

CROP INSURANCE : LITERATURE REVIEW AND CONCEPTUAL ANALYSIS

by

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INTRODUCTION

THE PROBLEM

In all its aspects and relationships, agriculture is subject to a considerable element of uncertainty. As a business enterprise, that is, as a system of production, distribution and exchange, it is susceptible to all the social and economic uncertainties which any other similar enterprise is called upon to face. As a mode of living, it has to reckon with all the personal uncertainties arising from death or impairment of health of farmers through sickness and accident and also from the inability of agricultural managers and laborers to sell or effectively employ their labor and management skills. On top of all these, agriculture is especially susceptible to the physical uncertainties of nature since it requires, as distinguished from most other major forms of business enterprises, direct contact with the force of nature.

Farmers have experienced severe droughts, hail storms, and tornados that affect their farms. Adverse events like these reduce farmers' crop yields and can have a significant impact on their cash flow. Unfortunately, there are many natural hazards including drought, excess moisture, flood, wind, frost, hail, disease, insects, and fire which are largely outside their

control. All these uncertainties can make agriculture very risky (Barnaby, p.1).

Table 1 depicts why wheat crops fail in Kansas, as measured by the multiple peril crop insurance (MPCI) claims experience from 1981 to 1986.

There are strategies that farmers can take to reduce the impact of these natural events. Risk-reducing strategies include holding reserves of cash; preparing realistic cash flow projections; and maintaining a good balance between short-term, intermediate-term, and long-term debts; hedging, forward contracting, and spreading of sales; improved manures; diversification or growing more than one crop; rotation of crops, ploughing, and accessory operations; share rental arrangements; use of insect-resistant varieties; purchase of crop insurance (Ray 1981, pp.17-9); different varieties; and geographical dispersion. Of the above strategies, crop insurance is dealt with in this report.

RISK AND UNCERTAINTY

The terms "risk" and "uncertainty", often used interchangeably, have different technical connotations. Risk and uncertainty can be distinguished on the basis of the state of knowledge about probabilities. According to the above definition if the probabilities are known, the decision problem is one of

Table 1. Causes of MPCl Loss Payments

Causes	Frequency
drought	35.4%
frost/freeze	21.1%
hail	17.1%
excess moisture	11.5%
wind	6.2%
others	3.6%
insects	2.8%
disease	2.3%

(Barnaby, P.1, his source was The American Association of Crop Insurers, Washington, D.C.)

risk. In contrast, if the probabilities are unknown, the problem is one of uncertainty. In other words, while uncertainty is subjective probability, risk is objective probability. The former represents a probable state of mind, the latter a state of things (Knight, p.233). Defined in terms of knowledge, if there is sufficient knowledge to specify a unique outcome, it is certainty. If there is insufficient knowledge, it is uncertainty. Thus an uncertain event is an event with more than one possible outcome (Robinson, p.12-13).

There is difference between Business risk and Financial risk. Business risk is defined to be the risk inherent in the firm, independent of the way it is financed (Van Horne, pp.207-8). Business risk generally is reflected in the variability of net operating income or net cash flows. A high (low) coefficient of variation of net cash flows would indicate high (low) business risk. Business risk may be evaluated at a point in time based on the probability distribution of net cash flows. Financial risk is defined to be the added variability of the net cash flows of the owners of equity that results from the fixed financial obligation associated with debt financing and cash leasing (Barges, p.16).

The following paragraphs about the natural and social risk are based on Ray 1981, pp.6-11.

Risks to agricultural property may be divided into three major groups: (a) natural risk, (b) social risk, and (c) economic risk, depending on whether the uncertainty involved is due to natural or social or economic factors. However, since crop insurance covers natural hazards, natural risk and risk of fire (a social risk) are discussed here.

Natural Risks

Natural risks mean natural hazards that reduce the yield and bring crop failure.

Natural hazards are composed of two kinds: (1) adverse weather such as hail, windstorm, frost, drought, excessive moisture, flood, and tornado, and (2) pests such as insects, plant diseases, and weeds.

