Psi \sum_i\sum_j r_{ij}C_{ij} - 1.65\hat{\sigma}_{\chi} \leq 0 \qquad (14)$$

Equation (14) indicates that net premiums will exceed indemnities by a certain amount 95 percent of the time. The schematic representation of the linear programming tableau is shown in table 1.

IV. Data

Data for the analysis come from ISA's insurance operations. Although scant, the figures still present some patterns which are of help in the design of premium rates by crop and zone. Table 2 shows the compositions of ISA's portfolio for 1980-81, the last available data set. During that year ISA insured crops and animals for a total of 13 million dollars. Aproximately 6.5 million dollars corresponded to crop insurance and similar figure to livestock insurance. Breeding cows had the biggest share of the portfolio with more than 26 percent of total coverage, followed by upland rice with approximately 25 percent.

The value of crop and animal losses, in proportion to their coverage, is shown on Table 3. The maximum number of years available for any one activity is five, with some new

activities having only two years of data. In term of actuarial history such lengths of time are practically meaningless but, in a normal year, they should yield a rough approximation to long term loss costs. As the table shows, the loss cost figures for some crops in some provinces are extremely high. They obviously indicate a bad year for that item and, therefore, should be viewed with caution.

In similar fashion, the administrative costs are shown in table 4. It can be seen that there is a close correlation between the loss and administrative cost figures. Items which had high losses also present high administrative costs, thus reflecting the additional time spent in claims assesment. It is then obvious that several of the items are being run at a loss, requiring a readjustment in their premium rates. For some cases, such as corn in the provinces of Panamá and Colón, and sorghum in Coclé and Veraguas, the premium rate adjustment cannot be as high as the loss cost due to their short actuarial history.

V. Model Results

Model results are based on several logistical premises. It is assumed that allocations to cropping and livestock activities are divided equally. At present, the proportion of the portfolio asigned to crops is 51.9% and the proportion asigned to livestock is 48.9%. In addition, a minimum loss

rate of 70% is assumed for the entire portfolio. That is, for every dollar received in terms of net premiums ISA must return at least 70 cents as indemnities. Finally, the proportions of the portfolio currently held by each province have been roughly kept equal to reflect the working capacity of each regional office.

The optimal model solution is shown in table 5. Comparing it with the composition of the 1980-81 portfolio it is evident that many of the current items have been left out. Such items are the ones contributing the most to ISA's actuarial losses. Furthermore, such activities also account for high administrative costs brought about by the cost of assesing the insurance claims. Thus, the portfolio is reduced from 39 to 17 items, or by roughly one half. It should be noted, however, that some of the activities in the optimal port folio, i.e. beans, have a relatively high loss cost and high administrative costs. Their presence in the optimal solution obviously obey model restrictions. Rice and breeding cows are the main activities in the solution, followed by the coverage of bulls and feeder cattle.

Net income is still negative. Due to the logistical restriction imposed by the model the net balance between net premiums and indemnities is not enough to offset the administration and inspections costs (table 6). As indicated in the second column of the table, optimization under current condi-

tions leads to a reduction of 43% in ISA's net deficit. Such savings are mainly due to the significantly lower losses and administrative expenditures brought about by the elimination of most of the losing activities. By trimming the portfolio the cost of actuarial losses diminish by 24% and the administrative expenses are reduced by 26 percent. The earnings on accumulated reserves remain constant since they are independent of the model solutions. Reserve allocations, however, have decreased due to the presence of reinsurance.

Since actual premium rates are actuarially unfair for some items in the portfolio a new premium rate structure was simulated. However, for lack of a better alternative, the costs of administration and the net deviations were kept at the previous levels. Rice premiums, which are now too high, were lowered substantially, while other items such as sorghum and maize were generally assessed a higher premium. The new premium rates are assumed to be only actuarially fair and do not account for some of the cases where administrative costs are overly high. Hence, the new rate structure attempts to reflect what would happen to the portfolio under present logistical conditions.

The results for the case of higher net premiums are similar to the original model solution, except for the fact that livestock activities have become more diversified than the cropping activities. (Table 7). Portfolio performance, as

previously shown in table 6, is slightly improved under the new rates. The net deficit is now 56% lower than the deficit for 1981. The significant increase in premium income is offset by the model restrictions. As a consequence, administrative costs are even higher than in the original solution and the loss rate increases to 83% of net premiums.

The standard deviation of income was so small in the cases described above, that it was considered non-significant . The chance constraint, however, was binding at a level close to one percent and, therefore, not considered a problem for portfolio strategy.

Given that the optimal portfolio also yields a loss, it is obvious that the conditions for a positive net benefit must be examined. From the previous results it can be ascertained that a positive income will not be obtained from premium rate manipulation alone. It is clear that lowering the administrative costs is also necessary. In order to break even, the administrative costs should decrease to 1.41 percent of coverage if current premium rates are maintained. If a new premium rate structure is implemented the cost of administration and inspection needs to be 1.62 percent of coverage in order to reach the break even point.

Achieving low administrative costs is feasible only when a certain degree of automation and a long agency-client rela-

tionship is established. The administrative cost per dollar of coverage has been steadily declining since ISA started its operations, from an initial 16.9 percent of coverage in 1977 to an average of 3.5 percent in 1981. Hence, the possibility of ISA lowering its operational costs and reaching some economies of scales is fairly certain.

Premium rate manipulation is an entirely different matter. Although the historical loss cost for certain crops in certain areas may indicate a rate of 10 to 20 percent of coverage, it is difficult to recommend that a similar premium rate be implemented. The low returns to agriculture among ISA's clients and the politically sensitive nature of a compulsory program make a farmer-supported insurance scheme unfeasible. Hence, the evidence from the model suggests that a net compensation to farmers, from the non-farm sector of the economy, must be sought.

The need for a subsidized premium may be argued on equity grounds. Consumers, as beneficiaries of farm production, should also help spread the risk now faced entirely by farmers. If, in addition, retail food prices are regulated as in the case of Panamá, the need for a subsidy becomes clearer. The above argument may be better understood in the case of a bad year. Model results indicate that when the value of losses relative to premiums received is high, the actuarial component of the insu-

rance program bears most of the burden. As shown in Table 8, the increment in loss rates (the ratio of indemnities to net premiums) affects the loss cost more than the value of the claims. If the insurance scheme is borne entirely by the farmers then the premium rates would have to increase substantially.

VI. Conclusions

For a compulsory scheme, such as the agricultural credit insurance program in Panamá, the results are useful for overall strategies and should not be interpreted as recipes for portfolio selection. In turn, such solutions are only appropriate in the context of a voluntary insurance program. Nevertheless, several conclusions regarding program structure may be drawn.

The combined actuarial and administrative cost of the program seems to be high relative to other productions factors such as the price of credit. Moreover, unless future actuarial performance indicates otherwise, the value of total losses and the cost of administrating the program have to decrease substantially just to reach a break even point. This suggest several strategies which may be pursued in the future. First, it is necessary to incorporate into ISA's portfolio a set of insurance activities which would yield a lower loss rate. The incorporation of life and farm machinery insurance is a good example.

Second, if a non-profit policy is to be maintained, then it is necessary to endow ISA with sufficient reserves in order to obtain more earnings with which to balance the portfolio. A deficitary program, maintained with grants and governmental budgetary allocations, will need a long time for reserve build up and will have little room for short run manouvering. Third, given that food prices are regulated downward (as in most Latin American countries), the cost of insurance may yield a net disincentive to farmers. This in turn suggests that consumers should also share farm risk. The consumer's share may be in the form of subsidized premium rates, as in the case of Mexico, with the subsidy being drawn from non-farm sources such as non-farm insurance or income taxes. The present budgetary subsidy received by ISA is drawn from agricultural sector budgets and it is only for ISA's take-off stage.

Finally, the optimization of the model seems to indicate that minimizing the costs of credit insurance in Panamá may yield little gain in terms of political impact. By insuring 17 of the 39 options now available ISA would save a maximum of 170,400 dollars but reduce geographic coverage a great deal. Such reduction may be damaging in terms of institutional image, albeit only in those cases where insurance is considered a positive assett by its clients.

In terms of program structure the model is very useful

for simulation. As shown in the previous section, new premium rates, cost subsidies, returns on reserve allotments, loss rates, reinsurance rates, and loss costs may be simulated in order to measure their impact. In addition, new activities may be incorporated into the model with little effort. However, there is still a great deal of room for model improvement. Specifically, it is necessary to develop linkages with reserve management and the bank's portfolio. Such linkages would permit the tracking of new credit policies and measure their effect on the insurance program. Finally, the model should be developed to allow for a more dynamic framework in reserve management, incorporating elements for stochastic cash demands at harvest time and planning the cash flow needs accordingly.

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Equations \ Activities		Insurance Options: Crops $X_1, \ldots X_k$ … Livestock … X_n	Total Indemnity	Total Administrative Expense	Deviation Counters	Standard Deviation	Cash Reserve	RHS
Net income	(3)	$R\,r_{ij} \ldots\ldots\ldots R\,r_{nn}$	$-R$	-1		$-\phi$	d	max
Total coverage for crops	(4)	$1 \ldots\ldots$						$= e \leq 1$
Total coverage for livestock	(4)	$\ldots\ldots\ldots 1$						$= (1-e)$
Administrative Cost	(5)	$b_{ij} \ldots\ldots\ldots\ldots b_{nn}$		-1				≤ 0
Indemnities	(6)	$P_{ij} r_{ij} \ldots\ldots\ldots P_{nn} r_{nn}$	-1					≤ 0
Loss Rates	(7)	$\bar{L}_{ij} \ldots\ldots\ldots\ldots \bar{L}_{nn}$						$\geq \bar{L}$
Cash Reserves	(9)	$0.1r_{ij} \ldots\ldots\ldots 0.1r_{nn}$					-1	≤ 0
MOTAD Equations	(10)	$(P_{ijt}-\bar{P}_{ij}) \ldots (P_{ijt}-\bar{P}_{nn})$			-1			≤ 0
⋮		⋮ ⋮			⋱			⋮
		$(P_{ijt}-\bar{P}_{ij}) \ldots (P_{nnt}-\bar{P}_{nn})$			-1			≤ 0
Deviation Identity	(11)				$2 \ldots 2$	$-T/H$		$= 0$
Social goals	(12)	$1 \ldots\ldots\ldots\ldots 1$						$\lesseqgtr D_k$
⋮		⋮ ⋮						⋮
		$1 \ldots\ldots\ldots\ldots 1$						$\gtrless D_k$
Chance constraint	(14)	$(\bar{P}_{ij}-\Psi r_{ij}) \ldots (\bar{P}_{nn}-\Psi r_{nn})$				-1.65		≤ 0

Table 2. Insurance Portfolio for the 1980-81 Fiscal Year.

Activity and Province	Insurance Coverage (in Dollars)	Percent of total Coverage
Total Coverage	13,114,208.0	100.0
<u>Rice</u>		
Chiriquí	2,212,380.0	16.870
Los Santos	315,620.0	2.407
Coclé	165,500.0	1.262
Veraguas	494,350.0	3.754
Panamá	151,790.0	1.157
<u>Corn</u>		
Chiriquí	45,508.0	0.347
Los Santos	817,078.0	6.230
Herrera	123,916.0	0.945
Coclé	22,714.0	0.173
Panamá	3,562.0	0.027
<u>Sorghum</u>		
Chiriquí	60,010.0	0.458
Los Santos	391,796.0	2.987
Herrera	469,030.0	3.576
Coclé	140,634.0	1.072
Panamá	73,256.0	0.558
<u>Beans</u>		
Chiriquí	31,237.0	0.238
<u>Tomatoes</u>		
Los Santos	934,500.0	7.126
Herrera	111,375.0	0.849
Coclé	241,380.0	1.840
Veraguas	3,000.0	0.023

Table 2. Cont...

Activity and Province	Insurance Coverage (in Dollars)	Percent of total Coverage
Feeder Cattle		
Chiriquí	425,349.0	3.243
Los Santos	825,492.0	6.295
Herrera	192,428.0	1.467
Coclé	8,680.0	0.066
Veraguas	178,487.0	2.886
Panamá-Colón	137,620.0	1.050
Breeding Cows		
Chiriquí	997,516.0	7.606
Los Santos	1,150.870.0	8.783
Herrera	200,665.0	1.530
Coclé	214,050.0	1.632
Veraguas	603,983.0	4.605
Panamá-Colón	325,776.0	2.484
Semen Bulls		
Chiriquí	247,690.0	1.888
Los Santos	342,925.0	2.615
Herrera	28,175.0	0.215
Coclé	42,500.0	0.324
Veraguas	124,135.0	0.954
Panamá-Colón	45,080.0	0.343
Others		
(Transport Insurance and Hog Insurance)	15,150.0	0.115

Source: ISA. Financial Report 1980-81

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Table 3. Loss Cost by Activity and Province. 1977-81

(In percent of coverage)

	Chiriquí	Los Santos	Herrera	Coclé	Veraguas	Panamá-Colón
Rice	1.31	0.74	-	4.54	2.73	0.03*
Corn	4.31	2.94	6.16	1.99	6.97	61.84
Sorghum	5.16	7.81	6.39	11.27	15.76	0.32
Beans	9.90	-	-	-	-	-
Tomatoes	-	3.99	9.41	7.69	47.18	-
Feeder Cattle	1.28	1.51	2.98	4.60	2.08	-
Bulls	2.51	1.35	0.0	2.33	3.74	3.13
Breeding Cows	2.08	1.18	1.49	2.02	1.79	1.03

* 1980-81 only

$$\text{Loss Cost} = \frac{\sum_{t}^{T} \text{Indemnities}_{ijt}}{\sum_{t}^{T} \text{Coverage}_{ijt}} \times 100.0$$

i = activity

j = province

t = years

Table 4. Administrative Expenses by Activity and Province. 1980-81

(In percent of Coverage)

	Chiriquí	Los Santos	Herrera	Coclé	Veraguas	Panamá
Rice	3.15	0.87	-	0.33	3.35	4.99
Corn	8.02	4.94	5.37	5.43	-	42.53
Sorghum	9.73	2.68	2.95	1.75	-	6.20
Beans	11.68	-	-	-	-	-
Tomatoes	-	3.54	3.91	6.57	32.36	-
Feeder Cattle	5.11	5.26	4.80	6.75	4.88	3.33
Bulls	0.89	0.85	1.54	1.75	12.2	0.96
Breeding cows	3.50	3.117	2.60	3.75	3.16	2.25

Table 5. Optimal Portfolio for 1980-81

Agricultural Insurance	Percent of total Coverage.	Livestock Insurance	Percent of total Coverage
Rice		Feeder Cattle	
Chiriquí	20.0	Panamá-Colón	12.0
Los Santos	8.4		
Corn		Bulls	
Coclé	4.38	Chiriquí	9.4
Veraguas	2.62	Los Santos	6.44
		Coclé	2.16
Sorghum		Cows	
Los Santos	2.01	Los Santos	4.15
Coclé	0.463	Herrera	13.46
Veraguas	1.99	Veraguas	2.39
Panamá	0.54		
Beans			
Chiriquí	0.6		
Tomatoes			
Los Santos	9.0		

Table 6 . Portfolio Performance Under Actual and Optimal Conditions. 1980-81

	1980-81 Portfolio	Optimal Portfolio	Optimal Portfolio Under New Premium Rates
Net Income	- 2.3173	- 1.32	- 1.018
Net Premiums	3.9619	3.309	4.241
Allocations to reserves	0.402	0.365	0.365
Earnings to accumulated reserves	0.076	0.076	0.076
Loss Cost	3.0664	2.34	2.77
Administrative Expenditures	3.6908	2.73	2.93
Loss Rate	0.77	0.70	0.83
Chance Constraint		1.188	0.753

Table 7 . Optimal Portfolio Under New Premium Rates.

Agricultural Insurance	Percent of total Coverage	Livestock Insurance	Percent of total Coverage
ice		Feeder Cattle	
hiriquí	20.0	Herrera	12.0
os Santos	8.4		
orn		Bulls	
oclé	4.5	Chiriquí	6.35
eraguas	2.5	Los Santos	5.64
		Coclé	2.5
		Panamá	3.52
orghum		Cows	
eraguas	4.5	Chiriquí	3.05
anamá	0.5	Los Santos	6.96
		Herrera	9.0
		Panamá	0.98
eans			
hiriquí	0.6		
Tomatoes			
Los Santos	9.0		

Table 8. Portfolio Performance Under Increasing Loss Rates.
(In % of total Coverage).

oss ate	Net Income	Loss Cost	Administrative Cost
.55	- 0.736	1.778	2.678
.6	- 0.799	1.817	2.714
.7	- 0.963	2.237	2.584
.8	- 1.146	2.696	2.446
.9	- 1.481	3.173	2.447
.0	- 1.869	3.522	2.591
.1*	- 3.396	3.451	4.105

Treshold loss rate for reinsurance.

CONFERENCE ON AGRICULTURAL RISKS, INSURANCE, AND CREDIT

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DRAFT

The U.S. Experience in Crop Insurance Programs

Bruce L. Gardner
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History of U.S. Crop Insurance

Multiple peril crop insurance was introduced in the United States by private companies in 1899 where The Realty Revenue Guaranty Company of Minneapolis agreed to purchase at the insuree's request the entire wheat crop at $5 per acre. Previously, the only insurance available for crop losses was the limited coverage afforded by hail and fire insurance. The fate of this early attempt at crop insurance is not documented, but the company discontinued the program after one year (Hoffman).

Crop insurance policies were written in 1917 in North Dakota, South Dakota, and Montana by three private companies (Valgren). The companies suffered heavy losses because of a drought. Apparently their ventures covered an area too small to adequately distribute their risks. The Hartford Fire Insurance Company offered a policy in 1920 that insured both price and yield risk. The company's president later testified before Congress that primarily because of sharp declines in crop prices this program resulted in payments for insured losses exceeding premiums received by $1.7 million (U.S. Congress). Several other

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* Bruce Gardner is a professor in the Department Agricultural and Resource Economics, University of Maryland, and Randall Kramer is an assistant professor in the Department of Agricultural Economics, Virginia Polytechnic Institute and State University.
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efforts by private companies to provide crop insurance were for the most part unsuccessful.

In 1922 the U.S. Senate passed a resolution calling for investigation of the general subject of crop insurance. The resolution provided for the appointment of a select Senate committee to investigate crop insurance with particular reference to:

1. The kinds and costs of insurance now available;
2. The adequacy of the protection afforded by such insurance;
3. The desirability of any practical methods for extending the scope of such insurance;
4. The availability and sufficiency of statistics necessary to properly and safely issue additional crop insurance (U.S. Congress).

The select committee held hearings on April 24 through April 27, 1923. The hearings represented the first time that crop insurance was approached as a national problem. The 116 pages of testimony of experts from government, agriculture, and insurance interests suggested that a successful program would have to be national in scope and would require better data than currently available. The committee adjourned for the summer and when it reconvened in the fall, economic conditions for agriculture had worsened to such an extent that agricultural interests in Congress turned their attention to more immediate measures of relief. By the time Congress adjourned in the summer of 1924, no additional crop insurance hearings had been held and no action on crop insurance was undertaken.

In 1936, President Roosevelt appointed a committee to make recommendations for legislation providing for government-sponsored crop insurance. The committee's recommendations were largely adopted in the Federal Crop Insurance Act of 1938 (Title V of the Agricultural Adjustment Act of 1938).

To implement the crop insurance program, the legislation established the Federal Crop Insurance Corporation (FCIC), an agency within the USDA. The management of the corporation was vested in a Board of Directors appointed by the Secretary of Agriculture. Insurance was authorized only for wheat. Growers could be insured between 50 and 75 percent of recorded or appraised average yield against losses because of "...drought, flood, hail, wind, winterkill, lightning, tornado, insect infestation, plant disease, and such other unavoidable causes as may be determined by the Board..." (52 Stat. 74). Premiums and losses could be paid in kind or cash equivalent.

The local committees of the Agricultural Adjustment Administration served as local units for administering the crop insurance program. For those farms with annual yield data, the county committees determined premiums by calculating a loss experience based on the amount of indemnities a farm would have received if it had been insured in previous years. Using an average yield for the base period, the committees calculated the amount of indemnity or loss cost for each year had the farm been insured at the 75 percent (or 50 percent) level. The annual loss costs were used to obtain an average loss cost for the farm. This average loss cost was then averaged with the county loss experience to determine the premium rate (Rowe and Smith).

The initial experience with federal crop insurance was less than encouraging. During the first year nearly one third of the insured farmers collected indemnities. Indemnities exceeded premiums by 2.6 million bushels. The loss ratio was 1.52. Part of the losses resulted from drought in several states, although nationally yields were slightly above average. In any actuarially based insurance program, one would not expect premiums to exactly equal indemnities in a given year, but there were some fundamental problems in

the program's administration that contributed to the poor loss ratio in 1939. Adequate farm level data were not available in many counties. Also, in many cases inexperienced estimators relied too heavily on county averages in setting premiums. This apparently led to an underestimate of yield variability of individual farms (Clendenin).

Another factor contributing to the large underwriting losses in 1939 was the late completion of contracts for wheat, which led to adverse selection. The calculation of premiums ran behind schedule and many farmers did not receive premium notices until after their crops had been planted. Nearly half of the original applicants did not respond to premium notices and thus nullified their contracts. Presumably, those cancelling their applications had crops in good condition (Clendenin).

The poor performance of the program in 1939 led to several changes in the methods used to calculate yields and premiums. Because inexperienced county committees were often appraising yields high, especially on low yielding farms, the FCIC established a key-farm system for future years. Under this system a representative sample of 50 to 100 farms with good yield data was selected for each county. In appraising yields and loss-costs for individual farms, committeemen were instructed to select a comparable farm from the key-farm list and use its data with appropriate modifications (FCIC, 1939).

The FCIC also established "county check yields." Farm yields and premium rates were then brought into alignment with estimated county averages by a factoring procedure. Individual farm figures were raised or lowered proportionally until their average was equal to the county check yield or rate.

Participation in the program increased steadily. The number of insured farms was 165,775 in 1939. This increased to 360,596 in 1940 and 371,392 in

1941. Despite the growth in participation and the modifications in yield and premium calculations, the federal crop insurance program continued to pay indemnities in excess of premiums received (FCIC, 1943).

The disappointing results of the first three years of operation of the wheat crop insurance program led to a total subsidy from the Treasury for operating expenses and underwriting losses of about $28 million. Although proponents of crop insurance had conceded at least a temporary need for a public subsidy of operating expenses, the annual subsidy of $4.4 million was larger than expected. Given the low level of participation, it became clear that the plan would not become self-supporting. For example, adding operating expense to the premiums would cost the average insured wheat grower 13 percent of his net income from wheat. The annual underwriting losses of approximately $4 million were even more troublesome to policy makers because these losses occurred during relatively good crop years when reserves should have been accumulated for paying indemnities in future bad years (Clendenin).

A similar crop insurance program for cotton began operation in 1942 and it encountered the same difficulties as the wheat program. Indemnities greatly exceeded premiums during both years. Administrative expenses totaled $3.5 million for the two years and underwriting losses amounted to $11 million (Benedict).

The crop insurance programs for wheat and cotton were severely criticized in 1943 Congressional hearings. Consequently, the Agricultural Appropriations Bill for 1943-44 prohibited the FCIC from writing any new crop insurance policies after July 31, 1943. The two major reasons for the Congressional cancellation of the crop insurance program were: (1) the large underwriting losses in each of the five years of the program's operations; and (2) the low

level of participation in the program. Although Congress had been willing to subsidize the administrative costs of the program, it had expected premiums to cover indemnities in normal crop years (Agricultural Finance Review, 1943).

The crop insurance program did not remain dead for long. In late 1944, an amendment to the Agricultural Adjustment Act of 1938 was passed which revived and expanded the program. Insurance was authorized for wheat, cotton, and flax crops planted for harvest in 1945. For the first time wheat premiums exceeded indemnities in 1945. However, because of drought, excessive rains, and boll weevil damage, there were large underwriting losses for cotton (FCIC, 1946).

Trial insurance was also offered in 1945 for corn in 15 counties and for tobacco in 12 counties (Agricultural Finance Review, 1945). The experimental program for corn had two options—a yield plan and an investment cost plan. The yield plan insured up to 75 percent of the farm average yield over a base period. The investment cost plan insured up to 75 percent of the investment a farmer had in his crop. Crop insurance for tobacco was also offered under two plans—an investment cost plan and a yield quality plan. Under the yield quality plan, a quality index was constructed for each farm based on the historical relationship between the price received by the grower and the seasonal price for the type or class of tobacco grown. The grower would then be insured for a return equal to three fourths of his average yield multiplied by his quality index multiplied by the average market price for the year of the insurance. The dollar value of the coverage would not be known until the close of the marketing season; until then it would be carried in pounds. Under this plan, a grower was insured on the basis of his relative position in the market, but he still bore the risk of overall fluctuations in the market price (Wrather).

The 1945 program also instituted increasing protection as crops progressed. If a crop was destroyed or substantially damaged early in the growing season after it was too late to replant, and the FCIC released the acreage for another use, then protection was reduced to 40 or 50 percent of what it would have been for a harvested crop. After that time, the level of protection gradually increased. This provision was added to provide for a sounder insurance program because it had been observed that in some cases it was more profitable to incur a crop loss than to have a successful harvest (FCIC, 1945).

Several new features were introduced in 1946. The FCIC had been experimenting for some time with a three year contract for wheat. This was designed to reduce the adverse selection problem and to reduce the cost of selling insurance. An important indicator of crop prospects is soil moisture at planting time. Many farmers were purchasing crop insurance only when soil moisture indicated a poor crop. The three year contract eliminated this problem, at least for the second and third year of the contract. A continuous contract for cotton was also introduced. This contact would remain in force year after year unless cancelled by the farmer or the FCIC.

It had become recognized that individual farm data might be adequate for determining expected yields but not for determining the variability of yields because of the relatively few years of data available. There had been a trend toward using county data and with the adoption of county premium rates in 1946, all crops were insured under county-wide rates. This change was permitted by the 1944 amendments which omitted a provision requiring premiums to be based on the recorded or appraised crop loss of the insured farm. Adjustments in premiums continued to be made for high-risk farms (Agricultural Finance Review, 1946).

Partial coverage was offered for the first time in 1946 Farmers were allowed to purchase a percentage of the standard contract so as to receive a lower level of protection for a corresponding lower premium. This option did not prove to be popular with farmers.

In 1947, the FCIC collected premiums in excess of indemnities on combined operations for the first time in history. Ironically, legislation was passed that year which severely curtailed the operations of the Corporation. The 1947 amendments effectively reduced federal crop insurance to an experimental program. As a result of the legislation, the Corporation reduced its operations from 2500 to 375 counties in 1947. Although the scope of the program was reduced, the FCIC was given greater latitude in experimenting with alternative forms of insurance. Two new experimental programs were tried in 1948. One was a program for dry edible beans instituted in four widely separated counties with different types of farming. The other was a multiple crop contract. For this type of contract, indemnities were determined on the basis of combined coverage evaluated at predetermined prices (FCIC, 1948).

The drought of the 1930s provided impetus for the establishment of government sponsored crop insurance; the drought of the early 1950s demonstrated the continued need for the program. In 1951 and 1952 indemnities totaled $42 million and enabled many farmers to avoid bankruptsy. Over the first five years of the experimental phase (1948-1952) the surplus of premiums over indemnities was $2.25 million. The loss ratio was less than one in three of the five years and the five year loss ratio was .97. This suggests that the program was beginning to operate on a sound basis, although reserves were not building up as quickly as would be desireable. For example, the total reserves after five years were substantially less than the underwriting losses incurred in one year—1949 (FCIC, 1955).

During the 1950s the crop insurance program began to stabilize. Although some new crops were added and minor experimentation continued, most changes were for "fine tuning" the program. The FCIC announced that beginning in 1956 insurance would no longer be sold in 14 counties in Colorado, New Mexico, and Texas. These were considered high risk farming areas not suitable for insurance because total indemnities had substantially exceeded total premiums. The Board of Directors was convinced that it would be impossible to develop a sound insurance program for these counties. If insurance had not been sold in these counties since 1948, the national program would have experienced a reserve of premiums over indemnities rather than a deficit.

Beginning in 1957 there was a five year period in which premiums exceeded indemnities every year. The loss ratio in 1958, .26, was the lowest in nineteen years of operation. This was well below what was ever expected to be experienced in the program. Premiums exceeded losses for every crop and, as a result, a total surplus of $2.5 million had collected since the experimental program began in 1948. In addition to good crop conditions, other factors contributing to the successes during this time period were improved operating methods including the withdrawal of the 14 high loss counties in 1956 and the advancement of closing dates for applications to reduce adverse selection.

The continued experimentation during the 1950s in methods and crops insured did not result in rapid increases in total coverage. In 1950 insured liabilities were $240 million. By 1959 this increased to $271 million, well below the $470 million worth of insurance written in 1947 before the beginning of the experimental phase. During the 1960s, the FCIC concentrated on increasing its coverage which reached $920 million in 1969. This rapid increase did not come without cost. In the last three years of the decade, the

Corporation paid indemnities that were about 29 percent of the total indemnities paid during the entire 1948-1969 period. Premiums did not keep pace with liabilities and indemnities. Premiums as a percent of liabilities declined from 6.9 in 1955-1961 to 5.8 in 1963-1969 (FCIC, 1969 and 1970).

Early in 1969, the Secretary of Agriculture appointed a new Board of Directors, Manager, and Deputy Manager. The new management undertook a review of the program to identify reasons for the poor financial position of the Corporation. They concluded that it was due "...in large measure to coverage increases and rate reductions which supporting statistics did not justify and a concentration of sales results where comparatively high coverage and low premiums applied..." (FCIC, 1969. p. 11). Adverse weather followed in some of the areas of increased coverage, particularly in cotton growing areas. The Corporation concluded that in many counties insurance structures had been weakened by the use of shorter time periods for determining coverages with the result that coverages were based on recent trends rather than long term averages. The cotton program was identified as one of the major sources of the Corporation's problems. For the 1948-69 period, the cumulative loss ratio for cotton was 1.5. Without cotton, the cumulative loss ratio for all crops would have been .91 rather than .97.

The Corporation's review revealed that in many cases premium rates had been reduced lower than experience could justify. For some new crops, risks had been miscalculated and premiums set too low. Overall, it was concluded that..."Unfortunately, this process of increasing sales was geared too much to liberalized coverages for premium rates too low to result in sound operations..." (FCIC, 1969, p. 12).

To offset these problems, the FCIC instituted several changes in the operation of its 1970 program. In most cotton counties premiums were increased and coverage was decreased. The top cotton price election (used to calculate the value of insured losses) was reduced to more adequately reflect market values. The experimental potato program, which had suffered large underwriting losses and had been utilized by few producers, was discontinued. Adjustments were made in the soybean and citrus programs to lower their loss ratios.