As a result of these natural hazards, the crop yield may be reduced. So the annual returns and incomes of a crop farmer can vary widely from year to year. Change in farm production is caused not only by adverse weather but also by diseases as well as by insects and other pests. Diseases affect diverse products like wheat, potatoes, tomatoes, and cotton. In the U.S., the losses caused by the uncertainties of weather

are great because there is a high level of technology to control diseases, insects, and other pests.

Social Risks

While agriculture is subject to various natural hazards, it is also liable to be affected by social risks. Although social risks include many factors, fire and theft are discussed here. The two factors are not always anticipated by farmers. Fires may happen by natural causes such as lightning. But fires are often caused by human beings. Theft moves farm property. In fact, the risk of theft of such farm property is great because farms are scattered over regions where it is impossible for a farmer to watch all his assets. Also, there are risks of changes in government policies such as government farm programs and tax policies. Loss of rented land is another major source of risk.

RESEARCH OBJECTIVES

This study focuses on crop insurance in the U.S. The objective is to review literature and theoretical models related to crop insurance. As a risk response, crop insurance responds directly to short-falls in crop yields. Crop insurance can play a role in reducing lending risks and contributing to the economic performance of both the borrower and the lender.

Crop insurance also has important policy implications because it is one of several policy instruments used by the federal government to become the primary form of disaster protection for farmers.

LITERATURE REVIEW

CONCEPT OF CROP INSURANCE

In this section an explanation of insurance in general is followed by a discussion focused on crop insurance. Insurance is a social device which aims at eliminating the uncertain risk of loss for the individual through combination of many individual risks and the distribution of a loss among the many insurers. In other words, insurance provides protection against economic losses arising from adverse events. For example, life insurance protects surviving dependents against the loss of income that occurs when a family member dies.

In general, while the occurrence of an individual loss can not be predicted, considered with a large number of similar losses its occurrence can be predicted. Therefore insurance implies the combining of small unpredictable risks so that annual losses for the combined group become predictable. It is possible for a person to avoid the burden of a loss by paying a

proportionate share of the losses for the group as a whole. Insurance distributes the burden of loss not only over space but also over time. It accumulates premiums that the insurers pay in the normal periods. So it uses accumulated funds to relieve any unusual loss burden occurring at an unfavorable period. Thus insurance evens out the loss burden over individuals and time (Ray 1974, pp.6-7).

This study is focused on crop insurance.

Crop insurance can be classified into different types according to different criteria. According to the hazards it may be classified into a specific-risk and an all-risk insurance. According to the object insured, it may be classified into either single-crop insurance or multiple-crop insurance. Classified on the basis of administration, it may be public or private insurance. Finally, according to the basis of its scope and application, it may be classified into voluntary insurance and compulsory insurance.

Generally, crop insurance is available in two forms:

- (1) limited peril insurance, including commercial hail and fire insurance; and
- (2) multiple peril crop insurance (MPCI)

Hail and fire crop insurance (H/FCI) undertakes to indemnify the farmer against loss of crops caused by damage

through hail and fire. It does not cover damage by other natural elements such as drought, excessive moisture, insects, disease and frost unless specially mentioned.

Hail and fire crop insurance is offered under two types of plans: spot and area. Spot plans indemnify insured-farmers against damage based on the percentage loss occurring because of hail and fire on specified acres. In contrast, area plans compensate insured-farmers for loss based on the percentage of yield loss due to hail and fire averaged across the insured unit.

While H/FCI covers the damage caused by hail and fire, MPCCI protect the farmers against uncertainties of crop yields arising out of all natural factors beyond their control. MPCCI covers loss in quantity as well as quality. It ensures a minimum average yield per acre for the insured crop. Protection is limited to a specified percentage (say 50-75%) of the average yield. If average yield for the insured unit falls below the specified level, the insured farmer can be paid the difference between average yield and the specified level (Barnaby, p.1).

THE HISTORY OF CROP INSURANCE

Most of this section is based on information found in "Agricultural Insurance" written by Ray 1981, pp.162-8.

Early Experience

The first crop insurance policies in the U.S. were written for tobacco farmers in colonial times. But in those early days, many of the small private companies writing policies had inadequate cash reserves and highly concentrated business. So when heavy losses occurred, claims had to be prorated. This caused dissatisfaction among policyholders, and often resulted in liquidation of the companies.

Since several efforts by private companies to provide crop insurance had been for the most part unsuccessful, in the early 1920s, officials in the U.S. Department of Agriculture became interested in crop insurance and carried on some research. Also the U.S. Senate passed a resolution calling for investigation of crop insurance. The resolution provided for the appointment of a select Senate committee to investigate crop insurance. However, at that time, it was thought preferable for the Government to assist private insurance companies rather than to go into the insurance business.

Federal Crop Insurance

Great interest in multiple-peril crop insurance took place in the mid-1930s because of the extended drought in the Great Plains. In 1936, President Roosevelt appointed a committee to make recommendations for legislation providing for Government-sponsored crop insurance. The administration passed 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). Insurance was authorized only for wheat. Farmers could insure between 50 and 75 percent of their recorded average yields against losses because of natural hazards.

The Federal Crop Insurance Program had originally three objectives:

- (1) protection of farmers' income against crop failure and a decline of crop price.
- (2) protection of consumers' against lack of food and a rise of crop price.
- (3) support to business and employment by providing continuous food supplies and establishing farm purchasing power.

The Initial Experience with Federal Crop Insurance

The original Act provided only for insurance on wheat in the first year, 1939. Insurance on cotton began in 1942. Both were very large programs in which the insurance was offered nationwide. The initial experience of crop insurance was less than encouraging. During the first year, 1939, nearly one-third of the insured farmers collected indemnities. Indemnities exceeded premiums. Also losses exceeded premiums on both wheat and cotton in each of the first 5 years, 1939-43. Although heavy losses resulted directly from droughts, there were also some defects in the insurance plan and administrative operations. Because of the disappointing experience of the early years, Congress passed legislation withdrawing the insurance in the 1944 crop year.

The crop insurance program was revived by Congress in 1945 with insurance on wheat and cotton to be made generally available. Also experimental work on corn and tobacco was to be started. Experience improved with wheat, and was satisfactory with corn and tobacco. However, large program losses occurred on cotton in both 1945 and 1946 because of widespread drought. In 1946, total indemnities for all crops exceeded premiums by about \$30 million. By the end of that year, more than 75 percent of FCIC's original capital stock had been used to pay losses not covered by premiums.

As a result of the heavy losses, legislation was passed to limit the operations of the corporation.

Limited Program

In 1947, the Federal Crop Insurance Corporation collected premiums in excess of indemnities on combined operations. But legislation passed that year curtailed the operations of the corporation. The 1947 amendments reduced federal crop insurance to an experimental program. As a result of the legislation, the corporation reduced its operation from 2,500 to 375 counties in 1947. Although the scope of the program was reduced, the Federal Crop Insurance Corporation 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, with indemnities determined on the basis of combined coverage.

During the 1950s, the crop insurance program began to stabilize. Although some new crops were added and minor experimentation continued, most changes involved fine tuning the program. The Federal Crop Insurance Corporation announced that beginning in 1956, insurance would no longer be sold in

fourteen 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.

Beginning in 1957, there was a five-year period in which premiums exceeded indemnities every year. The loss ratio in 1958 of 0.26 was the lowest in nineteen years of operation. This was well below what was ever expected in the program.

During the 1960s, the Federal Crop Insurance Corporation concentrated on increasing its coverage, which reached \$920 million in 1969.

Early in 1969, the secretary of agriculture appointed a new board. The new management undertook a review of the program to identify reasons for the poor financial position of the corporation. The corporation concluded that in many counties insurance structures had been weakened by the use of shorter time periods for determining coverages. The result was that coverages were based on recent trends rather than long-term averages.