In 1970 the Secretary of Agriculture appointed a task force of nongovernmental insurance experts to study the FCIC. The task force criticized the practice of establishing premiums on a county wide basis. According to the task force, the most urgently needed change in FCIC operations was the development of a program based on individual farm risks (FCIC Task Force). The General Accounting Office concurred with the need for individualized protection in a report released in 1977 (U.S. General Accounting Office, 1977). Individualized proection was proposed as a means of increasing farmer participation in the federal crop insurance program. The GAO concluded that low participation prevented FCIC from operating an effective disaster protection program.

Disaster Payments Program

The Agriculture and Consumer Protection Act of 1973 and the Rice Production Act of 1975 established a disaster payments program (DPP) which for some crops overlapped the protection of federal crop insurance. Prevented planting payments and payments for abnormally low yields were provided for producers of wheat, sorghum, corn, barley, upland cotton and rice. Farmers participating in price and income support programs were eligible for payments. Prevented planting payments were made to producers who were unable to plant or who

underplanted because of drought, flood, or other natural conditions beyond their control. Low yield payments were made when yields fell below two-thirds of normal. The Food and Agriculture Act of 1977 renewed this program with low yield payments activated when yields of wheat and feed grains fell below 60 percent of normal and when yields of rice and cotton fell below 75 percent of normal. The program ended in 1981. Disaster payments for 1974-1979 totaled $2.455 billion.

The DPP was popular with farmers because it provided disaster protection with no premium costs, and it provided coverage in high-risk areas where crop insurance was not available. Critics charged the disaster payments program led to an inefficient use of the nation's resources by encouraging production in high risk areas. The program was also criticized for insuring against "moral hazards," that is, avoidable losses caused by management decisions. According to a study by the U.S. General Accounting Office, a substantial portion of 1974 payments went to Texas producers whose cotton crops were damaged by drifting chemicals aerially applied to neighboring fields. Although the farmers may have had legal recourse against the damaging parties (who customarily carried insurance against such claims), they chose to collect disaster payments rather than pursue legal action (U.S. General Accounting Office, 1976). Furthermore, the prevented plantings provision provided incentives for producers in arid regions to collect payments rather than plant under marginal conditions, thus leading to adverse selection in the program (Miller and Walter). The question arises whether the DPP discouraged participation in the FCIC program. There does not appear to have been any large effect. In the three years prior to the implementation of the DPP, 1971-73, there were an average of 347,000 individual's crops insured under FCIC. During the first six years of the DPP, 1974-79, the corresponding FCIC figure was 320,000.

Federal Crop Insurance Act of 1980

The Federal Crop Insurance Act of 1981 (94 Stat. 1312) expanded the crop insurance program so as to become the major form of disaster protection. The Act authorized the expansion of the program to all counties with significant amounts of agriculture. If sufficient actuarial data were available, the FCIC was permitted to insure any agricultural commodity (including aquacultural species) grown in the United States. The initial expansion of the program was targeted for those counties with substantial acreages of crops formerly covered by the disaster payments program. In order to provide a transition period, the Act extended the disaster payments program through 1981. To encourage greater participation, the Act authorized subsidies of 30 percent of premiums on the 50 and 65 percent yield levels and somewhat a smaller subsidy at the 95 yield level. Those producers with private hail and fire insurance were allowed to delete the coverage from the Corporation's policy and pay premiums reduced by 15 to 30 percent.

The Act also permitted specific risk protection programs on prevented planting, wildlife depredation, tree damage and disease, insect infestation and others, provided such protection was not available from private companies. It authorized research and pilot programs on rangeland, livestock poisoning and disease, destruction of bees due to pesticide use, and "...other unique problems of special risk related to, but not limited to, fruits, nuts, vegetables, aquacultural species, forest industry needs (including appreciation), and other agricultural programs as determined by the Board...." The Act required a pilot program of individual risk underwritting in at least twenty-five counties from 1981 to 1985. The FCIC later announced that beginning in 1982 farmers with at least three years of yield data may request individualized yield protection.

Under this option premiums and coverage will be calculated on an individual farm basis.

The General Accounting Office studied the effects of the new legislation on the 1981 program and found that insured acreage increased from about 26.3 million to 47 7 million, or about 81 percent. For the 1981 crop year, the FCIC extended its coverage to 1,340 additional county programs and 252 additional counties. (A county program is defined as all insurable acres of a crop in a county.) For the 1982 crop year, 8,278 county programs and 1,050 counties were added. Producers chose to exclude fire and hail coverage on only 3,125 of 497,336 policies (U.S. General Accounting Office, 1981).

Of thirty private companies submitting applications for the 1981 reinsurance program, seventeen wrote policies resulting in premiums of $13 million, or 4 percent of the total premiums written. Another six companies entered into non-risk bearing sales and service agreements with the Corporation. There were two major reasons why more private companies did not participate in reinsurance: (1) lack of sufficient time to implement the program, and (2) concern that reinsured companies might be considered federal contractors subject to equal employment opportunity regulations (U.S. General Accounting Office, 1981).

Relationship to Other Farm Programs

The early development of U.S. crop insurance programs took place in conjunction with commodity price-support policy, as earlier discussion in this paper indicated. But in the post-World War II period commodity price-support programs seem to have followed a path of development independent of the FCIC programs. The most notable instance of this independence was the disaster payment program, which as discussed earlier was essentially a second crop

insurance program superimposed on the FCIC. During the 1970s there were in addition programs such as those providing disaster loans at low interest, the emergency feed program, and special indemnity programs for dairy producers and beekeepers. In terms of economic impact these were often more important then FCIC insurance. In 1977, about 2/3 of U.S. counties were classified as disaster areas for purposes of disaster loan programs (even though the U.S. crop output index was record-high at that time).1/ In fiscal 1980, the Farmers' Home Administration made about $4 1/2 billion in emergency loans (at an interest rate of 5 percent for the amount of losses claimed). An important purpose of the Federal Crop Insurance Act of 1980 was to create a better coordinated overall system of federally subsidized crop insurance in the United States.

A general reason for coordinating price-support and output-insurance programs is that either one by itself may have only small risk-reducing effects in the absence of the other. This situation arises when price fluctuations are caused by random output variations that are correlated across farms, since in this situation each farmers' years of low output tend to be years of high prices. When prices are stabilized by a government program, the risk-reducing features of crop insurance are enhanced. This is a possible reason why tobacco producers participate in FCIC programs more than producers of other crops, *ceteris paribus*, as discussed below.

A related large subject involves crop insurance and credit programs. The two merge into the same policy in the case of disaster assistance which takes the form of subsidized loans. The subsidy may involve interest rates below market rates, waiver of usual security terms, governmental guarantee of payoff

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1/See the testimony of the Secretary of Agriculture before the Senate Agriculture Committee, May 2, 1978, as reported in Farm Credit Administration (1978).

to lenders in case of default, or even forgiveness of repayment of the principal. In this case, credit policy and insurance are substitutes in risk management. However, the more usual case is that credit policy should be expected to increase the demand for crop insurance. The reason is that U.S. farm credit policy consists essentially of programs to provide credit to farmers at terms more favorable than the terms available from non-governmental lending institutions. This tends to increase farmers' use of credit, hence their leverage, and hence the value of insurance in reducing risks.

Unfortunately, we do not have the data necessary to test the importance of this effect, nor to assess the significance of the interactions of the various programs in influencing farmers' behavior by changing the risk/return alternatives that they face. However, there are county-level data on the FCIC and DPP programs which may be useful in drawing lessons from the U.S. experience about farmers' demand for crop insurance and about the effects of an insurance programs on farmers' risk-taking. To this subject we now turn.

Previous Studies

Economic research on crop insurance has been conducted in the United States for the past sixty years. The research falls into four general categories. (1) Prior to 1938 several studies explored possible forms which a government sponsored crop insurance program might take. (2) Given the low participation level and poor financial performance of the FCIC program in the early years of operation, researchers proposed alternative actuarial methods. (3) Several studies have been concerned with differences in the characteristics of program participants and nonparticipants. One purpose of this group of studies has been to shed light on factors influencing the demand for crop insurance. (4) The final set of studies has examined the farm level impacts of crop insurance.

Most of these have been conducted in a simulation framework to analyze the stream of net returns of representative farms with and without insurance.

One of the earliest economic studies of crop insurance in the United States was a USDA bulletin published in 1922 by V. N. Valgren. Reviewing the experience of private companies, Valgren identified principles fundamental to the development of a successful crop insurance plan. These principles were an elaboration of the basic requirements for crop insurance which Mayet presented 30 years earlier to the Japanese government:

> This insurance against failure of crops may be limited as follows, that a duty of indemnification exists only:
>
> I. When the failure is clearly due to natural causes and the farmer is not to blame, as when a whole province or county suffers loss.
>
> II. When the failue of the individual farmer of that province or county is a total or a considerable one, as for instance when the rice crop is less than 70% of an average crop, or that of other produce less than 60% or 50% or 40%, etc.
>
> III. When that indemnification is only partial and the farmer bears the other part of the burden.
>
> IV. When that indemnification is made, not according to market prices obtained during the year of failure, but according to an average price agreed upon when the insurance was first offered. (pp. 60-61)

It is interesting to note that the danger of insuring against price risk was recognized before the turn of the century.

To Mayet's list, Valgren added the requirement that "The premium, or cost of insurance, must bear a reasonable relationship to the value of the protection that it purchases" (p. 26). To accomplish this Valgren suggested the use of farmers organizations to keep the administrative costs as low as possible.

USDA research on crop insurance was renewed in 1936. A substantial amount of data on wheat and cotton yields on individual farms had been collected by the

Agricultural Adjustment Administration in the operation of its programs. Preliminary analysis of the wheat data indicated they could provide an actuarial basis for crop insurance (Agricultural Finance Review, 1935; Green).

After Congress temporarily suspended the FCIC in 1942, Sanderson proposed an alternative approach to the calculation of premiums. This approach was designed to reduce adverse selection which Sanderson blamed for the FCIC's problems. He proposed a program based on weather-yield relationships using a regression equation to predict the effect of weather factors on yields. Under this plan an equation would be estimated for each state. Farmers would receive indemnities if weather factors changed in a direction leading to below average predicted yields. Increases in predicted yields would determine the per acre premium paid by farmers in the state. Another version of this plan, also based on regression equations, would have resulted in fixed premiums and minimum yield protection. Sanderson's plan did not receive a great deal of attention, possibly due to potential difficulties in selection of appropriate explanatory variables. Furthermore, a farmer with greater yield variability than the state as a whole would likely not obtain adequate risk protection from such a plan.

After analyzing the extreme yield fluctuations of the semi-arid regions of the northern great plains, Pengra suggested a crop insurance plan which would discourage planting in dry years. He argued, "If a plan could be worked out to restrict or entirely eliminate the seeding of wheat during these low preseasonal precipitation years the cost of the insurance would be greatly reduced as well as the losses that must still be borne by the farmer in spite of the benefits from his insurance protection" (p. 569-70). However, since farmers often choose to plant in such seasons, even when they bear the full risk of crop losses, there is a strong presumption that the encouragement of idling land in these

years of likely scarcity would cause misallocation of resources from the social point of view.

An area-yield insurance plan was proposed by Halcrow (1948, 1949). Under this plan premiums and indemnities would be based on the yield of an area with normally uniform crop conditions. If the mean area-yield fell below a specified level, all insured farmers in the area would receive an indemnity. An obvious difficulty with such a plan is that it would not provide appropriate insurance for farms in the more risky environments within an area.

In 1953 Lee proposed citrus temperature insurance as a substitute for citrus frost insurance in Southern California, due to the greater availability of temperature data. Growers would receive indemnities if temperatures fell below specified levels at nearby weather stations.

The experience-credit feature of U.S. crop insurance allows a reduction in premiums over time for those farmers without losses. Myrick examined this and other features of the program in 1970. Because there are credits to but no debits against base rates, the base rates must be weighted to balance the credits. Myrick argued that this discouraged participation since premiums for new insureds are higher than average. He recommended a revised merit rating plan that would include debits as well as credits which would tend to lower the premium rate for new insureds. He also suggested a provision for reducing rates for new insureds if their individual yield records indicated a favorable loss-cost history.

One of the first studies of crop insurance participation was published in 1942. Based on surveys from individual farms in several states, Clendenin concluded that smaller farms were more likely to purchase insurance than larger farms. After classifying individual respondents' financial strength as "best,"

medium," or "weakest," he found that those in the weakest group were somewhat more willing to insure. This was less true in high risk areas where premium rates were an obstacle to participation. The investigation also revealed that tenants were slightly more likely to insure than owner-operators and nonfarming land lords. Surprisingly, farms heavily dependent on wheat income were less likely to insure than the diversified farms. (It should be noted that Clendenin's conclusions on differences among groups were based on group averages; no statistical tests were conducted.) Examining data on county premium rates and level of participation, Clendenin noted an inverse relation between the two. Participation volume was substantially greater in the low premium counties.

Several investigations of the characteristics of crop insurance participants and nonparticipants were conducted as a part of the Great Plains Regional Project GP-8. In an article summarizing the survey results from six states, Loftsgard noted that "A comparison of these characteristics, for farmers who participate versus those who aren't participating in the program, reveals little...for all the states studied, the only consistency observed was that participants are slightly older and rely more heavily on cash-grain income than nonparticipants" (p.34). Most farmers who participated reported that they did so to protect their investments in production expenses and to thus maintain their standard of living and keep their business solvent. The predominant reason given for nonparticipation was that the level of protection was toolow. Farmers were asked their opinion of the program. Many expressed dissatisfaction with the length of time between inspection of loss and payment of indemnity. The majority of participants and nonparticipants were in favor of changing the program to allow contracts for separate fields or tracts. Farmers tended to

oppose multiple-crop contracts because they reduced their chances of collecting indemnities.

Shipley examined the relationship between FCIC participation and soil type and groundwater availability in Northwest Texas. The rate of participation was significantly higher among those farmers with a poor water supply and with hard lands. Examining demographic and other characteristics of participants, prior-participants, and nonparticipants he found no significant differences in age, education, number of dependents, education, experience or yields.

For approximately half of the farmers surveyed, crop insurance substituted for diversification as a risk management tool.

Separate studies by Bray and Starr surveyed FCIC participants in Nebraska. Bray found that most of those interviewed

were strongly in favor of higher levels of coverage and said they would have been willing to pay higher premiums for increased protection. Farmers in Starr's sample thought that constantly increasing yields were the cause of inadequate coverage levels. Starr concluded that major reasons for low participation were insufficient coverage and a lack of information about the purposes of crop insurance.

In North Dakota, Delvo and Loftsgard surveyed farmers with FCIC insurance and farmers who had canceled it in the period 1960 to 1962. In low and medium crop risk areas, participants operated the largest farms. In high risk crop areas, the nonparticipants operated the largest farms. Average crop yields and production costs were about the same for both groups. Nonparticipants indicated their belief that the probability of collecting an indemnity was too low to make crop insurance worthwhile.

A 1965 survey in Virginia and Montana found that insured farmers were in a somewhat riskier situation than their uninsured counterparts in that they were less diversified, less likely to have irrigation, and had smaller incomes, fewer savings, and larger debts. Lenders reported better loan collections from those growers with crop insurance (Jones and Larson).

Beeson conducted a personal interview survey of East Tennessee tobacco farmers in 1969. Total farm income and total assets were significantly higher among those who did not purchase FCIC insurance. A higher percentage of income was from tobacco for those with insurance, while those without obtained a higher percentage of income from livestock. In contrast to the findings of Jones and Larson, those without insurance had a significantly larger amount of debt. If FCIC insurance had not been available, 65 percent of those insured indicated they would not have made any changes in their operations; the rest would have substituted private hail insurance. Of those who had dropped FCIC insurance, only 9.4 percent did so because of the level of premiums. Most had dropped because of insufficient amounts of coverage or dislike of loss adjustment procedures. Only 2.5 percent of the nonpurchasers indicated they would be induced to purchase by lower premiums; 73.8 percent said there were no changes in the program which would cause them to purchase.

The first in a long series of simulation studies was a study by Barber and Thair in which they constructed streams of net after tax income with and without crop insurance for a Kansas grain farm and a North Dakota grain and livestock farm. Using constant input and output prices and experiment station yields for

1915-1948 they examined the effects of two types of crop insurance—wheat insurance only and a multiple crop insurance plan. Crop insurance of either kind resulted in greater income stability for both farms as indicated by higher average net after tax income and by fewer years of negative income. (The authors did not report any variability measures.) However, there were as many years with insurance as without in which net income fell below estimated living costs. The authors suggested two program changes which would lead to greater income stability: (1) a higher yield coverage, and (2) premium payment only in years of above average yields.

A similar study of a Montana wheat farm (Heisig) demonstrated that crop insurance over the 1919-1944 period would have resulted in sufficient income every year to cover cash operating expenses and family living expenses except for minor deficits in a few years. In contrast, without insurance the farm would have experienced large deficits in five of the twenty-six years. However, Heisig pointed out that even with insurance, there would in many cases be insufficient income or reserves to make debt payments or to replace machinery or equipment during an extended period of drought.

Another study of Montana wheat farms examined the effects of crop insurance on farm survival (Rodewald). Once a charge was made for family living expenses, crop insurance alone was not adequate to guarantee survival. However, the use of insurance reduced the need for borrowing while at the same time it enhanced the possibility of obtaining credit.

In another simulation study, Miller and Trock found that with a 50 percent level of yield protection, crop insurance was more effective than the disaster payments program in stabilizing income from dryland winter wheat in Colorado. However, this analysis did not consider the relative cost of the two programs,

i.e., there was no adjustment made in the income calculations for crop insurance premiums.

Kramer and Pope analyzed the effectiveness of the 1981 crop insurance program in reducing risk for a representative Virginia corn farm. Using stochastic dominance analysis, a comparison was made of probability distributions of net returns for corn with and without crop insurance. The results suggested that crop insurance can be an attractive option for managing risk. Similar results were obtained in study by King and Oarnek, which also used stochastic dominance analysis. For dryland wheat producers in Colorado, the investigators found that crop insurance would be particularly attractive after the elimination of the disaster payments program.

Evidence on the U.S. Demand for Crop Insurance

We will consider two aspects of the U.S. experience in crop insurance. First, the demand for insurance—its response to the rate of indemnity payout, the premium charged, the variability of production, and various socio-economic aspects of rural communities. Second, the results of the introduction of crop insurance—particularly its impact on substitute risk-reducing activities like crop diversification, fallowing, irrigation, or pesticides, and on farmers' willingness to expand farm size or fertilize more. The possible lessons to be learned from this second subject pertain to how much it may be possible to increase the "progressiveness," specialization, etc., of farmers by introducing crop insurance in areas where it is unavailable. The lessons of the first part pertain to what preconditions in the rural population promote the acceptability of crop insurance, and how responsive the demand for insurance is to reductions in premiums paid by farmers relative to indemnity benefits paid to them (for example, by subsidizing insurance).

The Demand for Crop Insurance

A competitive insurance market: Crop insurance is a contingent contract, an agreement in which a farmer pays a price, the premium, after which his crop output ("yield") determines a payout or indemnity The contingency is that only certain (low) yields result in indemnities, and yield is a random variable whose value if unknown when the insurance contract is purchased. Sellers or "writers" of insurance enter the business in pursuit of profit. Therefore, the expected indemnities must exceed the premium by the costs of writing insurance, and the equilibrium condition is that in a competitive insurance industry there would be a tendency for expected indemnities to equal premiums plus these costs.1/

A farmer's demand for a crop insurance contract depends on (a) the farmer's utility function of income, (b) his current income, (c) his subjective frequency distribution of future income, (d) the change in the frequency distribution of future income generated by the contract, and (e) the premium or price of the contract. Item (d) determines the returns from insurance, and item (e) its cost. The expected returns must fall short of the costs, with a viable competitive (or monopoly) insurance industry, because of the above equilibrium condition. Therefore, we know one fact about the change under (d); namely, it must reduce the expected value of future income.

The preceding argument can be restated in terms of the demand for and supply of insurance as in figure 1. With risk-neutral producers, no insurance is sold. With risk aversion, a producer will pay to have the income risk

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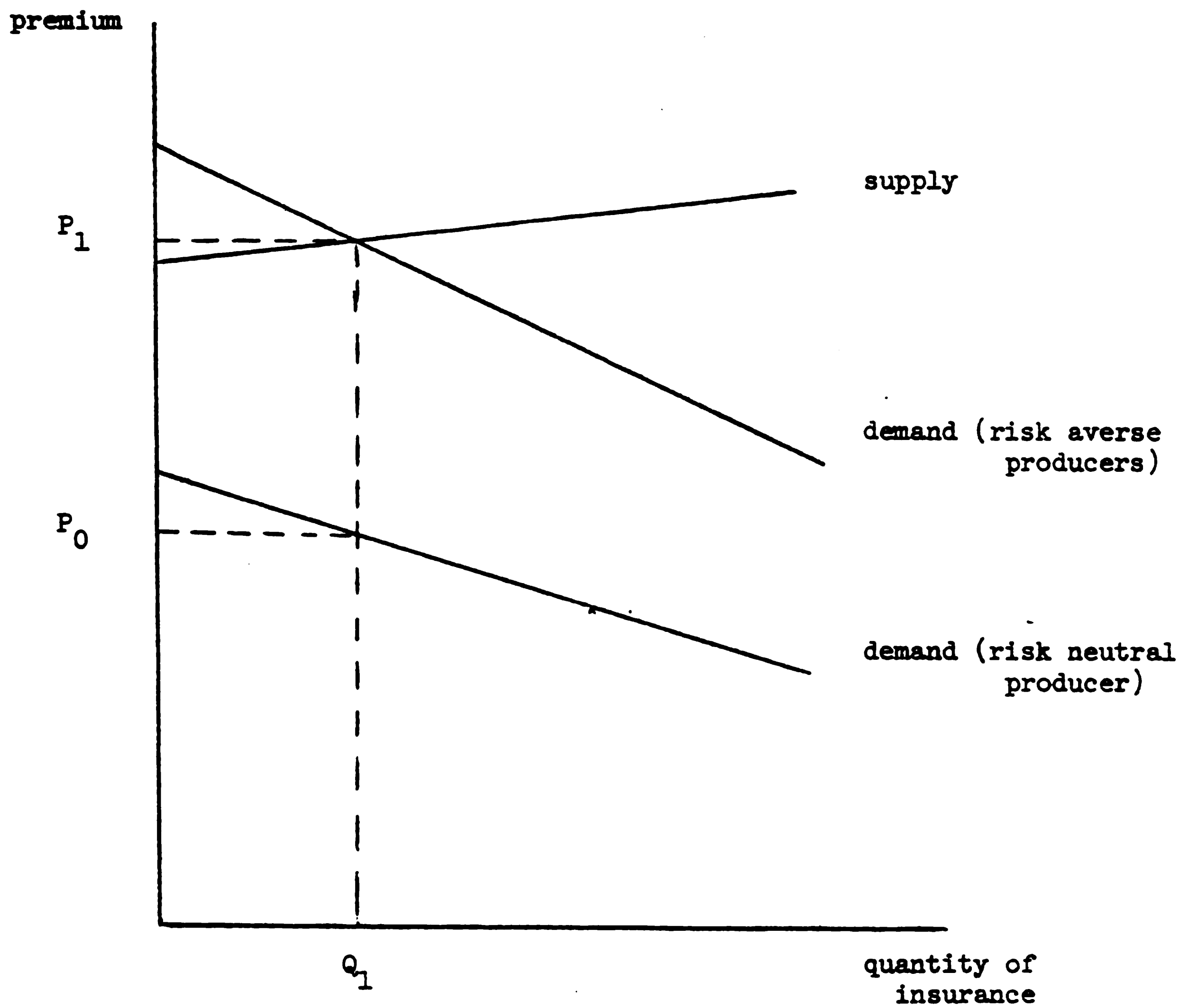
1/This would be true for the industry and for each firm in the industry, and for each contract written. However, there may be no equilibrium in a competitive insurance market even if demand and cost conditions suggest at first glance that there should be. This situation, which depends on imperfect information about differences in individuals' risks, is explored in Rothschild and Stiglitz, and the competitive market equilibrium conditions are derived there for a simple 2-state model.

Figure 1. Demand and Supply Curves for Insurance



reduced. How much a producer will pay depends on his utility function, his income (unless the utility function exhibits constant risk aversion), and the nature of the insurance contract and how it fits in with his portfolio of other activities. One could think of applying the capital-asset pricing model here, thus identifying "how it fits in" as the "beta" of the insurance contract relative to the aggregate of all other assets. But we will follow the more usual approach of considering only portfolios consisting of crop-growing and insurance contracts. This can be justified by supposing that the returns from a portfolio of growing crops and insurance has zero variance in returns (or alternatively that the remaining variance occurs over an approximately risk-neutral range of utility outcomes).[1/]

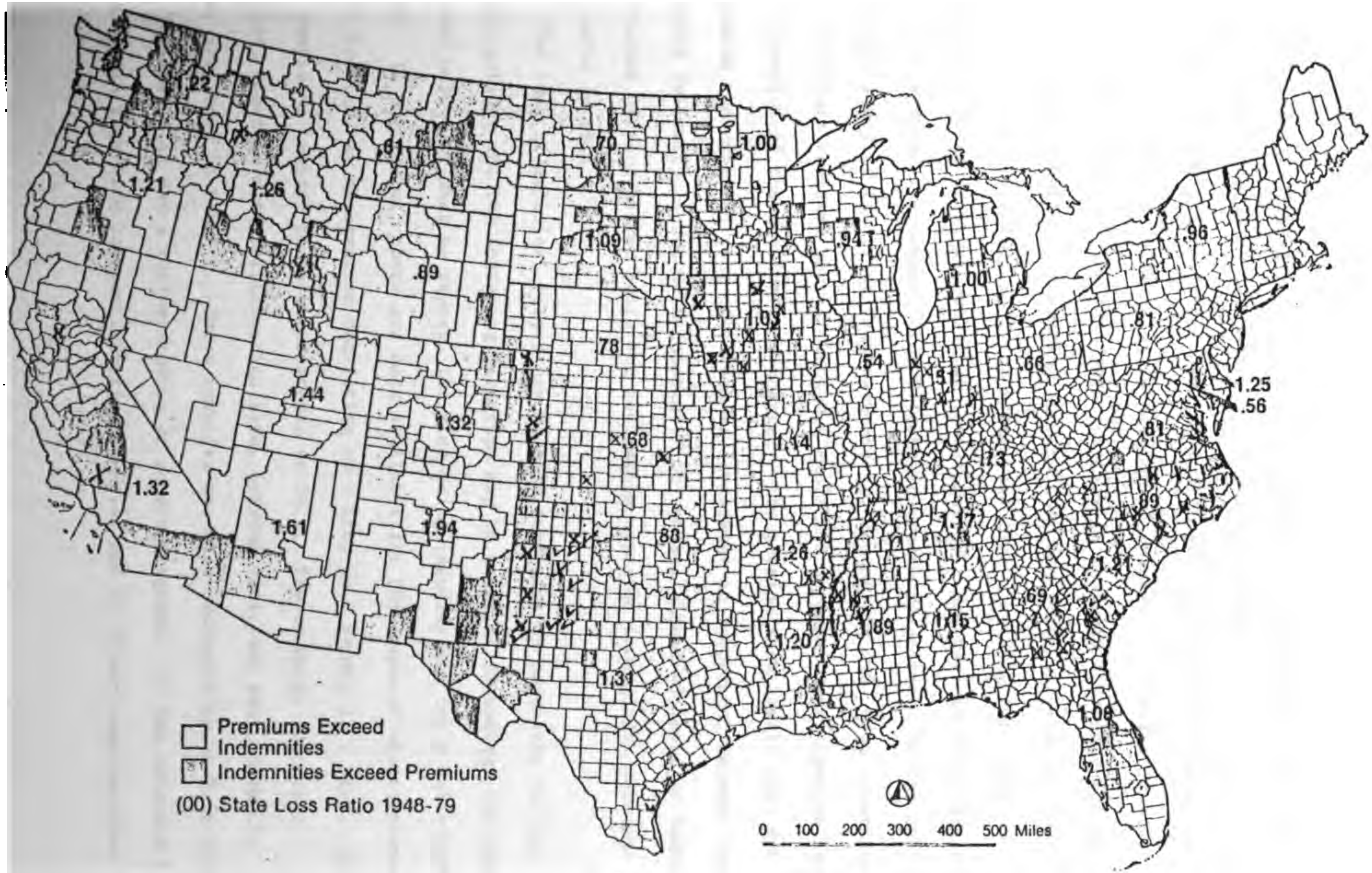
Risk aversion varying from producer to producer can generate a downward-sloping demand curve for insurance, as in figure 1 where the equilibrium amount of insurance written is Q_1, and the corresponding premium is P_1. The "quantity of insurance" refers to acreage or bushels covered, and is limited by the crop acreage (although this is not a necessary constraint—one could have side-bets on crop outputs as we do for prices in futures markets). In what follows, we will use as our quantity variable the percentage of the crop covered, as the 0-1 range is proportional to $0-Q_{max}$. (Note: we are not to imagine the terms of the contracts varying as Q varies. We need separate supply and demand curves for each type of contract written.)

The positive payoffs on insurance when the farmer's output is low is normally expected to reduce the variance of returns because low crop output means low crop returns. But if the farmer's output is highly correlated with aggregate output, and market demand is inelastic, then high output could mean low returns and crop insurance mght not reduce risk. In general, we need not only crop insurance but also forward sales (as in McKinnon) or, more nearly parallel with insurance, put options.

<u>Governmental</u> <u>involvement</u> <u>in</u> <u>insurance</u>: Even if farmers are risk-neutral or not risk-averse enough to generate a viable insurance market, one can be created by having the government offer insurance at a premium that does not cover all costs. Thus, in figure 1 the government could get the risk-neutral producers to buy quantity Q_1 by selling insurance at price P_0. Alternatively, in a market context, it could accomplish the same objective by paying a subsidy of $P_1 - P_0$ on privately issued insurance.

Why a government would wish to promote the use of insurance by farmers will be left aside for the time being. The point here is that the U.S. has provided crop insurance, and there has been sufficient experimentation to permit the estimation of some aspects of the U.S. demand for insurance. The relevant history was discussed above. The FCIC experiments are useful for present purposes because crop-insurance contracts for different crops in different counties vary considerably in their ratio of indemnity payments to premium payments over a long period. Figure 2 shows some relevant data. The "loss ratio" is premiums divided by indemnities. For the U.S. as a whole in the 1948-79 period, total indemnities were \$1.26 billion and premiums were \$1.21, for a loss ratio of 1.21/1.26 = 0.96 (FCIC, 1980, p. 22). Thus, if administrative costs were neglible, FCIC insurance would have been a profit-making business. FCIC estimates of these expenses add up to \$351 million for 1949-79 (Ibid. p. 17). Therefore, the economically relevant loss ratio is (1.21 + .35)/1.26 = 1.24. This figure can be interpreted as saying that there has been a roughly 24 percent subsidy to FCIC crop insurance, in the sense that a break-even (and untaxed!) private insurance industry would have charged premiums 24 percent higher. Even so, overall participation has been low as discussed earlier.

County Experience, 1948-79



Source: FCIC, Annual Report to Congress, 1980.

Empirical estimation of U.S. insurance demand: The relevant experimental data are variations in participation by crop and by county, which range from practically no participation for some Corn Belt grains programs to more than 50 percent (more than half the eligible acreage is insured) in tobacco in some Southeastern counties. The empirical question is what explains this variation.

Our first thought in preparing this part of our paper was that we could review existing studies of FCIC insurance, the time available not being sufficient for an original empirical investigation. However, it turns out that empirical work on the demand for U.S. crop insurance is scarce. In the only empirical study of the price responsiveness of demand for U.S. crop insurance in the literature reviewed above, Clendenin explained farmers' participation rates as a function of the premium rate charged. The premium rate itself does not determine the expected rate of return to investment in insurance, because the expected indemnity is not held constant. Of course, almost 40 years of further experience gives a better basis for estimating expected indemnities than was available in 1942.

The lack of empirical literature made it necessary to undertake our own investigation, and the foregoing paragraph may be taken as an apology for the sketchy nature of what we report, the time being insufficient for a full-fledged study. In particular, there are data available for thousands of observations of participation, an observation consisting of 1 crop in 1 county in 1 year. But our sample is limited to 56 observations in 1979. The counties and crops sampled, together with participation rate, premium rate, and past indemnity rate, are shown in table 1. These counties are also indicated by an X in figure 2. The sample is not a random drawing of county programs. It was selected to obtain both high- and low-participation counties and to obtain some counties

Table 1. Statistics on FCIC insurance in 57 counties, 1979.

State	County	Crop	Percentage of acreage insured	Premium as % of liability	Expected return as % of liability	Expected rate of return to insurance (%)
Arkansas	Arkansas	Soybeans	2	5.2	1.5	- 71.2
Arkansas	Jefferson	Soybeans	6	6.6	5.6	- 14.4
California	Kern	Cotton	7	4.9	4.1	- 15.5
Colorado	Cheyenne	Wheat	18	21.6	16.6	- 22.9
Colorado	Logan	Wheat	29	10.6	7.3	- 31.3
Georgia	Bullock	Tobacco	11	6.3	6.7	5.8
Georgia	Bullock	Peanuts	8	4.7	1.8	- 61.3
Georgia	Coffee	Tobacco	36	2.8	4.7	69.3
Georgia	Coffee	Peanuts	22	4.8	1.6	- 66.1
Georgia	Worth	Tobacco	22	2.7	0.9	- 64.8
Georgia	Worth	Peanuts	9	3.5	0.8	- 76.7
Idaho	Lewis	Wheat	48	3.3	3.7	11.6
Idaho	Power	Wheat	7	6.2	5.4	- 13.3
Indiana	Benton	Corn	2	2.9	1.3	- 54.0
Indiana	Benton	Soybeans	2	3.1	0.02	- 99.5
Indiana	Morgan	Corn	2	3.6	2.8	- 22.9
Indiana	Morgan	Soybeans	3	4.5	3.8	- 15.2
Indiana	Tippecanoe	Corn	5	3.1	1.7	- 45.7
Iowa	Boone	Corn	22	4.2	5.5	31.3
Iowa	Boone	Soybeans	17	3.4	2.0	- 39.7
Iowa	Cass	Corn	21	4.5	4.9	9.1
Iowa	Cass	Soybeans	16	5.7	2.7	- 52.8
Iowa	Grundy	Corn	11	2.8	1.7	- 39.6
Iowa	Grundy	Soybeans	13	2.7	0.8	- 71.6
Iowa	Hancock	Corn	10	3.9	1.9	- 51.3
Iowa	Hancock	Soybeans	9	3.5	1.8	- 49.5
Iowa	Mills	Corn	28	5.4	8.0	48.0
Iowa	Mills	Soybeans	16	5.0	2.2	- 56.2
Iowa	Plymouth	Corn	32	6.3	6.8	8.2
Iowa	Plymouth	Soybeans	25	5.0	2.9	- 41.5
Iowa	Taylor	Corn	22	5.2	7.8	50.6
Iowa	Taylor	Soybeans	19	5.9	3.6	- 38.6
Kansas	Harvey	Wheat	17	5.8	2.8	- 52.0
Kansas	Meade	Wheat	3	13.6	7.1	- 47.7
Kansas	Rush	Wheat	20	6.8	1.7	- 75.1

Table 1. Statistics on FCIC insurance in 57 counties, 1979 continued.

State	County	Crop	Percentage of acreage insured	Premium as % of liability	Expected return as % of liability	Expected rate of return to insurance (%)
Maryland	Caroline	Wheat	1	3.1	0.03	- 99.2
Maryland	Caroline	Corn	16	4.7	4.5	- 5.0
Maryland	Caroline	Soybeans	6	4.9	2.2	- 56.0
Maryland	Queen Anne's	Corn	11	3.9	3.4	- 13.7
Maryland	Queen Anne's	Soybeans	4	4.6	2.7	- 42.0
Maryland	Talbot	Corn	3	4.0	1.2	- 69.0
Maryland	Talbot	Soybeans	1	4.6	0.4	- 91.7
Mississippi	Bolivar	Cotton	13	6.1	14.5	138.4
Mississippi	Holmes	Cotton	29	3.3	5.8	74.7
Mississippi	Leflore	Cotton	8	3.9	4.8	23.5
orth Carolina	Bladen	Tobacco	41	2.3	2.0	- 10.9
orth Carolina	Lenoir	Tobacco	75	1.8	1.9	7.9
orth Carolina	Granville	Tobacco	57	2.2	2.6	18.6
orth Carolina	Halifax	Tobacco	34	2.3	2.0	- 11.6
orth Carolina	Moore	Tobacco	22	2.0	0.8	- 58.3
orth Carolina	Wilkes	Tobacco	65	3.4	4.3	26.0
Tennessee	Dyer	Wheat	14	4.9	12.7	158.8
Texas	Briscoe	Cotton	12	12.3	15.3	24.7
Texas	Dawson	Cotton	2	12.2	15.5	27.0
Texas	Garza	Cotton	6	8.8	7.3	- 17.1
Texas	Gray	Wheat	1	13.2	10.3	- 22.2
Texas	Hockley	Cotton	15	9.5	14.6	53.7

located near counties with no FCIC program for purposes of the comparisons made later in this paper. There is also some clustering in relatively few states in order to make data collection easier. However, the sample was not selected with reference to any independent variable to be used in the following regressions, so that we do not believe that sample selection bias is a problem.1/

The data that we have for each county program are the following:

Acreage insured and FCIC's estimate of potential acreage insured: The dependent varible, the "quantity of insurance" is the percentage of potential acreage that is insured. In our sample it varies from 1 in soybeans in Talbot County, Maryland, to 75 in tobacco in Lenoir County, North Carolina.

The aggregate premiums paid for each crop in each county: (Premiums are sometimes adjusted for individual farms within counties, but we do not have individual-farm data. In effect, we are treating each county as a single large farm.) In order to obtain a common representation across crops and counties of different sizes, we express the premium as a percentage of the FCIC's liability, which is the value of indemnities if the county's crop were wiped out. This way of expressing the cost of insurance is analogous to expressing the cost of a lottery ticket as a percentage of the maximum prize. It could be misleading if the size structure of prizes in a multi-prize lottery, which is the appropriate analogy for crop insurance, changes significantly. However, this does not seem to be the case in crop insurance.

The ratio of aggregate indemnities to liability for 12 years preceding 1979: Also available is the FCIC's "loss ratio," indemnities divided by premiums, for these 12 years. However, the loss ratio does not measure the

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1/However, there is unavoidable sample selection bias in the sense of Heckman since counties with no programs are excluded. This suggests a sample that may not be representative of U.S. farmers' utility functions, variability of output, or other relevant characteristics of insurance demand.

appropriate data for estimating expected returns to investment in insurance because the premiums are adjusted over time. Thus, a county with a high historical loss ratio will tend not to be as attractive an investment as the loss ratio suggests, because the premium rate will have adjusted. Indeed, in preliminary work for this research there was some question whether the expected rate of return to buying insurance would vary enough across counties to constitute a meaningful experiment, because premiums are supposed to be set to equalize the rate of return near zero by making expected indemnities roughly equal to expected premiums. For the U.S., as a whole, this is in fact close to being the case, as the 0.96 aggregate loss ratio for 1948-79 indicates. However, there is substantial variation in the expected rate of return across counties. The expected rate of return for 1979 is calculated as the 12-year average ratio of indemnities to liability divided by the 1979 ratio of premiums to liability, minus 1. The rate of return so defined ranges from a low of -99.5 percent (for soybeans in Benton County, Indiana) to a high of 159 percent (for wheat in Dyer County, Tennessee). Benton County had a low premium rate, but very little indemnity payments, while Dyer County had a premium rate almost as low, but with much greater indemnities. Other counties, such as Cheyenne and Logan in Colorado, had even higher indemnities but premiums so much larger that the rate of return was lower than in Dyer County.

OLS regression results explaining participation are shown in table 2. The coefficient of the expected rate of return indicates that participation does indeed respond to economic incentives. The coefficient of 18.5 in equation (1) implies that an increase in the rate of return of .10 (e.g., a subsidy that increases the farmer's expected rate of return from an expected loss of 20 percent of premiums paid to an expected loss of 10 percent) would increase

Table 2. Regression coefficients explaining U.S. county data on FCIC participation, 1979 (t statistics in parentheses)

dependent variable: percentage of acreage insured

independent variables	(1)	(2)	(3)	(4)	(5)***	(6)
expected rate of return	18.5 (3.9)	19.6 (4.5)	44.3 (0.8)	20.4 (4.2)	1.7 (4.9)	15.4 (3.8)
standard deviation of return	-.135 (2.7)	-.146 (4.5)	.006* (1.5)	-.085** (3.3)	-.006 (2.9)	-.100 (2.2)
return innovation		6.4 (4.6)	4.7 (2.6)	6.5 (4.5)	0.4 (3.7)	5.8 (3.6)
schooling						-.024 (1.5)
tobacco						23.2 (5.2)
part owners						25.1 (1.7)
off-farm work						-.956 (.04)
intercept	9.40	8.35 (4.9)	17.5 (3.3)	35.1 (9.1)	.70 (2.2)	25.8
R^2	.219	.432	.338	.431	.393	.630

*s.d. calculated according to equation (8) with p=1

**s.d. calculated according to equaion (8) with p=0.3

***dependent variable is log(x(1-x)) where x is percentage of acreage insured.

participation by 3.7 percentage points. Thus, to take an example pertinent to the Federal Crop Insurance Act of 1980, a subsidy of 30 percent on premiums would be expected to increase participation by 11.1 percentage points, e.g., from 20 percent participation to 31.1 percent participation.

The proponents of an expanded U.S. crop insurance program are looking for larger effects than this, and may obtain them. However, the GAO estimates cited earlier suggest that the 81 percent expansion of insured acreage in 1981 would increase participation from about 13 percent (26 million acres insured out of 200 million potential) to 24 percent, which is 11 percentage points as the regression coefficient predicts for a 30 percent subsidy. Nonetheless, the coefficient of the expected rate of return is likely to be understated in the regressions because of a serious errors-in-variable problem. The 12-year series is probably not long enough, yet the error structure of production would probably be changed in much older data. Moreover, the contract terms for indemnities have been changed over time when the loss experience suggested it. For example, the expected rate of return to the purchase of insurance in Dyer County is unlikely actually to be 159 percent. The big payoffs that generate the high returns occurred in 4 years out of the 6-year period 1968-73, with none in 1974-79.

To test for the possibility of innovations in expected returns, owing either to changes in the FCIC contracts or changes in the error structure of production, the "return innovation" variable is added in regressions (2) and (3). This is the difference between the rate of indemnity payment in the most recent two years and the 12-year average. With a stable structure, this difference should be a random variable unrelated to the dependent variable. The fact that it is significantly positive indicates that farmers indeed place more weight on recent experience, which is consistent with a changing structure.

The standard deviation of returns from crop insurance is calculated from the same 12 years of data used to estimate mean returns for each county. It is used in the absence of county data on the variability of yields. Normally, a greater variance in returns from an asset is expected to reduce the demand for the asset, which is what regression (2) shows. However, as a proxy for yield variance, this variable should have had a positive sign (the variance of returns from the portfolio of crops and insurance being reduced by the purchase of insurance). There are difficulties in measuring this variable, for one reason because our data are for counties while the relevant variance is that facing the individual producer. This becomes a problem because the relationship between individual and county variance depends on the number of farms in the county, and this varies from county to county. Carter and Dean (1960) derive the relationship between individual and county variance as

(7) σ^2 (county) = σ^2 (farm) $/N \cdot 1 + (N-1)\rho$

where N is the number of farms and ρ is the (presumed equal) correlation coefficient between the yield deviations of each pair of farmers. If ρ=1, the county standard deviation equals the individual standard deviation, and there is no problem with the regression as specified. If ρ=0, i.e., farmers' yields are independent, then s.d. (individual) = s.d. (county) $\cdot \sqrt{N}$. In this case we should multiply our county s.d. variable by the square root of the number of farms in it for the regressions. Unfortunately, $0<\rho<1$, but we do not know what the value of ρ is.[1/] It is unfortunate because if the $\sqrt{N}$ weight is used, while ρ

1/In terms of standard deviations, the s.d. of the individual farmer, which is relevant for his insurance demand, is related to the observed county s.d. as follows:

(8) s.d. (farm) = s.d. (county) $\sqrt{N} / \sqrt{1 + (N-1)\rho}$.

For example with 100 farms and ρ=5, s.d. (farms) = s.d. (county) . 1.41, while if ρ were only .1, the multiplier would have been 3.03.

is close to zero, we introduce spurious correlation between s.d. and the dependent variable.

In order to test for the important of this problem, σ^2 (farm) was calculated for each county according to equation (8), with alternative values of ρ (ρ=0, 0.05, 0.10, 0.30, 0.50, 1). Regression (2) has ρ=1 (so that s.d (farm) = s.d. (county)). Regression (3) has ρ=0, and regression (4) has ρ=.3. Using ρ=0 does result in a change in sign of the s.d. coefficient, but overall regression (3) performs worse than regression (2). Regression (4) fits almost as well as regression (2), but the negative sign on s.d. returns.

Regression (5) respecifies the dependent variable in logit form. This is done to rule out forecasts of negative participation. Regressions 1-4 predicted negative acreage insured in 1 or 2 counties. However, the logit specification does not appear to make any appreciable difference in the regression results.

Regression (3) adds other variables that may influence the demand for crop insurance. Schooling is not quite significant. If the negative sign were to hold up, it would suggest that those with more schooling are less risk averse or that they have work options that diversify their income sources sufficiently to make crop insurance less valuable to them. However, the off-farm work variable is insignificant. The fraction of part-owners in a county is marginally significant and has a positive effect on insurance purchases. This perhaps reflects the moe highly leveraged state of part-owners as compared to full owners, with creditors encouraging or requiring crop insurance as part of the security for debts. (Both tenancy and full-ownership have equally negative effects on participation rates as compared to part-ownership). Average farm size and age of farm operators were also included in a regression, but had insignificant effects.

The most significant of the added variables is the "tobacco" variable, a dummy variable equal to 1 for tobacco crop insurance contracts. Participation is 23 percent higher in tobacco, ceteris paribus. Suggestions as to why this should be the case are welcome.

Effects of Crop Insurance

The U.S. crop insurance programs were introduced sporadically and in a variety of pre-program circumstances. However, it is difficult to find "experimental" results that will permit inferences about the effects of the introduction on a permanent basis of crop insurance in an area where it previously did not exist. Many of the FCIC programs were not widely enough adopted by farmers to lead to any notable county-level effects. But the relevant data for individual farms are not available. And for some of the massively adopted but short-lived insurance progams in the 1930's and 1940's, we do not have aggregate before-and-after data.

The program that offers the best chance of observing the effects of policy intervention in the area of insurance is the disaster payments program (DPP), which covered the major grains and cotton between 1974 and 1981. This program paid indemnities but charged no premiums, and the indemnities were substantial, averaging about $400 million per year in 1974-79 (compared to $90 million for FCIC insurance over the same period). There is good data for experimental observation since there was a Census of Agriculture, generating county-level data in 1974, when the program should not yet have had much impact. (The Census was taken at about the time the first indemnities were paid). There was again a Census of Agriculture in 1978, the county data from which were published in 1981, by which time there should have been some reaction to the DPP. Therefore, the basis for our tests is changes between 1974 and 1978 Census data at the

county level. Of course, there is the problem of what changes would have occurred anyway as a consequence of other events. This problem can be evaded to some extent because of the existence of variation in the pre-1974 insurance regime.

There are a number of counties in the Great Plains and Southeast which have significant crop production but no FCIC program. Some of these are the 14 counties mentioned above whose FCIC programs were eliminated in 1956. Thus, they are counties in which production is especially risky. If the DPP has significant effects, they should show up in these counties.

Table 3 shows some data for a small sample of non-FCIC counties. The location of these counties is shown by a check in figure 2. The average payments per acre under the DPP have been greater for the non-FCIC counties, confirming that they are indeed riskier production areas. However, this is observed because the non-FCIC counties are more concentrated in the Southwest. In order to obtain a geographically comparable comparison, a sub-sample of 18 Texas and Colorado counties was compared, with 9 counties having FCIC programs and 9 counties having no programs. In this sub-sample, the non-FCIC counties received less disaster payments per acre.1/ Note, however, that the non-FCIC counties received well above the U.S. average disaster payment of 90 cents per cropland acre (last column of table 3).

The data of table 3 indicate that cropland was expanded more in the non-FCIC counties, which can be attributed to either higher expected returns or reduced risk in non-FCIC counties due to the DPP. The difference in gain in

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1/Based on payments in the 4 years, 1976-1979, for which county data were available. The 1974-75 data exist, but not in a form that could be made available in time for this study. At the national level, 1976-79 is representative of the whole 1974-79 period. U.S. aggregate payments averaged $404 million annually in 1976-79, and $420 million in 1974-75.

Table 3. County data in 1974-1978, averages per county

	non-FCIC counties[1/] (12)	FCIC counties (44)	Texas & Colorado non-FCIC (9)	Texas & Colorado FCIC (9)	U.S.
Disaster payments per year ($/cropland acres)	4.4	3.0	4.7	6.4	0.9
Acres per farm	2404	721	3068	1601	497
Cropland harvested					
1978 (th. acres)	68	193	68	231	440 (mil.)
% change, 1978/74	20.3	6.8	30.1	20.4	6.5
Crop failure					
1978 (th. acres)	13	7	16	30	5.7
% change, 1978/74[2/]	+3.9	-2.0	+4.0	-9.5	-0.4
Summer fallow					
1978 (th. acres)	20	18	27	52	33
% change, 1978/74	1.4	-0.4	1.8	-1.5	0.0
Diversification					
Herfindahl index, 1978	.634	.534	.701	.652	
change, 1978-74	.095	.044	.134	.126	
Cover crops					
1978 (th. acres)	21	26	27	52	6.6
% change 1978/74	-0.5	0.1	-0.3	-0.4	+0.5

[1/] Texas: Armstrong, Andrews, Borden, Donley, Kent, Motley, Scurry, and Wheeler;
Colorado: Kiowa; Georgia: Screven, Telfair, and Washington.

[2/] For this item and those below, percentage change base is cropland, i.e., 3.9 means 3.9 percent more of the county's crops failed in 1978 than in 1974.

expected returns between non-FCIC and average U.S. counties is 4.4-0.9 = \$3.30 per acre. With average rental value of cropland of \$40 per acre, the DPP increased the expected rate of return to land by about 8 percent in the non-FICC compared to all U.S. counties. The difference in rate of growth of cropland is 13.8 percent. Therefore, the elasticity of supply of cropland in the non-FCIC counties would have to be 1.5 or more if the difference in expected return due to the DPP were to explain the acreage expansion in the non-FCIC counties. Unfortunately, without information on the elasticity of supply of cropland, we cannot tell how much, if any, of the observed acreage expansion is due to response by risk-averse producers to reduction in risk under the DPP.

The other items in table 3 are intended to detect behavioral changes that might be attributable to the introduction of the DPP. The Herfindahl index, the sum of squared shares of crops in a county's crops, is an indicator of specialization. If only 1 crop is grown in a county, then the index is 1.0. If two crops are grown, each occupying one-half the county's land, then the index is $.5^2 + .5^2 = .50$. If one occupies 90 percent of the county, then the index is $.9^2 + .1^2 = .82$. If there are 5 crops, each using one-fifth of the land, the index is $5(.2)^2 = .20$. This index is widely used in the study of industrial concentration. Its use as a measure of specialization is discussed in Pope and Prescott. The table 3 data suggest that specialization has increased everywhere, but slightly faster in the non-FCIC counties. This is consistent with the idea that the introduction of crop insurance induces farmers to undertake riskier farming practices. This is also suggested by the fact that crop failure increased in the non-FCIC counties while it decreased elsewhere. In addition, the use of cover crops decreased in the non-FCIC counties while it increased slightly in the U.S. as a whole. However, summer fallow increased as

a fraction of cropland in the non-FCIC counties while it decreased elsewhere. Generally, it appears that the DPP encouraged crop production, specialization, and perhaps other elements of risk-taking in the risky production areas (Texas and Colorado in our sample) as compared t the U.S. as a whole, and that the DPP especially encouraged expansion in the areas that previously had no crop insurance available.

There is also evidence that the introduction of the DPP had effects in the land market. The 9 non-FCIC counties in Texas and Colorado experienced annual rates of land price increase that averaged 15.5 percent between the 1974 and 1978 Censuses. The 9 sample FCIC counties in these states had a rate of land price increase of 10.5 percent, while the U.S. average farm real estate price index also increased at a 10.6 percent annual rate between November 1974 and November 1978.

At the same time, however, the average size of farms in the Texas-Colorado sample increased more for FCIC counties (3.6 percent) than for the non-FCIC counties (-0.7 percent). And the number of farms increased at practically the same rate in FCIC and non-FCIC counties (2.8 and 2.5 percent, respectively). Thus, the DPP seems to have encouraged cropping of previously uncropped acreage, but not farm enlargement or new farming enterprises.

No test statistics have been presented on the statistical significance of these differences. Under the assumption of (1) a common underlying variance (not of yields but of land price changes, acreage changes, and so forth), and (2) counties are independent obervations, the standard F statistic cannot reject the null hypotheses of the same changes in the-FCIC counties and the FCIC counties at the 10 percent level. However, some of the differences between the Texas and Colorado counties and the U.S. average are significant. However, it

may be said that taking counties as observations greatly understates the degrees of freedom since each county figure is an average of hundreds of individual farms. In this case, if assumption (1) holds, there should be a quite small between-county variance within, say, the 9 non-FCIC counties in Texas and Colorado. In fact, there is substantial variation from county to county in most of the 1974-78 changes calculated. The standard analysis of variance test take this into account; thus I conclude that the marginal-at-best significance of the table 3 differences must be taken seriously. It will take at least a larger sample of counties to nail down the effects of the DPP. Nonetheless, the table 3 data are suggestive of some effects of the kind hoped for when a crop-insurance program is introduced. (At least they are hoped for in the LDC context; the DPP in the U.S. was not intended to promote risk-taking and output expansion in marginal production areas. The likelihood of such effects was seen, for example, by Miller and Walter, as a drawback of the DPP. The present results can be taken as a tentative confirmation of the potential problems they saw as a result of their study of Kiowa County, Colorado.[1/])

Conclusions

While the small sample size makes this more a pilot study than a definitive research project, the U.S. experience with crop insurance seems to show the following. (1) An insurance program against low yields that has expected indemnities roughly equal to premiums paid, i.e., an expected rate of return of about zero (alternatively put, an expected net cost of zero), induces participation of 10 to 20 percent of farmers. (2) U.S. farmers respond to both

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1/Miller and Walter, based on 31 years of data (1945-76), forecast average annual disaster payments of $4.02 per acre in Kiowa County. This is very close to the $4.13 per acre of total cropland actually paid out on average in 1976-79 in this county—a little less than the $4.70 average for the 9 Texas and Colorado counties shown in table 3.

the premiums charged and the expected level of indemnities, each percentage point increase in the rate of return to investment in insurance increasing the participation rate of farmers by about one-third of a percentage point. Thus, it would take a quite large subsidy, probably more than 50 percent of premiums charged, to get a majority of U.S. acreage enrolled. (3) The introduction of a widely adopted crop insurance program, as exemplified in the disaster payments program, appears to encourage crop production in marginal areas and other risk-taking in farming, but the effects detectable as of 1978 from the program introduced in 1974 do not appear dramatic, even in areas that had no FCIC coverage prior to the DPP.

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CONCEPTUAL ISSUES IN THE DESIGN OF CROP CREDIT INSURANCE SCHEMES

Andrew J. Hogan

San José, Costa Rica

CONCEPTUAL ISSUES IN THE DESIGN OF CROP CREDIT INSURANCE SCHEMES

by

ANDREW J. HOGAN, Ph.D.

Operations Research Analyst
Wisconsin Health Care Research, Inc.

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I. INTRODUCTION

This paper will address three major sets of issues concerning the design of crop credit insurance schemes. The first set of issues relates to forced consumption of crop insurance to prevent adverse selection. While this issue has been discussed in the literature before (Crawford 1977: 31-32, Maurice 1977: 14-16, Roumasset 1978), the discussion has been developed in a general indemnity insurance framework. The special features of crop credit insurance (insurance tied to publicly sponsored investment programs for farmers) has not been adequately explored. We shall see that the arguments for compulsory insurance are much more compelling in the case of crop credit insurance.

Secondly, we will review the role which crop insurance can play in a general farm income stabilization program. We will see that there are realistic circumstances under which piecemeal stabilization (price stabilization without yield stabilization and yield stabilization without price stabilization) can actually destabilize farm income. Worst of all are situations where a stabilization program is undertaken but poorly implemented -- this is particularly a problem with price stabilization which often involves the operation of large-scale storage and marketing facilities. An alternative, a rate of return insurance, will be proposed for those cases where an effective price stabilization program is lacking.

Thirdly, we will analyze some of the special problems which crop credit insurance programs face in coordinating their insurance

activities with the lending practices of the agricultural credit program which they are designed to support. The first major issue within this set has to do with the lack of coordination between credit and insurance programs in the selection of a portfolio of credit recipients. In general, it seems that the credit programs are myopic concerning the impact of their lending practices on the financial management of the insurance program. Such a lack of coordination seems likely to lead to a less than optimal allocation of public financial resources.

The second coordination issue relates to the maintenance of duplicatory field supervisory staffs by the credit and the insurance programs. It is usually argued that maintaining two field staffs keeps the credit and the insurance programs honest. It is not clear that the additional benefit outweighs the cost. Furthermore, having two sometimes rival staffs in the field clouds the climate in which effective coordination of portfolio selection can take place. An alternative recommended on a pilot basis is an in-house risk management component within the agricultural credit program, which would include crop credit insurance. This would bring risk analysis directly into the lending practices of the credit program and provide an adequate organizational framework for risk management (changing the nature and/or distribution of risk) in addition to the risk spreading benefits of insurance.

II. COMPULSION VS. FREE CHOICE

Whether crop credit insurance should be obligatory or optional for farmers requesting loans from agricultural development credit programs is one of the most important issues in designing crop credit insurance schemes. I will argue here that crop credit insurance should be mandatory. However, in order that obligatory insurance generate the maximum net social benefit, it is necessary that certain current actuarial rate setting practices employed by crop insurance agencies be abandoned.

The argument on behalf of obligatory crop credit insurance is usually made by reference to the problem of adverse selection. Adverse selection refers to the inability of the insurance program to identify certain groups in a risk pool as having higher risks of incurring an indemnifiable loss. If these individuals are aware that they are more likely to suffer a loss than the typical risk pool member, they will most certainly purchase an insurance policy since in the long run they will receive more in compensation than they paid in premiums. Conversely, a low risk individual will have little demand for an insurance policy based on the typical risk pool member. For this individual, the insurance premiums will be too high. Under such circumstances, the insurance program relying on traditional consumer sovereignity will find itself burdened with a portfolio of bad risks and an insufficient premium income to cover compensation payments.

This kind of financial crisis can be avoided by forcing all members of the risk pool to purchase the insurance policy designed

for the average risk pool member. This approach, widely followed by crop credit insurance programs, solves the problem of the financial viability of the insurance program, but it does not solve the problem of the low risk individual who pays too high a premium and the high risk individual who pays too low a premium. We will return to the possible disincentive generated in a moment.

There is another and perhaps more compelling argument for compulsory crop insurance based not on insurance management, but on credit management. Bottomley (1963a, 1963b, 1964a, 1964b, 1964c, 1969, 1975) in a series of articles on rural credit markets points out that the cost of credit consists of four components: the opportunity cost of capital, the cost of administration, a risk premium and the rate of profit. Since we are dealing here with public credit programs, we will ignore profits. The risk premium for a credit institution arises from the necessity of covering loan defaults. Ignoring administrative costs for a moment, the risk-adjusted interest rate charged by a lender can be specified:

(1) $$r = i + (1+i)d$$

where i is the opportunity cost of capital
d is the default rate $0 \leq d \leq 1$, and
r is the risk-adjusted interest rate.

The risk premium is the difference between the opportunity cost of capital and the risk-adjusted interest rate:

(2) $$\pi = r - i = i + (1+i)d - i = (1+i)d$$

where π is the risk premium.

In order for the credit program to break even, it must collect a risk premium from all borrowers to cover the losses resulting from defaults. There is a certain injustice in this system: those who repay their loans are forced to cover the losses from those who do not repay their loans. If this is not done, the lending institution will become decapitalized and all borrowers will be forced to forego the advantages of the credit market.

Hammonds and Padberg (1970) developed a simple technique for estimating the appropriate risk premium due to venture attrition: the rate of failure of enterprises or ventures within a particular line of economic activity; in the case of financial institutions, this becomes the default rate. Using a continuous discounting model, Hammonds and Padberg (1970:606) develop a formula for the risk-adjusted present value (RAPV) of a venture:

$$(3) \qquad RAPV = \int_0^T L_t e^{-it} e^{-ct} \, dt$$

$$\text{where } RAPV = \int_0^T L_t \, e^{-rt} \, dt;$$

L_t is the amount loaned at time, t;
e^{-ct} is the probability that the venture is in the existence at time, t;
and all other notation is the same as above.