The corporation's review revealed that in many cases premium rates had been reduced below what experience could justify. For some new crops, risks had been miscalculated and premiums set too low.

The Federal Crop Insurance Corporation instituted several changes in the operation of its 1970 program. In most cotton counties, premiums were increased and coverage was decreased. The experimental potato program was discontinued.

In 1970, the General Accounting Office concurred with the need for individualized protection. The General Accounting Office concluded that low participation prevented Federal Crop Insurance Corporation from operating an effective disaster protection program. To increase farmers' participation in the federal crop insurance program, individualized protection was proposed.

Disaster Payments Program

The Agriculture and Consumer Protection Act of 1973, and the Rice Production Act of 1975 established a disaster payments program. Farmers participating in price and income support programs were eligible for payments. Payments for prevented planting were made to producers who were unable to plant or who underplanted because of natural hazards.

The disaster payments program was popular with farmers, because it provided disaster protection with no premium costs and coverage in high-risk areas.

The legislators decided to establish a more comprehensive program for the protection of the farmers against natural hazards. As the administrator of the Agricultural Stabilization and Conservation Service (ASCS), USDA, observed in 1977: "The proposed farm Production Protection Act will expand multiple-risk protection to all counties and cover almost all crops as well as other production investment on farms. This new bill will establish a program that combines the insurance provisions of the FCIC Act and the USDA disaster and indemnity payment programs to protect producers against losses. Most important, it will be a more responsive program to deal with the economic problems that farmers may face" (FCIC,USDA, p.3). Although the title of the proposed legislation was later changed to "Federal Crop Insurance Act of 1979," its basic purpose remains the same.

The Crop Insurance Act Amendments of 1980

The Crop Insurance Act Amendments of 1980(CIAA) were far reaching. They provided a vehicle for all agricultural producers to be protected by private companies backed by the federal government, and corrected many of the inadequacies of previous crop insurance programs. The result is affordable protection for most farmers throughout the U.S. In addition, this 1980 Act expanded the crop insurance program to become the major form of

disaster protection in the U.S. The Act authorized the expansion of the program to all counties with significant agriculture. If sufficient actuarial data were available, the FCIC was permitted to insure any agricultural commodity grown in the U.S. 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.

The Act also permitted specific risk protection programs for prevented planting, wildlife depredation, tree damage and disease, and insect infestation, provided such protection was not available from private companies. It authorized research and pilot programs on rangeland, livestock poisoning and disease, and destruction of bees due to pesticide use.

To summarize, the U.S. government became involved in crop insurance only after several attempts in the private sector to provide multiple-peril crop insurance failed. These private efforts failed for a number of reasons: (1) coverage of price as well as yield risk, (2) inadequate geographical dispersion of risks, and (3) insufficient data for a sound actuarial program. The public program begun in 1938 encountered some of these same difficulties, particularly inadequate data. High loss ratios

resulted, and the program was subsequently reduced to an experimental basis in 1948. During the next several decades, the program gradually expanded and operated on a limited but successful basis.

Because of the high cost of the disaster payment programs during the 1970s, the crop insurance program was expanded by 1980 legislation to become the nation's primary means of disaster protection for farmers. Subsidies were greatly increased, and the private insurance industry was encouraged to assume much of the marketing role for FCIC.

REASONS FOR CROP INSURANCE

Much of this section is based on information found in Ray 1981, pp.109-111. This section is divided into two parts, need and benefits.

Need for Crop Insurance

The business of farming involves numerous risks, natural and social. But the principal characteristic which distinguishes farming from most other businesses is its great dependence on nature. Farming has to be carried on in the face of uncertainties rising out of diverse natural elements such as

wind, flood, drought, frost, hail, insects, other pests and various crop diseases. Normally the greatest impact of all these factors falls on crop production.