We can convert this into a one-period model by using discrete discounting. (3) then becomes:

(4) $$L/(1+r) = \int_0^1 L/(1+i)\, e^{-ct}\, dt$$

Eliminating L from both sides and multiplying by (1+i), we have:

(5) $$(1+i)/(1+r) = \int_0^1 e^{-ct}\, dt$$

$$= -1/c\ (e^{-ct} \big|_0^1) = (1 - e^{-c})/c$$

Solving for r, we have:

(6) $$r = c(1+i)/(1-e^{-c}) - 1 \quad *$$

Hammond and Padberg (1970:608) show that c is the reciprocal of the mean life of the venture or, in our case, the number of loan periods before a default is expected to occur.

We see in the above discussion that the risk premium which can fairly be charged a borrower is a function of the probability of default. Most agricultural credit programs deal with defaults in one of two ways (usually after some efforts to refinance the debt): either to forgive the debt and let the borrower continue as before,

*An example: let i = .10 and c = 1/20, then r = .128.

or to exclude the defaulting borrower from the credit system. In either case, if the government does not provide a subsidy, those borrowers who do not default must cover the losses of those who do. What is needed is a mechanism to assess and collect prospectively the risk premium appropriate for a particular class of farmers. Crop credit insurance is such a mechanism.

Crop credit insurance is a financial market device to reduce the injustice of financing loan defaults. Clearly, those who will eventually default on their loans will not be willing (may not know) to designate themselves in advance and pay a risk premium sufficient to cover the cost of the credit default; this would be equivalent to eliminating defaults. Alternatively, all lenders can be asked to purchase an insurance policy against default. The insurance premium is calculated based on the likelihood and size of the default. Since many defaults result from circumstances beyond the control of the borrower (e.g. crop failures due to natural disaster), circumstances all borrowers face, it is clear that all borrowers contribute to the risk of default and can be asked to remove that risk through an insurance policy. Such an insurance policy is a highly dependable and liquid form of loan collateral. Since collateral would normally be required for all borrowers in proportion to their dependability and the size of the loan, it is not an unreasonable requirement that, in the absence of this collateral, an insurance policy specific for the crop and production environment of the loan be required. The fact that this obligatory insurance collateral program is a solution to the pro-

blem of adverse selection is more of a fortunate by-product than a goal in itself.

We can summarize this argument by recognizing that the amount of insurance-collateral which an insurer is expected to purchase is not properly a function of the borrower's risk preferences, but rather the probability of default. Thus, that a risk neutral farmer does not feel the need to purchase insurance is irrelevant. What is relevant is that the farmer presents a threat to the credit institution by his or her ability to default on the loan. With crop credit insurance, the agricultural bank asks each borrower to remove that risk by offering an insurance policy as collateral. In the absence of crop credit insurance, the bank would be forced to cover its default losses by collecting a risk premium from those who do not default. Of course, crop credit insurance as a practical matter can only reduce defaults arising from insurable risks, usually natural disasters, but these are a significant portion of all defaults.

Having shown that borrower risk preferences are not an important consideration in determining whether crop credit insurance should be obligatory or optional, we should be quick to recognize that the design of the crop credit insurance policy will have a significant impact on the benefits which arise from the credit program. I have argued elsewhere (Hogan 1981b) that crop credit insurance can significantly enhance or detract from the benefits of agricultural credit. Here I would like to review how crop credit

insurance can detract from the benefits of agricultural credit because the insurance is mandatory.

We know that persons with certain kinds of risk preferences will not purchase insurance, namely persons who are risk neutral and risk seeking. When the insurance which these persons are required to purchase is actuarially fair, little or no utility loss is incurred (see Hogan and Aubey 1981, for analytical results). Insurance is actuarially fair when the expected compensation payment is equal to the premium; premiums and indemnity payments are equal over the long run.

A risk neutral farmer will receive no benefit from insurance; such a farmer is by definition neutral to risk and does not care if the variability of the income stream is modified by insurance so long as the expected income is not changed. The expected income will not be changed if the insurance is actuarially fair.

It is commonly believed that an individual's aversion to risk diminishes as wealth increases (Leland 1968). Thus, small farmers who have successfully adopted new technology and improved their net asset positions are more likely to be risk neutral (profit maximizers) than similar small farmers who have not been as adept in their use of new technology and credit. It would seem to be a poorly conceived policy to penalize these progressive farmers in favor of their less successful counterparts. But this is what seems to be happening too often in crop credit insurance programs.

The case of Plan Puebla in the central highlands of Mexico illustrates this problem (CIMMYT 1974). The agroecological zone

used by the Mexican insurer encompasses the area to the west and south of the city of Puebla. The area to the west is endowed with better rainfall, a rich volcanic soil and a model agricultural extension program called Plan Puebla. The area to the south of the city is much poorer, drier and not as intensively encouraged. The farmers and officials of Plan Puebla have over the years complained that their insurance premiums were too high (CIMMYT 1974, Diaz 1975, CEICADAR 1979). The Mexican insurer was able to produce data showing very high loss ratios in the area as a whole. Subsequent analysis revealed that these losses were due principally to the area to the south of the city of Puebla. A ten year study of Plan Puebla (CEICADAR 1979) shows a very slow growth in the use of official insured credit and a constant turnover in the population of the borrowers. It seems that Plan Puebla farmers used insured credit principally to learn the use of the new technology and to develop a "credit history". Then they drop the insured credit and rely either on their own resources or other formal and informal lenders who do not require insurance.

The problem in Plan Puebla rests on the actuarial practice being employed. The progressive, richer farmers of Plan Puebla are subsidizing the insurance premiums of their poorer and riskier southern neighbors. The disparity is clearly enough of a disincentive to lead some Plan Pueble farmers to seek other credit arrangements. Obviously, some farmers have been discouraged from using credit altogether.

It has been claimed that this kind of redistribution policy is socially desirable. While such an argument can be made, it presents many difficulties in implementation. It is very difficult to assess the degree of impact which an actuarially unfair insurance policy will have on one group and an actuarially superfair policy will have on another group. (Note that this problem arises because we decided to force all borrowers to purchase insurance.) This is not beyond doing, but I would suggest that an adequate cost-benefit analysis will be difficult and expensive.

As an alternative, each separate risk group might be required to pay an insurance premium as close to actuarially fair as possible. Actuarially fair insurance offers no disincentive to the profit maximizing farmer and a positive incentive to the risk averse farmer. The risk seeking farmer is very unlikely to be prejudiced by an actuarially fair insurance scheme (see Hogan and Aubey 1981). Where more sophisticated underwriting techniques are not capable of remedying poorly targeted premiums, I would propose a relatively simple mechanism (e.g. a farmer having four years without a claims payment will receive the fifth year's policy free). In my opinion, farmers must be convinced that insurance is fair if they are to continue using it.

The use of actuarially fair premiums in crop credit insurance will again allow us to virtually ignore the risk preferences of individual borrowers. This is a great advantage because risk preferences are difficult and expensive to measure. The use of actuarially fair crop credit insurance which eliminates the need for

the risk premium in the interest rate offers incentives to farmers of all risk preferences to use agricultural credit productively.

III. CROP INSURANCE AND INCOME STABILIZATION

The riskiness of farm income derives from two sources: first, the variability in the price of the product; second, the variability in the physical yield. The price and the yield of a crop can covary in some systematic fashion, and depending on the direction of the covariation, piecemeal stabilization (price stabilization without crop insurance or crop insurance without price stabilization) may actually increase the riskiness of farm income. In Table 1, an example is presented based roughly on Panamaian production data.

TABLE 1

Year	Yield	Price (+)	Price (-)	Price (S)	Revenue (+)	Revenue (-)	Revenue (S)
1	19	46	31	42	874	589	798
2	29	53	38	42	1537	1102	1218
3	15	42	46	42	630	690	630
4	4	31	53	42	124	212	168
5	13	38	42	42	494	546	546
M	16	42	42	42	731.8	627.8	672
SD	8.15	7.40	7.40	0	470.09	286.29	342.2
CV	.51	.18	.18	0	.64	.46	.51
CORR		.991	-.733	0			

Table 1 presents five years of production data, the mean (M), the standard deviation (SD), the coefficient of variation (CV = SD/M), and the correlation coefficient (CORR), where applicable. The column, Yield, shows the physical yields in each of the five years, along with the summary statistics. There are three columns labelled Price. Price(+) presents five years of price figures arranged such that yields and prices are positively correlated (CORR = .991). Price(-) presents the same prices but arranged such that the price is now negatively correlated with the yield (CORR = -.733). Lastly, we present a set of stabilized prices, Price(S). Next we have the revenue streams which result from the three different price/yield scenarios: Revenue(+), Revenue(-) and Revenue(S), when prices are positively correlated with yields, when prices are negatively correlated with yields and when prices are stabilized, respectively. If we use the coefficient of variation as an indicator of relative riskiness, we see that in terms of farm income, the least risky income stream is produced not when prices are stabilized (CV = .51), but when prices and yields are negatively correlated (CV = .46). Clearly, price stabilization as a piecemeal income stabilization policy is undesirable in situations where prices and yields are strongly negatively correlated. This is not a new result (Hazell and Scandizzo 1979), but it is worth repeating.

Analytically, Bohrnstedt and Goldberger (1969) have shown that the expectation of a product is the product of the expectations plus the covariance:

(7) $$E(Y \cdot P) = E(P)E(Y) + C(P \cdot Y)$$

where P is the price,

Y is the yield,

E(.) is the expectation operator, and

C(.) is the covariance operator.

The variance of the revenue when prices and yields are distributed multivariate normal is:

(8) $$V(P{\cdot}Y) = E^2(P)V(Y) + E^2(Y)V(P) + V(P)V(Y) + 2E(P)E(Y)C(P{\cdot}Y) + C^2(P{\cdot}Y)$$

where V(.) is the variance operator.

When full price stabilization is implemented, $C(P{\cdot}Y) = V(P) = 0$, and (8) reduces to:

(9) $$V(P(S){\cdot}Y) = V(Y)P^2(S)$$

where P(S) is the stabilized price.

Expected revenue then becomes:

(10) $$E(P(S){\cdot}Y) = E(Y)P(S) \quad .$$

In terms of our measure of riskiness, the coefficient of variation, when we stabilize prices we reduce the variance of prices directly, but we also reduce the covariance. If the covariance's contribution was negative, the variance of revenue may actually rise

as the covariance is reduced (see Table 1). At the same time, the reduction in the negative covariance will increase the expectation of the product.

Depending on the distribution of prices and yields and their intercorrelation, one can generate a rather complicated criteria for determining when piecemeal price stabilization will not be effective in reducing the riskiness of revenue. The example in Table 1 demonstrates the potential destabilizing effects of piecemeal price stabilization under fairly reasonable circumstances.

Crop insurance has the effect of stabilizing yields, i.e. the resulting income stream is the same as that produced by an in-kind payment made each time yields fall below the critical level. The indemnity payment is based upon the shortfall in physical production; the compensation payment equals the physical shortfall times the market price of the product, either the market price or the stabilized price. For analytical purposes, let us consider an insurance policy which pays an indemnity for any output below the mean, i.e. the insurance forces the negative semivariance of yields to zero. Insurance does not reduce total variability as much as price stabilization, but it is directed at those kinds of variability which have negative consequences.

Nevertheless, crop insurance can under certain conditions destabilize farm income. Consider the case presented in Table 2. Here we see that in period 3 a very low income is experienced due to a low price. Since the insurance stabilizes only yields, the farmer is forced to pay an insurance premium in the time period

TABLE 2

Year	Yield	Price(-)	Revenue(-)	Indemnity	Premium	Revenue(I)
1	15	21	315	210	67.6	457.4
2	30	15	450	0	67.6	382.4
3	35	6	210	0	67.6	142.4
4	17	16	272	128	67.6	332.5
5	28	16	448	0	67.6	380.4
M	25	14.8	339			339
SD	7.72	4.87	95.82			106.12
CV	.31	.33	.28			.31
CORR		-.825				

TABLE 3

Year	Yield	Price(S)	Revenue(S)	Indemnity	Premium	Revenue(IS)
1	15	14.8	222	148	53.3	316.7
2	30	14.8	444	0	53.3	390.7
3	35	14.8	518	0	53.3	464.7
4	17	14.8	251.6	118.4	53.3	316.7
5	28	14.8	414.4	0	53.3	361.1
M	25	14.8	370			370
SD	7.72	0	114.26			55.06
CV	.31	0	.31			.15

when gross income is lowest. This leads to the insured income, Revenue (I), which has a higher coefficient of variation (.31) than the uninsured income (.28). Thus crop insurance in the absence of price stabilization can under fairly realistic circumstances destabilize farm income. This problem disappears when crop insurance is implemented in a stabilized market. Using the same production data in Table 2, we stabilize the price to produce the results in Table 3. We see that the stabilized revenue stream, Revenue(S), is more risky (CV = .31) than is the revenue stream which is both stabilized and insured, Revenue(IS), (CV = .15).

The conclusion we can draw is that piecemeal income stabilization programs can lead to anomalous situations. These situations can be rectified by implementing the complementary stabilization mechanism. In the case where price stabilization already exists, this implies that a crop insurance program could be started to guarantee against possible destabilization resulting from removing negative covariance of prices and yields. At present, price stabilization policy is not integrated with crop insurance program design. In the two countries where I have done field work (Mexico and Panama), price stabilization is undertaken only for basic grains (maize, beans, rice, etc.). Crop insurance was not undertaken because it was known that piecemeal stabilization was destabilizing farm income. Nor is it known whether income is being destabilized for insured crops which do not have their prices stabilized. It seems likely that price stabilization is more a response to the needs of urban consumers than of farmers.

Consider the problem we face when it is discovered that income from an insured crop is being destabilized by insurance, for example, the case presented in Table 2. If we stabilize the price of the crop without insurance, we experience the revenue stream, Revenue(S) in Table 3, with a coefficient of variation of .31. If we insure the yield without price stabilization, we again experience a coefficient of variation of .31, Revenue(I) in Table 2. Clearly, we are better off without either price stabilization or insurance separately; the natural income stream, Revenue(-) in Table 2, has a coefficient of variation of .28. However, if we employ both policies, we can produce an income stream, Revenue(IS) in Table 3, which is significantly less risky (CV = .15).

Thus, it would seem that governments contemplating the implementation of farm income stabilization programs may be faced with the likelihood of needing both price stabilization and crop insurance for some of the crops which they wish to encourage. While crop insurance programs are hardly trivial to fund, staff and implement, effective price stabilization is perhaps even more difficult. In most developing nations, effective price stabilization is likely to involve the government in large-scale domestic marketing activities, construction and management of large storage facilities, and the importation/exportation of foodstuffs from and to international markets. Such undertakings can be quite expensive and the managerial talent to administer them may be scarce.

If our goal is to stabilize farm income (as opposed to also stabilizing consumer prices), there is a possible modification to

actual crop credit insurance programs which will guarantee income stabilization without the necessity of a separate price stabilization program: rate of return insurance.*

Rate of return insurance is uniquely adapted to support an agricultural credit program because it focuses on stabilizing investment income. Rate of return insurance will obviate the need for price stabilization.

Gross revenue, as was mentioned above, is a function of the price and the yield:

(11) $$R = P \cdot Y$$

where R is revenue,
P is the unit price, and
Y is the yield.

The level of output is a function of the level of inputs. Inputs may be either self-financed (equity) or debt-financed (credit):

(12) $$Y = f(Q + L)$$

where Q is equity,
L is debt, and
f(.) is the production function.

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*The author would like to thank James C. Hickman for pointing out the possibility of this kind of insurance mechanism and to Robert T. Aubey for his suggestions on implementation.

The combination of debt and equity represents the total investment, and the revenue is the gross return on investment. Thus, the rate of return on investment can be defined by:

$$(13) \qquad 1 + k = P.Y/(Q + L)$$

where k is the rate of return.

The rate of return is a random variable, since it is a function of prices and yields, which are random variables.

Rate of return insurance would guarantee that the rate of return on investment made by a farmer participating in an agricultural credit program would not fall below a specified level.

For example, an insurance policy could be written to guarantee that the rate of return would never fall below -0.05, i.e. the farmers would be guaranteed to recover at least 95% of their investment. Such an insurance policy would protect farmers against poor yields in a year with average prices or a very low price in a year with average yields -- situations which would not be handled by piecemeal price stabilization or piecemeal crop insurance.

Table 4 presents sample data based on Table 2 to illustrate how a rate of return insurance might work. The yield, price and revenue data are the same as those in Table 2. The column "actual r" calculates the actual rate of return on an investment of $300. An indemnity payment will be made to the extent that the actual rate of return falls below -0.05. Two indemnity payments are made in the third and fourth time periods. A actuarially fair insurance premium is collected in all time periods and the resulting stabilized

TABLE 4

Year	Yield	Price	Revenue	Actual r	max (0, $-r-.05$)	Indemnity	Premium	Revenue(I_r)
1	15	21	315	.05	0	0	17.4	297.6
2	30	15	450	.50	0	0	17.4	432.6
3	35	6	210	-.30	.25	75	17.4	267.6
4	17	16	272	-.09	.04	12	17.4	266.6
5	28	16	448	.49	0	0	17.4	430.6
M	25	14.8	339	.13				339
SD	7.72	4.87	95.82	.32				76.43
CV	.31	.33	.28					.23

(INVESTMENT = \$300)

income is reported, Revenue(I_r). The income stream stabilized by the rate of return insurance has significantly reduced the coefficient of variation from .28 to .23. The reader can verify that if the rate of return insurance coverage were set to guarantee a 13% return on investment (the expected rate of return), the coefficient of variation would be identical to that of the insured and stabilized income stream, Revenue(IS) reported in Table 3.

There are some practical problems with implementing rate of return insurance, but it seems possible to surmount them. With ordinary crop insurance, indemnity payments are made not when yield falls below the mean, but when certain specified events occur -- hail, flood, insect plague, disease, etc. With rate of return insurance, we need to consider not only natural disasters which

affect physical productivity, but also we need to take account of "price events" as well. Even more than that, we must look at the joint distribution of natural disasters and price events. A widespread drought may force most farmers to suffer some production losses; it could happen in such a situation that the widespread decline in yields will cause prices to rise, compensating production losses and obviating the need for any insurance indemnity payments.

Thus, for rate of return insurance to be implemented, we must know yields and prices in order to calculate the rate of return. Clearly, we cannot measure the yields of each farmer, just as we cannot determine the prices which each of them receives. We can, however, sample insured acreage and product markets in areas that are candidates for low rate of return indemnity payments. Now if farmers claim in a particular area a price disaster, the insurance program can use the area average yield to determine if the actual rate of return will fall below the critical level. Likewise, when farmers report yield disasters, the area average price will be employed to determine if the actual rate of return will fall below the critical level.

These kinds of data are now collected in Mexico and Panama, although data gathering would need to be improved and accelerated. Such data are crucial to planning for the agricultural credit program, and collection does not really represent an additional expense above and beyond what is already required.*

*Recent changes in the Federal Crop Insurance Corporation program in the U.S. come very close to a rate of return insurance. See Miller (1981) for details.

IV. PROBLEMS IN COORDINATING AGRICULTURAL INSURANCE AND CREDIT PROGRAMS

In the first section of this paper it was pointed out that the primary role of crop credit insurance is to help control defaults in agricultural credit programs. In the absence of crop credit insurance, the agricultural bank will evaluate lines of credit according to both the expected social benefit and the threat which they present to its financial viability (the probability and magnitude of default). The process of portfolio selection by the bank will attempt to balance the goals of social benefit and financial viability.

As was explained above, crop credit insurance provides a superior mechanism with which to deal with defaults in publicly sponsored credit programs. The mere existence of an insurance program does not mean that the management of those defaults covered by insurance becomes a trivial matter. Ideally the insurance program would wish to assemble a portfolio of crop credit policies which is so balanced that claims and premiums would virtually balance out in each production cycle. Large fluctuations in the level of claims over time will force the insurance agency to maintain large reserves against loss. These reserves will have to be generated either by increasing premium rates or by government subsidy.

Elsewhere (Hogan 1981a, chp. 4), it was shown that crop credit insurance programs are institutionally constrained in the management of their portfolios. Crop credit insurance agencies are

usually limited in the planning stage to approving or rejecting new lines of credit as insurable on a case-by-case basis. How a new line of credit will affect the overall insurance portfolio is not a consideration. At the operations level, the agricultural bank determines which farmers will receive credit. Borrowers are, of course, obliged to purchase crop insurance, and with rather limited exceptions, the crop insurance agency is obliged to sell each credit recipient a policy regardless of the impact on its portfolio.

The agricultural bank has been freed from concern for certain kinds of loan default and may well find it convenient to expand lines of credit to classes of farmers who would have been previously considered too risky. In doing so, the bank may choose its portfolio in a way that seriously undermines the financial viability of the crop insurance program. Such difficulties could be overcome by close coordination of portfolio selection in the two institutions. This kind of coordination is not presently in evidence in the programs with which I am familiar, nor will it be easy to achieve given the institutional rivalries which exist. Below I will discuss a possible solution to this problem. For the moment, the reader should be cautioned that some criticisms of crop insurance as too expensive (Roumasset 1978, Gomez 1976) have ignored these institutional constraints on the crop insurance program. Evaluating crop credit insurance programs with the same standards as one applies to a private life insurance program will produce very misleading results.

The second major problem area in coordinating crop insurance and agricultural credit programs is field supervision. The actual design of crop credit insurance schemes involves the maintenance of a separate field staff whose role is to supervise client farm operations. I have been able to detect little difference in either the kind of field personnel employed by crop insurance and agricultural credit programs or in the kind of supervision provided. There can be little doubt that the field personnel of the credit programs, mostly agronomists, are professionally capable of carrying out the supervisory functions performed by the field staffs of the crop insurance agency.

Why, then, do we have a separate field staff for crop insurance? The answer seems to be institutional rivalry. Because the credit program is operated by a separate institution, its field staff cannot be trusted to defend the interests of the crop insurance program. The existence of poor relations between the two programs in Mexico and Panama is not a well-guarded secret. Furthermore, this does not seem to be due to any special quarrelsomeness of agricultural bureaucrats in either country. Tha actual design of the crop credit insurance program encourages this kind of rivalry and lack of coordination.

The maintenance of a secondary supervision field staff is the single most expensive operational cost of a crop credit insurance program. Since there is no technical reason why agricultural credit personnel cannot perform this supervisory role, it is logical to ask: is there some way to redesign crop credit insurance programs

such that the secondary supervisory staff component can be eliminated? I think there is. The crop credit insurance program can be directly incorporated into the credit program. I would suggest that the crop credit insurance program become a major division within the agricultural bank with the program chief directly responsible to the director of the bank.

The benefits of such a re-organization are considerable. First, the redundant field staff would be greatly reduced. I would be surprised if a fifty percent reduction in field staff were not possible. With some administrative streamlining, more field staff and some administrative staff could be eliminated as well. Second, the problem of inter-institutional coordination is resolved. By incorporating the insurance function into the credit program, the bank now becomes responsible for the risk magnifying effects of its own portfolio selection process. The bank will not be able to export to another institution the financially destabilizing impacts of its decisions to loan to farmers with high default risks. Lastly, the merger of the bank and the insurance program will create an environment in which risk management can flourish. At present, the crop credit insurance programs are peripheral to the design of new agricultural technology and new lines of agricultural credit. With the insurance program housed within the bank, incentives to explore means of actively managing risk by design and research will be present. I have been surprised by the passivity of the crop credit insurance programs which I have visited; I do not believe that this

passivity can be fully overcome without a redesign of the institutional structure of the agricultural credit system.

The principal criticism which this proposal for redesign is likely to find is that the bank will mismanage and exploit crop insurance to disguise its own managerial shortcomings. I would respond that this is precisely what is happening now, and that crop credit insurance programs are helpless to overcome major managerial mistakes in the agricultural credit program short of abrogating their principal role of supporting that same credit program. To put the question in the jargon of finance, crop credit insurance is a "contingent project" whose social benefits derive from enhancing the benefits generated by the "independent project", the credit program. Crop credit insurance is not capable of turning a poorly run credit program into an effective one.

V. SUMMARY AND CONCLUSIONS

In this paper three major issues were addressed:

1. Should agricultural credit programs require their clients to purchase crop credit insurance?
2. What role can crop credit insurance play in the stabilization of farm income?
3. How can crop credit insurance be coordinated with agricultural credit programs?

In response to the first issue, it was shown that the crop credit insurance premium was merely a substitute for the risk premium which borrowers would normally pay to a lender unless they

were able to offer adequate collateral. Since crop insurance requires that those who produce the risk pay for it, in distinction to the risk premium which is paid by those who do not default, crop credit insurance is more economically efficient and more equitable.

In response to the second issue, it was pointed out that piecemeal stabilization (crop insurance without price stabilization or vice versa) can destabilize income in certain instances. Thus, stabilization programs must be better coordinated to assure that disincentives are not created. For circumstances where a sponsoring government is unable or unwilling to provide a price stabilization mechanism to complement a crop insurance program, a rate of return insurance was proposed. Rate of return insurance would assure the farmer a minimum rate of return on investment and could be tied directly to the agricultural loan. The administrative requirement for a rate of return insurance is likely to be less onerous than those involved in operating both a crop insurance and a price stabilization program.

The last issue of inter-institutional coordination led to the suggestion that crop credit insurance programs be organizationally incorporated into the existing agricultural credit program. The redesign would resolve the difficulties in coordinating insurance and credit programs, the lack of which has tended to undermine the financial viability of the insurance program. It would allow for the consolidation and streamlining of field operations. Lastly,

this consolidation will create a better framework in which creative approaches to risk management can be developed, which are neglected under the present fragmented institutional structure.

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"PLANNING FOR THE EFFICIENT OPERATION OF CROP CREDIT INSURANCE SCHEMES"

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William M. Gudger*
Luis Avalos**

San José, Costa Rica
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*Head of the Division of Agricultural Insurance and Credit, Inter-American Institute for Cooperation on Agriculture (IICA). P.O. Box 55, 2200 Coronado San José Costa Rica.

**Specialist in Agricultural Insurance, Inter-American Institute for Cooperation on Agriculture Office in Ecuador, P.O. Box 201-A, Quito Ecuador.

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"PLANNING FOR THE EFFICIENT OPERATION OF CROP CREDIT INSURANCE SCHEMES"

1. INTRODUCTION

The three preceding sessions have focused upon insurance and farmers, public policy and their design. These discussions have been theoretical in their majority and built principally upon economic and financial analysis.

Session IV, and in particular this presentation, requires a change of focus and of modes of analysis. The starting point for the present paper is an expressed desire of a government (or more properly someone within that government) to establish an agricultural insurer. Assuming the expression reaches an institution capable of responding --be it national or international-- what are the processes required to build an institution capable of assuming the new and specific function of agricultural insurance.

Our mode of analysis is very much one of the rational "conscious actor". We do not believe that viable "efficient" institutions such as insurers have much possibility of developing without a guiding hand capable of shaping their structure and function. This paper takes the view of a practicioner called upon to assist in planning an insurer and at the same time working jointly with national staff to preside over its establishment and initial operation.

Many times the situation that the agricultural insurance professional confronts is the following: A group within national government has decided that the country should establish an agricultural insurer. They frequently have little idea about the internal mechanics of such insurers for they operate at the policy level and delegate operational responsibilities. Thus the focus of this paper is what happens once a government (or some part of it) says in effect "Yes, we want to establish an agricultural insurer. What can we do to maximize the possibilities of creating an efficient operation within the constraints imposed by the political and economic system?".

Over the last five to ten years there has been a renewal of interest in Latin America in agricultural insurance as an instrument to protect both farmers and lenders from decapitalization. This interest is not the first time that agricultural insurance has reached the public agenda. It has in fact been discussed since the 1930's and some countries such as Mexico (1960) and Costa Rica (1969) have established public sector insurers. In other countries, such as Argentina and Brazil, experiments have not proven overly successful.

When again the countries of the Western Hemisphere began considering the possibility of establishing agricultural insurers, the situation had begun to change. They found an installed technical assistance capability and a very new but growing body of knowledge about the field of agricultural insurance. This new group installed in IICA was able with its limited resources to assist several countries to conceptualize, plan and establish insurers. Those insurers are carrying out pilot programs in Ecuador, Bolivia and Venezuela in addition to an expanded program in Panamá. At the same time these countries serve as research laboratories to develop more information about the socio-economic impact of agricultural insurance as well as the administrative and financial techniques required for the successful operation of the schemes.

After three years of work and experimentation it is possible to offer some tentative finding on what this seminar's organizers' have called the "efficient operation" of crop-credit insurance. Although these conclusions do go beyond most of the little existing literature, we should like to stress their tentativeness. They are based upon three years of field work in a limited number of countries during average to excellent agricultural years. On the other hand, the work has been carried out under a very wide range of socio-economic and political conditions which characterize most of Latin America and the developing world. It is within this context that we offer a summary of our work.

2. SOME DEFINITIONS

Lewis Carroll had one of his characters in Alice in Wonderland, the Queen of Hearts most likely, remark that words mean "exactly what I say they mean". As we are working in a new area where there is not a large literature that has worked out a precise set of definitions for all the terms, we would like to start with a short terminological exercise.

2.1 A Concept of Planning

Our concept of planning is briefly the process of bringing talent, organization and money together for the solution of an agreed upon problem. We concieve "planning" in our work as a series of interrelated, ongoing activities which begins with a statement of the problem, procedes the organization of institutional structures, recruitment of talent and negotiation of finance. At this stage, planning does not stop; it is instead the ongoing activities of monitoring, testing, modifying, and gradually expanding operations to the entire agricultural sector. As we face an almost totally unknown set of problems associated with agricultural insurance, our planning process is continuous and dynamic. We begin with a very small pilot project and gradually expand our program, learning and innovating as we grow larger and expand to insure more productive activities. Thus, planning is for us an ongoing process of channelling talent and resources and developing innovative organizational structures to meliorate conditions that we have encountered in the agricultural sector so that we may both strengthen and improve the range and quality of services that we are able to offer. Our conception of "planning" goes beyond a static concept of "design". For us planning is the continuous activity of adapting the insurer to changing internal and external factors so that it may respond effectively and operate efficiently.

2.2 "Efficient Operations"

Few terms are as value - ladened as "efficiency" and perhaps none more difficult to define. In establishing new financial institutions, (i.e. the insurers) we attempt to: 1) Develop institutional structures which can

persist over time; 2) Which possess reasonable autonomy over important areas of decision-making (who to hire and fire, what to insure, how to insure it and at what cost); 3) Are financially viable over the long term; and 4) Are capable of steady incremental growth and expansion, while learning from their past experience.

Each of these admittedly arbitrary criteria is in itself an area in which social, economic and political variables must be carefully weighed and balanced against other constraints that exist in the "real" world of developing countries. The process of developing new institutions requires a close study of the political process and personalities, of "relevant others" in the sociologists' argot. Within this political framework one has to review the legally possible structures and the administrative norms and practices that characterize each. These factors must be combined with an appraisal of the present and future finance available for the insurer. Finally, one must honestly evaluate the quality of managerial talent available and the likely ability of this management to sustain growth and expansion.