Some of the present uncertainty of crop production could be removed by such measures as irrigation and improvements in social and institutional organization. Still a good deal of uncertainty will always be there. For one thing, no imaginable measures could make crop cultivation completely independent of the natural hazards. Secondly, most of the physical measures are to be justified by their cost-benefit ratio. There may be many places, for example, where flood is preventable, but the cost of preventive measures would be greater than their benefit. In such cases it would not be economical to spend more capital in preventing a risk than would be lost by the risk itself. It may be in the interest of the individual owners that such lands should remain in production even if there were occasional risks of failure.

So the risks of crop production have to be faced. A serious crop failure means not only the loss of farmers' incomes but also the loss of their investments in crops. The resulting low incomes of farmers may lead to the failure to pay rents and taxes, to their loss of purchasing power, and to mounting debt.

Thereby, the entire community is affected by risks of which the farmers are the direct and primary victims

Various methods have been adopted for helping the farmers to compensate for losses of their crops through natural hazards. Reduction of land rent and taxes, cancellation of accumulated agricultural debts and direct relief from the government are among the principal methods applied. There are two major reasons why such policies are undesirable. First, farmers cannot expect them as a right, but only as a privilege, the extent of which is largely dependent on the policies and resources of the government. Even when concessions and relief are provided by law, their permanence may not be feasible nor strictly desirable. For large expenditures on relief can only be provided through budgetary appropriations representing an additional burden on Government. Second, the continued prospects of relief may make recipients depend on the government and are also likely to be questioned by the non-farming community. An important measure that is largely free from the above difficulties is insurance of growing crops against all natural and unavoidable hazards. But crop insurance is dependent on the government to the extent it is subsidized by the government.

The need and justification for crop insurance have been

stated in an annual report of the Manager of the United States Federal Crop Insurance Corporation:

"Large sums of money are spent each year in agricultural research to develop better varieties of seed, more effective means of controlling insects and diseases and improved methods of farming. Soil conservation practices have been encouraged by making available technical assistance as well as cash payments to the farmer. Price supports have been provided for more than a decade to help maintain some degree of stability in farm income. Despite all these measures the farmer will receive but little income in any year if he invests his time, money and effort to produce a crop only to be faced with a crop failure due to some cause over which he has no control. Insurance protection spans this crop failure gap. It is an essential part of a well-rounded agricultural program designed to provide security for farmers" (USDA 1947, p.20).

Benefits of Crop Insurance

The benefits to be derived from crop insurance will vary according to the nature and extent of protection provided by it.

Crop insurance cushions the shock of disastrous crop loss by assuring farmers a minimum of protection against natural hazards. Crop insurance spreads the crop losses over space and time. Losses suffered by farmers in particular localities are borne by many scattered over wide areas. Reserves accumulated in good years, in large part out of the premiums paid by the farmers themselves, are used to meet losses in bad years.

Crop insurance can facilitate increased agricultural production by making farmers willing to adopt new and more productive (but uncertain) technology.

With crop insurance, a certain income is guaranteed to the farmer even if the crop fails. The farmer can afford the risks that may be associated with some of the more intensive cultivation methods. He can also make his farming more extensive. With insurance proceeds to retire the outstanding loan, he will be a more creditworthy risk and thus able to qualify for a loan to obtain the resources he needs to resume cultivation in the next growing season. Crop insurance thus provides greater stability to farm output over time.

In addition to benefiting farmers, crop insurance can be of direct benefit to the government. Crop insurance can facilitate implementation of a consistent national agricultural policy.

With proper planning, crop insurance can contribute to the development of more stable farm prices by encouraging farmers to produce continually. The added agricultural production promoted by the crop insurance program can improve the country's balance of payments position by increasing its exports or reducing its imports.

Crop insurance can also be of significant benefit to financial institutions. A difficulty facing government-sponsored agricultural lending institutions is the severe decapitalization they experience when crop losses render a large volume of their agricultural loans uncollectible. However, crop insurance can be used as a form of collateral, thereby improving the creditworthiness of the farmers.

Thus, crop insurance can be used as an important instrument of social and economic policy to be pursued by the government especially for the protection of the farming community and for ensuring stability in farm and general income.

CONCEPTUAL ANALYSIS

THE THEORY OF CROP INSURANCE

This section is based on information found in Hazell, Pomareda, and Valdes, pp.35-42.

This discussion of the theory of Crop Insurance will be limited to the farmer level. Farmers allocate their resources to obtain desired combinations of expected income and income risks. Higher expected incomes typically require more risk. So most farmers trade some expected income for reduced fluctuation of income.

The intended purposes of Crop Insurance are to stabilize income and ensure enough income each year to repay debts and meet essential living costs. If these objectives can be met, farmers will be encouraged to seek higher expected profits.

In the case of single-crop farms, insurance can reduce income risks if it reduces the variance of returns from that activity and increases the level of income realized in bad years. Assume that production costs are not risky and the objective is to reduce the variability of income as measured by its variance. Then the variance of income can be expressed as

the following equation (Anderson, Dillon, and Hardaker 1977, p.33),

$$V(R) = E(P)^2 V(Q) + E(Q)^2 V(P) + 2E(P)E(Q)Cov(P,Q). \quad (1)$$

where R : revenue
P : the price of the crop
Q : the yield of the crop
V(R) : variance of returns
V(Q) : variance of yield
V(P) : variance of price
E(P) : expected price
E(Q) : expected yield
Cov(P,Q) : covariance between price and yield

Currently crop insurance insures a specified yield level and does not insure price. In the above equation, if variance of price, $V(P)$, is the major factor of risk facing farmers (suppose that yields do not vary much), compensating for reductions in yield may not have much effect on $V(R)$. The second term on the right side of equation 1 would then tend to dominate $V(R)$. Since crop insurance does not cover price, crop insurance would only act on the remaining two terms, $E(P)^2 V(Q)$ and $2E(P)E(Q)Cov(P,Q)$, in the equation. Under these situations, stabilization of price will be more effective. Yield

compensation will be less effective in reducing $V(R)$ when prices and yields are negatively correlated. High prices will tend to offset low yields and vice versa, and the covariance term will be negative. Then, $V(R)$ may not fluctuate much and can be stabilized. Poor yields may not even coincide with the worst revenue outcomes if the negative correlation is strong enough.

For the case of multicrop farms, it is also necessary to pay attention to the covariance between the returns of different crops. A j subscript represents the j^{th} crop, then the variance of total farm revenue is

$$V(R) = V(\sum_j R_j) = \sum_j V(R_j) + \sum_{i \neq j} \sum_j \text{Cov}(R_i, R_j). \quad (2)$$

Even though crop insurance for the j^{th} crop were successful in reducing $V(R_j)$, it still may not stabilize farm income. This depends on how the crop insurance affects the covariances between the returns of the j^{th} crop with the returns of all other crops. A desirable insurance scheme should reduce the positive covariances and increase the absolute value of the negative ones in order to reduce $V(R_j)$. However it is possible for insurance to reduce $V(R_j)$ yet increase the size of positive covariances to the point where $V(R)$ increases.

The most established decision theory in economics is the expected utility theory. The expected income-variance criterion assumes that a farmer's preferences among alternative farm plans are based on expected income $E(y)$ and associated income variance $V(y)$. Expected utility theory offers a useful way of formalizing a farmer's distaste for fluctuations in income. This theory assumes that each individual has a utility function for money. The shape of this function determines the income distribution parameters that the individual considers when choosing among strategies with risky outcomes. In this case it is assumed that farmers behave according to a closely related decision criterion: the mean-income standard-deviation criterion. It is also assumed that farmers maximize an expected utility function of the form,

$$E(u) = E(y) - \theta V(y) \quad (3)$$

where $E(u)$: expected utility

$E(y)$: expected income

θ : a risk-aversion parameter

$V(y)$: standard deviation of income

This criterion means that the farmers try to choose the farm plan for which the associated standard deviation of income is minimum for a given level of expected income. They will be willing to sacrifice expected income in order to reduce $V(y)$ to the point where the marginal trade-off is exactly θ . If the

farmer is risk averse, then θ is positive and the iso-utility curves are linear and upward sloping in $E(y)$, $V(y)$ space (Figure 1).