Thus, for us "Planning for the Efficient Operation of Crop Credit Insurance Schemes" is a dynamic interactive process of locating and bringing together expertise, finance and institutional structures within the existing socio-political and economic framework so as to create a new financial entity that will increasingly become an institution capable of serving both borrowers' and lenders' needs. As planning implies a planner, the role of the technical assistance group is to act as a catalyst, a coalition builder, a negotiator, and a technical resource to those who actually carry out the work.

3. INSTITUTIONAL STRUCTURE

It is likely that no single planning decision is as important as the institutional structure of the new insurer. To a very significant extent, the structure will influence the method of operation; it will open or close many opportunities for growth. Structure will be an important variable in managerial control and even the content of managerial decisions. It will

affect the ability of the insurer to sustain the "worst possible loss" or the "drought (or flood) of the century". Administrative structure may in certain cases open the insurer to exogenous decision making based upon other than technical grounds, be that for better or worse. Likewise, the administrative structure will very strongly affect the ability of the insurer to have its product made obligatory and thus will affect operational costs and diversification of its portfolio. Finally, the administrative structure and the autonomy of managerial decision making will bear upon the ability of the insurer to either purchase reinsurance under favorable terms or to arrange exchanges of portfolio with other reinsurers.

3.1 A Public Institution

At the outset, we worked with an inherited concept of the process by which an insurer was formed. Historically most agricultural insurers have been the product of legislative enacments. Almost without exception, these insurers have been public sector entities provided with finance from the treasury and with direction, guidance or control from other public sector entities. In many cases, the insurer forms part of the agricultural bureaucracy under the control of the Ministry of Agriculture. Thus, the insurer serves as part of the overall agricultural policy apparatus.

There are very distinct advantages to utilizing the legislative process. The insurer once established, is almost certainly a permanent bureaucracy. As a government agency it has priority access to the budget. Likewise, it can more easily work with other government institutions such as banks and ministries. Finally, the government is usually willing to guarantee its financial solvency from its own resources or from loans, grants and guarantees obtained abroad.

This would seem to be a very strong case indeed for a public sector insurer created by legislative fiat. However in practice the creation process is lengthy and beset with a series of problems. In the American context, it has been remarked that a camel is a horse created by a congressional committee. Many agricultural insurers around the world have failed because of poorly drafted legislation or because of the impact of

special interest groups upon the final legislation. The legislative process can risk the dilution or loss of technical control of structure.

It is also usual that insurers created by legislative action will operate under the personnel rules of the public sector. The results are frequently that the insurer is staffed with the "discards" of other ministries or with inexperienced but politically well connected management. Frequently, neither staff nor management are held to any other than financial accountability criteria (and sometimes not too strictly to those).

Public sector institutions confront a very serious problem of innovation. It is usual practice for legislatures to write restrictive legislation and to require congressional approval for modifications. Likewise, management seldom has the ability to innovate and initiate new and experimental programs. As agricultural insurance is a new and experimental field which requires a constant process of innovation, situating the insurer in the public sector can poise substantial problems. Finally, in a public sector insurer technical decisions such as premium rates, coverages, underwriting and loss adjusting criteria frequently have a political dimension.

The problem of a public sector insurer can farther be complicated in developing countries which are reluctant to accept all the risk inherent in a large scale program. Indeed, many do not have the liquid assets at any given time to pay the maximum possible loss. The solution is to utilize the international reinsurance market to arrange intertemporal resource transfers. At the moment, the position of the largest international reinsurer is that they are not interested in public sector, all risk agricultural insurance in Latin America. Once burned by a Latin American president who declared a total disaster just before an election, twice wary. Reinsurance may be available to government reinsurers. Indeed countries as diverse as Panama and Israel have reinsurance contracts. However, the coverage is extended only if and when reinsurers can be certain that the socio-political risk of decision making on other than technical grounds has been minimized. While there are means of reducing the socio-political risks in the process of preparing the basic law and, far more importantly, in

writing the insurers' by-laws, this risk will to some degree be present*.

There is then a trade off. Entry into the government club requires payment of a high membership fee and fairly large maintenance fees. On the other hand, once a member many financial problems are reduced but administration can be complicated by the internal rules.

3.2 A Mixed Capital and Fade Out Ventures

No where is it written that immutably the insurer must be in the public sector. Historically, most have been government agencies. As we have seen there are distinct advantages and some quite severe drawbacks to establishing a public sector insurer. As a means of trying to meliorate the problem of politically motivated decision making and at the same time provide more flexibility than offered by public administration, we are experimenting with a mixed capital (hopefully) fade-out venture which will in time produce a private sector, non-profit insurer.

The Ecuadorian insurer, CONASA, was established as would be a regular stock company. Only enabling legislation of one paragraph was required; the establishment of the company followed the procedures established by the commercial code and the insurance regulatory agency. The stock was purchased by both public and private entities. At the outset, the public sector holds an overwhelming capital position. In addition, the Central Bank supplied the reserve. However, the bylaws are open to (and management openly seeks) new investors from the private sector. Cooperatives, mutual aid associations, organized producers, and other service or financial institutions** can supply capital and participate as members of the board of directors.

The insurer is in the private, non-profit sector and as such operates as an idependent entity controlled by its Board of Directors and regulated by the insurance laws of the country. The insurer is thus outside the

*One obvious solution is for the reinsurers to develop a loss verification capacity. The market, however, is still far too small for this to be practical.

**Unfortunatly, Eduadorian law prohibits the participation of banks in the capital structure.

government heirarchy and operates under its own rules and bylaws.

The mixed capital enterprise is more than an alternative way of structuring capital; it profoundly alters the decision making environment and the scope of managerial autonomy and entrepreneurship. To the extent that the board of director functions effectively, important decisions are made collegially at open meetings instead of heirarchically with in government bureaucracies. Likewise, a wider variety of interests are represented. The manager has relative autonomy of the technical decisions and considerable independence in personnel policy and investment strategies. The institution thus escapes the rigidity of public sector bureaucracy and to a substantial extent the risk of politically motivated decision making.

This autonomy has its price however. The insurer has no priority access to public funds and may not be tax exempt. It likewise must negotiate a government "full faith and credit" guarantee as well as exhibit considerable entrepreneurship in obtaining additional reserve capital and an operational subsidy. Most of these problems are medium term ones. To the extent that a mixed capital insurer can overcome the initial capitalization problem through government grants, soft loans, guarantees, and other financial instruments and to the extent it can arrange adequate reinsurance, it has a very good chance of becoming a viable insurer.

A mixed capital insurer imposes one other severe constraint: The quality and dynamism of management become extremely important. The initiative to grow comes from within the insurer; it is not simply imposed by legislative or executive action. Thus, there is both an opportunity for dynamic management to move quickly; likewise, an overly conservative management may build a small, insignificant, ineffective insurer. The imperative of reducing the extremely high costs of supervision are also placed upon the management which can either respond with innovative cost cutting strategies or select a small relatively low cost clientele. There is then a marked risk of stagnation without dynamic management.

3.3 The Private Sector Alternative

A private sector agricultural insurer would not seem to be a viable choice under conditions of development. Private sectors are not likely to put at risk very large volumes of capital on an unproven and probably unprofitable enterprise without very substantial guarantees from the government. There is also the policy question of whether one would wish to introduce a for-profit insurer.

There are around the world a number of private sector agricultural insurance schemes. In Spain, the private sector carries out a limited risk program with very heavy government reinsurance and an administrative subsidy. The U.S. has numerous crop-hail insurers. Last year a private Chilean company began an insurance program for fruits and grains. The Swiss have operated a private sector insurer for many years.

Almost all the institutions are characterized by their small size, limited clientele, and inablity to sustain catastrophic losses. While the Spanish system can survive due to heavy concessional reinsurance from the government, most other programs run by private companies could not. Likewise, there is always the risk that management and investors will seek more profitable, less risky investment alternatives. Indeed this has happend many times. One would certainly wonder at the rationality or perhaps even sanity of an investor who would reinvest in an agricultural insurer that had been hit by very adverse experience.

There is however a form of private sector insurer which may be viable under certain circumstances. Above we have cited the interesting case of the government dominated mixed capital insurer which is attempting to steady reduce government participation. In Bolivia, we have developed a modified strategy of creating a private sector non-profit mutual. The Bolivian insurer, ASBA, began as a government institute but is evolving toward a mutual in which the insureds themselves are the owners of the company. In Bolivia, the insureds and the owners are one and the same but with a professional management to function as an intermediary and to protect the company's assets.

4. FINANCIAL PLANNING

Frequently, even before recovering from jet lag, we are told "Yes, yes we know all about crop credit insurance,but how much does it cost". How much it costs is composed of two very distinct types of costs; one we can estimate with considerable precision, the other is at the outset very problematic. In operating an insurer, one must plan for the administrative costs plus the contingent costs. The former are composed of the central office staff, the field staff, and the operating costs. The latter are comprised of indemnity costs and the cost of establishing, and in the case of adverse experience replenishing,a reserve for the insurer.

4.1 Administrative Costs

Administrative costs are relatively easy to estimate once a program size is decided upon and a medium term growth plan is laid out in its broadest parameters. The central office staff should as a very general rule not exceed 5 or 6 persons at the outset and may be expected to grow to 10-15 during the next five to eight years. The central office's staff is responsible for planning, product development, interinstitutional relations, budgeting, accounting, policy emission, claims processing and payment and control of the field staff. There has been a tendency to contract an overly large and highly specialized staff composed of lawyers, certified accountants, and actuaries. These professionals will not be fully utilized in a new insurer. Instead, at the outset what is required is a core staff of managers capable of designing and implementing all the administrative, accounting and auditing functions of the new insurer. At current prices in Latin America for pilot projects, our experience has been that this cost is about $120,000 per year, plus a one-time $100,000 start up expenses. The rate of growth of the central office should be relative slow, perhaps reaching $150,000 per year in the fourth or fifth year.

At the outset, it is critical importance to develop a personnel plan that carefully lays out what specialists will be contracted and when so as to avoid costly overstaffing. There is a marked tendency to over-staff new institutions and thus raise the administrative costs. The central office's

functions can be routinized with only two exceptions. The Central Office requires a research and product development specialist to test the acceptance of the product among the insureds and to develop new lines of insurance and new ways of doing insurance to meet the perceived demands of the clients. The second function which escapes routinization is the managerial function.

We have discovered that very considerable savings can be made by quickly moving from a manual to a computerized information system for personnel, for individual insured's records and for budgeting and accounting. Again, the tendency to overbuy must be avoided. Small computers that can be integrated into larger systems are quite adequate for the first 10 years of the insurer's life. It should be borne in mind that an agricultural insurer requires a relatively small on-line capacity, given the cyclic nature of agriculture.

Finally, the central office should resist a tendency to permit the staff to grow as the program grows. Additional insurance can be undertaken without necessarily increasing staff. At the outset, the insurer will probably have relatively few policies to service and thus the number of policies per person will be very small. Most insurance policies do not require other than routine processing and can be handled quickly. It is when indemnities are to be paid that the amount of time per policy increases. The initial staff of 5 to 6 persons should handle 3,000 policies without difficulty with a small computer system. Again as a very general rule, an additional staffer will be required for each 2,000 policies up to about 10,000. After that, new staff should not be required until the insurer is of a quite large size.

At the outset, a monitoring system should be established to insure that the administrative costs per hectare or per unit of coverage are steadily declining. The impact of new hiring on this ratio should be carefully watched. Likewise, management should for internal purposes segregate the central office costs and insure that these costs decline rapidly at first and steadily thereafter as a percentage of total costs of the system. At some point (rather distant we think) an equilibrium will be reached. New personnel and administrative costs should be measured against this ratio

to ensure that the administration remains efficient.

There is in Latin America a marked tendency to overstaff central offices. Part of this arises from a lack of systems designed to monitor and contain costs and part of it arises from the quite natural tendency of personnel to want to move from field operations to more attractive urban living conditions and usually higher paying jobs. Efficient operations requires that management establish monitoring systems that measure the impact of hiring as well as internal personnel transfers upon the administrative cost/coverage and the administrative cost/total costs ratios.

4.2 Field Operations Costs

The second element of the administrative costs are the field operations costs. These costs are much more problematic as they vary according to the method of operation selected; the infrastructue, both human and physical; and the loss experience. If the insurer must undertake functions that are related to insurance but usually performed by other agencies such as credit supervision or extention work, the field costs will rise considerably. Likewise, if field agents are assigned to zones with small scattered holding or ones with little physical infrastructure operational costs rise. Our experience demonstrates that the major cost of field work is to put the inspector on the farm. Once there the marginal cost of additional inspections on ajoining farms is slight. Larger, more educated farmers are less costly to service than are their smaller counterparts; likewise monocultures are less expensive to service than are highly diversified farming systems.

In planning for operations, these factors play a key role in determining how many insureds are assigned to each inspector. The ratio will vary as dramatically within countries as between them. For example, in Panamá, a country characterized by relatively easy access, relatively dense numbers of insureds in a zone and relatively commercial agriculture, a single inspector may be able to provide insurance services about 1,200-1,500 hectares and perhaps 120-150 farmers with basic insurance inspections and

a modicum of technical assistance. Bolivia, on the other hand, is characterized by extremely limited infrastructure; small, scattered plots on mountainsides; and a subsistence potato monoculture. Under these conditions, it is extremely difficult to service the farmer. This difficulty is further complicated by cultural and linguistic differences. In Ecuador, the mountains of the country are much like Bolivia while the coast is similar to Panamá.

It is clear, although an exact quantification is elusive, that field operations costs are quite high in absolute terms. A very substantial portion of this cost is due to the fact that other institutions, such as extention services, do not exist or do not function well, as is the case with credit supervision. To protect its financial interests, the insurer must assume many of these functions.

A cost containment program to lower these operational costs should be comprised of several elements. First, the insurer must work with other institutions to attempt to obtain the required extention and supervision among the insureds. As a condition for protecting the bank against lack of recovery, the bank should provide effective credit supervision. Working with rural integrated development projects offers another cost reduction strategy. Land tenure can also be used to reduce costs. By offering reduced premiums or increased coverages to groups, operating costs can be lowered.

Internally, the insurer must plan carefully to reduce field operations costs. The cyclical nature of agriculture offers the single largest opportunity. In most countries of Latin America, a second production cycle is possible with irrigation (or ocassionally drainage). Likewise, the mountainous topography creates microclimates suited to quite distinct production cycles. Permanent crops also offer opportunities. An insurer must carefully plan to utilize the field staff year around to the extent permitted by the environment. Since dry cycle agriculture is irrigated and quite capital intense, it may be possible to triple, even quadruple, the total amount of coverage (the basis upon which premium is calculated) under the control of a single agent. Cross-training in livestock and/or fish pond

insurance will further increase efficiency. Moving inspectors from zone to zone, however, is seldom advisable except for short periods of intense activities, such as occur at seeding and harvest times or following disasters, as the subsistence and travel costs offset any gains. Thus a careful selection of the portfolio will impact upon the cost and relative efficiency of the insurer's field staff.

Other strategies of cost-containment that are recommendable are the training and utilization of part-time agents and the use of self-reporting systems for certain clients. Training of village personnel to carry out some of the more routine task will significantly lower costs. Many of the inspections do not require the presence of an insurer's agent or can be spot checked at a later date. For example, there is little need for an inspector to verify the amount of land insured and then return to verify an adequate germination. Likewise, limited damage by many phenomena such as hail can be reported by a paraprofessional.

Insurers can also "grade" their clients by their past records and gradually reduce inspections for clients who have few problems while concentrating on those who have losses year after year. Hard pressed inspectors do this almost subconsciously; it should be formalized with clear criteria and with a financial incentive such as reduced premiums for the better insureds. Spot checks and random sampling techniques can determine if the fraud losses exceed the administrative cost savings and detect and remove some of those who cheat on self-reporting and limited inspection systems.

Finally, the efficiency of the agents themselves should be carefully monitored and spot checked for veracity and accuracy. Both the number of field checks performed and the accuracy of the adjustments performed should be monitored to insure that the field staff is performing effectively.

4.3 Financing the Administration

Developing countries almost by definition are capital short. Excepting the petroleum exporters, few are in a position to assume additional financial

obligations against the general fund. Quite frequently for social and political reasons, they are unwilling to charge the whole cost of administration to the insureds.

This situation requires considerable creativity,flexibility and entrepreneurship on the part of the planners to create a viable financial system. Although each case is distinct, even unique, we would like to generalize about the possibilities of financing agricultural insurance. The options that we identify are by no means an inclusive list; they are instead some alternatives that we have found to be feasible.

At the outset, a planner must have a clear idea of how public and private financial institutions operate in the agricultural sector. There is a tendency to view an insurer as yet another expensive bureaucracy. Indeed, it may be without careful planning. Since under a crop credit insurance scheme, the insurer reimburses the bank for natural losses, the total amount of money flowing in the credit system is roughly the same. Lenders should require less frequent recapitalizations and should have lower loss ratios. To the extent that extention,marketing and other services are available, the insurer can confine itself to relatively low cost pure insurance functions. These functions' cost, from a systemic viewpoint, replace the carrying cost of unpaid bank loans. These costs have been estimated at about $50 per year per loan For considerably less, a well designed insurer should be able to service a client.

Thus, two options for finance can be explored. Frequently, the recapitalization of lenders is an onerous burden economically (and sometimes politically) that falls unexpectedly upon the government. To lower the frequency, governments will frequently agree to cover part of the administrative costs of an insurer from general revenues or from a special fund that would be destined to recapitalization. Quite frequently central banks have rediscount operations. A percentage point or two of the interest rate differential for funds flowing to agriculture can finance part of the administrative cost.

Banks are the direct beneficiaries. They should show considerably higher recover rates under insurance. Their risk is substantially lower with insured clients; their operating costs should likewise decline. Under these circumstances, banks can on a "fee for service" basis destine a percent or two of the interest charged to the borrower to cover the administration. Alternatively, banks may be asked to establish a revolving fund capitalized by the increase in the recovery rate to help finance the insurer. This fund would be divided between the bank and the insurer according to preestablished rules.

These two sources, general revenues destined to recapitalize lenders, to operate rediscount systems, and to pay the carrying costs of the lending banks, poise few policy questions. The money is roughly the same; it merely flows in a different manner. The most salient policy problem of the administrative cost structuring is what, if any, portion of administrative costs should be charged to the farmer.

The arguments for and against charging administrative costs tend to follow those about subsidized interest rates; indeed they frequently are taken directly from them. Our own experience is that agricultural production is characterized by so many disarticulated direct and indirect subsidies, cross subsidies, incentive, disincentives and penalties at all steps of the production process that it is very difficult indeed to generalize about the desirability or the financial ability of the insureds to bear the administrative costs.

As a general rule, we recommend that the subsidy arrangements be made explicit. Instead of absorbing a specified percentage of these costs, we recommend that the decision making be disaggregated and the decision be taken by the government on a crop by crop basis. It would therefore be possible to target subsidies to socially and/or economically desirable options. If an administrative subsidy is offered, we would strongly urge it not be offered in the same way as a general interest rate subsidy but instead on a more selective basis. The insurer can each year estimate the

cost of servicing a given clientele and negotiate with the government what portion it will bear. In all cases, it is highly advisable that the entire premium paid by the farmer be financed to ease his cash flow problem, irrespective of whether the premium is pure risk premium or risk premium plus administrative costs.

In addition to domestic sources of finance for administrative costs, external grant or loan funds may be available from international donor institutions. These funds should be considered only as short or medium term sources of finance; it is unrealistic to believe an external subsidy is likely to do more than help offset the initial costs. Financial planning must from the beginning plan the replacement of these funds with domestically generated ones. The most useful role of these funds is to help cover the extremely high per units costs during the experimental period of the first 5-10 years. Any such grants and concessional loans should identify sources of replacement and contain a gradual fade out schedule.

4.4 Capitalizing and Maintaining Reserve

The administrative costs are sure and certain costs whose magnitude can be estimated with reasonable precision. The reserve, on the other hand, is a contingent cost. At the outset, little is known about the loss experience to be expected. A reserve set at almost any level may be consumed in its entirity or left whole. Thus structuring a reserve poses a pecular problem: the charges to be made against it are the product of stochastic variables such as wind, drought, and freezes. At the outset, neither the frequency nor the magnitude (severity) can be estimated in other than a rough manner. If these problems did not present a sufficient challange to planners, they must bear in mind that agricultural insurance has a catastrophic loss potential, and the events producing losses can not be assumed to be independent of each other. A widespread drought can easily destroy the agriculture of a region or nation. There has been no rain in Spain in all of 1981, and over one-half the agricultural production is destroyed. Ecuador recently completed two year drought. The American and Canadian breadbaskets are hit with relatively frequent droughts.

The sources for capitalizing a reserve are much the same as those for covering administrative expenses, and thus need not be repeated. The accumulation of the reserve, however, may be gradual, with increased amounts destined to the reserve as the insurer's coverage increases year by year.

The fact that the reserve cost is a contingent cost offers a considerable opportunity that should not be passed over by planners. An insurer need not hold a reserve equal to the maximum probable loss; it need only have the means to cover this loss should it occur. Dr. Arcia has in an earlier paper presented a portfolio management approach to keeping the maximum probable loss relatively low. Notwithstanding, it will statistically occur with an unknown frequency over a long run of years and must be planned for.

To establish an adequate reserve guarantee mechanisms, contingent loans, and concessional as well as commercial reinsurance may be mixed into a "reserve cocktail" to establish the required security. At the outset, the insurer must have at least the legally required reserve to constitute the company if it is either a mixed capital or private sector insurer. A much larger reserve is strongly recommended as agricultural insurance is catastrophic loss business.

In addition, public sector agencies, either ministries, central banks, development banks, international lenders or development agencies can often extend a guarantee to cover excess losses. In some cases, governments may be willing to accept joint liability. The guarantee is perhaps the easiest to obtain but probably the most difficult in terms of operations. When insurers are hit by excess losses, they require an immediate flow of cash. The process of cashing a government guarantee can be lengthy.

A much better mechanism to insure the solidity of the insurer is a contingent loan. This pre-arranged loan could be drawn when losses reached a specified magnitude. As an acquired obligation, the bank would increase its reserves to insure it could disimburse the loan when required. The insurer would in turn have a contractual right to draw down the loan under specified circumstances.

The final device to insure the financial solidity of the insurer is reinsurance. At the outset, it is unlikely that commercial reinsurance will be available. After several years of operations, commercial reinsurers may be willing to offer one of several risk spreading schemes to cover higher than expected, but probably not catastrophic, losses. Reinsurance is rather complex and each contract is individually negotiated. A usual package of reinsurance would consist of a quota share agreement under which the reinsurer accepts a specified part of the risk of the company, and receives a specified part of the premium income. This expands the insurers "capacity". It can write more insurance against a given reserve. Coupled with this quota share agreement it is usual to find an "excess of loss" or a "stop loss" agreement whereby for an additional part of the premium, the reinsurer agrees to pay losses in excess of a given amount up to maximum figure that usually is in the range of 200-300% of premium income.

Reinsurance from commercial reinsurers is a commercial product. The market may not be willing to take the risk or the premium quoted may be too high. Likewise, the level of coverage offered may be inadequate for major disasters. Many governments around the world operate reinsurance funds either as a substitute for commercial reinsurance or in a pool type arrangement with commercial reinsurers.

To offer one example of how an "excess risk 'cocktail'" may be structured, let us create a hypothetical insurer with a small, well diversified portfolio that has produced an average 85% loss ratio over 5 years of operation during which it has charged an average 5% premium. This insurer has a reserve of $1 million. It operates all risk agricultural insurance and limited risk livestock coverages programs. Management, aware of its exposed position and 10 to 1 liabilities to reserves ratio has developed a plan to enable it to expand its operations and to protect the small reserve from heavy unsupportable losses.

The first layer is a 30% quota share agreement under which the insurer delivers 30% of its net premium income to the reinsurer and the reinsurer pays 30% of it losses plus returns 5% of the reinsurance premium to help offset the costs of acquiring and administering the portfolio. In addition, the reinsurer agrees to pay 95% of all losses in excess of 100% of premium income up to a maximum of $1,000.000 for an additional 5% of premium income. On top of this

agreement, the government has offered catastrophic loss reinsurance from $1,000,001 to $5,000,000 for an additional 3% of premium.

If losses in any single year or any 3 consecutive years exceed $5,000,000, the agricultural development bank has agreed to open a line of credit for up to $2,000,000 to recapitalize the reserve on favorable terms. The bank in turn has negotiated a contingent loan with an international development bank. Finally, for individual or cumulative losses for over $5 million, the government has accepted join liability. Thus by combining a series of reinsurances, contingent loans for recapitalization, and a guarantee for very infrequent catastrophic losses, the insurer is able to meet any liability arising from its operations in a catastrophic loss field.

5. OPERATIONAL PLANNING

5.1 Developing the Pilot Project

Once the planning staff has developed the institutional, legal, and financial structures of the insurer, it can move on to the design of the operations of the insurer. At this stage, one confronts two sets of theories as to how to procede. One current in parts of Asia,and perhaps influenced by P.K. Ray's theoretical work, holds that agricultural insurance is not distinct from other classes of administrative activities,and there is no reason not to procede to a large scale multi-crop program. Another theory, current in Latin America probably arises from some chastising failures and the conversion of insurers into expensive subsidy channels with little noticeable policy impact. This theory holds that agricultural insurance is such a special class of business due to the catastrophic risk factor coupled with the socio-political risk of putting perpetually cash short governments into the insurance business that extraordinary design times are required. Lengthy detaliled studies are required; careful negotiation and embodiment in law of all operational aspects are the order of the day.

In our opinion, both theories overlook the key element of operational learning. Our experience indicates that agricultural insurance is similar to other classes of business and can be administered as would be most other enterprises. However, there are some unique aspects of agricultural insurance that

can only be learned from actually operating an insurer; from trial-and very frequently-error. We have found that many of problems that insurers must confront cannot be forseen in the planning process, and must be confronted by a flexible innovative management. At the same time, a large national multicrop program would probably have suffered losses that endangered its existence if management had gone ahead without a period of adjustment and learning. Errors are to be expected;planning must design mechanisms to convent them into learning experiences for a still fluid bureaucracy. The unity of theory and action with the latter continually enriching and modifying the former we hold is the way to develop an efficient effective insurer.

To that end, we have strongly urged that countries develop experimental programs that begin quite small and gradually grow as they learn. It must be admitted that this approach must steer a course between Scylla and Charybdis. On the one hand, it risks the loss of dynamism and the creation of a small complacent insurer; on the other, a too rapid expansion driven by the urge to be done.

In a pilot stage of 5 to 10 years, several major classes of problems must be confronted and resolved. Bureaucratic routines must be developed to handle the bulk of the work flow in a smooth and orderly manner. The first is the problem of interinstitutional relations. As the new insurer covers the credit extended by other institutions it must carefully work out a modus vivendi with those institution as to who does what, when,where, and how. We advise our insurers to work out detailed formal agreements specifying the obligations and rights of each party. The critical points in an insurer-lender agreement are how much credit will be extended for each crop, zone, and technology; how much insurance will be offered; and who will do what in the countryside. The problem of interinstitutional communication must receive special attention. Banks must advise insurers when credits are approved. Insurers must report to banks when coverage is approved. Information about the development of the crop cycle must move quickly between institutions.

While writing agreements and developing communications can be learned through experimentation, there is a unique problem of learning cooperative behaviour. The partially conflictive, partially cooperative nature of agricultural credit insurance requires both lender and insurer to learn to accept and live with a negotiated, less than optimal situation. Banks naturally want to insure their worst and most risky loans and maximize recovery rates. Insurers want

to prevent the bank from selecting adversely against the insurer and to obtain a spread of risks that will produce an acceptable financial result. Unless careful attention is paid to structuring a jointly acceptable portfolio, destructive tensions arise, and banks claims, "the insurer only wants the loans we know we will recover" while the insurer claims "the bank wants us to take its 'garbage' sure loser loans". The debate is arid and destructive; behavior must be learned to permit the negotiation of an acceptable mini-max solution.

We can suggest two useful ways of fostering cooperative behavior at the central level. One is technical; the other administrative. The creation of a joint portfolio management model in which the insurer and the bank can engage in a bargaining process along the lines suggested in an earlier paper by G. Arcia moves the discussion from the level of generalities to alternative concrete solutions to a joint problem. Another way is to have bank representation on the insurer's board and insurer representation on the bank's board. Capital participation is also highly recommendable. Thus, there is a sharing of problems at the highest levels and each institution has a financial interest in the performance of the other.

At the field level, several problems arise. Banks frequently loosen already loose loan eligibility requirements and suspend costly credit supervision as the loans are insured. Loss adjustments have a judgemental element. Banks and insurers frequently disagree over the cause and/or magnitude of losses and consequently the indemnity due the bank and the farmer. The situation is complicated by the fact that the insured usually sides with the bank in favoring a larger indemnity. Banks and insurers, therefore, must jointly work out acceptable guidelines for granting and administering insured credit, and for measuring and adjusting losses. At the same time, they must develop procedures for resolving differences. Joint working groups and indemnity arbitration committees should have representation from the bank, the insurer, the farmers, and from a disinterested expert and must operate under rules which structure decisions on purely technical grounds.

The second set of operational routines that must be developed through experimentation is what we have called the "plan of insurance". It is the insurer's internal operational plan. What will be insured, where, where and at what price? How will be business be serviced and by whom?

Developing the policies, forms, notices and other information and documentation is a gradual process from which the problems with previous cycles becomes the input for the revision process. Decisions on what to insure at what premium rate and with what level of coverage are likewise learned by doing. Data is almost always inadequate for more than an approximation of a just premium. Constant review and revision must be built into the system so that experience is gradually incorporated into the premium determination process. Special care is required so that one group or crop does not inavertently subsidize another.

A key element in implementing the plan of insurance is the process of recruiting,training,and administering a field staff. Developing countries are usually as short of human capital as they are of financial capital. To operate successfully,it is necessary to recruit and train a field staff capable of the exacting and demaning task of risk management and loss adjustment. Agricultural professionals have to be cross trained in insurance techniques. They must learn a new set of skills and attitudes to operate successfully. Formal training coupled with extensive field experience is required. Management must at the same time learn to supervise these inspectors. The insurer needs to experimentally determine how many insureds can be assigned to an inspector. It needs to develop a system for utilizing the inspectors year around and moving them from zone to zone for critical periods such as seeding and harvesting. Finally, management needs to develop supervision and management routines to insure that inspectors are inspecting and that adjustments are timely and accurate.