Figure 1 represents a set of indifference curves corresponding to equation 3. For any farm planning problem there is also an efficient mean-income standard-deviation set of farm plans. For each of these plans, $V(y)$ is as small as possible for the corresponding level of $E(y)$. In figure 1, the efficient frontier, OQ , is the locus of all efficient mean-income standard-deviation plans; all other feasible plans lie to the right of this frontier and are not efficient. Once the efficient $E(y)$, $V(y)$ frontier is known, then knowledge of the risk aversion parameter, θ , leads to identification of the optimal. The optimal plan for farmers is the one that maximizes their utility. This plan will always be a member of the efficient set. In figure 1, it is the plan defined by point P , the point where the utility surface is tangent to the efficient frontier.

The chosen decision criterion provides a direct rationale for farmers to purchase crop insurance. Crop insurance may reduce $V(y)$ for various levels of $E(y)$ in Figure 1. This will bring the point of tangency with the utility surface upward, allowing farmers to achieve higher

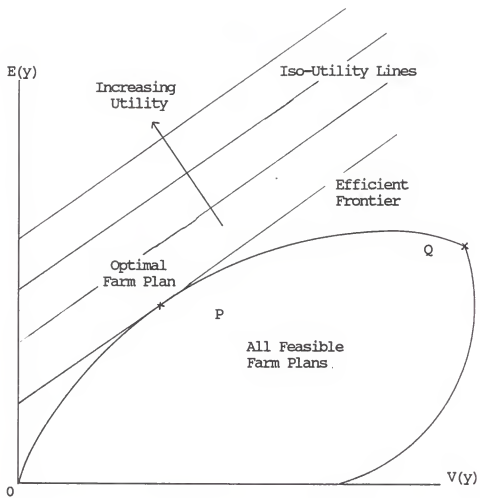


Figure 1. The Optimal Mean-Income Standard-Deviation Farm Plan

levels of expected utility. For effective crop insurance the reduction in $V(y)$ obtained, multiplied by θ , must compensate more than for the insurance premium charged to $E(y)$.

$V(y)$, as the measure of risk, is useful for formalizing the second objective, namely the avoidance of disastrously low incomes. This objective can be written as a probability criterion of the form:

$$\Pr(y_t > S) > 1 - \alpha, \quad (4)$$

where y_t : the t^{th} possible outcome for income net of all production costs and any interest charges on borrowed credit,

S : the minimum income required by farm families to meet essential living costs, and

α : a preassigned level of risk.

Since a positive income implies that all input costs financed with credit are recovered, then 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 equation 4 requires that income exceed S at least 95 percent of the time.

When equation 4 is not satisfied, since farmers think more highly of the survival of themselves and their families than the repayment of debt, farmers default on loans. So equation 4 can be interpreted as the probability of default, with α specifying the acceptable default rate. Farmers and lenders may differ about what is an acceptable default risk. The lenders' acceptable default rate may be constraining to farmers. On this basis, there is no reason why α should bear any relation to θ , since they do not represent risk tolerances for the same individual.

THEORETICAL ANALYSIS OF WHY FARMERS MIGHT NOT PARTICIPATE.

The following three problems associated with crop insurance have been mentioned in the literature; (1) Poor support of the federal Government (American Association of Crop Insurers), (2) Overpayment of claims (USGAO), and (3) Low participation of farmers (Ray 1981).

For the purpose of this report, the problem of low participation of farmers will be addressed. Specifically, "Why would the farmers not participate?" Four reasons that farmers might not participate are discussed below.

The first reason is based on equation 1, that is,

$$V(R) = E(P)^2 V(Q) + E(Q)^2 V(P) + 2E(P)E(Q)\text{Cov}(P,Q)$$
, in the theory of crop insurance. As discussed earlier for the single crop model, suppose variation of price has lots of impact on the variation of returns; but yields do not vary much. Since, crop insurance insure a specified yield level and does not insure price, farmers will not benefit from purchasing crop insurance.