During the pilot phase, management will need to develop the required financial routines. It will need to develop an investment strategy that provides security, liquidity, and acceptable yields on investment. In rather unstable financial markets such as those that characterize Latin America, this strategy needs to carefully consider the exchange requirements of the insurer for payment of reinsurance premiums and the periodic devaluations which will make reinsurance progressively more expensive. One solution is a wholly-owned reserve in a hard currency held by a reinsurer if this is permitted by law. The insurer must through it pilot years develop an accurate cash budget so that it will have adequate liquid funds available when indemnity and other payments fall due without the insurer being forced to sell off productive investments to meet cash flow requirements.

The final set of routines that an insurer needs to develop during the experimental pilot project is the linkage of the insurance product to the felt needs of the insureds. The level of satisfaction with the product and the way it is serviced is crucial to the farmers' acceptance. Farmers first must be made aware of how the product fuctions but at the same time the insurer need to understand the farmers view of insurance. A universal given of insurance is that the premium is too high and the indemnity too low and too infrequent. There is a natural tendency for insured farmers who suffer a loss to want an indemnity. Deductibles and salvage values tend to be viewed as tricks to avoid payment. Communication and education can help farmers understand what his premium buys. At the same time, insurers must learn what farmers need. Perhaps insurers are offering products of limited utility and not covering other perceiving risks; perhaps, farmers are not content with the service received. It is crucial, and especially so in voluntary systems, that insurers have accurate information about their clients and their potential market.

To carry out operational planning, we have advised that insurers develop a research and development capacity from the very outset. This department, initially staffed by a single professional, reporting directly to top management, develops new products, surveys insureds needs and desires, produces educational materials, and works with management to monitor the performance of the administrative systems.

5.2 Expansion to the National Scale

Bureaucracy is to a large degree a function of size. Change becomes increasingly difficult and slow as the organization grows. Routines will inevitably develop. At the outset, it is crucial that the insurer carry out a pilot phase to develop effective efficient operational strategies. At the end of the pilot phase, a detailed study is necessary before beginning to attempt to reach a national market. Too many financial institutions have sprung up and grown haphazardly without careful evaluation and planned pauses for readjustment. While this gradual process of building

a new financial institution will seem overly conservative to many, we remain convinced that only through careful monitoring of the results and planned evaluations can we build institutions capable of coordinating all the components that impact upon the success or failure of agricultural insurance.

The study of the results of the pilot phase should address several sets of considerations. First, a careful evaluation should be carried out to determine if the new insurer has had a positive impact on farmers. One would likely wish to address two central issues: Has insurance affected production and/or productivity and has insurance affected the financial position of the farmer? These effects are a matter of degree and should be measured against the costs of operating the system. It is highly likely that some socio-economic strata will be more affected than others. We have, by way of example,seen a tendency for insurance to affect most positively those producers who are on the borderline between subsistence production in which any surplus is marketed and a commercial market oriented production system. The ability of insurance to permit the absorption of more debt without having to accept the ruinous consequences of failure enables farmers to move from subsistence into small-scale commercial production. This tentative finding is contrary to early expectations that the insurance would assist marginal farmers to obtain and repay credit. It, needless to say, has considerable importance for institutional design and for client selection as the program grows to nation wide scale.

The second set of considerations that should be evaluate is how the insurance system has affected the credit system. Increased recovery rates measured against operational costs is one rough measure. Likewise, one would certainly want to know what effect the insurance has upon the supply and demand for credit. _A priori_ one would expect insurance would increase the demand for credit. However, the premium rate almost certainly will affect the marginal increase in demand. One would also expect that at some premium rate insurance would stimulate demands that could not be met for agricultural credit. The results would be frustrated expectations and

perhaps angry farmers. Insurance is also a credit rationing device that may have positive or negative effects on the allocation of credit among the various groups and production options.

The final set of considerations that merit careful study in the planned pause between the pilot project and the national scale program is the effectiveness of the insurer's operation and the utility of its product. Has management developed adequate administrative and financial systems? Do farmers find the product useful? Are there alternative way of insuring or other equally useful products? Finally, the insurer must carefully measure its ability to plan, program, administer and supervise a nation wide program.

At the end of the pilot project these is a crucial decision to be made. The insurer can continue experimenting; it can decide to move to a large scale program or, if the evaluations are negative, to begin at the beginning again. Building agricultural insurers is every bit as problemmatic as building agricultural lenders. There is the potential for a very wide range of outcomes, including negative ones, unless the effects of insurance on the users and the effectiveness of the insurer itself are subjected to careful evaluation during the planned pause before launching a nationwide program.

6. CONCLUSION

In the foregoing sections, we may justly be accused of stating much that is obvious and at considerable length. However, in our day to day work, we find that the pressure of time frequently does not allow sufficient liberty to reflect upon alternatives nor study other countries experiences. The "in" box is always overflowing. Thus, we have tried in the brief space alloted to us to develop a clear and sequential series of planning decisions that seem to us necessary to establishing an agricultural insurer. This is less a detailed roadmap and more of a topographical one. We have tried to indicate a series of features in the environment that must be considered together with some alternative approaches to them.

In closing, instead of recapitulating, we would like to focus upon several critically important points. First, every effort must be made to provide for maximum initial flexibility and to provide for feedback so that the new insurer can make the necessary judgements as it interacts with its environment and learns. Solidifying the routines of bureaucracy too early is counterproductive. Second, the quality and entrepreneurship of management is critical to the ultimate success of the insurer. A dynamic highly motivated management cannot in and of itself assure success; a staid bureaucratic management can, however, produce a small ineffective institution with a secure clientele and lacking the desire to continue to grow. Perhaps the major challenge to planners is creating a legal, institutional, and financial environment in which learning, change, and innovation can occur as we acquire more knowledge about how to operate agricultural insurance programs.

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INSURANCE AND FARM CROPPING STUDIES IN MEXICO AND PANAMA

Peter Hazell
Luz María Bassoco
Gustavo Arcia

San José, Costa Rica

INSURANCE AND FARM CROPPING STUDIES IN MEXICO AND PANAMA*

by

Peter Hazell

International Food Policy Research Institute

Luz Maria Bassoco

Sistema Alimentario Mexicano

Gustavo Arcia

Interamerican Institute for Cooperation on Agriculture

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INSURANCE AND FARM CROPPING STUDIES IN MEXICO AND PANAMA

Introduction

Agricultural production is typically a risky process in which farmers are confronted by numerous natural and economic sources of uncertainty. Considerable empirical evidence exists suggesting that these risks can have important consequences for farmers' decisions, especially amongst small farms in developing countries. In order to reduce risks, farmers tend to diversify over a wider mix of crops than they would in the absence of risks, and they may be more reluctant to use modern inputs (such as fertilizer) or to adopt higher yielding crop varieties because of the increased risks associated with their use.[1/]

Risk averse behavior can be quite rational for the individual farmer, but it can also be costly to society when it leads to less than an optimal allocation of resources. In theory, social welfare is always greater when risks are pooled over large numbers of people, since the cost of risks to the individual producer can be considerably reduced, allowing him to allocate resources to achieve higher expected profits. Risk sharing institutions abound in industrialized countries: for example, stock markets, futures trading, insurance and credit institutions, and such legal arrangements as limited liability laws (Arrow). Such institutions are generally more rudimentary in developing countries, and are even less accesible to small farmers. This is not to deny that some risk sharing opportunities exist for small farmers. Roumasset, for example, has stressed the role of share cropping, traditional credit and kin support in diffusing risks within peasant economies. But the limited possibilites

these arrangements offer for pooling risks over geographically diverse areas, or over many individuals makes them a poor match for well organized risk sharing institutions. It is not therefore surprising that crop insurance has been advocated as a direct way of assisting small farmers, usually with the expectation that insurance would lead to less risk averse behavior and the more efficient use of farm resources. In Mexico, for example, subsidized crop insurance schemes for maize and beans are being expanded in the temporal, rain fed areas, with the explicit hope of increasing both average farm incomes and the marketed surpluses of these important food crops. In Panama, credit insurance schemes have been introduced for five crops and three livestock activities to protect farmers against the vagaries of nature, and to encourage more intensive production techniques.

Crop insurance is not without its problems. Reliable and objective data on crop risks are difficult to obtain for small farms. Crop risks can also vary widely between small geographic areas (even between farms and fields), thereby requiring a fine grid of regionally designed contracts with resultant increases in the expense and difficulties of operating an insurance scheme. Even then, differences in risk levels between farms can lead to "adverse selection" problems, whereby only the above-average-risk farmers may find it profitable to purchase insurance for which the premia are based on average risk levels, but the indemnities are based on individual farm yields. Many crop risks can also be changed by the very act of insurance. The so called "moral hazard" problem is a case in point. For example, a farmer having purchased yield insurance may be less conscientious in trying to avert a yield disaster than he would be in the absence of insurance.

Difficulties of these kind have lead agricultural insurance schemes to focus on very specific kinds of risks (e.g. hail insurance for wheat). Such risks can be more readily measured and monitored than many of the

more general risks confronted by farmers. But it is not widely recognized that such schemes may be ineffective in encouraging farmers to allocate resources in a more profit maximizing way. A farmer growing a diversified portfolio of crops, for example, may find that his income is only weakly correlated with the yield of an individual crop, and yield insurance for that crop may have little bearing on the variability of his income, or on his ability to repay debt or provide family subsistence requirements.

The purpose of this paper is to analyze farm level considerations which determine the kinds of crop insurance that might be effective in reducing risk averse behavior. These considerations are elucidated at a quite general level in the next section, and then formalized into a specific mathematical model. This model is then used to analyse the efficiency and potential benefits of current crop insurance schemes in Mexico and Panama.

Objectives and Theory of Crop Insurance

The kinds of crop insurance considered here are concerned with the within year (or within crop season) risks that a farmer confronts between the planting and harvesting and marketing of his crops. Such risks comprise, though not all are insurable, yield losses arising from natural causes, storage and marketing losses, uncertain product and input prices and unreliable input supplies. In aggregate, these risks have a direct impact on the level of farm income achieved each year, hence on the variability of income over time, and on the farmers ability to repay debt each year and meet family subsistence requirements.

Behavioral research suggests that once subsistence is assured, farmers allocate their resources to obtain desired combinations of average income and income risk. Higher average incomes require more risk, and most farmers trade some average income against reduced income fluctuations. Farmers with a marketed surplus are therefore likely to allocate resources more

efficiently if insurance helps stabilize their income. At the same time, farmers using modern inputs and borrowing farm credit need to ensure that their income is adequate each year to repay debts and meet essential living costs.

The intended purposes of crop insurance are therefore twofold. Crop insurance should help stabilize cash income, and it should help ensure that the farm family has the necessary income each year to repay debts and meet essential living costs.[2/] These objectives must be achieved at a cost which is less than the initial cost of risk to the farmer. If these objectives can be met, the farmer will be encouraged to seek higher average profits and to make additional farm investments. These requirements are now discussed in detail.

a. Reducing Income Risks

In the case of single crop farms, insurance will help reduce income risks if it reduces the variability of net returns for that activity and/or it increases the level of income realized in bad years. Simply compensating farmers for poor yield outcomes need not achieve either of these objectives. Consider for example the case where production costs are not risky, and the objective is to reduce the variability of income as measured by its variance. Let R denote revenue, and let P and Q denote the price and yield of the crop, respectively, then the variance of revenue, and hence income,[3/] can be approximated by (see Anderson, Dillon and Hardaker, pp.33),

$$V(R) \simeq E(P)^2V(Q) + E(Q)^2V(P) + 2E(P)E(Q)\ \mathrm{Cov}(P,Q) \qquad (1)$$

Now if price variations are the major source of risk confronting a farmer, compensating for shortfalls in yield may have little numerical impact on V(R). This is because the second term on the right hand side of (1) would tend to dominate V(R), whereas crop insurance would only compensate for the remaining two terms. Under these circumstances, price stabilization is likely to be more effective. Further, yield compensation will be less effective in reducing V(R) when prices and yields are negatively correlated. This is because high (low) prices will tend to offset low (high) yields, and revenue will be more stable than if the correlation were positive. Indeed, poor yields may not even coincide with the worst revenue outcomes if the correlation is strong enough. This stabilizing role of a negative price - yield correlation is apparent in (1) because Cov(P,Q) is then negative, and the last term in the equation subtracts from V(R).

In the case of multicrop farms, it is also necessary to take account of the covariances between the returns of different crops. Let a j subscript denote the j^{th} crop, then the variance of total farm revenue is;

(2) $V(R) = V(\Sigma_j R_j) = \Sigma_j V(R_j) + \Sigma_{i \neq j} \Sigma_j \text{Cov}(R_i, R_j)$

Now, even if crop insurance for the j^{th} crop were successful in reducing $V(R_j)$, it still need not stabilize a farmer's income. This depends on how the insurance affects the covariances between the returns of the j^{th} crop with the returns of all other crops. A good insurance scheme should reduce the positive covariances and increase the absolute value of the negative ones. But it is quite possible for insurance to reduce $V(R_j)$, yet to increase the size of positive covariances to the point where V(R) actually increases. We shall encounter such a case in our Mexican data.

An ideal crop insurance scheme would eliminate all income variability. The most direct way of doing this would be to guarantee the farmer his

average income each year, collect premia in years when income exceeds this average, and pay indemnities in all other years. Unfortunately, such a scheme would be very difficult to operate. Measuring farm incomes in developing countries is a hazardous business at best, and farmers are not likely to cooperate in providing objective data. Problems of moral hazard are also likely to thwart such a scheme. Nevertheless, the concept of ideal insurance will prove a useful one in providing a measure of the maximum gain that is attainable from any other insurance scheme.

b. Costs of Insurance

Risk creates a direct cost to the farmer. It is the amount of income he forgoes on average in order to pursue strategies that reduce his risk to acceptable levels. If insurance is to be effective, it must remove risk at a lower cost than this. Only then will the relative profitability of an insured crop be improved. But it is exactly this cost reducing role of a well designed insurance scheme that makes it attractive.

Crop insurance is able to reduce risk costs by spreading risks in three ways. First, insurance pools risk between farms. Unless crop risks are perfectly and positively correlated between farms, then such pooling leads to an automatic reduction in the aggregate risk facing the insurance agency. A farmer, for example, may face serious financial loss if his crop fails, but an insurance company can diversify its risk over farmers growing different crops in different regions so as to be reasonably certain that only a controlled fraction of its clients will require indemnity payments in any one year. By so doing, the cash flow for an insurance agency can be kept in the black with relatively small amounts of liquid reserves.

Second, an insurance agency can diffuse crop risks to other sectors of the economy. The agency may reinsure its policies with other institutions, sell stock, or if it is a government agency, rely on the ultimate security afforded by the taxpayer. Sharing risk in this way enables the agency to act in a more risk neutral way, thereby assisting in the reduction of its average costs.

Third, an insurance agency can spread risks over time by accumulating reserves. Since the proportaion of farmers requiring indemnities in any one year is largely controllable, an insurer would also have a much better chance than an individual of surviving a run of bad years.

An ideal insurance agency would operate with zero transactions costs, and charge a premium to farmers which, over a number of years, would be equal to the average indemnities received. Such a scheme could, in conjunction with ideal insurance policies which eliminate income variability, bring about a situation in which farmers were freed from any concerns about risk.[4/] Of course, such a scheme is not attainable, and the real question is whether realistically designed schemes can provide a cheaper and more effective way of reducing risk costs to farmers than traditional channels of risk sharing.

Farmers in peasant societies are not without some means of reducing risk. They can pursue cropping patterns and technology choices which reduce risk, but these strategies have a direct cost in terms of the average income forgone. Share cropping arrangements, traditional credit and kin support provide ways of sharing risks amongst individuals (Roumasset), but the localized nature of these institutions and the small numbers of people involved are bound to limit the amount of risk so dispersed. The premia for such arrangements are hidden in rental shares, interest charges and social obligations, and these may be almost as high as the initial risk

cost. While there is a need for good empirical research on these hidden costs, there are clearly a priori grounds for believing that risk sharing opportunities can be more cheaply provided through well designed insurance schemes.

Our discussion so far has taken for granted the desirability of encouraging farmers to act in more risk neutral ways. Debreu, Arrow and Samuelson have all provided elegant theorems establishing the desirability of such behavior for increasing aggregate income in a competitive economy, and it is not intended to review such arguments here. It suffices to say that if risk is interpreted as a real cost of production for risk averse producers, then removing or reducing this cost through risk sharing must lead to a higher social return to the resources they employ. Of more importance here is the need to distinguish between the social good and farmers' incomes. In the act of encouraging farmers to act in more risk neutral ways, an insurance agency might unwittingly help bring about a decline in average farm incomes. This could happen if insurance leads to the increased production of crops for which the market demand is inelastic. Under these circumstances producers' incomes will fall and consumers' welfare will increase. Such redistributional effects are likely to be of some policy consequence, and a government concerned with high food prices for its urban consumers might take a favorable view of such outcomes. Put in these terms, it can also be seen that an oft used argument that crop insurance would be sold by private companies if it were worthwhile (eg. Roumasset) may be seriously flawed. A private company must collect its premia from the farmers, and it will be unlikely to do so if farmers become worse off as a result of that insurance. A government, however, can act in the interests of society at large, and may be willing to subsidize

insurance for farmers, knowing that it can justify recouping these costs from consumers if it so wishes.

A Model for Evaluating Crop Insurance

We have already defined the objectives of crop insurance as (i) helping to stabilize farm income fluctuations over time, and (ii) helping to ensure that the farm family has adequate income each year to repay its debts and meet essential living costs. In order to evaluate crop insurance schemes empirically, it is useful to formulate these objectives more precisely.

Expected utility theory offers a useful way of formalizing a farmers distaste for fluctuations in income. This theory postulates that each individual has a utility function for money, and the shape of this function determines the income distribution parameters that the individual considers when choosing amongst strategies with risky outcomes. For example, if his utility function for money is quadratic, then a farmer will choose between farm plans solely on the basis of their mean and variance of income,(Markowitz The mean-variance criterion can also be regarded as an approximation to all other expected utility criteria, since it can always be derived from the first two terms of a Taylor expansion of the underlying utility of money function. In this paper we assume that farmers behave according to a closely related decision criterion: the mean income-standard deviation (or $E(y)$, σ_y) criterion. Specifically, we follow Baumol and assume that farmers maximize an expected utility function of the form

(3) $E(u) = E(y) - \phi \sigma_y$,

where ϕ is a risk aversion parameter. When y is normally distributed, this decision rule is equivalent to maximizing a specific lower percentile (determined by ϕ) of the probability distribution of income. For example, if $\phi = 1.65$, then the farmer will select a plan that has the largest 0.05

percentile.

More generally, the E(y), σ_y criterion implies that for a given level of mean income E(y), a farmer will always prefer the plan with the smallest standard deviation σ_y. Further, he will be willing to sacrifice mean income in order to reduce σ_y to the point where the marginal tradeoff is exactly ϕ. Figure 1 portrays a set of indifference curves corresponding to equation (3). For any farm planning problem there is also an efficient E(Y), σ_y set of farm plans. Each of these plans has the property that σ_y is as small as possible for the corresponding level of E(y). In Figure 1, the efficient frontier AB is the locus of all efficient E(y), σ_y plans; all other feasible plans lie to the right of this frontier and are not efficient. Now the optimal plan for a farmer is clearly the one that maximizes his utility. This plan will always be a member of the efficient set, and in Figure 1, it is the plan defined by point C; the point where the utility surface is tangent to the efficient frontier.

The E(y), σ_y criterion provides a direct rationale for a farmer to purchase crop insurance. Crop insurance should act to reduce σ_y for each level of E(y), thereby rotating the efficient frontier to the left in Figure 1. This will shift the point of tangency with the utility surface upwards, thereby allowing the farmer to achieve a higher level of expected utility. Of course, if crop insurance is to be effective in this way, then the reduction in σ_y obtained multiplied by ϕ must more than compensate for the premium which is to be charged to E(y).

The choice of σ_y as our measure of risk also happens to be useful for formalizinq the second objective of crop insurance; namely the avoidance of disastrously low income outcomes. This objective can usefully be written

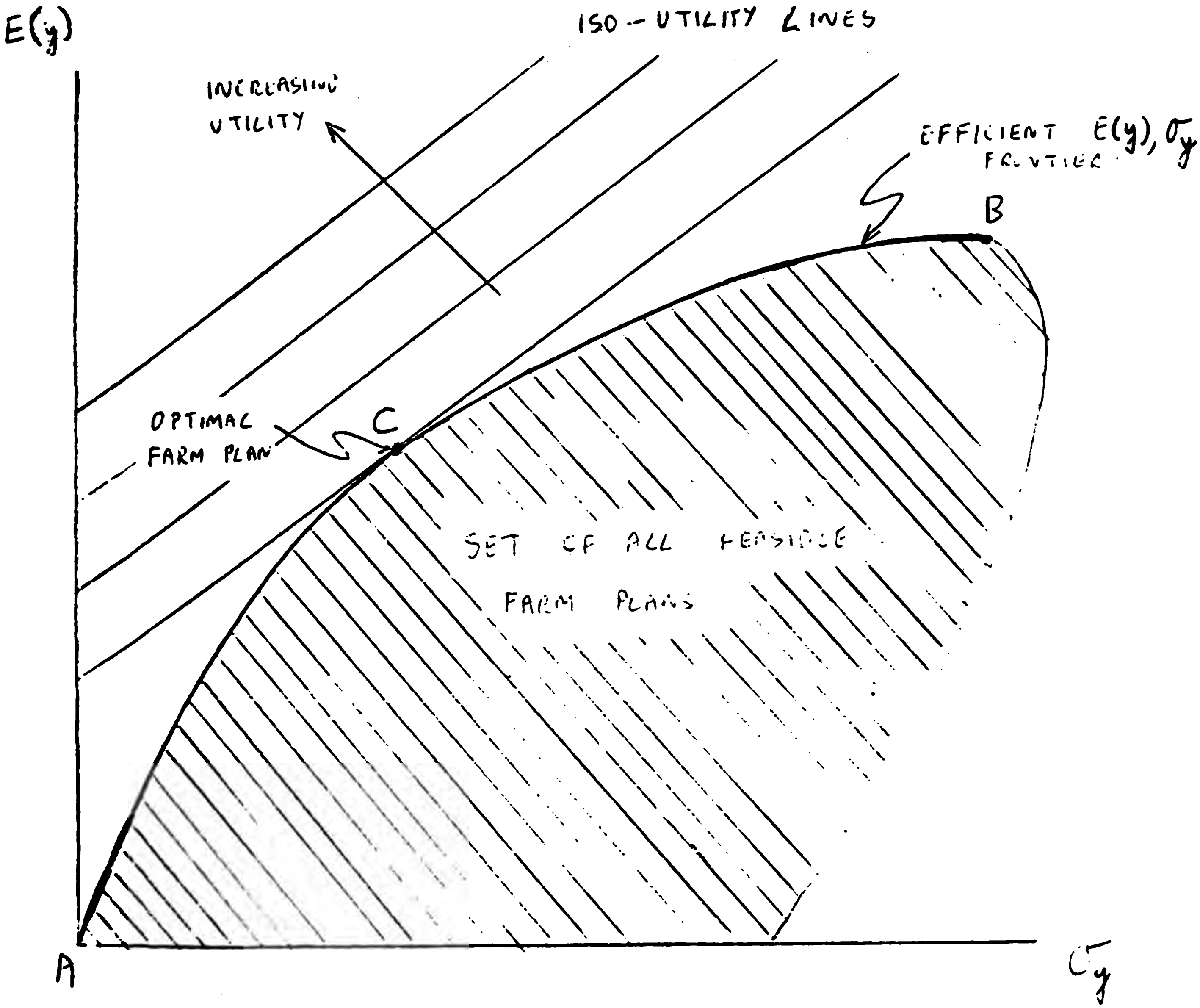


FIGURE 1 THE OPTIMAL $E(y), \sigma_y$ FARM PLAN

as a probability criterion of the form:

(4) $Pr\{y_t \geq r + S\} \geq 1 - \alpha$

Where y_t denotes the t^{th} possible outcome for income, r denotes the amount of credit to be repaid, S denotes the minimum amount of income required by the farm family to subsist, and α is a pre-assigned level of risk. The criterion requires that a farm plan be chosen so that income is adequate to cover debt repayment and family subsistence at least $1-\alpha$ proportion of the time. If α is set at 0.05, then (4) requires that income exceed r + S at least 95 percent of the time (or 95 years out of 100).

Since a farmer is likely to give greater priority to the survival of himself and his family than to the repayment of debt, we shall assume that when (4) is not satisfied the farmer defaults on his loan. On this basis, equation (4) can be interpreted as the probability of default, and α specifies the acceptable default rate. The farmer and the lender, which we shall presume to be a bank, may have rather different ideas about what is an acceptable default risk. However, since the banker's ideas are probably more stringent, and therefore more constraining to the farmer, we shall interpret α as the default rate acceptable to the bank. With this interpretation in mind, there is no reason why α should bear any relation to the farmer's risk aversion parameter ϕ, since they do not represent risk tolerances for the same individual.

If income y is normally distributed, equation (4) can be expressed in certainty equivalent form (Charnes and Cooper). Let K = r + S, then (4) is $Pr\{y_t \geq K\} \geq 1-\alpha$. This can be expressed as,

$$Pr\left\{\frac{y_t - E(y)}{\sigma_y} \geq \frac{K - E(y)}{\sigma_y}\right\} \geq 1 - \alpha,$$

or Pr $\{Z_t \geq K^*\} \geq 1 - \alpha$ where $Z_t = (y_t - E(y))/\sigma_y$ and $K^* = (K - E(y))/\sigma_y$. Z_t is a standardized normal (0,1) variable, and K^* is the value of Z at which α percent of the distribution lies in the tail to the left of Z. (Z is the α percentile). Consequently, by using tables of the cumulative function of the standard normal distribution, one can always find a value of k_α such that

(5) $E(y) - k_\alpha \sigma_y \geq r + S$

is exactly equivalent to (4). For example, if $\alpha = 0.05$, then $k = 1.65$.

Equation (5) clearly has much in common with the $E(y)$, σ_y utility function defined in (3). In fact, maximization of (3) will also help a farmer to comply with (5), since the maximization will tend to increase $E(y)$ and reduce σ_y. Again, crop insurance which reduces σ_y and increases expected utility will also serve to reduce the probability of default as defined in (5).

We now have the rudiments of a formal model of the farmer's planning problem. To complete this model it is necessary to introduce some explicit assumptions about the nature of the production process. Linear programming has proved to be a useful and plausible way of modelling these processes, and we shall adhere to this framework here.

In stylized form, the farm model can be written as follows:

(6) Max $E(u) = E(y) - \phi \sigma_y$

where $y = R'x - c'x - ir$,

subject to the constraints;

(7) $Ax \leq b$

(8) $w'x - r \leq h$

(9) $E(y) - k_\alpha \sigma_y - r \geq S$,

where x is a vector of crop areas grown,

R is a vector of crop revenues per unit area,

c is a vector of direct crop production costs per unit area,

r is the amount of bank credit borrowed,

i is the interest charge on bank credit,

w is a vector of crop credit requirements,

h is the amount of funds available from the farm family for on-farm investment,

A is a matrix of crop resource requirements,

b is a vector of fixed resource supplies,

and all other notation have already been defined.

In words, the farmer seeks to maximize expected utility (specified as an $E(y)$, σ_y utility function) subject to a set of constraints on the available resources he can use. Equation (7) requires that the amounts of fixed resources used, Ax, (eg. land and labor) do not exceed the available supplies b. The constraint might also include husbandry restrictions such as crop rotation requirements, or minimum constraints on the amount of food crops grown for home consumption. Equation (8) requires that any crop credit requirements w'x in excess of own funds h must be provided by borrowing credit r. Such credit has an interest charge i which is deducted from income in (6). Finally, (9) is the debt default risk constraint developed above. It limits the amount of credit borrowed to the amount where the probability of default is equal to α; the default risk acceptable to the bank. The risk of default will increase with $E(y)$, since the efficient frontier is always a monotonically increasing function in $E(y)$ and σ_y. Equation (9) therefore puts a ceiling on the level of expected income that a farmer can attain, and which in some cases may be lower than the level of $E(y)$ he would attain on the basis of his own risk aversion preferences.

This feature of the model can lead to some interesting results in which the farmer is required to act in a more risk averse way than his own preferences would suggest simply in order to obtain sufficient credit. Indeed, as we shall see, the model can even lead to situations where it is quite rational for the farmer to purchase crop insurance to reduce σ_y even when he is risk neutral, ($\phi = 0$). This result is quite contrary to much of the established theory on insurance, and arises only when the bank's risk preferences (as reflected in $k\alpha$) are different from the farmer's risk preferences (as reflected in ϕ).

For computational purposes it is necessary to have an explicit relationship between σ_y and x. We assume that production costs c and the interest charge i are not stochastic,5/ so that income risks arise only from fluctuations in crop revenues. Then, letting Ω denote the covariance matrix of activity revenues, we have the relation

(10) $\sigma_y = (x'\Omega x)^{\frac{1}{2}}$.

Since (10) is non-linear, the model can only be solved in its present form with non-linear programming alogorithms, and these are not nearly as convenient as linear programming. Fortunately, (10) can be replaced by a linear estimator of σ_y by using Hazell's MOTAD approach. This method is appropriate when σ_y is estimated on the basis of time series data on crop revenues.

Let R_{jt} denote the t^{th} observation (t = 1 to T) on the revenue of the j^{th} crop x_j, and let $\bar{R}_j$ denote the sample mean revenue for this crop over the T years. Then following Hazell, the classical estimator of σ_y defined in (10) can be replaced by the less efficient, but more

easily linearized estimator

$$\hat{\sigma}_y = F \{\frac{1}{T} \Sigma_t \, |\Sigma_j \, (R_{jt} - \bar{R}_j) \, x_j|\}$$

where $F = [T \, \pi \, / \, 2 \, (T - 1)]^{\frac{1}{2}}$ and π is the mathematical constant. By defining new variables $z_t \geq 0$, all t, which measure positive devidations in total revenue around the mean for the t^{th} set of revenue outcomes, it follows that

$$2 \, \Sigma_t \, z_t = \Sigma_t |\Sigma_t \, (R_{jt} - \bar{R}_j) \, x_j|$$

and hence $\hat{\sigma}_y = (2F/T) \, \Sigma_t \, z_t$

For this technique to work the z_t variables must be chosen in a minimizing way, but this is already ensured in the model because $\hat{\sigma}_y$ is deducted from the model maximand.[6/]

A more convenient formulation of the model for computational purposes is therefore the following.

(11) $\text{Max } E(u) = E(y) - \phi \, \hat{\sigma}_y$

such that

(12) $E(y) = \bar{R}'x - c'x - ir.$

(13) $Ax \leq b$

(14) $w'x - r \leq h$

(15) $(R_t - \bar{R})'x - z_t \leq 0$, all t

(16) $\hat{\sigma}_y = (2F/T) \, \Sigma_t \, z_t$

(17) $E(y) - k_\alpha \hat{\sigma}_y - r \geq S$

The linear programming tableau for this model is set out in Table 1. Note the economy achieved in the model because $\hat{\sigma}_y$ appears as the relevant risk term in both the expected utility function (11) and the debt repayment row (17). Alternative risk formulations are unlikely to be handled so simply.

Simulating the Effects of Insurance Policies

The model can be used to evaluate the effects of alternative insurance schemes on a farmer's decisions, including his demand for and repayment of credit. Insurance will affect the model by changing the coefficients in the revenue deviation constraints. This will lead to changes in $\hat{\sigma}_y$, thereby affecting both the model maximand and the debt repayment row.

Suppose for example that the first crop in Table 1 is to be insured. The existing coefficients in the revenue deviation rows t = 1 to T measure the variability of the crop's revenue over a historical period in which there was no insurance. To simulate the effect of insurance, a new set of revenue deviations must be calculated corresponding to what that initial time series would have been had the crop been insured. These calculations involve the derivation of a new series of crop revenues which differ from the original series in those years in which indemnities would have been paid. The mean of the new series is then calculated, and the revenue deviations obtained.

Table 2 contains an illustrative set of calculations. The initial uninsured revenue series is based on the product of historical prices and yields. These prices and yields should first be detrended where necessary, so that all variability around their means represent real elements of risk. The mean of the uninsured revenue series is 1158.6, and the coefficients for the revenue deviation constraints are calculated as the deviations around this mean. Now the hypothetical insurance scheme pays an indemnity in those years when the yield is less than 85 percent of the mean yield, and this indemnity amounts to the difference between the mean uninsured revenue and actual revenue. The insured revenue series has been calculated on this basis (indemnities are

paid in years 3 and 5), and then the revenue deviations are calculated from the new mean of 1273.2. Note that the insurance scheme reduces the standard deviation of revenue from 268.0 to 112.6, and is therefore quite effective in reducing risk.

Table 2 Example of Insurance Calculations

Year	Price	Yield	Uninsured Series: Revenue	Uninsured Series: Revenue Deviations	Insured Series: Revenue[1/]	Insured Series: Revenue Deviations
1	5164	0.273	1410	251.4	1410	136.8
2	5119	0.252	1290	131.4	1290	16.8
3	5104	0.159[2/]	812	-346.6	1159	-114.2
4	5049	0.267	1348	189.4	1348	74.8
5	5014	0.186[2/]	933	-225.6	1159	-114.2
Mean	5090	0.227	1158.6	0	1273.2	0
σ	59.1	0.054		268.0		112.6

1/ Indemnity paid out when actual yield is less than 85 percent of the mean yield. The Indemnity payment is calculated as the difference between actual revenue R_t and the mean revenue $\bar{R}$.

2/ Years in which indemnities paid.

Calculations of this kind lead to a new series of revenue deviations which sum to zero. There is no point in deducting a fixed premium from the new revenue series since this will not affect the revenue deviations. The premium (or net subsidy if relevent) must be subtracted from expected income in equation (12) if it is to have any bearing on the model's results.

If the revenue deviations corresponding to the insured crop are substituted for the original series in the model, then the ensuing model experiments will correspond to a compulsory insurance scheme. If it is desired to evaluate an optional insurance scheme, then rather than modify existing coefficients, one simply adds additional crop activities which have the modified average revenue and revenue deviation coefficients. The model is then free to choose between the insured and uninsured alternatives.

A Mexican Application

a) Description of Model

Two of the primary objectives of the National Food Plan in Mexico (the Sistema Alimentario Mexicano, or SAM) are to achieve national self-sufficiency in food, and to raise the incomes of farmers operating in temporal, rain fed areas. One component of the SAM policies is an expanded program of crop insurance for these farms. In particular, it is hoped that government risk sharing for maize and beans will lead to an improved allocation of resources to these crops, both in terms of the areas grown and the intensity of modern inputs used.

An aggregate model of the temporal, rain fed areas was obtained from the CHAC model of Mexican agriculture (Duloy and Norton 1973, Bassoco and Rendon). This model has recently been updated to a 1976 data base, and now has a risk formulation based on the E(y), σ_y utility model described in this paper. With minor changes to the treatment of credit, the model was easily made to conform to the structure portrayed in Table 1.

The region portrayed by the model is not contiguous, but comprises a set of non-irrigated Municipios lying at altitudes of 500 to 1000 metres, and having an annual rainfall between 600 and 800 mms. In total the model encompasses about 36,800 farms and about 116,000 hectares of arable land. The principal crops grown are maize, peanuts, sesame and sorghum, but small amounts of black beans, lima beans, barley and wheat are also grown. The region's output of these crops represent insignificant shares of national production, so all crops are assumed to face perfectly elastic demands in the model.

The model permits the production of all the above crops with a variety of possible planting dates and with two levels of mechanization (basically mules or tractors). Land and labor constraints are specified monthly, and labor is provided by hired laborers (at fixed wage) or by farm family workers.[7/] The latter are charged a reservation wage of 40 percent of the hired laborers' wage. Credit is required for all crops to purchase agrochemicals and seeds and to cover mechanization costs where appropriate. Credit is available from the national agricultural bank at a 12% interest charge. The risk coefficients are based on time series data on prices and yields for the period 1967 to 1976.

Because of varying agroclimatic conditions, not all the available land is suitable for all crops. In the absence of more precise information on these restrictions, two types of constraints are included in the model. The total land area that can be planted to peanuts, sesame, sorghum, barley, lima beans and wheat is restricted to be equal or less than the average area devoted to these crops in the base year. Also, no one of these individual crops is allowed to exceed 1.25 times the largest area planted to that crop in 1975, 1976 or 1977.

These are no direct upper limits on the amount of beans and maize that can be grown in the model. However, in order to provide for family food consumption, minimum production constraints are imposed on these crops. These constraints are based on farm family consumption of 400 grams per capita per day of maize, and 32 grams per capita per day of beans. Surplus production over these requirements can be sold in the model, and income is measured net of the value of home consumed maize and beans.

b. Basic Model Results

Table 3 contains some basic model results for different values of the risk aversion parameter ϕ. These results are based on a default risk of 5 percent. Insurance options are not offered in this version of the model.

Expected utility in the model is defined as average producers' income less the reservation value of family labor and less the disutility cost of risk, $\phi\sigma_y$. Since expected utility is maximized, the shadow price on a binding resource constraint can be interpreted as the rate of return to an additional unit of that resource. In the case of credit constraints, the shadow prices conveniently translate into the percentage rates of return.

For risk neutral behavior ($\phi = 0$), average producers' income (net of home grown foods) is 54.3 million pesos, or 1,475 pesos per farm. Income falls progressively as farmers are assumed to become more risk averse, and is only 44.5 million pesos, or 1,209 pesos per farm when $\phi = 2.0$. This reduction in E(y) is matched by a corresponding reduction in the standard deviation of income σ_y, and the coefficient of variation of income remains virtually constant at 40%. The matching pairs of E(y), σ_y for each solution lie on the efficient frontier, and this has the same shape as AB in Figure 1 when plotted against E(y) and σ_y.

Expected utility is negative in Table 3, and declines as risk aversion increases. This is because risk becomes more costly to producers through the term $\phi\sigma_y$. Risk averse behavior also leads to a large decline in maize production for ϕ values greater than 1.0, and since this is not offset by any production increases of other crops, resources become used less intensively. Employment and the use of credit and agrochemicals fall rapidly as ϕ increases beyond 1.0, land becomes idle and there is a switch from mechanized to labor and mule intensive techniques.

The debt default constraint is binding for all values of ϕ, and credit has a shadow rate of return which greatly exceeds the interest charge of 12%. Even when farmers are assumed to be risk neutral ($\phi = 0$), it is clear that the debt default constraint is acting to force a risk averse strategy in order to increase the amount of credit that can be borrowed. This explains why the standard deviation of income remains constant until = 1.0.

Table 4 shows additional model results obtained by varying the debt default risk parameter $k\alpha$. The level of risk aversion is fixed at $\phi = 1.5$ in these experiments.

Expected utility increases as the rate of debt default is allowed to increase. Surprisingly though, both average income and the standard deviation of income decline. There is also a decline in maize production, and a substantial substitution of machinery for labor and mules in the choice of crop technologies. These results arise because, with a ϕ value of 1.5, there is greater scope for increasing expected utility through reductions in the use of family labor (and hence in its reservation cost) than through production increases designed to increase average income.

Table 3 and 4 provide some indication of the potential gains from crop insurance. Suppose farmers actually have risk aversion coefficients of 1.5, (this would be close to the levels of risk aversion accepted by most statisticians when conducting hypothesis tests), then the observed state of the world under equilibrium conditions would correspond to the fourth column of Table 3. Now an ideal insurance scheme which ironed out all fluctuations in income (hence $\sigma_y = 0$) and which operated at zero costs would have two effects.

First, it would lead farmers to act in a risk neutral way, so that the first column of Table 3 would more correctly describe their new behavior (that is, $\phi = 0$). Expected utility would increase from -59.6 to -26.9 million pesos, average income would increase from 50.3 to 54.3 million pesos, and maize production would increase by 10.5% to 72.2 thousand tonnes.

At the same time, however, an ideal insurance scheme would reduce the risk of default, since all income risk would be removed.

Farmers could therefore borrow more credit, and this would have the same effect as the relaxation of the debt default risk in Table 4. The comparable results to Table 4 for $\phi = 0$ are not shown, but expected utility would increase further from -26.9 to about -20.0 million pesos, while maize production would remain at 72.2 thousand tonnes, and average income would decline to 42 million pesos.

The net effect of an ideal insurance scheme with $\phi = 1.5$ would therefore be to increase expected utility from -59.6 to -20.0 million pesos, to increase maize production by 10%, but to reduce average farm incomes by about 20%.

Of course, such an ideal insurance scheme could not be implemented in practice, but these changes provide a useful estimate of the maximum potential gains that could be realized from more realistically designed insurance schemes.

c. The Crop Insurance Options

There is already a national crop insurance scheme in Mexico operated by Aseguradora Nacional Agricola y Ganadera, S.A (ANAGSA). This scheme is a credit insurance scheme which assists farmers in repaying bank credit for insured crops in the event of certain natural disasters (eg. hail, flood or drought damage). The scheme is not very effective in the temporal, rain-fed areas, and three additional crop insurance schemes have been proposed as part of the SAM. A key feature of these proposals is an intent to compensate farmers as well as banks in the event of natural disasters, thereby enabling the government to share more of the risks confronted by farmers. These insurance schemes are specifically targeted for maize and beans.

With the aid of our model, we turn now to an evaluation of these schemes. The following questions are of particular relevance to the SAM. Under what circumstances will any of the proposed insurance policies be attractive enough to farmers that they might be purchased on a voluntary basis? Are the schemes likely to have any impact on maize and beans production? Will average farm incomes improve under these schemes? Are there any other policies that might better attair the government's objectives?

In order to undertake the necessary model experiments, revenue deviation series of the kinds illustrated in Table 2 had to be derived for each of three insurance schemes. These are shown in Table 5 for traditional maize, and in Table 6 for beans. Indemnity payments for all three insurance schemes are triggered by the event of certain natural disasters. Because these events are difficult to identify in aggregate time series data, we made the approximating assumption that a natural disaster occured whenever the yield was less than 80 percent of the mean yield. In the case of maize this only happened in one of the ten years, but it happened in three of the ten years for beans.

The first insurance scheme considered involves a modification of the existing ANAGSA scheme. Indemnities would be paid for a crop whenever actual yield is less thn 80 percent of the mean yield, and the indemnity would be calculated according to the formula:

$$I_{tj} = (1 - Q_{tj}/\bar{Q}_j)\ w^*_j \quad (1.4)$$

where Q_{tj} and $\bar{Q}_j$ denote, respectively, actual and mean yields for the j^{th} crop, and w^*_j is the maximum amount of credit that can be borrowed from the agricultural bank (Banco Nacional de Crédito Rural) for that

crop. This indemnity is designed to repay a proportion of the credit borrowed--where the proportion is based on the ratio of actual to mean yield--and to assist the farm family directly by adding in an additional indemnity of 40 percent of the amount paid to the bank.

The second scheme considered is a revenue insurance scheme. Again indemnities would be paid if the yield is less than 80 percent of the mean yield, but the indemnity would be calculated according to the formula:

$$I_{tj} = \bar{R}_j - R_{tj} ;$$

that is, the difference between mean revenue and actual revenue. Finally, a combined insurance scheme is also considered which would pay an indemnity amounting to the sum of the above.

The proposed schemes involve a direct subsidy, as the premia to be charged would not cover all the costs of providing insurance. Since insurance subsidies are equivalent to increased support prices for maize and beans, all the model experiments are conducted under the assumption that the insurance schemes are costless, and the question of subsidies is analyzed separately through price support experiments.

Table 5 shows that maize is a moderately risky crop. The standard deviation of uninsured revenues is 213.7 pesos, which when divided by the mean revenue gives a coefficient of variation of 15 percent. This is much lower than for beans which has a coefficient of variation of uninsured revenues of 26.8 percent (Table 6). A decomposition of the components of the revenue variances using equation (1) is shown below:

	$V(R)$		$E(P)^2V(Q)$		$E(Q)^2\ V(P)$	$2E(P)E(Q)Cov(P,Q)$	Residual
Maize	45,686	=	50,266	+	8, 460	- 11,774	- 1,266
Beans	148,254		133,710	+	4,074	6,110	4,360

In both cases, yield variability is the main source of revenue instability, suggesting that crop insurance may be useful. However, maize has a negative correlation (-0.256) between price and yield which is bound to weaken the revenue stabilizing role of crop insurance (notice that the lowest yield does not occur in the same year as the lowest revenue) Beans on the other hand have a small but positive correlation (0.086) between price and yield, which enhances the role of crop insurance.

These expectations are confirmed in Tables 5 and 6. The modified ANAGSA scheme reduces the standard deviation of maize revenues by 8 percent, but it reduces the standard deviation of bean revenues by 47 percent. The revenue insurance scheme has a similar impact, but the combined insurance scheme is not nearly as effective. This is because the indemnities are sufficiently generous that poor yield years become high revenue years, and the corresponding shift in the mean revenue increases the revenue deviations for other years.

On the basis of Tables 5 and 6 it is tempting to exclude the combined insurance scheme from further consideration, but this would ignore revenue covariance relations with the other crops (see equation (2)). Table 7 shows the correlations between the insured revenue series for maize and beans in Tables 5 and 6 and the revenue series for all other crops in the model. It can be seen that the three types of insurance have different correlations with other crops. For example, the combined insurance series for maize is negatively correlated with peanuts whilst the modified ANAGSA and revenue insurance series are positively correlated with peanuts. Since the relative importance of different correlations cannot be determined a priori, the need for model experiments becomes apparent.

d. The Crop Insurance Experiments

All three insurance options for maize and beans were incorporated in the model, and the model was allowed to choose between insuring or not insuring maize and beans, as well as choosing particular insurance policies or linear combinations thereof. The experiments were repeated for two values of the risk aversion parameter ϕ, and for different levels of the debt default risk $k\alpha$.

Table 8 presents the results obtained with a debt default risk of 5 percent. For each value of ϕ, three sets of results are reported; our discussion begins with the columns headed 'no-insurance' and 'with-insurance'. As these names suggest, the former excludes all insurance options, whereas the latter has all the three insurance options discussed above for maize and beans.

Beans are only grown at the minimal level required for family consumption in all the solutions, and insurance is not purchased. Maize insurance is very attractive though, and the entire crop is insured when polices are available.

Assuming $\phi = 1.5$, then the maize insurance schemes lead to a small increase in maize production of 3,110 tonnes (or 4.8%). Expected utility increases from -59.6 to -48.9 million pesos, but average income declines by 7% while the coefficient of variation of income falls from 40% to 36%. Additional credit is used, but this is mostly used to finance a switch to more mechanized techniques, with a consequent decline in total employment (12% less jobs). These results are clearly disappointing given the objectives of the SAM.

Maize insurance is also purchased on a voluntary basis even when producers are assumed to be risk neutral (that is, $\phi = 0$). This unusual result

arises because the debt default risk constraint is binding, and farmers are required to act in a risk averse way in order to obtain more credit.

Another interesting feature in Table 8 is the choice of insurance policy. There is a definite preference for the combined insurance policy, even though we found this to be inferior for reducing the standard deviation of maize revenues in Table 5. This result stems from the more negative correlations between peanuts, sesame, beans and combined insured maize than between these crops and modified ANAGSA or revenue insured maize (Table 7).

The results in Table 8 were obtained with a debt default risk of 5%. Table 9 shows the corresponding impact of insurance when the debt default risk is relaxed to 20%. Qualitatively, insurance has much the same impact at the higher debt default rate. Although expected utility is increased, average income still declines, and in this case there is a negative effect on maize production.

The advantage of single crop approaches to insurance is that they are much easier to manage and monitor in the field. The question arises as to how much of the potential gain from ideal income insurance can be obtained from single crop insurance for maize and beans. To this end additional model experiments were conducted in which 'ideal' single crop insurance was added to the options discussed above. Ideal single crop insurance is defined here as a scheme in which the revenues for the insured crop are stabilized at their mean level each year. This means that ideally insured maize and beans have zero variances and covariances in their revenue series. Such insurance policies provide the

maximum risk reduction possible with single crop insurance and can be used in the model to estimate the maximum gains attainable from any other single crop insurance approach. The relevent model results for these experiments are to be found in Tables 8 and 9 under the columns leaded 'ideal insurance'.

The introduction of ideal insurance leads to full and voluntary insurance coverage of all the corn and beans grown in the model. This leads to a dramatic reduction in both the standard deviation and the coefficient of variation of income, regardless of the level of risk aversion or debt default risk. Note that the model chooses to diversify between ideal and combined insurance policies for both maize and beans even though the ideal insurance leads to a complete revenue stability for these crops. This is another example of the powerful role covariances play in this kind of problem. Negative covariances (of which maize with combined insurance has several in Table 7) can be preferable to zero co-variances for diversifying against risk, even if this means accepting a higher variance.

Ideal single crop insurance is dramatically more effective in reducing total income variability than the previous insurance schemes considered. Figure 2 shows the efficient E(y), σ_y frontiers corresponding to different insurance options and a debt default risk of 5%. Crop insurance rotates the frontier downwards, enabling farmers to reduce risk for given levels of mean income. But the rotation is larger for ideal single crop insurance, especially for the lower values of E(y) and σ_y corresponding to more risk averse behavior.

The reduction in income risk is also portrayed in Figure 3. Here fluctuations around the mean in total farm income are shown for the different insurance schemes. These income fluctuations are calculated for each of the 10 years included in the model; they are the data on which the standard deviation calculations are based. Ideal insurance not only dramatically reduces the size of the income fluctuations, but it also greatly reduces the liklihood of a very low income outcome each year. Without insurance, for example, income could have fallen as low as 13 million pesos in one of the ten years, whereas the lowest income outcome that would have occurred with ideal insurance is 27 million pesos.

With risk averse behavior (ϕ = 1.5), ideal insurance would lead to significant increases in maize production (to 72.2 thousand tonnes). With a default risk of 5%, this would be accompanied by a decline in average income, and a further shift to more mechanized production techniques. Expected utility, however, would increase quite markedly, and within the behavior postulates of the model, this is the ultimate measure of the farmers' gains from insurance.

Our results on ideal single crop insurance suggest that better insurance schemes could be designed for the SAM. Schemes should focus more directly on reducing revenue variations for maize and beans, and should give less attention to yield disasters. Insurance policies need to take account of both price and yield risks and this is best measured through revenue outcomes. However, our results in Tables 3 and 4 suggested that even larger benefits could be attained if insurance were focused instead on total income risks for the whole farm plan. One way to achieve this would be to increase the number of crops insured. If the revenue

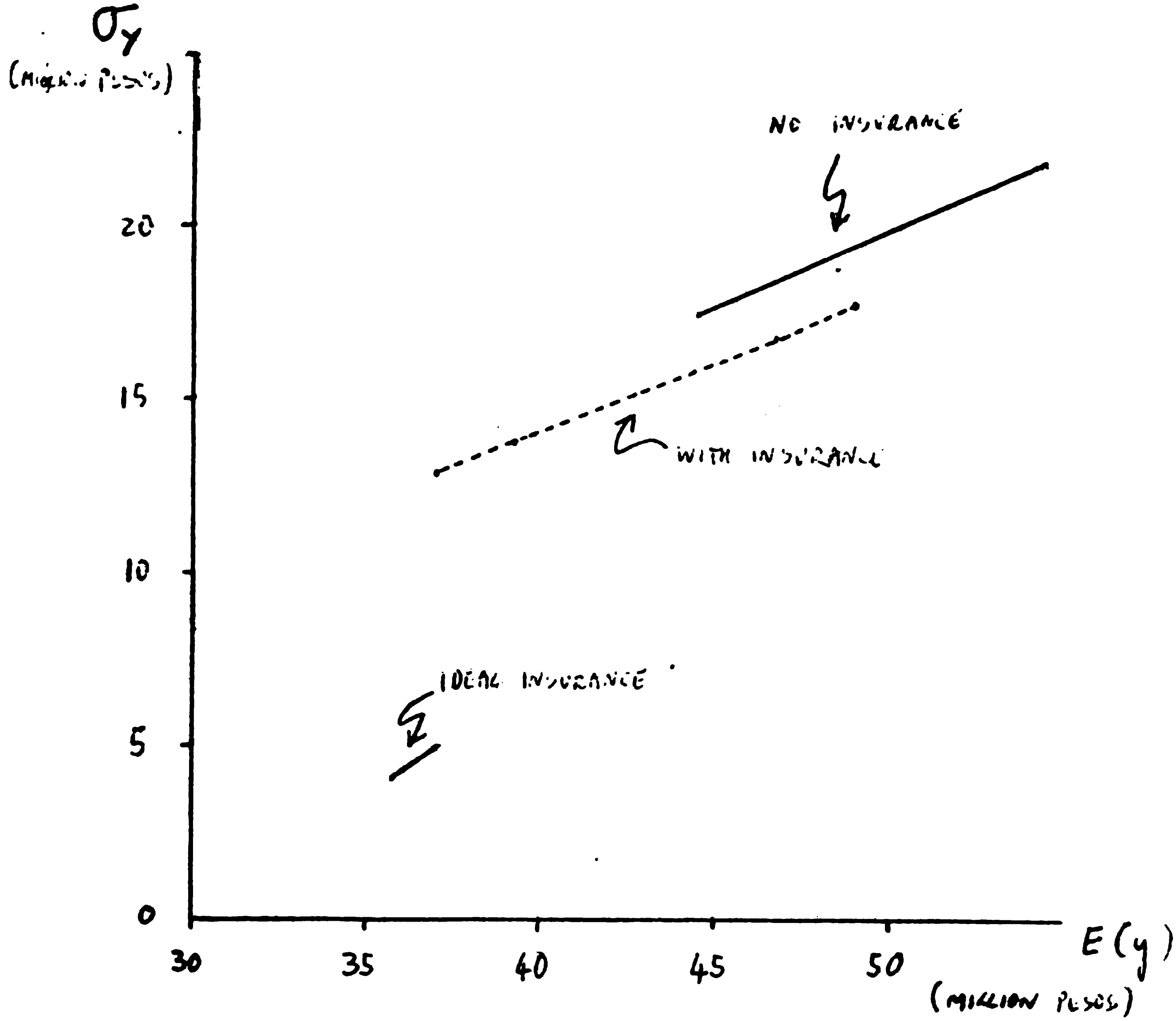


FIGURE 2 EFFICIENT E(y), σ_y FRONTIERS FOR DIFFERENT INSURANCE SCHEMES, MEXICAN MODEL

(DEBT DEFAULT RISK 5 %)

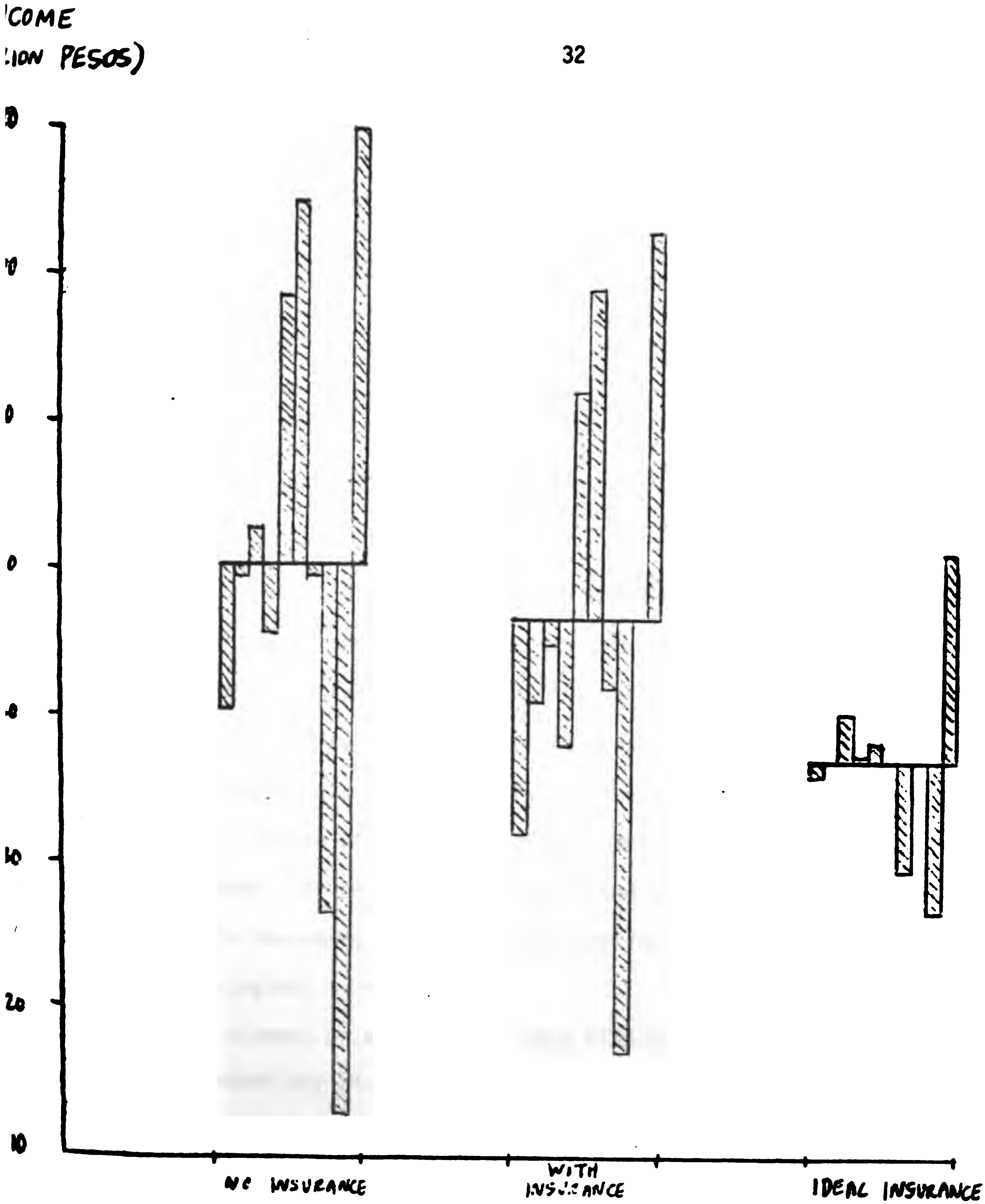


FIGURE 3 FLUCTUATIONS IN INCOME AROUND THE MEAN WITH DIFFERENT INSURANCE SCHEMES, MEXICAN MODEL (DEBT DEFAULT RISK 5%, $\phi = 1.5$)

variations for different crops are ironed out individually, then the variance of total income should also fall. An entirely different approach might be the introduction of a farm consumption credit scheme, through which farmers could borrow money in bad years to suppliment their income, and repay in good years. Obviously the repayment schedule would have to be flexible.

e) Introduction of an Improved Maize Technology

The results in the previous section were disappointing in terms of the goals of the National Food Plan. While the proposed insurance schemes did increase expected utility and reduce income risk, they had little or no impact on the marketed surplus of maize and beans, and actually reduced employment and average farm income. The problem can be traced to the highly inelastic nature of maize production under established technologies in the rain fed areas. Price experiments conducted with the model show that even large price increases would have little effect on maize production with existing technologies.

A further element of the National Food Plan is the propogation of an improved maize technology in the rainfed areas. This technology relies on improved seeds and the more intensive use of agrochemicals, but it is still to be grown under rainfed conditions. The improved maize would have an average yield of 2.11 tonnes per hectare compared to 0.75 tonnes per hectare for the established technology. In order to encourage farmers to grow the improved maize, additional farm credit is being offered, the price of maize has been increased, and crop insurance is being offered.

If the improved maize technology is successful, the supply of maize is likely to become more elastic, and therefore more responsive to price policy and to the introduction of crop insurance. In this section we introduce the improved maize technology into the model, and re-evaluate the effects of crop insurance.

Technical coefficients for the improved maize were obtained from experimental data. Since there are few time series data on yield outcomes for the improved maize, we had to settle on the simple expediency of assuming that the yields each year are a simple scalar multiple of the yields of the established maize technology. The scalar multiple used was the ratio of the mean yields. This assumption implies that the coefficients of variation of yields are identical for the two technologies.

Table 10 contains the revenue deviations for the improved maize, and shows how these would change under the modified ANAGSA, the revenue and the combined insurance policies. Using these data and assuming a debt default risk of 5%, the results in Table 11 were obtained. The maize price was retained at its base year value of 1900 pesos per metric ton.

In the absence of insurance, maize production is about equally split between the established and improved maize technologies, with a total production of 139.2 thousand tonnes. This compares with a production of about 70 thousand tonnes in Table 8, where only the established maize technology was available. The use of credit and agrochemicals has increased markedly, employment is about 35% greater, and average income is more than twice as large. Clearly the improved maize technology should be very attractive to farmers even if not accompanied by additional insurance or any price increases.