The second reason not to participate is based on equation 2 ,
$$V(R) = V(\sum_j R_j) = \sum_j V(R_j) + \sum_{i \neq j} \sum_j \text{Cov}(R_i, R_j)$$
, in the theory of crop insurance. This equation represents the case of multicrop farms. What is important is how the covariance term impacts on $V(R)$, the total variance of all crops. Generally, a good insurance scheme should reduce the positive covariances and increase the absolute value of the negative ones. However it is possible (but not very likely) for insurance to reduce $V(R_j)$ yet increase the size of positive covariances to the point where $V(R)$ actually increases. If farmers produce lots of crops, the impact of covariance terms on total variance of returns may become great. Therefore, farmers may choose to protect themselves from risk by diversification rather than purchasing crop insurance.

The third reason is discovered in equation 3,

$$E(u) = E(y) - \theta V(y).$$

In this case, the risk parameter has a important role. If farmers are risk-neutral ($\theta = 0$), then expected utility is expected income. If farmers are risk-takers ($\theta < 0$), then expected utility increases as risk increases. So these farmers do not take crop insurance. Even if farmers are risk-averse, in cases where $V(y)$ increases less than $E(y)$ increases and the size of θ is small, utility may increase as standard deviation of income becomes larger.

The fourth reason is based on equation 3 and 4,

$$\Pr(y_t > S) > 1 - \alpha.$$

S (the minimum income for essential living cost) will be concentrated on. Suppose the farmers have large amounts of cash reserves and credit. Then S becomes very low. As S becomes low, the risk parameter becomes low, and farmers are not motivated to purchase crop insurance.

In summary, farmers will not be motivated to purchase crop insurance if the following be true, (a) if the variation of price is high and yields do not vary much, (b) if they are able to reduce variation in total income by producing many kinds of crops, (c) if they are risk-reutral or risk-takers, and/or (d) if they have large amounts of cash reserves and credit.

SUMMARY AND CONCLUSIONS

The purpose of this report is to review literature and theoretical models related to crop insurance.

Drought, flood, freeze, hail, disease, and insects are some of the hazards farmers face in growing crops. Crop losses, especially in successive years, can be serious. They can result in increased debt, reduced reserves, and curtailed spending. In extreme situations, farmers may be forced to discontinue operations. Lenders and businesses dealing with farmers and the entire local rural economy may be adversely affected when farm incomes drop.

Insurance with the Federal Crop Insurance Corporation provides a means by which some farmers can reduce the financial impact of crop failures. Federal crop insurance is mainly multiple-peril insurance which covers unavoidable losses from natural hazards. Farmers take out insurance for stated levels of crop production. Both quantity and quality may be specified. If the production is less than the guarantee, indemnity is paid for any shortage.

In the theory of crop insurance, the proposed models indicate how crop insurance can affect income risks and expected utility. In the case of single-crop farms, the reduced

variance of yields that happens due to crop insurance decreases variance of income. In the multi-crop farms, crop insurance could reduce the variation of individual crop returns and covariances between the returns of one crop with the returns of other crops. In the expected utility theory, crop insurance can be used to reduce standard deviation of income. Whether reduced standard deviation of income increases expected utility depends on the risk-aversion parameter and impact on expected returns. Crop insurance can support the minimum income necessary to meet essential living cost.

There are, however, some problems in implementing any scheme of crop insurance. In this report the problem of low participation of farmers is analyzed by using theory to address the question, "Why would the farmers not participate?" Farmers will not be motivated to purchase crop insurance if the following be true, (a) if the variation of price is high and yields do not vary much, (b) if they can sufficiently reduce variation in total income by producing many kinds of crops, (c) if they are risk-neutral or risk-takers, and/or (d) if they have large amount of cash reserves and credit.

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CROP INSURANCE : LITERATURE REVIEW AND CONCEPTUAL ANALYSIS

by

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AN ABSTRACT OF A MASTER'S REPORT

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