When insurance is introduced, there is a substantial increase in maize production, regardless of the level of risk aversion. Assuming risk

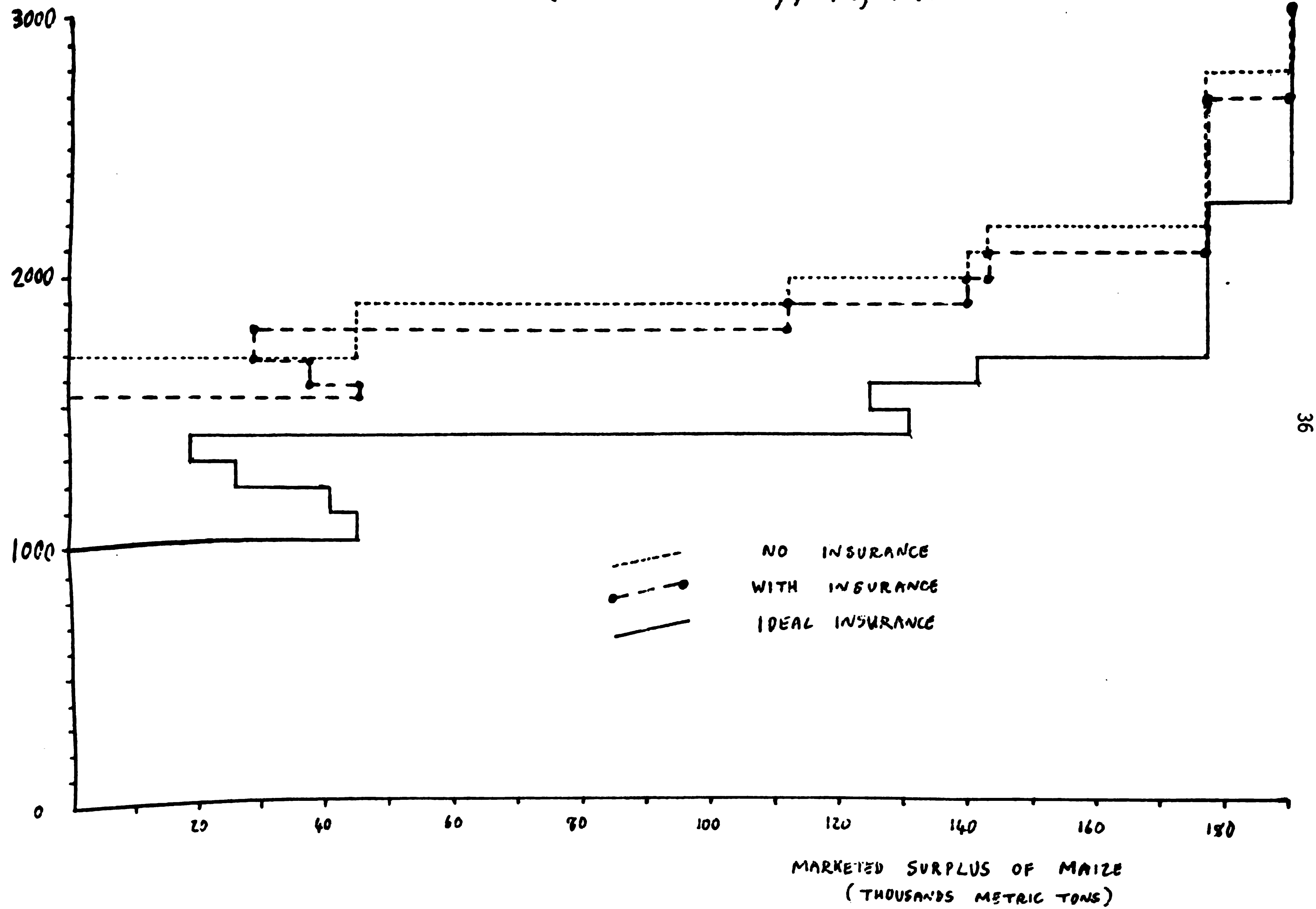
averse behavior (ϕ = 1.5); then the insurance policies being considered as part of the SAM could increase maize production by as much as 20%, even without an increase in the maize price. Furthermore, this production increase could be accompanied by a 15% increase in average income, and a drop in the coefficient of variation of income from 31.7% to 27.4%. There would be a dramatic switch to mechanized techniques, but because the improved maize requires a lot more labor, total employment would not change.

The last column in Table 11 shows that maize production could be increased even further if more efficient revenue insurance schemes could be designed. Ideal insurance greatly increases expected utility, and has a dramatic impact on both the standard deviation and the coefficient of variation of income. Average farm income does not change, however, from the levels attained under the proposed SAM insurance schemes.

So far we have ignored the costs of running the proposed insurance schemes, and our results were derived assuming that farmers would not pay any premia. Since a fixed premia is equivalent to a price reduction, and prices are supported by the government, our assumption is not unreasonable. But the Mexican SAM goes further than this; it is also planned to raise the support price for maize. Such a price increase should make maize more profitable relative to other cash crops, and might lead to a situation in which maize supply is also more responsive to insurance. To examine this possibility additional insurance results were obtained by varying the maize price in the model. This led to the maize supply functions graphed in Figure 4.

These supply functions were derived with a risk aversion parameter of 1.5 and a debt default risk of 5 percent. The supply function corresponding to no insurance is very elastic over a price range of 1700 to 2200 pesos

INSURANCE SCHEMES, MEXICAN MODEL
(IMPROVED MAIZE, $\phi = 1.5$, DEBT DEFAULT RISK 5%)



per tonne. At the base year price of 1900 pesos per tonne, a total maize surplus of 112.3 thousand tonnes is marketed. But if the price were increased to 2200 pesos per tonne, the surplus would jump to 176.7 thousand tonnes. Supply becomes much more inelastic for prices greater than 2200 pesos per tonne.

Introduction of the insurance options considered in SAM leads to to a similarly shaped supply function but one which lies slightly below the no-insurance supply function. Insurance increases the amount of maize that would be marketed for each price below 2200 pesos per tonne. For example, at the base year price, 112.3 thousand tonnes of maize is marketed without insurance, and 139.9 thousand tonnes is marketed with insurance. Price policy is therefore more effective in increasing the supply of maize when insurance is available.

Ideal insurance has a much more dramatic effect. In this case the supply function lies well below the other two, and much more maize is forthcoming at lower prices.

Of course, if insurance is successful in generating more elastic supply functions, then the imposition of an insurance premium is likely to lead to relatively large declines in output. Consider, for example, the supply function corresponding to the proposed SAM insurance schemes. At a price of 1900 pesos per tonne, 139.9 thousand tonnes of maize is marketed. Now a price decline of only 100 pesos per tonne, (which is equivalent to an insurance premium of 211 pesos per hectare for modern maize[8/]), would lead to a 20% decline in the marketed surplus. This result not only lends credence to Mexico's policy of subsidizing insurance, but bodes well for a policy of increased maize prices.

f. Conclusions from the Mexican Application

Our results show that with established technologies for maize and beans, the supply of these crops is not responsive to price supports or crop insurance programs. Crop insurance schemes, such as envisaged in the SAM, would help farmers reduce income risks and increase their expected utility, but these schemes would fail in terms of achieving the SAM goals of increasing food supplies and increasing farm incomes.

If an improved maize technology could be introduced, as is envisaged in the SAM, then the situation changes dramatically. The supply of maize becomes much more elastic, and crop insurance and price support policies become very effective tools for increasing supply. Our model predicts that the SAM insurance policies would be voluntarily purchased for all the maize grown, and that they would contribute to significant increases in maize output, average farm income and agricultural employment. Price policy is also more effective for increasing maize supply in the presence of insurance than without. This means that smaller price increases are required to attain specific production targets if insurance is also offered. Of course, a more elastic supply also implies that government subsidization of insurance costs will lead to larger increases in maize supplies, especially if the maize support price is not increased.

Our results are not encouraging for beans production. Beans are produced in the model only to the level required to meet farm family consumption requirements. Production is not responsive to insurance, and can probably only be increased through significant price increases or through the introduction of improved technologies.

There is considerable scope for improving on the design of the proposed SAM insurance schemes. At present, they focus exclusively on yield risks, and are therefore less efficient in helping to stabilize the per hectare revenue from maize and beans. Schemes which insured against both

price and yield risks could greatly enhance the value of crop insurance in contributing to the goals of SAM.

A Panamanian Application

a. The Credit Insurance Program In Panama

The crop credit insurance program in Panama was initiated with a social role in mind. Concious of the lack of private insurers in the agricultural sector, the Panama government created the program to protect farmers against climatic risk. Price risk was not considered in the program since the government operates a price stabilization mechanism. Participation is now compulsory for those farmers borrowing funds from government banks for all farming activities covered by the insurance program. Participation is voluntary for farmers using their own funds or funds from commercial banks. At present, five crops and three livestock activities are covered. Approximately five percent of the cost of production of crops and three percent of the value of livestock is charged as insurance premium. In return, farmers are covered by an amount roughly equal to eighty percent of the actual costs of production. Each farmer gets his crop or animal inspected at least once. Additional inspections occur when a problem is detected or at the farmer's request for technical assistance. Technical assistance is automatic in the case of livestock since the insurance program provides for a free vaccination service to clients. Since the program does not account for price risks, yields are used as the triggering mechanism for claims. Claims can be filed for partial or total disaster. The requirement for a claim to be paid is that the value of the harvest does not exceed the amount covered by the insurance policy. The value of the indemnity is then computed as the difference between the salvage value of the crop and the amount of coverage.

b. The Small Farm System in Panama

Data for the analysis were collected in the district of Bugaba, about 450 kms. northwest of Panama City. The district is located on a plateau about 300 meters above sea level, with a mean temperature of 26^{0}C. Rainfall is moderate at 4200 mms. and well distributed throughout nine months of the year. The rainy season runs from April to December, followed by a dry spell from January to March. Soils are of volcanic origin and of medium to high fertility. About 30% of the district is suitable for mechanization, the rest being either too steep or too rocky and therefore more suitable for livestock. Bugaba has a population of about 11,000 people, with good access to adequate health and education facilities.

Sixty four percent of the farms in the district are of less than 5 hectares, occupying about 5% of the land. Approximately 85% of all farms are less than 20 hectares. All small farms produce both for home consumption and market. Rice, corn, pole beans and tobacco are the main annual crops and sugarcane, plantains, oranges, coffee and avocados are the main permanent crops. Tobacco and sugar are grown under quota arrangements with local processors, and farms without such contracts do not grow these crops. In addition, the family plot often includes one to three cows, three to four pigs and some chickens, all kept mostly for home consumption. The level of crop technology used is intermediate to high relative to other Latin American Countries. Land preparation is usually mechanized, pesticides and herbicides are used widely but harvesting is mostly done manually. Mechanical harvesting of rice and corn is found only on medium to large tracts (i.e: 10 to 50 hectares) but is not widespread. Marketing is done locally. Farmers sell their grains to the government marketing board at a fixed price or to intermediaries who offer a lower price but pay more promptly. Fruits and other perishables are sold at the farm to local intermediaries at prices fixed by the government.

Farm credit is obtained through the Bank of Agricultural Development at interest rates approximating 14%. Credit is rationed depending on the geographic area, the type of loan, and the farmer's credit record. Generally, loans do not include labor costs if the area planted is small (i.e. 2 hect.) Net farm incomes for the area oscillate between $3,000 to $5,000 per year for a 5 hect. farm to $6000 to $10,000 per year for farmers cultivating around 20 hect.

c. <u>The Farm Model</u>

In evaluating the crop insurance scheme we focus on its potential impact on the smallest two thirds of the farms. The farm model is constructed for a typical 5 hectare farm.

All the activities in the model are currently found in the district of Bugaba. In the case of rice, corn, and intercropped corn and beans, several technologies were identified for each crop. Differences between technologies relate to the use of machinery at planting and/or harvesting, intensity of pesticide use and the degree of substitution between labor and machinery. Table 12 describes the corn and rice technologies in more detail.

Corn and beans are often interplanted, with corn being used as a support for the climbing beans. Again, different technologies are identified in the model based on seed quality, fertilizer and pesticide use, and the degree of mechanization.

Tobacco and sugar are technically feasible on many small farms, but few have the necessary contracts with local processers. Consequently, these crops are not included in the model for our typical farm.

Labor intensive crops are grown in the family plot around the homestead. Yams and the care of pigs account for most of the labor used in this plot. However, small quantities of oranges, plantain, bananas and

coffee are produced, together with the care of a few poultry and a cow or two. Most of these products are retained for family consumption, but small amounts are sold. All these possibilities are incorporated in the model. Minimum constraints are imposed on each house lot product to ensure that adequate amounts are grown for family consumption, and limits on selling are imposed where local marketing is limited.

Credit is required in the model to cover the cost of seeds, fertilizers, pesticides, machinery hire and wage labor. Small farmers do not generally own machines, and must choose between manual techniques or renting in machinery services from contractors or large farms. Credit is available in the model either from own family funds, or from the agricultural bank at an interest charge of 14%.

The debt repayment constraint in the model is identical to that described in Table 1. We also assume that the farmer maximizes $E(y)$, σ_y utility.

Since prices are fixed by the government each year prior to planting, the only risk confronting farmers is yield risk. Suitable yield data were available for the years 1976 to 1981, and led to the revenue calculations in Table 13 for the more important crops-corn, rice and interplanted corn and beans. These data are based on district level averages, and are calculated using 1981 prices; this being the year for which the model is specified:

Table 13 shows that, for the less intensive techniques, rice is the more risky crop with a coefficient of variation of revenues exceeding 15%. Surprisingly, intercropped corn and beans are relatively more risky than sole cropped corn when grown with less intensive techniques.

However, these relationships change with more intensive production techniques. Corn 4, for example, is more risky than rice 4, whilst corn/beans 4 is least risky. In the case of rice, adoption of more intensive techniques

reduces the coefficient of variation of revenues, because the average return increases faster than the standard deviation.

The revenue series for different techniques of production for each crop tend to be highly correlated (Table 14). However, they often have differing correlations with other crops. The revenue series for rice also tend to be negatively correlated with corn and interplanted corn and beans. This bodes well for a rational diversification between these crops to reduce whole farm income risk.

Suitable risk data were not available for the crop and livestock activities produced in the house lot. However, since these activities account for only a small share of the total land use, and since the products are largely home consumed, then ignoring risks in these activities should have little effect on the standard deviation of total farm cash income. This does mean, however, that the model cannot be used to evaluate livestock insurance policies.

d) Model Results and the Non-Economics of Insurance

Table 15 contains some basic model results for different values of the risk aversion parameter ϕ. These results are based on a default risk of 5 percent and are derived assuming that no insurance options are available.

Since no reservation wage is charged for family labor in this model, expected utility is simply average income less the risk cost $\phi\ \sigma_y$. Expected utility declines as ϕ increases, but not by very much. Average income is also relatively stable for different values of ϕ, and only declines by 11% as ϕ increases from zero to 2.5. Apparently, risk is not very costly to our typical Bugaba farm. This is also shown by the relatively flat E(y), σ_y frontier in Figure 5.

The coefficient of variation of income is 7.4% for $\phi = 0$, and declines to 1.6% for $\phi = 2.5$. This contrasts markedly with our Mexican results where the coefficient of variation of income was about 40% (Table 3) and barely declined as ϕ increased. Farming under the agroclimatic conditions of Bugaba district is clearly a much less hazardous undertaking than in the temperate, rain fed areas of Mexico.

Rice proves to be the most risky crop in the model, and total rice sales decline as risk aversion increases. Unlike Mexico, however, maize sales increase as farmers become more risk averse.

The choice of production techniques is only weakly related to the level of risk aversion. There is a switch away from more intensive technologies for rice and intercropped corn and beans as ϕ increases, but this is not offset by any increase in the less intensive technologies for these crops. Credit use does decline as ϕ increases, indicating less use of modern inputs overall, but total labor use changes very little.

Because of the low level of income risk in all the model solutions, the debt default constraint is not binding at the 5% risk level. This means that

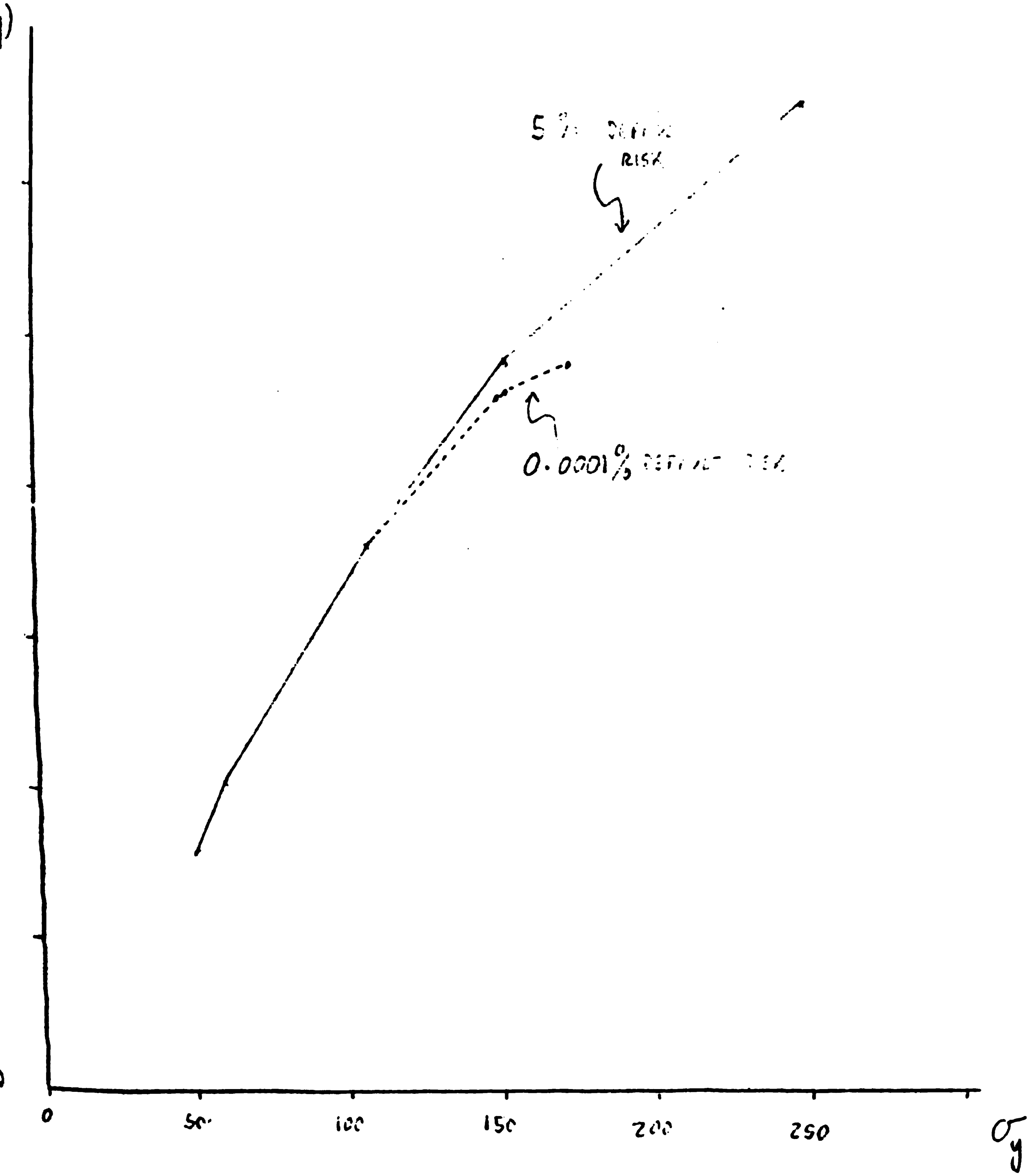


FIGURE 5 EFFICIENT $E(y), \sigma_y$ FRONTIERS FOR TWO LEVELS OF DEBT DEFAULT RISK PANAMANIAN MODEL

credit is borrowed to the point where its marginal rate of return is equal to the interest charge of 14%. Since the debt default constraint is not binding, then crop insurance will not effect the farmers' ability to borrow credit. Experiments with the model at even lower debt default risks led to similar findings. Indeed, the debt default risk constraint only became binding, (and marginally so), when the debt default risk was reduced to 0.0001%.

The only potential benefit from crop insurance therefore lies in enabling farmers to act in a more risk neutral way. Assuming a risk aversion parameter of 1.5 for our typical farmer, then an ideal insurance scheme which removed all income fluctuations would have the effect of moving the farmer from the fourth to the first column in Table 15. This would lead to a gain in average income of only $146.

If the maximum possible gains from insurance are so small, then the returns from realistically designed schemes -which would be less effective in stabilizing incomes- cannot be encouraging. Indeed, the income gains are unlikely to cover the required premia.

The current crop insurance schemes in Panama cover the farmer for eighty percent of the approved costs of production. Indemnities are paid in the event of yield disasters. In our model the insurable crops are corn and rice, though the less intensive technologies of CORN 1, CORN 2 and RICE 1 cannot be insured since they do not qualify for loans from the agricultural bank. The insured coverage is about $340 per hectare for corn and $500 for rice. The annual premium is $17 per hectare for corn and $25 per hectare for rice.

It turns out that in the revenue series in Table 13, no indemnities would have been paid for the more intensive corn and rice technologies during the period 1976 to 1981. Only in the case of CORN 3 and RICE 2 do the

EPILOGUE

In this paper we have used normati
crop insurance schemes at the farm leve
farmers make rational economic decisior
adhere to the behavioral postulates of
postulates are widely accepted in econc
for using them here.

Some may object to this nomative a
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acceptible to farmers in practice. On
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Our Mexican model shows that crop
in the temporal, rain-fed areas, if it
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established maize technologies.

In our Panama study, we found a ve
is far less important to farmers, and c

marginal contribution to their welfare, even in the presence of improved technologies. Our model cannot justify making such insurance compulsory whenever bank credit is borrowed, and we leave it to the scheme's proponents to justify this policy.

is defined in three month units. In other words, if family labor is used in the model, then it is hired for three months at a time. Similarly, hired labor must be hired for one month at a time. This feature of the model leads to some stickiness in the results.

8/ A premium of 211 pesos per hectare is equivalent to about $10 per hectare. In the Panamanian insurance scheme, the current premium for maize is $17 per hectare.

Table 1 *Linear Programming Tableau for Farm Model*

Equation \ Activities	Production Activities $x_1 \cdots\cdots x_n$	Borrow Credit r	Positive Deviation Counters z_1	z_2	$\cdots$	z_t	$E(y)$	$\hat{\sigma}_y$	RHS
Expected Utility (11)							1	$-\phi$	MAX
Average Income (12)	$\bar{R}_1 - c_1 \cdots\cdots \bar{R}_n - c_n$	-1					-1		$= 0$
Resource Constraints (13)	$A_1 \cdots\cdots A_n$								$\leq b$
Credit Requirements (14)	$w_1 \cdots\cdots w_n$	-1							$\leq h$
Revenue Deviation Contraints (15)									
$t = 1$	$R_{11} - \bar{R}_1 \cdots\cdots R_{n1} - \bar{R}_n$		-1						≤ 0
$t = 2$	$R_{12} - \bar{R}_1 \cdots\cdots R_{n2} - \bar{R}_n$			-1					≤ 0
$\vdots$	$\vdots$				$\ddots$				$\vdots$
$t = T$	$R_{1T} - \bar{R}_1 \cdots\cdots R_{nT} - \bar{R}_n$					-1			≤ 0
Standard Deviation Identity (16)			1	1	$\cdots\cdots$	1		$-T/2F$	$= 0$
Debt Repayment (17)		-1					1	$-k_{\alpha}$	$\geq S$

Table 3-Results for various levels of risk

	0.0
INCOME AND UTILITY MEASURES (Million Pesos)	
Expected Utility	-26.93
Average Income	54.34
Standard Deviation of Income	21.87
Coefficient of Variation (%)	40.25
PRODUCTION (Thousand Tonnes)	
Barley	-
Beans	2.10
Lima Beans	-
Maize	72.22
Sorghum	-
Peanuts	9.00
Sesame	1.35
Wheat	-
INPUTS	
Employment (10^3 man years)	17.29
Credit (Million Pesos)	1.83
Agrochemicals (Million Pesos)	2.19
Machinery ( )	2.61
Mules ( )	134.88
SHADOW PRICES (% Return)	
Credit Requirement Row (14)	88.88
Debt Repayment Row (17)	68.65

Table 4-Results for Various levels of debt risk, M

	5%
INCOME AND UTILITY MEASURES (Million Pesos)	
Expected Utility	-59.58
Average Income	50.25
Standard Deviation of Income	20.09
Coefficient of Variation (%)	39.98
PRODUCTION (Thousand Tonnes)	
Barley	-
Beans	2.10
Lima Beans	-
Maize	65.36
Sorghum	-
Peanuts	9.00
Sesame	1.35
Wheat	-
INPUTS	
Employment (10^3 Manyears)	16.96
Credit (Million Pesos)	1.71
Agrochemicals (million Pesos)	2.14
Machinery ( )	1.79
Mules ( )	135.67
SHADOW PRICES (% Return)	
Credit Requirement Row (14)	106.56
Debt Repayment Row (17)	84.43

Table 5 Revenue Deviations for Traditional Maize Under Different Insurance Options, Mexican Model

Year	Price (pesos/tonne)	Yield (tonnes/ha)	Revenue (pesos/ha)	Revenue Deviations from Mean (pesos/ha)			
				Uninsured	Modified ANAGSA Insurance	Revenue Insurance	Combined Insurance
1	1987	0.653	1298	-123.4	-146.2	-147.9	-170.3
2	1948	0.716	1395	-26.5	-48.9	-50.7	-73.0
3	1879	0.739	1389	-32.7	-55.1	-56.8	-79.3
4	1860	0.724	1347	-74.6	-97.1	-98.8	-121.2
5	1841	0.908	1672	250.3	227.9	226.2	203.8
6	1832	0.971	1779	357.6	335.2	333.5	311.0

Table 8-Results from various crop insurance expe[...]

	Risk Neutral Beha[...]	
	No Insurance	W[...] Ins[...]
INCOME AND UTILITY MEASURES (Million Pesos)		
Expected Utility	-26.93	
Average Income	54.34	
Standard Deviation	21.87	
Coefficient of Variation (%)	40.25	
PRODUCTION (10^3 Tonnes)		
Barley	-	
Beans	2.10	
Lima Beans	-	
Maize	72.22	
Sorghum	-	
Peanuts	9.00	
Sesame	1.35	
Wheat	-	
INPUTS		
Employment (10^3 manyears)	17.29	
Credit (Million Pesos)	1.83	
Agrochemicals (Million Pesos)	2.19	
Machinery ( )	2.61	
Mules ( )	134.88	
SHADOW PRICES (% Return)		
Credit Requirement	88.88	
Debt Default	68.65	
INSURANCE (% Area)		
Maize:		
Modified Anagsa	-	
Revenue	-	
Combined	-	
Ideal	-	
Uninsured	100.00	
Beans:		
Modified ANAGSA	-	
Revenue	-	
Combined	-	
Ideal	-	
Uninsured	100.00	

Table 9-Results from various crop insurance experi

	Risk Neutral Beh
	No Insurance
INCOME AND UTILITY MEASURES (Million Pesos)	
Expected Utility	-20.27
Average Income	42.53
Standard Deviation	21.87
Coefficient of Variation ( )	51.42
PRODUCTION (10^3 Tonnes)	
Barley	-
Beans	2.10
Lima Beans	-
Maize	72.22
Sorghum	-
Peanuts	9.00
Sesame	1.35
Wheat	-
INPUTS	
Employment (10^3 Manyears)	13.69
Credit (Million Pesos)	2.40
Agrochemicals (Million Pesos)	2.19
Machinery ( )	4.88
Mules ( )	85.64
SHADOW PRICES (Return)	
Credit Requirement	16.24
Debt Default	3.73
INSURANCE (Area)	
Maize:	
Modified Anagsa	-
Revenue	-
Combined	-
Ideal	-
Uninsured	100.00
Beans:	
Modified Anagsa	-
Revenue	-
Combined	-
Ideal	-
Uninsured	100.00

Table 10-Revenue deviations for improved maize under different insurance Options.

Year	Price (Pesos/Tonne)	Yield (Tonnes/Ha)	Revenue (Pesos/Ha)	Revenue Deviations from Mean (Pesos/Ha)			
				Uninsured	Modified ANAGSA Insurance	Revenue Insurance	Combined Insurance
1	1987	1.837	3650	-349.8	-427.0	-417.5	-494.8
2	1948	2.014	3923	-76.6	-153.9	-144.4	-221.6
3	1879	2.081	3910	-89.7	-166.9	-157.4	-234.7
4	1860	2.037	3789	-211.1	-288.3	-278.8	-356.1
5	1841	2.557	4707	707.6	630.3	639.8	562.5
6	1832	2.734	5008	1008.8	931.5	941.0	863.8
7	1953	2.136	4171	171.7	94.4	103.9	26.7
8	1629	1.881	3064	-935.7	-1013.0	-1003.5	-1080.8
9	2070	1.605*	3322	-677.5	18.0	-67.8	627.8
10	2001	2.225	4452	452.3	375.1	384.6	307.3
Mean	1900	2.111	4000	0	0	0	0
σ	122.6	0.333		602.6	553.6	554.1	595.9

*Denotes years in which indemnities paid.

Table 12-Rice and Corn Technologies in Bugaba District, Panama

Technology	Cultural Technique						Average Yield	Coefficient of Variation of Yield (%)
	Land Preparation	Planting	Fertilizer	Pesticides	Herbicides	Harvest		
CORN 1	manual	manual	no	no	no	manual	26.0	6.3
CORN 2	manual	manual	no	no	yes	manual	28.0	5.8
CORN 3	mechanized	manual	no	no	yes	manual	33.0	11.2
CORN 4	mechanized	mechanized	no	no	yes	manual	41.2	11.2

Table 13-Revenue outcomes for corn, rice and interplanted corn and beans in different years, Bugaba District, Panama

	CORN 1	CORN 2	CORN 3	CORN 4	CORN 5	RICE 1	RICE 2	RICE 3	RICE 4	RICE 5	CORN/ BEANS 1	CORN/ BEANS 2	CORN/ BEANS 3	CORN/ BEANS 4	CORN/ BEANS 5
1976	264	285	325	401	530	563	611	784	922	952	234	255	331	442	574
1977	298	320	360	498	564	430	477	649	787	810	261	282	359	477	608
1979	294	315	355	431	561	612	659	831	975	991	268	290	356	473	604
1980	260	282	322	397	526	652	700	872	1009	1032	273	296	331	439	571
1981	288	310	421	497	626	496	711	883	1021	1107	301	324	351	539	670
Average	281	302	356	445	561	551	632	804	943	978	267	289	345	474	605
Standard Deviation	17.6	17.6	39.9	49.9	40.1	89.1	94.8	94.7	95.2	110.2	24.1	24.9	13.6	40.3	39.8
Coefficient of Variation (%)	6.3	5.8	11.2	11.2	7.1	16.2	15.0	11.8	10.1	11.3	9.0	8.6	3.9	8.5	6.6

Table 14-Correlation coefficients between crop revenues, Bugaba District, Panama

	CORN 1	CORN 2	CORN 3	CORN 4	CORN 5	RICE 1	RICE 2	RICE 3	RICE 4	RICE 5	CORN/ BEANS 1	CORN/ BEANS 2	CORN/ BEANS 3	CORN/ BEANS 4	CORN/ BEANS 5
CORN 1	1.0														
CORN 2	1.0	1.0													
CORN 3	0.62	0.63	1.0												

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